



Original Article

The Comparison of the Effect of Deep and Superficial Heat on Healthy Ankle Joint Position Sense

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ARTICLE INFO

Article History:

Received: 20/1/2014

Revised: 17/6/2014

Accepted: 2/7/2014

Keywords:

Deep heat

Superficial heat

Joint position sense

ABSTRACT

Background: Heat therapy is one of the natural treatments that can affect the information transferred by the proprioceptive receptors. Heat has an effect on the conduction velocity of peripheral nerves, but the exact effect of two kinds of deep and superficial heat on the joint position sense is not known clearly. The present study aimed to compare the effect of deep and superficial heat on ankle joint position sense.

Methods: Thirty healthy male students aged between 18 to 30 y/o participated in this study. Deep heat by short-wave diathermy and superficial heat by water of 42 °C were applied for 15 minutes in two sessions for all participants.

In all of the tests, active and passive ankle joint position sense in dorsiflexion and plantarflexion were measured by pedal goniometers prior to and after heat application. The Non-Parametric-Paired T-test Wilcoxon and Non-Parametric-Paired T-test Mann-Whitney were used to analyze the data.

Results: The superficial heat does not have any positive or negative effect on the ankle joint position sense. After the deep heat, the absolute angular error of active dorsiflexion was increased, but passive plantarflexion was decreased significantly. Comparing the two types of heat, the results revealed that the deep heat increased the absolute angular error of active dorsiflexion significantly more than superficial heat.

Conclusion: According to the results, deep heat therapy improves passive ankle joint position sense in plantar flexion, but it worsens the active joint position sense of dorsiflexion. Therefore, it seems that after applying deep heat therapy on an ankle joint, exercise prescriptions need to be cautious.

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Introduction

Conscious perception of each person from his body and his position from his environment with automatic joint reaction is called articular sense or proprioception [1]. This sense makes a person aware about joint position, type of joint movement, the direction of movements, and

finally it causes muscle contraction for joint movement and stability [2].

The central nervous system receives the information related to joint position sense from different receptors, such as muscle receptors (muscle spindle and Golgi tendon organs), joint capsule mechanoreceptors, skin receptors (free nerve endings), visual, auditory, and vestibular receptors [3].

Joint position sense is essential for keeping true joint action in sports, ADL, and occupational tasks [4]. The protective role of joint position sense is more important in distal joints, because these joints are exposed to more

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forces and injuries due to more mobility [5]. In addition, the ankle joint tolerates most of the weight of the body and, because of its different movements, joint position sense is very important in this joint [6].

Joint position sense is influenced by different factors, such as vibration and muscular-nervous conditions around the joint and joint destructive factors like arthritis, which subsequently can decrease joint position sense of the joint and affect other joints [7, 8]. Disability in this sense affects the muscle action and joint stability and its weakness can cause acute and chronic injuries in the joint. Therefore, in their treatment, attention must be paid to joint position sense improvement programs [1].

Nowadays, heat modalities are used in curing and as analgesics for musculoskeletal lesions and also for increasing tendon elasticity and decreasing muscle spasms on a large scale [9]. Studies showed that temperature had a remarkable effect on the peripheral nervous system because some biological and chemical processes controlling the nervous system are sensitive to temperature. These include acetylcholin-esterase, voltage canals, and the skeletal muscle contraction properties [10]. In addition, researchers have indicated that there is a linear relation between the speed of spindle-efferent discharge and muscle temperature. This is important because each change in efferent signal can cause a change in the sensitivity of the muscle spindles and, thus, influence the accuracy level of joint position sense [11]. This may alter the balance and motor response. Therefore, it is important to find out the effects of heat on position sense. Proprioception of the ankle joint plays an important role in balance in different positions like walking, standing, and other ADL's, and the use of heat for curing problems of the ankle joint has become a common modality in physiotherapy clinics. Also, in respect to superficial heat and deep heat affecting different tissues, in the present study the effect of two kinds of heat modalities in the forms of deep and superficial heat have been investigated on the position sense of the ankle joint. The aim of this research is to determine and compare the effects of superficial and deep heat on ankle joint position sense.

Methods

In an experimental research study, thirty healthy male students (age range of 18-30 years old, mean age 21.83 ± 2.23 years old, mean height 175.56 ± 7.6 cm, and mean weight 73.43 ± 11.75 kg) from a rehabilitation school in Shiraz city in a convenient sampling took part in this study. No participants were athletes, their right legs were dominant, and they had no history of trauma to the ankle joint or neuropathy diseases. The volunteers were randomly and equally divided into two groups: a short-wave diathermy group and a superficial heat group. All subjects gave written informed consent to participate in the study. The study was approved by the Medical University of Shiraz for Health Sciences Research involving Human Subjects.

For superficial heating, each subject kept half of his leg in hot water 42 ± 1 for 15 minutes. Short wave diathermy

(SWD) (manufactured by Enraf Nonius Company, Netherlands) was used for application of deep heating, operating in continuous mode with an intensity of 6 watts. Each subject was seated on the bed in long sitting position with his ankle off of the edge of the bed and received 15 min of SWD applied by malleable electrodes by contraplanar method on the two sides of the ankle joint [12].

All subjects were familiarized with the procedure by explanation and demonstration. Measurements were performed for all participants at same time of day (12-2 p.m.), in two nonconsecutive days, in the same room with a temperature of 28° C to decrease the effects of environmental changes. Each subject was seated in a chair with feet not reaching the floor, and the foot was placed in a pedal goniometer. The participant's eyes were closed and the foot was taken from the neutral position passively to dorsiflexion up to 10° . After 5 seconds, the foot was taken to its original place. Dorsiflexion of the same foot was done passively and the examiner was informed when the particular angle was reached and the angle was recorded. It was repeated again by active motion. This test was done for plantarflexion position sense up to 20° both passively and actively. All motions were repeated three times and the mean of the angle was calculated as data. Before and after both superficial and deep heating, the position sense of the right foot for active and passive dorsiflexion and plantarflexion was measured in two sessions for all participants.

Statistical Analysis

The difference between the two angles, (absolute angular error -AAE) was taken as an error which was statistically considered. To prevent error, all actions were learnt by the therapist and were applied to the case with a constant speed. Non-parametric paired T-test Wilcoxon was used to find the relation between the variable before and after the heat application, T-test Mann-Whitney was used to compare the two groups of the deep heat and superficial heat application.

Results

As Table 1 revealed, after the use of deep heat, the AAE of active dorsiflexion has more error ($P=0.014$). Conversely, after the use of deep heat, passive plantarflexion of the ankle has less error rate ($P=0.024$).

According to Table 2, after superficial heat, AAE of any ankle movements were unchanged.

In comparing deep and superficial heat, it was seen that deep heat decreases the accuracy of active dorsiflexion significantly more than superficial heat (Table 3).

Discussion

According to the results, it was revealed that superficial heat does not change the position sense of ankle active and passive dorsiflexion and plantarflexion. One of the reasons that the position sense of the ankle is not affected by superficial heat is that superficial heat affects only the

Table 1: Difference between the absolute angle error (AAE) of the ankle motions before and immediately after application of deep heat

Motion	Time	Pre-intervention measure (Mean±SD)	Post-intervention measure (Mean±SD)	P value
Dorsiflexion	Active	2.23±0.49	2.94±0.74	0.014
	Passive	2.26±0.19	1.5±0.19	0.829
Plantarflexion	Active	2.01±3.3	2.52±1.3	0.305
	Passive	2.81±2.42	2.25±1.11	0.024

Table 2: Difference between the absolute angle error (AAE) of the ankle motions before and after application of superficial heat

Motion	Time	Pre-intervention measure (Mean±SD)	Post-intervention measure (Mean±SD)	P value
Dorsiflexion	Active	1.35±0.83	1.47±0.85	0.754
	Passive	1.49±0.78	1.39±0.59	0.381
Plantarflexion	Active	1.82±0.71	2.03±0.99	0.736
	Passive	3.00±2.56	1.84±2.65	0.08

Table 3: The comparison of differences of absolute angle error (AAE) before and after two types of heat

Motion	Difference of AAE	Superficial heat (Mean±SD)	Deep heat (Mean±SD)	P value
Dorsiflexion	Active	1.81±0.02	2.89±1.23	0.018
	Passive	1.55±0.19	2.38±0.66	0.994
Plantarflexion	Active	2.35±0.28	2.83±0.7	0.411
	Passive	3.54±1.16	3.19±1.31	0.853

receptors of the skin, but the receptors of the position sense are inside the capsule of joints and muscle [2]. In addition, the result of Clark, F.J; Burgess, R.C, et al research showed that the muscle spindle receptor of the back of the leg plays a good role in the position sense of the ankle especially in dorsiflexion [13]. The results that were demonstrated from this research are the same as the results of Hopper and his coworker's studies. Hopper's result stated change of temperature on the skin does not change the position sense of the ankle [14]. Similarly, in other studies it has been proved that the change of temperature on the skin in the form of heat as well as cold does not affect the position sense of the ankle [15]. In Haruhiko Sato's research, the elastic responses of the muscle spindle of the tibialis anterior muscle of a cat after the use of superficial heat were investigated. It was seen that superficial heat affects mostly the skin afferent fibers, and its effects on the afferent fibers of the muscle spindle was about 43% [16]. Metre's, D & Knardahi, S demonstrated that the use of cold temperatures can increase sympathetic activity, but cannot affect the position sense of the ankle, and this again shows that the receptors of the muscle spindle have more effects on the position sense of the ankle than the sympathetic system receptors [17].

As we have seen from the results, AAE of active dorsiflexion after deep heat had increased significantly. This could be due to the fact that, after deep heat application, extensibility of the surrounding tissues of the joint, such as the calf muscles, increased. This leads to decreasing muscle tone, and therefore sensitivity of the receptors was reduced. Robertson et al also showed that deep heat has more effects on muscle extensibility than superficial heat [15]. However, in contrast to active

dorsiflexion, the AAE of the passive ankle plantarflexion after the use of deep heat decreased to a great extent. The reason for betterment of the position sense of the ankle in passive plantarflexion could be the positive effect of deep heat on the velocity of conduction of the nerve and the decrease of motor and sensory range in normal nerves at high temperature. These changes can be secondary to changes in ion channels of the nerves and muscles [2]. Similarly, Tilki and his coworkers demonstrated that the nerve conduction velocity improved after increasing the temperature [18], but in active dorsiflexion, the conduction velocity is under the effect of increasing extensibility.

Although deep heat had a positive effect on position sense of passive plantarflexion, position sense of active plantarflexion had not significantly changed. The reason may be the effect of gravity on active plantarflexion. While the subject had repeated active plantarflexion, the effect of gravity had to be controlled at the same time. This could be the reason for decreasing the ability of the person for achieving that angle of active plantarflexion. In passive plantarflexion, the therapist had control on gravity and the person only had to concentrate on the angle formation. Comparing the effect of deep and superficial heat on the position sense of the ankle, it was seen that only in active dorsiflexion was there a significant difference. This means that after deep heat application the absolute error angle of the active ankle dorsiflexion increased, which showed the effect of extensibility of the calf muscle on the position sense of the ankle.

Other researchers have demonstrated that doing a warm-up after simple exercise for increasing temperature can have a positive effect on the position sense [7, 19], but deep heat does not show the same effects. Therefore, it's suggested that, in future studies, the effect of deep heat

and warm-up should be considered on the position sense of ankle.

Conclusion

According to the results, it can be demonstrated that superficial heat does not have any positive or negative effect on the ankle joint position sense. Although deep heat has decreased the error rate in the position sense after passive plantarflexion, it has increased the error rate in position sense after active dorsiflexion. Therefore, it can have a destructive effect on this joint. As the disturbed position sense of ankle dorsiflexion has more destructive effect on ankle ligaments during exercise, deep heat therapy should be used with caution and no heavy exercises should be done after deep heat therapy in order to prevent the ankle joint from any damage.

Acknowledgments

We would like to thank everybody who helped us in this study.

Conflict of Interest: None declared.

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