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Rajan Balakrishnan
Senior Lecturer, Asia Metropolitan University, Malaysia.

William Charles
Student Asia Metropolitan University, Malaysia.

Correspondence
Rajan Balakrishnan
Senior Lecturer, Asia Metropolitan University, Malaysia.

The effect of cold water immersion cryotherapy on normal ankle joint position sense in young adults among AMU students

Rajan Balakrishnan, William Charles

Abstract
Purpose of study: To determine whether the fifteen-minute water immersion treatment affects the normal ankle joint position sense (JPS) at the middle range of dorsiflexion and plantar flexion actively.
Objective: Significant or no significant finding on using the water immersion cryotherapy treatment for 15minutes would affect the normal ankle joint position sense.
Study design: Research Design: Experimental, Sampling: Purposive sampling through questionnaire.
Material and method: Subjects*:* Twenty healthy volunteer's participant in the experiment. All subjects selected according to their dominant leg (The dominant leg was defined as the leg that the subject would choose to kick a ball), as the treatment leg in this study. Subjects were excluded if they had special disease as diabetes, musculoskeletal disease and history of fracture or other orthopedic problems. Instruments: Firstly, skin surface temperature was measured by using a Liquid Crystal Body Temperature with contact the body surface. The temperature of the cold water was also closely monitored with a battery operated by Aqua Digital thermometer. The digital thermometer submissively attached to the end and was accurately control the temperature at (18±1°C) using ice. Ankle JPS was measured using a pedal goniometry consisting of four parts a pedal with two clamps and pointer or a back piece with a protractor or a leg fixator and a metal base. Information such as age, weight and height were recorded in a questionnaire.
Statistical analysis used: Paired t-test used to calculate the Joint Position Sense (JPS) ROM and Temperature by using SPSS 16.0.
Results: The result show significant changes on the Joint Position Sense and Temperature 15 minutes after the cold water immersion therapy. The result analysis was taken into 3 stages which is Before, After & 15 minutes after cold water immersion. All the result based on the performance of the volunteers regarding the effect of the cold water immersion which divided into 2 groups by gathering the data collection of active plantar flexion and dorsi flexion for JPS and Temperature. The result has been analyzed by using the paired T-Test to be more accurate in for each group by avoiding any miscalculation. All the data as stated into table that presented below from table 3, 4 and 5.
Conclusion: These findings suggest that a 15-minute cryotherapy (18±1°C) is deleterious to JPS and alteration of the temperature at the same time it can't be safely used at the range of (18±1°C) for physical treatment or physiotherapy management this to avoid further complication.

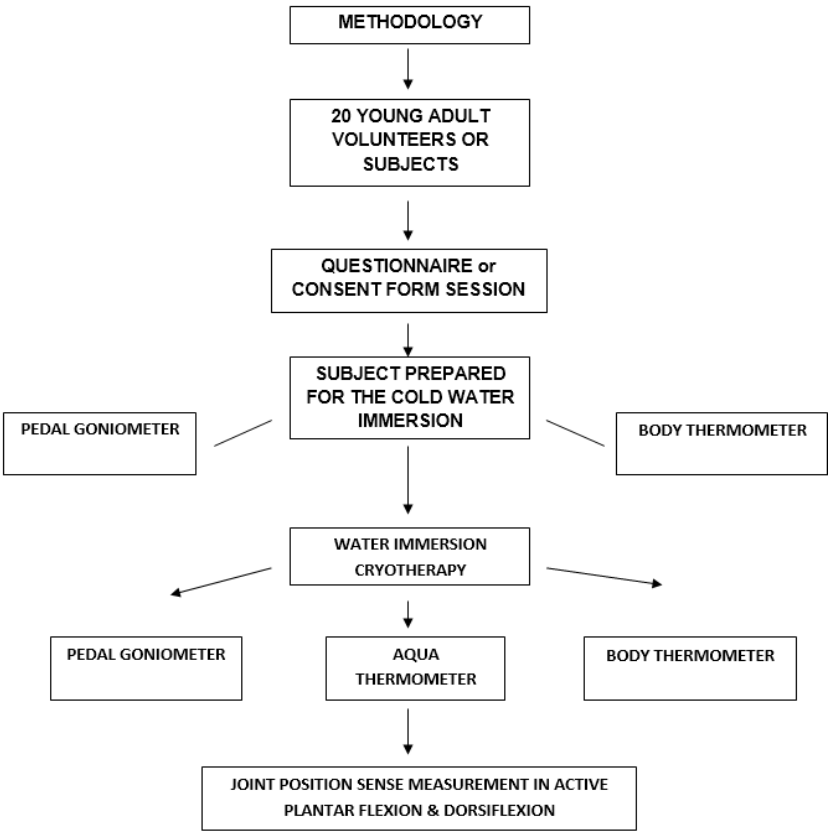
Keywords: Cryotherapy, Ankle JPS (Joint Position Sense), Proprioception & Immersion.

Introduction
The term cryotherapy refers to the lowering of tissue temperature by the withdrawal of heat from the body to achieve a therapeutic objective. Cryotherapy or cold therapy is commonly employed by physiotherapist, athletes and others for various clinical reasons. Cryotherapy has been used for decades by sports people to decrease pain, swelling, secondary hypoxic injury, arterial or venous constriction, relieve muscle spasm, facilitate movement and reduce core and skin temperature [3]. Various methods of applying cryotherapy are as follows: Ice massage, Ice bag, Chemical cold pack, Cold whirlpool, Cold water immersion slush bath. Equal parts of ice and water are placed in a plastic bucket and the injured area is submerged in the ice water slurry for 15 minutes. This form of cryotherapy is used primarily for distal extremities such as hands and feet because of the increased area of surface contact, water immersion likely causes more joint and muscle cooling compared with more superficial applications such as

ice. Cryotherapy, or icing and/or submersion of the foot and ankle in cold water, is a very popular treatment method for both acute and chronic athletic injuries because of its ability to reduce pain, inflammation, and muscle spasm. Moreover, cryotherapy influences neuromuscular properties including nerve conduction velocity and muscle contraction. The term proprioception, developed as a result of Sherrington's [8] landmark work in the early 1900s, is commonly defined as the cumulative neural input to the central nervous system from mechanoreceptors. Most recently, the term proprioception has evolved into including measures of the joint position sense, threshold of detection of passive movement and force reproduction. Angular measurement have been used by researcher to assess joint position sense as one of sub modalities of proprioception. Gordon and Chan *et al* designed a pedal goniometry to assess proprioception at the ankle and Chan *et al* designed to measure the range of ankle inversion in a plantar flexion. The device was proven highly reliable with values of the Pearson's correlation coefficient for intra-tester and inter-tester reliability of (r=0.96) and (r=0.91) respectively. Cryotherapy is commonly used during rehabilitation as a treatment modality for acute and chronic injuries. The aims of cryotherapy interventions include pain reduction, inflammation control, and edema reduction. Cryotherapy before exercise may change the biomechanical properties of the joint, resulting in inadequate peripheral feedback and potentially lead to injury when rehabilitation or exercise is resumed. As cold exposure shown to reduce the nerve conduction velocity, balance and alter neuromuscular transmission in muscles, it is possible that cold water immersion could also reduce the joint position sense.

Methods and materials:
Research Design: An Experimental design
Sampling: Purposive sampling through questionnaire
Number of Sample: 20 subjects
Location: Asia Metropolitan University
Duration of study: 2 months.
Subjects: Twenty healthy participants in the experiment. All subjects selected according to their dominant leg (The dominant leg was defined as the leg that the subject would choose to kick a ball). Subjects were excluded if they had any disease as diabetes, musculoskeletal disease and history of fracture or other orthopaedic problems. Instruments: Firstly, skin surface temperature was measured by using a Liquid Crystal Body Temperature with contact the body surface. The temperature of the cold water was also closely monitored with a battery operated by Aqua Digital thermometer. The digital thermometer submissively attached to the end and was accurately control the temperature at (18±1°C) using ice. Ankle joint position sense was measured using a pedal goniometer consisting of four parts a pedal with two clamps and pointer or a back piece with a protractor or a leg fixator and a metal base. Information such as age, weight and height were recorded for the inclusion criteria.

Procedure



Procedure: First section: Subjects ankle joint is measured using the pedal goniometer. Second section: Subject given the questionnaire or consent form and subject are screened for any contraindication. Procedures: 20 healthy ankle joint subjects, aged between 18 and 25 years old were treated by using water immersion cryotherapy for 15 minutes in range of (18±1°Celcius) the water temperature is measured by using the Digital Aqua thermometer (picture 1).The subjects skin temperature over anteromedial aspect of dominant foot measured by the Liquid Crystal Body thermometer (picture 2)

device before, immediate and 15minutes after the water immersion. Ankle joint position sense tested through the Pedal goniometer (picture 3) at 3 stages similar to the skin temperature.First stage: The subject was instructed to remove their pants to acclimatization to room temperature (range: 18.7°–24.5°C). To measure the subject's skin temperature, the Liquid Crystal Thermometer was applied over the anteromedial aspect of the ankle (lateral to medial malleolus) and skin temperature was recorded. Then, the range of motion of volunteer's ankle calculates by using pedal goniometer. Subject also blinded to eliminate any visual cues during the ankle measurement. The subject's foot moved to the target angle after preparation from neutral position to the middle range of dorsi flexion (10 degrees), and the subject was asked to focus on the position of her ankle joint in space for 3 seconds. After returning to the starting position, subject's asked to move the foot towards dorsi flexion with constant velocity. Then, subject was asked to inform us once they felt the target angle has been achieved and recorded. Second stage: The volunteer's foot, immersed in the 18±1 degree water with the distance of 5 cm above the malleolus. After 15 minutes of cooling or cold water immersion, skin temperature and JPS (Joint Position Sense) immediately measured. Third stage: 15 minutes after cooling, skin temperature and JPS were measured. In interval of 2nd and 3rd stage, subject was relaxed and barefoot. The JPS measured in the active plantar flexion and dorsi flexion movement the interval begin from before water immersion, after water immersion and 15 minutes after water immersion.

Inclusion Criteria

20 Participants, all participants are assessed with dominant leg and participant that undergoes with sedentary lifestyle.

Exclusion Criteria

Participants excluded if had any health problem like diabetes and musculoskeletal conditions with the history of fracture or orthopedic problems.

Review of data (Joint Position Sense)/Before Water Immersion & After Water Immersion

Group	BWI Plantar Flexion	AWI Plantar Flexion
Mean	130.15	126.20
SD	11.77	12.37
SEM	2.63	2.77
N	20	20

Paired t-test results – Between BWI & AWI

P value and statistical significance

The two-tailed P value is less than (0.0001) by conventional criteria this difference is considered to be statistically significant. Confidence interval the mean of BWI Plantar Flexion minus AWI Plantar Flexion equals 3.95, 95% confidence interval of this difference from 2.90 to 5.00. Intermediate values used in calculations is t = 7.9021, df = 19 &standard error of difference = 0.500

Review of date Joint Position Sense)/Before Water Immersion & After Water Immersion

Group	BWI Dorsi Flexion	AWI Dorsi Flexion
Mean	75.00	72.05
SD	7.48	7.28
SEM	1.67	1.63
N	20	20

P value and statistical significance: Paired T – Test.

The two-tailed P value is less than 0.0001 by conventional criteria this difference is considered to be statistically significant. Confidence interval the mean of BWI Dorsi Flexion minus AWI Dorsi Flexion equals 2.95, 95% confidence interval of this difference from 2.35 to 3.55. Intermediate values used in calculations is t = 10.3367, df=19 &standard error of difference = 0.285.

Review of data (Joint Position Sense)/After Water Immersion & 15 minutes After Water Immersion

Group	AWI Plantar Flexion	15 min AWI Plantar Flexion
Mean	126.20	131.15
SD	12.37	11.44
SEM	2.77	2.56
N	20	20

P value and statistical significance: Paired T-Test.

The two-tailed P value is less than 0.0001 by conventional criteria this difference is considered to be statistically significant. Confidence interval the mean of AWI Plantar Flexion minus 15 min AWI Plantar Flexion equals -4.95, 95% confidence interval of this difference from -6.48 to -3.42. Intermediate values used in calculations is t = 6.7733, df=19 &standard error of difference = 0.731

Review of data (Joint Position Sense)/After water immersion & 15 minutes after water immersion

Group	AWI Dorsi Flexion	15 min AWI Dorsi Flexion
Mean	72.05	75.65
SD	7.28	8.46
SEM	1.63	1.89
N	20	20

P value and statistical significance

The two-tailed P value is less than 0.0001 by conventional criteria this difference is considered to bestatistically significant. Confidence interval the mean of AWI Dorsi Flexion minus 15 min AWI Dorsi Flexion equals -3.60, 95% confidence interval of this difference from -4.38 to -2.82. Intermediate values used in calculations is t = 9.6578, df = 19 & standard error of difference = 0.373.

Review of data (Joint Position Sense)/Before Water immersion & 15 minutes After Water Immersion

Group	BWI Plantar Flexion	15 min AWI Plantar Flexion
Mean	130.15	131.15
SD	11.77	11.44
SEM	2.63	2.56
N	20	20

P value and statistical significance

The two-tailed P value equals 0.0097 by conventional criteria, this difference is considered to be statistically significant. Confidence interval the mean of BWI Plantar Flexion minus 15 min AWI Plantar Flexion equals -1.00, 95% confidence interval of this difference from -1.73 to -0.27.Intermediate values used in calculations is t = 2.8742, df = 19 & standard error of difference = 0.348.

Review of data (Joint Position Sense)/Before water immersion & 15 minutes After water immersion

Group	BWI Dorsi Flexion	15 min AWI Dorsi Flexion
Mean	75.00	75.65
SD	7.48	8.46
SEM	1.67	1.89
N	20	20

P value and statistical significance

The two-tailed P value equals 0.0729 by conventional criteria this difference is considered to be less statistically significant. Confidence interval the mean of BWI Dorsi Flexion minus 15 min AWI Dorsi Flexion equals -0.65, 95% confidence interval of this difference from -1.37 to 0.07. Intermediate values used in calculations is t = 1.8984, df = 19 & standard error of difference = 0.342.

Review of data (Temperature)/Result Before Water Immersion & After Water Immersion.

GROUP	Before Water Immersion	After water Immersion
MEAN	36.850	34.745
STANDARD DEVIATION	0.564	0.786
N	20	20

Paired t-test – Between BWI & AWI

The P value and statistical significance shows that the two tailed P value is less than <0.0001 by the criteria this difference is considered to be significant. The mean of BWI minus AWI is equals to 2.105 and 95% interval of this differenced is from 1.741 to 2.469 values. Intermediate values used in calculations is t = 12.0953, df = 19&standard error of difference = 0.174.

Review of data (Temperature)/Results: Before Water Immersion & 15 minutes After Water Immersion

GROUP	Before Water immersion	15 minutes After Water Immersion
MEAN	36.850	36.040
STANDARD DEVIATION	0.564	0.486
N	20	20

Paired t-test – Between BWI & 15 minutes AWI

P value and statistical significance

The two tailed P value is less than <0.000, and the criteria of this difference is considered to be significant. The mean of BWI minus 15minutes AWI is equals to 0.810 and 95% interval of this difference is from 0.538 to 1.082 values. Intermediate values used in calculations is t = 6.2424, df = 19&standard error of difference = 0.130

Result

The result show significant changes on the Joint Position Sense and Temperature 15 minutes after the cold water immersion therapy. The result analysis was taken into 3 stages which is Before, After & 15 minutes after cold water immersion. All the result based on the performance of the volunteers regarding the effect of the cold water immersion which divided into 2 groups by gathering the data collection of active plantar flexion and dorsi flexion for joint position sense and Temperature. The result has been analyzed by using the paired T-Test to be more accurate in for each group by avoiding any miscalculation. All the data as stated into table that presented below from table 1.1 to 3.2.

Discussion

The results revealed that 15-minute water immersion with 18±1°C has significant effect on the ankle Joint Position Sense and Temperature at the plantar flexion & dorsiflexion actively from mid range of the ankle movement with the P value < 0.0001/ < 0.0005. In Hopper's study, application of water immersion (15 minutes, 4°C) produced a significantly greater reduction in skin surface temperature (15°C). Therefore, we selected the 15-minute water immersion of 18°C to achieve a skin temperature within this range. Dover believed that the afferent information from the gleno humeral joint (GH joint) may have been affected by the cryotherapy, but subjects were able to use peripheral information from other areas to modify the motor response. Perhaps even little afferent information which travels to the Central nervous system is enough for the efferent or central command information to correct the joint position sense despite the alternation caused by the cryotherapy in this experiment. Besides, the temperature of the GH joint may be difficult to be lowered to a level of clinical significance. Hence, the shoulder may have not been cooled enough to measure a difference in the motor output joint position sense. As mentioned previously, muscle spindles have autonomic fibers besides somatic innervations. Therefore, each factor stimulating autonomic system may change sensitivity of muscle spindles and accuracy proprioception. For instance, cold as one stimuli of sympathetic system may be effective in proprioceptive acuity. However, Matre *et al* at a study on the human observed that stimulation of sympathetic nerves through cold pressor has no effect on the proprioception, but after glucose intake which is a natural stimuli of sympathetic system, the proprioceptive acuity is higher into flexion, but not into extension and diabetes subjects was one of the exclusion criteria in this study to avoid the changes in blood flow in skeletal muscles after the cold water immersion. Uchio *et al* indicated that applying cooling pad to the knee for 15 minutes under the circulating medium at 4°C increases inaccuracy of position sense by 1.7 deg that is in consistent with our study. One of the plausible reasons may be related to 4°C, because pain receptors are very fired at this temperature. Hence, this matter may have negative effect on the proprioception. Uchio *et al* identified decreases in nerve conduction velocity after cryotherapy as the culprit for altered proprioception. A significant difference in ankle Joint Position sense following fifteen minutes of ice immersion was found in Hopper's study. However, the magnitude of this difference is (0.5 degree). Surenkok *et al* were the only investigators who employed proprioceptive tests Joint Position Sense and static balance after 2 separate cryotherapy interventions in a crossover study design. In this research, significant differences were found before and after cold pack application and also before and after cold spray application. Riemann and Lephart suggested that cutaneous afferents play only a minor role in joint proprioception, whereas muscle spindles and joint receptors have a much more significant role. Therefore, whether superficial applications of cryotherapy such as cold spray or ice can cool deep tissue sufficiently to elicit a reduction in proprioceptive or joint position acuity is questionable. Generally, Skin surface temperature serves as a useful measure in determining the cooling efficiency of cryotherapy agents. Authors reported that a skin surface temperature of 13.6°C reflects local analgesia and 12.5°C reflects a 10% reduction in

nerve conduction velocity. Skin surface temperatures between 10°C and 11°C reflect a 50% reduction in cellular metabolism, with the onset of cell hypo metabolism occurring at a skin surface temperature of 15°C. These findings define a therapeutic skin surface temperature ranging from 10°C to 15°C. Therefore, an efficient agent has a post application temperature within this range. When nerve temperature decreases, the velocity of nerve conduction will also decrease in order to the temperature and duration of the temperature change. It is not directed to the nerve fibers thickness or diameters rather, this research also indicates that cold has the greatest effect on conduction by myelinated and small fibers and the least effect on conduction by unmyelinated and large fibers. A-delta fibers which are small diameter-myelinated and pain-transmitting fiber demonstrate the greatest decrease in conduction velocity in response to the cooling. Fifteen-minute cooling at 18±1°C may have effect on the function of proprioception but using lower temperatures or longer periods may indicate the other findings because of further affecting conduction velocity of afferent fibers running from receptors to CNS, and further activation of pain receptors. Of course researches that have investigated effects of pain on the proprioception have found different findings and no exact correlation has been found between perceived pain intensity and decreased acuity so far. For instance, Mater *et al* reported that muscle pain declines the proprioception. Our results are significant that cold immersion therapy could alter the joint position sense neither with those who found no change in joint position sense after a cold therapy session. Different cooling techniques may produce different degrees of joint cooling. Hence, we believe that the modality of cooling ice-water immersion, a cooling pad, or ice application may be critical in governing the effect on joint position sense. This study has been done on the ankle joint. However, this point should be regarded that mechanism of proprioception in various joints ankle, knee and shoulder is different. Furthermore, differences between the results may be related to the various methods of studies because soft tissue thickness, type of modality, contact time, primary temperature of tissue and modality are very important in cooling process and can influence the results.

Limitation

All subjects participating in this study had uninjured ankles. Since the injury or acute inflammatory processes may affect the results, findings of the present study are not applicable to an injured population. Moreover, cutaneous fat thickness and changes in intramuscular and joint temperature were not measured. I assumed that the cryotherapy application has altered the tissue temperature and Joint Position Sense, yet this was not verified. More studies should be performed to investigate various sectors of the ankle's range of motion.

Recommendation: In this study it is recommended that the use of convenience samples should be avoided so that it can be applied to other group setting. Larger age group should be recruited. Moreover, the next study should at least use the non dominant ankle or limb so that the difference can be seen and this will help in treatment wise of a patient.

Conclusion

These findings suggest that a 15-minute cryotherapy (18± 1°C) is deleterious to joint position sense and alteration of the temperature at the same time it can't be safely used at the range of (18±1°C) for physical treatment or physiotherapy management to avoid further complication.

References

1. Low J, Reed A. Electrotherapy explained: Principles and Practice. Oxford: Butterworth Heinemann, 1994.
2. Michlovitz SL. Thermal Agents in Rehabilitation. 3rd ed. Philadelphia: FA Davis, 1996.
3. Knight KL. Cryotherapy in sports injury management. Champaign, IL: Human Kinetics, 1995.
4. Roya khanmohammadi. the Effect of cryotherapy on the normal ankle joint position sense, 2011.
5. McAllister D. Therapeutic Modalities. E-medicine. Available at: http://www.caryacedemy.org. Cited: 17 JUL, 2008.
6. Meeusen R, Lievens P. The use of cryotherapy in sports injuries, 1986.
7. Abramson DI. effect of tissue temperature and blood flow on motor nerve conduction velocity, 1966.
8. Payne KA. Ankle injuries and ankle strength, flexibility, and proprioception in college basketball players, 1997.
9. Lee HM. Evaluation of shoulder proprioception following muscle fatigue, 2003.
10. Jones LA. Peripheral mechanism of touch and proprioception, 1992.
11. Karkouti E, Marks R. Reliability of photography range of motion measurement in healthy sample: Knee and Ankle joint measurement, 1997.
12. Gordon DS. Pedal Goniometer to assess ankle proprioception, 1988.
13. Chan M, Chu M, Wong S. Reliability of a pedal goniometer for the assessment of inversion in the plantar flexed position, 1990.
14. Bleakley C. The use of ice in the treatment of acute soft-tissue injury, 2004.
15. Nadler SF. The physiologic basis and clinical application of cryotherapy and thermotherapy for the pain practitioner, 2004.
16. Surenkok. Cryotherapy impairs knee joint position sense and balance. Isokinetic and Exercise Science, 2008.
17. Uchio Y. Cryotherapy influences joint laxity and position sense of the healthy knee joint. Archives of Physical Medicine and Rehabilitation, 2003.
18. Algafly. The effect of cryotherapy on nerve conduction velocity, pain threshold and pain tolerance, 2007.
19. Makinen TM. Postural sway during single and repeated cold exposure, 2005.
20. Coulange M. Consequences of prolonged total body immersion in cold water on muscle performance and EMG activity, 2006.
21. Costello, Joseph. Effects of cold water immersion on knee joint position sense in healthy volunteers, 2011.
22. Lee JM, Warren MP, Marson SM. Effects of ice immersion on nerve conduction velocity, 1978.
23. JT Hopkins. Cryotherapy and Transcutaneous Electric Neuromuscular Stimulation Decrease Arthrogenic Muscle Inhibition of the Vastus Medialis after Knee Joint Effusion, 2002.
24. Daryl C. Osbahr BS. The effect of continuous cryotherapy on glenohumeral joint and subacromial space temperatures in the postoperative, 2002.
25. Freeman H, Nickerson RF. Research Service of the Worcester State Hospital, Worcester, Massachusetts, 1938.
26. Hopper D, Whittington D, Davies J. Does ice immersion influence ankle joint position sense, 1997.
27. Dover G, Powers ME. Cryotherapy does not impair

shoulder joint position sense, 2004.
28. Riemann BL, Lephart SM. The sensorimotor system, part I: the physiologic basis of functional joint stability, 2002.
29. Costello JT, Donnelly AE. Cryotherapy and joint position sense in healthy participants: A systematic review, 2010.
30. Kennet J, Hardaker N, Hobbs S. Cooling efficiency of 4 common cryotherapeutic agents, 2007.
31. De Jesus PV, Hausmanowa – petrusewicz I, Barchi RL. The effect of cold on nerve conduction of human slow and fast nerve Fibers, 1973.
32. Matre D, Knardahl S. Sympathetic nerve activity does not reduce proprioceptive acuity in human, 2003.
33. La Riviere J, Osternig LR. The effect of ice immersion on joint position sense, 1994.
34. Wassinger CA, Myers JB, Gatti JM. Proprioception and Throwing Accuracy in the Dominant Shoulder After Cryotherapy, 2007.