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HOW DOES TEMPERATURE CHANGE CAUSED BY COLD APPLICATION TO THE KNEE JOINT AFFECT JOINT POSITION SENSE AND MUSCLE STRENGTH?

MSc. PT. Cemaliye Hürer[1]*, Prof. Dr. Zafer Erden[2] and Assoc. Prof. Dr. Ender Angın[3]

[1]Cyprus International University, Faculty of Health Sciences, Department Of Physiotherapy And Rehabilitation, Nicosia, Mersin, Turkey.
[2]Hacettepe University, Faculty of Physical Therapy and Rehabilitation, Ankara, Turkey.
[3]Eastern Mediterranean University, Faculty of Health Sciences, Department of Physiotherapy and Rehabilitation, Famagusta, Mersin, Turkey.

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***Corresponding Author: MSc. PT. Cemaliye Hürer**
Cyprus International University, Faculty of Health Sciences, Department Of Physiotherapy and Rehabilitation, Nicosia, Mersin, Turkey.
Email ID: churer@ciu.edu.tr,

ABSTRACT

Cold application (CA) is one of the thermal treatment methods used as an analgesic treatment for the reduction of inflammation after acute injury or trauma. CA reduces neuronal transport speed, therefore fewer muscle fibers proliferate with insufficient proprioception that affect muscle strength. This study was carried out to determine whether joint position sense (JPS) and muscle strength would change according to temperature change caused by CA. 30 healthy males aged between 18 and 30 were included in the study. CA was performed on the knee joint for 15 minutes. Knee JPS and muscle strength were evaluated using an isokinetic dynamometer. Temperature change was monitored by digital hand-held thermometer. To determine the responses of the participants related to physiological temperature change for cold application, the temperature change of the skin was analyzed before and after the cold application for 15 minutes, and the median value of all participants was determined. Therefore, the participants were divided into two groups as those with a skin temperature change amount below 11.90°C (n=15) and above 11.90°C (n=15). The 15-minute CA didn't cause any effect on JPS and muscle strength at all angles of the analyzed knee ($p>0.05$). Considering the differences between the physiological responses of the participants to thecold application, there was no difference between the two groups in terms of their knee JPS and concentric muscle strength ($p>0.05$). 15-minute CA could be used safely without causing a reduction in proprioceptive sense or muscle strength before exercises or during sports competitions.

KEYWORDS: Cryotherapy, proprioception, somatosensory system, therapeutic modalities, knee.

INTRODUCTION

Proprioception was first defined by neurophysiologist Sir Charles Sherrington in 1906 as the "perception of joint movement and position, as well as the location of body parts in space".[1] Today, proprioception is defined as the cumulative input of information perceived from special nerve endings known as mechanoreceptors located onthe joint, joint capsule, ligament, muscle, tendon, and skin.[2-4] Proprioception contributes to the conscious and non-conscious senses, to the automatic control of movement, balance, postural control, and joint stability.[5] The proprioceptive sense has three functions in the knee joint. It is responsible for protecting the knee from excessive, compulsive movements that may cause injury, stabilizing of the knee joint, and coordinating complex motion systems.[6,7] It has two components as joint position sense and kinesthesia sense.[3,8] Joint position sense determines the perception ability of the presented joint angle of the individual, and after the extremity is moved, it is expected to find the same joint angle actively or passively. [5]

Cold application is one of the thermal treatment methods commonly used as an analgesic treatment for the reduction of inflammation after acute injury or trauma of the musculoskeletal system in Physiotherapy since Ancient Greece as cryotherapy.[9] Cryotherapy lowers skin, subcutaneous, and muscle temperature.[10,11] A decrease in tissue temperature is perceived by cutaneous receptors. Sympathetic nerves are stimulated. These nerves provide vasoconstriction due to the contraction of smooth muscles around vascular structures. This situation moderates the production of metabolites, therefore reducing pain, edema, and inflammation by limiting the degree of injury.[12] It also affects neuromuscular functions including neuronal transport speed and muscular spasm.[13,14] This change in the electrophysiological activity of the muscle may result from decreased sodium, potassium, and calcium diffusion in the nerves and motor end plate.[15] As a result of these changes, cold application reduces neuronal transport speed, and therefore, fewer muscle fibers proliferate with insufficient proprioception that might affect muscle strength.[16] This state may compromise the motor control of the joint. This is why as cryotherapy is a common treatment method in various aspects, it is essential to determine its effects on proprioception and muscle strength around the knee to prevent an increase in the risk of injury and ensure the safety of its use before exercise.[17] Various studies have been performed on the effects of cryotherapy on proprioception and muscle strength[17-19] but the results have not yet gained clarity due to methodological differences that attracted our interest. Moreover, there is no study on the effects of temperature changes caused by cold application on joint position sense and muscle strength. Additionally, as mentioned in a systematic review, the effective potential of cryotherapy in joint position sense is not completely known due to the limited number of publications.[20]

This interventional study was carried out with objective methods to determine joint position sense and muscle strength changes based on temperature changes caused bycold application performed on the knee joint in healthy individuals. The clinical benefits expected from the results of this study involve showing the effects of this treatment modality, which is applied due to injuries occurring during or before sports competitions, on joint position sense and muscle strength in physiotherapy practices.

MATERIALS AND METHODS

This study was carried out in the Neuromuscular Education Laboratory of the Eastern Mediterranean University, Faculty of Health Sciences, Department of Physiotherapy and Rehabilitation between 10.06.2019 and 10.07.2019.

Population and sample

This study was approved with the decision dated 23.05.2019 and numbered 2019/15-12 by the Scientific Research and Publication Ethics Board of the Eastern Mediterranean University. Individuals aged between 18 and 30 who gave informed consent were included in the study. According to the power analysis taking the study by Uchio et al.[21] as reference, with the assumption of α=0.05 and β=0.20, the minimum number of individuals that needed to be included in the study was determined as 21. 30 volunteer male individuals were included in the study.

The study was conducted as a comparative study.

Inclusion criteria

- Being a healthy volunteer aged between 18 and 30
- Being able to cooperate
- Having a Body Mass Index between 18.5 and 24.9
- Being male
- Being sedentary (individuals who do not exercise more than 30 minutes per day and 3 days a week)

Exclusion criteria

- Taking part in a physiotherapy program because of knee pain in the last 3 months
- Using any assistive walking device
- Having pain or discomfort around the knee
- Having a history of lower extremity surgery, rheumatic diseases and/or traumatic hip, knee, or ankle
- Having a pathologic condition involving the musculoskeletal system or the neurological system
- Having a chronic disease, peripheral vascular disease, and/or cardiopulmonary disease including but not limited to diabetes, hypertension
- Being unable to perform daily activities independently
- Having a steroid injection into the knee joint in the last 6 months
- Using medicines that influence the musculoskeletal and/or psychosomatic system
- Having a sensory disorder, sensitivity to cold, cold urticaria, Reynaud syndrome,or a skin disease

Procedures

Sociodemographic and clinical characteristics

The sociodemographic characteristics of the participants including age, height, body weight, and body mass index were recorded on a demographic information form. For the measurements, the dominant leg of each participant was used. To determine their dominant leg, the shooting-the-ball test was applied. The leg which was preferred by the participant to shoot the ball was chosen as his dominant leg, and the implementations and evaluations were made based on this leg.[22] Before data collection, information about the use of equipment in the tests was provided. For the participants to become familiar with the equipment, they were allowed enough repetation before the evaluation. All evaluations were made by the same physiotherapist.

Knee joint position sense

The knee joint position sense of the participants in the study was evaluated using an isokinetic dynamometer (Cybex NORM ®, Humac, CA, USA), which is shown in Fig. 1, before and after the cold application.[23] For the standard conditions of the evaluation, the unit's temperature was adjusted to 28°C.[24] During the assessment of knee joint position sense, to eliminate the tactile sense, an air pump splint was used[25] To dampen the sounds from the isokinetic dynamometer or the surroundings of the participant and prevent distractions, headphones were given to the participant, and it was ensured that the evaluation environment was a quiet as possible. To prevent visual input, an eye mask was given to the participant during the measurements. For standardization, the participant was asked to wear shorts and take off his socks and shoes from his dominant leg. For the knee joint position sense test, the participant sat on the chair of the isokinetic test system, and his knee was positioned at 90° flexion.[26] The target angles were determined as 30°, 45°, 60°, and 90°, and the angular speed was set at 10°/sec.[25,27] The dynamometer was set to its passive motion mode. The dominant leg was passively brought to a randomly determined angle among the target angles and left there for 5 seconds. The participant was asked to focus on that point. The extremity was then brought to the starting point passively. After this, the participant was asked to push the warning button when he thought he reached the target angle. Repetition with both eyes-open and eyes-closed states were performed, and then, the tests were held. Three evaluations were made at every angle, and the absolute value of the difference between the measured and target angle was recorded as the error angle. The average result of the 3 measurements was used in the statistical analyses. Thirty seconds of resting was provided between measurements to prevent memory development, and different angles were used randomly in no particular order.[25]

Figure 1: Knee proprioception analysis by isokinetic dynamometer.

Muscle strength

An isokinetic dynamometer *(Cybex NORM ®, Humac, CA, USA)* was used to evaluate the strength of the M. Quadriceps Femoris and Hamstring muscle group of the participants. The participant was asked to sit on the isokinetic dynamometer seat with his body upright, hip and knee at 90˚ flexion, and to prevent compensatory motion during the test, the body and femur were stabilized with stability belts. The motion center of the dynamometer was set to be next to the lateral condyle of the femur. To evaluate concentric muscle strength, an angular speed of 60°/sec was used.[28] Three repetation were allowed for the participant, and 30 seconds of resting was provided. The tests were performed 5 times at a 60º/sec angular speed. The measurements were made in a motion range of 0-90° knee flexion. By the end of the tests, the maximum torque values of the M. Quadriceps Femoris and Hamstring muscle group were measured. The participants were informed about the measurements beforehand and asked to finish the test without getting support from their hands to prevent measurement errors.[5]

Cold package and skin temperature assessments

Before the cold application, a digital handheld thermometer was used to determine the temperature of the cold package. Thus, it was ensured to start the application at a standard temperature of 0ºC. The skin temperature of the individual was evaluated using a handheld non-contact thermometer before the cold application and at the 5th, 7th, 10th, 12th, and 15th minutes of the cold application.[4] The center of the patella was taken as the target to have the measurement from the same place. The temperature was evaluated by holding the thermometer at 10 cm from the targeted point for 5 seconds as shown in Fig. 2.[19] The difference between the temperature before the cold application and that at the 15th minute of the application was recorded as the "temperature change" of the skin.

Figure 2: Knee Temperature analysis by laser thermometer.

Cold application

The cold package *(cold pack, 20x25)* was applied to the knee joint for 15 minutes. The center of the cold pack was placed next to the center of the knee joint. To prevent frostbite, the cold packs were covered with a thin towel. During the application, the individuals were asked to wear shorts and sit for 15 minutes in the long sitting position shown in Fig. 3. During the application, they were asked to relax for minimizing any change in their tissue temperature and limit their muscle activity. After the application, they were called twice to evaluate the instant effects of the cold pack. On the first day, the joint position sense of the individuals was evaluated. After 15 minutes of cold application, the joint position sense of the individuals was evaluated again. On the next day, they were called to continue the study, and the effect of the cold application on muscle strength was analyzed. The evaluations were made right after the completion of the cold application.[29]

Figure 3: Cold application to the knee joint.

Groups formed according to temperature changes

Since the physiological responses of individuals to cold may show differences, the median value of the temperature change amount calculated after the cold application in all participants was determined. The median value was 11.90°C. Accordingly, the individuals were divided into two groups as those with a skin temperature change value of 11.90°C or lower (n=15) and those with a change value above 11.90°C (n=15), and intragroup and intergroup comparisons were made for the analyzed parameters.

Statistical analysis

The descriptive statistics of the discrete and continuous variables of the study are presented as mean and standard deviation, minimum, maximum, and median values. The level of statistical significance was accepted as $p<0.05$. The *Statistical Package for the Social Sciences* (SPSS) 24.0 package program was used in the analysis. The significance of the difference between two mean values obtained before and after the treatment within each group was tested using the Wilcoxon test. The Mann-Whitney U test was used for the intergroup comparisons of the continuous variables.

RESULTS

Table 1: Ages and Anthropometric Measurements of the Participants (n=30).

	$\bar{x}$	sd	M	Min	Max
Age (year)	22.33	2.25	22	18	29
Height (cm)	1.78	0.05	1.79	1.68	1.90
Body Weight (kg)	74.25	6.82	75	61	89
BMI (kg/m^2)	23.33	1.46	23.96	19.29	24.89

n: Number of Participants, BMI: Body Mass Index, $\bar{x}$: Arithmetic Mean, sd: Standard Deviation, M: Median, Min: Minimum, Max: Maximum

Table 2: Ages and Anthropometric Measurements of the Participants in the Groups (n=30).

	Group	n	$\bar{x}$	sd	M	Min	Max	Z*	p*
Age (year)	0 - 11.90°C	15	22.60	2.41	23	18	29	-0.208	0.836
	above 11.90°C	15	22.07	2.12	22	18	27		
Height (cm)	0 - 11.90°C	15	1.78	0.05	1.78	1.69	1.9	-1.165	0.244
	above 11.90°C	15	1.78	0.06	1.8	1.68	1.85		
Body Weight (kg)	0 - 11.90°C	15	74.03	7.03	75	61	89	-0.083	0.934
	above 11.90°C	15	74.47	6.84	73	64	84		
BMI (kg/m^2)	0 - 11.90°C	15	23.24	1.49	23.93	19.29	24.65	-0.353	0.724
	above 11.90°C	15	23.42	1.48	24.18	20.74	24.89		

n: Number of Participants, BMI: Body Mass Index, °C: Degrees Celsius, $\bar{x}$: Arithmetic Mean, sd: Standard Deviation, M: Median, Min: Minimum, Max: Maximum, *: Mann- Whitney U Test

The ages and anthropometric measurements of the participants are given in Table.

The Mann-Whitney U test results of the differences of these characteristics between the two groups are given in Table 2. As seen in Table 2, there was no statistically significant difference between the groups in terms of their BMI, body weight, height, or age values($p>0.05$).

Table 3: Joint Position Sense (JPS), Concentric Maximum Torque (MTV), and SkinTemperature (ST) Values of the Participants.

		$\bar{x}$	sd	Min	Max
Before the treatment	30° JPS	4.54	3.18	0.30	12.60
	45° JPS	4.47	3.08	0.40	14.30
	60° JPS	2.52	1.88	0.30	6.40
	90° JPS	5.70	2.77	1.70	13.60
	M. Quadriceps Femoris MTV	215.27	42.93	108.00	293.00
	M. Hamstrings MTV	126.17	34.53	15.00	191.00
After the treatment	30° JPS	5.33	3.58	0.30	13.30
	45° JPS	4.93	3.68	0.00	17.70
	60° JPS	3.64	3.49	0.00	16.00
	90° JPS	4.64	3.57	0.70	15.00
	M. Quadriceps Femoris MTV	210.20	46.68	99.00	298.00
	M. Hamstrings MTV	126.70	32.26	37.00	191.00
Skin Temperature	Initial ST	29.65	1.09	25.80	31.2
	5th-minute ST	19.47	3.78	8.80	25.60
	7th-minute ST	18.22	4.19	6.80	26.00
	10th-minute ST	17.43	4.69	6.00	24.80
	12th-minute ST	16.96	4.38	5.60	24.60
	15th-minute ST	16.86	4.67	5.20	24.80
	Temperature Change	12.79	4.62	5.80	25.20

$\bar{x}$: Arithmetic Mean, sd: Standard Deviation, Min: Minimum, Max: Maximum

Table 3 presents the arithmetic mean, standard deviation, minimum, and maximum values of the participants in terms of joint position sense before and after the treatment, concentric maximum torque values of the M. Quadriceps Femoris and the Hamstring muscle group, and the temperature change values of the knee joint measured at the beginning and at specific times.

Table 4: Comparison of Joint Position Sense (JPS) Values According to the Groups and Measurement Times.

	Group	Before			After			p_3
		$\bar{x}$	sd	p_1	$\bar{x}$	sd	p_2	
30° JPS	0 - 11.90°C	4.42	3.22	0.836	5.43	3.65	0.934	0.550
	above 11.90°C	4.65	3.25		5.22	3.63		0.363
45° JPS	0 - 11.90°C	4.56	2.59	0.533	5.70	3.84	0.177	0.572
	above 11.90°C	4.39	3.60		4.16	3.46		0.865
60° JPS	0 - 11.90°C	2.92	1.96	0.244	4.12	4.25	0.724	0.691
	above 11.90°C	2.13	1.77		3.16	2.59		0.348
90° JPS	0 - 11.90°C	5.95	2.31	0.308	4.43	2.75	0.723	0.057
	above 11.90°C	5.45	3.24		4.85	4.33		0.683

$\bar{x}$: Arithmetic Mean, sd: Standard Deviation, p_1 and p_2: significance (intergroup), p_3:significance (intragroup)

Table 4 shows the results of the Wilcoxon test for the intragroup comparison of the joint position sense values of each group and the results of the Mann-Whitney U test for the intergroup comparison of these values. There was no statistically significant difference between the two groups in terms of their joint position sense values before the intervention (p_1>0.05). There was also no statistically significant difference between the two groups in terms of their joint position sense values after the intervention (p_2>0.05) In Group 1 (0 - 11.90°C), the joint position sense values before and after the intervention were not significantly different (p_3>0.05). In Group 2 (higher than 11.90°C), the joint position sense values before and after the intervention were not significantly different either (p_3>0.05).

Table 5: Comparison of Concentric Maximum Torque Values (MTV) of the Participants According to the Groups and Measurement Times (n=30).

		Before			After			p_3
	Group	$\bar{x}$	sd	p_1	$\bar{x}$	sd	p_2	$\bar{x}$
M. Quadriceps Femoris MTV	0 - 11.90°C	212.13	37.36	0.713	198.60	42.53	0.171	0.089
	above 11.90°C	218.40	49.01		221.80	49.16		0.432
M. Hamstrings MTV	0 - 11.90°C	126.00	30.00	0.935	117.67	36.16	0.206	0.096
	above 11.90°C	126.33	39.62		135.73	25.95		0.109

$\bar{x}$: Arithmetic Mean, sd: Standard Deviation, p_1 and p_2: significance (intergroup), p_3: significance (intragroup), MTV: Maximum Torque Values

Table 5 shows the results of the Wilcoxon test for the intragroup comparison of the concentric maximum torque values of each group and the results of the Mann-Whitney U test for the intergroup comparison of these values. There was no statistically significant difference between the two groups in terms of their maximum concentric torque values before the intervention (p_1>0.05). There was also no statistically significant difference between the two groups in terms of their maximum concentric torque values after the intervention (p_2>0.05) In Group 1 (0 - 11.90°C), the maximum concentric torque values before and after the intervention were not significantly different (p_3>0.05). In Group 2 (higher than 11.90°C), the maximum concentric torque values before and after the intervention were not significantly different either (p_3>0.05).

DISCUSSION

There are some studies conducted using cold application about the relationship between muscle strength and joint position sense in the literature. However, different results have been obtained due to the variety of cold applications used in different studies, the duration of application, the place of application, the characteristics of individuals, and methodological differences. Therefore, this relationship has not been completely clarified yet. This study was carried out to analyze the effects of cold application on the concentric muscle strength of the M. Quadriceps Femoris and the Hamstring muscle group and joint position sense according to the physiological responses of the participants. The results of this study showed that cold application to the knee joint for 15 minutes did not significantly change muscle strength and joint position sense around the knee joint based on temperature change.

To have a homogeneous distribution of the participants, male participants in the "normal weight" category according to their BMI values were included in the study. Therefore, the effects of menstruation and adipose tissue thickness differences on physiological responses were eliminated. Although there are studies in the literature about the relationship between cold application and the variables of joint position sense and muscle strength, the degree of temperature change on the knee between before and after cold application was not analyzed, and there is no study on changes in these parameters according to different physiological responses that may occur in individuals. This study is the first study that evaluated 2 different types of responses to cold by looking at different physiological reactions. This study is also important in terms of analyzing how joint position sense and muscle strength parameters are influenced after cold application which is important and interactive in terms of injury and stability in the knee joint. Based on the responses occurring in different receptors on different knee angles, the feeling may change, and by examining this, knee joint position sense was evaluated at 4 different angles. To evaluate muscle strength and joint position sense, an isokinetic system, which is a highly objective method in terms of system validity and reliability, was used. This increased the reliability of our results.

In 2014, in a review of 11 studies on the effects of cryotherapy on the proprioceptive system, four of the reviewed studies showed that cold application affected joint position sense negatively, whereas 7 of them showed that cold application did not significantly affect this parameter. Each study had a different joint position sense test and a different cryotherapy procedure which paved the way for difficulty in the discussion and comparison of their results. Considering the contradictory results of studies, it is difficult to determine whether cryotherapy influences joint position or not.[30]

In a review analyzing the factors that influence proprioception, the effects of cryotherapy on proprioceptive senses were investigated. According to the analyzed studies, cold application was generally made to the joint, but only in one study the application was performed on the muscle. The examined studies evaluated proprioception by measuring position sense in different joints including the shoulder, leg, and ankle. In the end, there were similarities between the studies that reported increased rates of joint position errors and those that did not report a significant change after cryotherapy. As there is a limited number of studies in this field and because of methodological differences, the effects of cryotherapy on proprioception have not been clearly defined.[30]

In a study that was conducted with healthy volunteers in 2011, the effects of immersion in cold water on knee joint position sense were examined. All participants were subjected to cold water (14ºC±1ºC) immersion once and warm water (28ºC±1ºC) immersion (control) once. During both cryotherapy and control sessions, the individuals were sat in a water tank, and their extremities were immersed in the water up to the umbilicus level for 30 minutes. Before and after immersion in cold water, knee joint position sense was evaluated using a three-dimensional motion analysis system. After 30 minutes of immersion in cold water, there was no significant difference compared to the warm water immersion intervention. It was concluded that the use of cryotherapy before exercise would not increase the risk of injury.[20]

In a study that analyzed the effects of applying ice to the knee for 20 minutes on knee joint proprioceptive sense, 37 individuals were divided into two groups as the ice group and control group. Joint position sense was evaluated at knee angles of 90º, 60º, and 30º degrees using an isokinetic dynamometer. According to the results, there was no significant difference between the two groups in terms of their proprioceptive sense measurements at different angles. The reason for this was proposed as that the evaluations were based on gravity. In the evaluations from 60º to 30º or from 30º to full extension, gravity was effective, and to eliminate this effect on the knee joint, it was recommended to test individuals by having them lie down or sit in an upright position.[25]

Oliviera et al.[24] aimed to analyze the effects of applying cryotherapy to the M. Quadriceps Femoris on proprioception, as joint position sense is primarily signalized by muscle receptors (muscle spindle). A 20-minute cryotherapy application was made once to the knee joint and once to the M. Quadriceps Femoris among 15 individuals. Joint position sense was evaluated using the illustration method. After the cryotherapy application to both the muscle and the joint, an increase was observed in absolute and relative angular error values. The effects of the intervention on the knee joint and that on the M. Quadriceps Femoris were found the same. Therefore, it was concluded that the location in cryotherapy application in terms of proprioception was insignificant. Their results emphasized the importance of joint mechanoreceptors such as muscle spindles.[24]

A review study revealed striking results on the effects of cryotherapy on the function of muscles around the ankle and the knee. The researchers stated that cryotherapy applied to the ankle joint for 30 minutes significantly promoted soleus function based on motor neuron activation.[31] After the application of cryotherapy to the knee joint, there was an increase in the maximum voluntary contraction during isometric knee extension and the peak torque of knee extension.[32,33] Pietrosimone et al.[31] stated that in tibiofemoral osteoarthritis patients with arthrogenic muscle inhibition, local knee joint cooling facilitated M. Quadriceps Femoris activation, and the effects were maintained after the removal of the ice pack. According to the results of study, joint cryotherapy could be promising for maximizing muscle activation and strength in people with or without joint pathology.

In a study on the effects of the early application of cryotherapy on M. Quadriceps Femoris and EMG activity and isometric strength following knee surgery, cryotherapy increased M. Vastus Medialis EMG activity and the isometric strength of M. Quadriceps Femoris. Cryotherapy may prevent inhibitor synapse activation and/or reduce M. Quadriceps Femoris inhibition by increasing the stimulability of anterior horn cells. This significant difference in the EMG activity of the M. Vastus Medialis could have been due to the M. Quadriceps Femoris being the most affected part by arthrogenic muscle inhibition.[34]

A study that was carried out with 54 individuals to investigate the short-term effects of cryotherapy on knee joint proprioception and the isometric strength of the M. Quadriceps Femoris evaluated isometric muscle strength and proprioception using an isokinetic system. After 20 minutes of cryotherapy application, it was shown that cryotherapy did not affect the proprioceptive rightness of the knee joint or the isometric strength of the M. Quadriceps Femoris negatively, and thus, it was argued that cryotherapy could be used safely during physical activities and training programs.[27]

In a study on the effects of cooling the knee joint on the concentric torque production of the M. Quadriceps Femoris, concentric M. Quadriceps Femoris strength was measured right before the cooling intervention and after 20 minutes with concentric peak and average torque outputs using an isokinetic dynamometer. Skin temperature was also measured using a hand-held thermometer. The dominant sides of individuals were included in the evaluation, and the participants were asked to perform knee extension three times at 60°/sec. According to the findings of the study, following cryotherapy, there was a reduction in the concentric strength of the M. Quadriceps Femoris.[35]

LIMITATIONS

A limitation of this study was that the evaluations were performed on a small number of healthy men.

CONCLUSION

Fifteen minutes of cold application did not have a significant effect on physiological responses regarding muscle strength and knee joint position sense. Differences in the physiological responses of the participants did not cause a change in the concentric strength of the knee muscles and knee joint position sense. This result suggested that cold application did not make a significant difference in the 15-minute period. Therefore, it was concluded that cold application could be performed safely before exercise or during sports competitions without negatively affecting proprioceptive sense. However, different pathologies and tissue differences may cause different physiological responses.

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