Cubed-ice vs Wetted-ice as a Cryotherapeutic Agent in the Malaysian Climate

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Abstract

The effects of cubed-ice and wetted-ice on cutaneous temperature were studied. Skin temperature was taken at every two-minute intervals, for a period of 20 minutes. 20 female varsity students with mean age of 21.7 ± 0.6 years, mean height of 161.6 ± 5.47 cm, and mean body mass of 54.1 ± 8.8 kg participated in this study. Paired sample t-test showed that cubed-ice was a better cryotherapeutic agent than wetted-ice. The result contradicts the findings of past studies suggesting that ambient temperature and relative humidity could have an effect on the efficacy of the cryotherapeutic agents.

Keywords: Malaysia climate; cutaneous temperature;cube ice; wetted-ice

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1.0 Introduction

Cryotherapy had been practiced since ancient times by using ice and snow, as advocated by Hippocrates. An athletic trainer, Don Bennet, in an article appearing in the 1961 winter issue of *Athletic Training*, has been credited with publishing "one of the first, if not the very first, mention of cold therapy for athletic injuries in American Literature" (Myrer et al, 2001). Ice is a therapeutic agent used in medicine as an integral part of injury treatment and rehabilitation (Baker et al, 2009).

Cryotherapy is now a standard procedure for treating acute injury involving sprain and strain. An immediate effect of cryotherapy is numbing sensation, thus reducing the feeling of the injured area.

According to Algafly and George, 2007; cryotherapy can significantly reduce the nerve conduction velocity and increase the pain threshold and pain tolerance.

Furthermore, cryotherapy is one of the least expensive and most used therapies recommended in the immediate treatment of the skeletal muscle injury. The major objective of the use of cryotherapy in the early follow-up of muscle injury is to minimize adverse effects related to the damage process, as pain, edema, haemorrhage and muscle spasm, but above all, reduce the area of secondary injury caused by ischemia induced by the primary injury (Knight, 1995; Knight and Londeree, 1980; Merrick et al., 1999, Jarvinen et al., 2005).

Cryotherapy reduces tissue temperature by transferring the heat energy from the tissue to the cryotherapeutic agent via conduction. Cryotherapeutic agent is simply anything cold that can be used to transfer the heat energy. The most common cryotherapeutic agents that are being used are ice, gel packs, frozen peas and ice-water immersion (Hardaker et al, 2007). The ice that is used for cryotherapy comes in various forms such as cubed-ice, crushed-ice and it can be fully solid or wetted form. This form of treatment for management of soft-tissue injuries is common among elite and amateur athletes and sports participants, as it is commonly used by sports physicians, physical therapists, athletic trainers, and others. The modes of delivery include wet-ice, submersion in a cold-water bath, thermoelectric cooling, dry ice, cold packs and chemical spray. However, in clinics, and hospitals (outside sports arenas) cold packs are more frequently used (Allen et. al., 2002).

The lowering of tissue temperature in cryotherapy is explained by the withdrawal of heat energy from the body to achieve a therapeutic effect. Heat energy is removed via conduction from the skin to the agent during cryotherapy. Efficacy is the capacity of the agent to produce an absolute cooling effect regardless of its preapplication temperature. Efficiency is the production of a desired effect with a minimal waste. Thus, cooling efficiency is the ability of the cold agent to bring local skin surface temperature to equilibrium. (Hardaker et al, 2007).

Using ice during treatment is proven as the best treatment for acute injury involving soft tissue. It had been practiced in the local and international sporting scene. Wetted-ice had been proven as a better cryotherapeutic agent rather than cubed-ice (Baker et al, 2009). However, would the effects be the same in the Malaysian hot and humid climate? Hence, the present study is designed to investigate the effectiveness of cubed-ice and wetted-ice as a cryotherapeutic agent in the Malaysian climate.

Other than that, the findings from this study may be useful to those who are in the sport and emergency care field such as first aiders, sport aiders, athletic trainers and even for coaches, managers and even athletes themselves to determine which cryotherapeutic agent is best used during the early treatment of soft tissue injury which is very important to minimize the injury as well as speeding up the recovery period. Rozita et. al, 2011, emphasized that the government of Malaysia has encourage physical activities and health promotion among especially the teenagers, therefore the findings from this study may also enhance the individual knowledge, attitudes and skills in managing the early treatment of soft tissue injuries.

The air temperature and humidity in Malaysia might play a role in affecting the ice melting rate as compared to past researches. The average temperature ranges from 26°C - 35°C in Shah Alam (www.met.gov.my), and the mean monthly relative humidity is between 70 to 90%, varying from place to place and from month to month (www.met.gov.my).

2.0 Literature Review

Cryotherapy is defined as "the use of ice or cold in a therapeutic setting". The main purposes of using cryotherapy on injuries are to decrease pain, decrease muscle spasm, and to decrease farther harm from acute injuries (Fisher, 2009). Cryotherapeutic agent is the medium to which the heat energy is withdraws. Heat energy is removed via conduction from the skin to the agent during cryotherapy (Kennet et al, 2007).

Allen et al, 2000, stated that cryotherapy or therapeutic tissue cooling is a common form of treatment dating back to ancient Greece. It is believed to relieve pain by inducing local analgesia, and known to decrease edema, inflammation, blood flow, metabolic rate, intramuscular temperature, hypertonicity, and nerve conduction velocity.

Cryotherapy is commonly used immediately after acute musculoskeletal injuries to prevent swelling and secondary hypoxic injury and to reduce muscle spasm. Furthermore, cryotherapy reduces pain and may increase motoneuron poll excitability, which enhances a patient's ability to perform therapeutic exercises. Therapeutic exercises are thought to be critical during recovery from injury (Edwards et al, 2006). It has been accepted for decades that cryotherapy is an effective, inexpensive and simple intervention for pain management after many acute sport injuries (Algafly and George, 2007).

In acute management of musculoskeletal injuries, cryotherapy, the therapeutic use of cold, is the most commonly used modality. The primary rationale for the use of cold involves the ability of the cold to reduce the metabolic rate of a tissue. This metabolic reduction may help the uninjured tissue to survive a post injury period of ischemia or to be protected from damaging enzymatic reactions that may accompany injury. It is assumed that immediate cryotherapy application will be more beneficial than the delayed application since the sooner the metabolic rate is reduced after injury, the less will be the secondary damage. Thus, cryotherapy techniques that provide more rapid cooling of tissues may offer some advantage than slower cooling techniques (Jutte et al, 2003).

Kennet et. al, 2007 showed that ice is the most effective cooling agent. Another study conducted by Algafly and George, 2007; observed that wetted-ice are better cooling agent

than cubed-ice. Wetted-ice is defined as ice and water added together in an ice or premade icepack that has begun to melt (Algafly and George, 2007).

The research conducted by Blake et. al., 2002, used ice-water immersion and cold-water immersion as the cryotherapeutic agents. The cooling rates were almost similar between ice-water immersion and cold-water immersion.

Brucker et. al., 2005, in their research entitled "Exercise and Quadriceps Muscle Cooling Time" used crushed-ice bag as their cryotherapeutic agent. To make sure temperature readings were not affected by different superficial tissue thickness, only subjects with a right anterior mid thigh skinfold measurement between 20 and 30mm were included. A study by Dykstra et. al., 2009 showed wetted-ice produced the greatest overall temperature change during treatment and recovery, and crushed-ice produced the smallest change.

Hardaker et. al., 2007, compared four cryotherapeutic agents including crusheded-ice (CI), gel pack (GP), frozen peas (FP), and ice-water immersion (WI) to determine which agent provided the greatest cooling efficiency after a 20-minute application. The study showed crushed-ice and ice-water immersion produced significantly greater reduction in skin surface temperature compared to the gel pack and frozen peas at $p < 0.001$. Hence, crushed-ice and ice-water immersion had the greater cooling efficiency and sustained decreased skin surface temperatures better than gel pack and frozen peas during postapplication, indicating they are potentially the most clinically beneficial.

Application of CI reduced skin surface temperature to just outside the defined therapeutic range, suggesting that a decreased application time still produces beneficial results. The CI and WI reduced skin surface temperature enough to promote local analgesia and cellular hypometabolism. Application of FP caused skin surface temperature to fall just within the therapeutic range and to elicit the onset of cell hypometabolism, but this temperature was not sustained beyond the first minute of the rewarming period. The GP failed to reduce the skin surface temperature to the therapeutic range. (Hardaker et. al., 2007).

Noncontact, digital, infrared TI cameras area a valid and reliable tool for measuring skin surface temperature; nothing radiates to or touches the body. Previous applications of noncontact TI cameras highlight their capacity to track dynamic changes in skin surface temperature, so the cameras are considered an ideal tool for monitoring recovery of skin surface temperature after application of cryotherapeutic agents. These TI cameras are advantageous because they enable temperature measurement over an area, and data analysis that is facilitated by computer software enables extraction of relevant temperature data from a specific ROI within the image. (Hardaker et. al., 2007).

The results from the study demonstrated that wetted-ice was more effective than both cubed-ice and crushed-ice at decreasing skin surface temperature during and after a 20-minutes treatment. This greater effectiveness may be due to the increased contact between the wetted-ice and the skin, because water within the pack has a greater ability to mold to the surface of the treatment area than the ice does. Water also has a much higher ability to conduct thermal energy compared with air, which is found between the individual ice pieces within the other 2 forms of ice pack. Cubed-ice and crushed-ice packs use air to transfer thermal energy between the individual pieces of ice, whereas a wetted-ice pack uses water

to transfer the thermal energy within the pack. Thus, cubed-ice and crushed-ice have a decreased ability to transfer thermal energy within the ice pack compared with wetted-ice.

Baker et. al., 2009, studied the cooling effectiveness of ice packs made with cubed, crushed, and wetted-ice on intramuscular and skin surface temperatures. The research showed that crushed-ice produced the smallest temperature change, decreasing 4.3°C intramuscularly and 15.0°C at the surface. Wetted-ice produced the greatest temperature change, decreasing 6.0°C intramuscularly and 17.0°C at the surface. Cubed-ice decreased 4.8°C intramuscularly and 14.1°C at the surface. Hence, wetted-ice was the best at reducing surface temperature, followed by cubed-ice and the least crushed-ice. Differences between cubed-ice and crushed-ice, showed that ice pack effectiveness may be less affected by moldability than by ability to transfer thermal energy. The ice pieces in the crushed-ice pack are less dense than those in the cubed-ice pack and rely more on air transfers thermal energy less effectively than ice.

3.0 Methodology

20 female students of the Faculty of Sport Science and Recreation (FSR) aged between 20 and 23 years old volunteered in the study. Prior to participation, participants were informed of the purpose, benefits and risks of the study and all provided written informed consent. They also had to fill up a modified physical activity readiness questionnaire.

All the data regarding to surface temperature were measured using the Infrared thermometer Model TM-956, manufactured by Lutron Electronic Enterprise Co. Ltd.

The HS-3 digital stopwatch, manufactured by Casio was used to keep the time progression of the whole period of time of the test; during the 20 minutes of the treatment period and 20 minutes of the rewarming period.

All data regarding to air temperature and relative humidity were measured using the MICROTHERM Heat Stress WBGT model HB3279-03, manufactured by Casella CEL.

The independent variables were the two different cryotherapeutic agents, air temperature and relative humidity, while the cutaneous skin surface temperature was the dependent variable. The study was conducted in the open air area within UiTM Stadium to observe the effects of air temperature and relative humidity effects of the cooling agent. The test on the cubed-ice and wetted-ice were carried out on two separate days to allow proper rewarming of the skin temperature. The test involved 20 minutes treatment time and 20 minutes rewarming period.

All participants were asked not to engage in any physical activities that could alter the body temperature prior to the test. They were then asked to sit down and placed their hands on a table in a supination position. The ice was then placed at the mid portion of the antebrachial area.

Cubed-ice pack was prepared beforehand by putting cubed-ice into a 15 $\times$ 20 cm zip lock polyethylene bag and removing excess air. For wetted-ice pack, cubed-ice was first being filled into the zip lock bag and then half of the remaining cavity within the zip lock bag was filled with water. Freestanding ice packs were placed on top of the treatment area and were not secured with any types of wraps.

Skin temperature, air temperature and relative humidity baseline measurement were taken before the ice packs were placed on top of the treatment area. Skin temperature was taken at every two-minute intervals both during the 20 minutes cooling and rewarming periods. Air temperature and relative humidity was taken at every 10 minutes interval.

4.0 Results and Discussions

Demographic data

20 female students were invited to participate in the study. Table 1 shows the mean (±SD) for age 21.7 years old (±0.55), height 161.6cm (±5.47), weight 54.1kg (±8.77) and BMI 20.7kgm^{-2} (±3.96). All participants were classified as healthy and active at the moment data was collected.

The mean changes in surface temperature throughout the cooling and rewarming phase are shown in Figure 1. Collectively, cubed-ice produced greater temperature change and wetted-ice produced the smaller temperature change throughout the whole process. The differences of the skin temperature changes can be significantly seen throughout the 2nd minute up till 20th minute

Table 1: Demographic data of all participants

	Minimum	Maximum	Mean	±SD
Age (years old)	21.0	22.8	21.7	0.55
Height (cm)	154.5	173.3	161.6	5.47
Weight (kg)	45.3	74.1	54.1	8.77
BMI(kgm^{-2})	17.1	31.04	20.7	3.96

Mean temperature during the 20-minute cooling and rewarming phases

Figure 1 shows the means for temperature change of the skin surface throughout the treatments with cubed-ice and wetted-ice. It is obvious that cubed-ice showed greater temperature change compared to wetted-ice during the cooling phase. However, both treatments showed similar trend during the rewarming phase.

Inferential analysis

Paired-sample t-test was used to compare the efficacy of the cryotherapeutic agents. Significant level of the study was set at $p < 0.05$.

A significant value of 0.006 was obtained when the analysis was run between the means of temperature with cubed-ice and wetted-ice. This is less than the significant p value set at 0.05. Therefore, cubed-ice had significantly produced a greater change in skin surface temperature than wetted-ice.

Mean relative humidity of the air

Figure 2 shows the mean relative humidity of the air during the treatment with cubed-ice and wetted-ice. It is shown that relative humidity was higher during treatment with cubed-ice than wetted-ice.

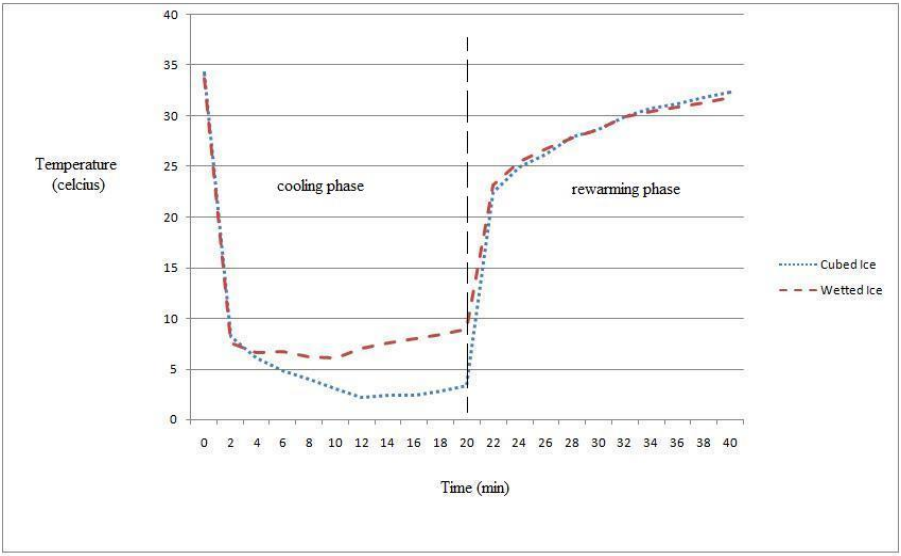

Figure 1: Mean temperature during 20-minute cooling phase and rewarming phase of cubed-ice and wetted-ice treatment

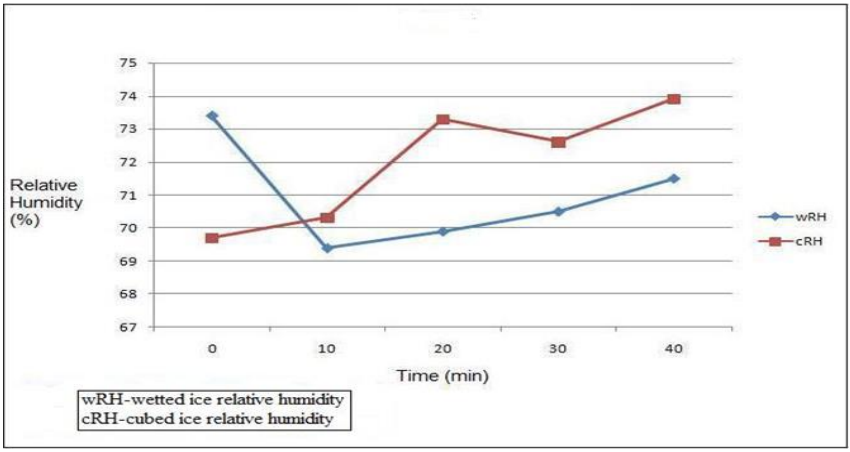

Figure 2: Mean relative humidity during treatment with cubed-ice and wetted-ice

Mean ambient temperature

Figure 3 shows the mean ambient temperature throughout the treatments with cube-ice and wetted-ice. It is also shown that the air temperature was higher during the treatment cubed-ice than wetted-ice.

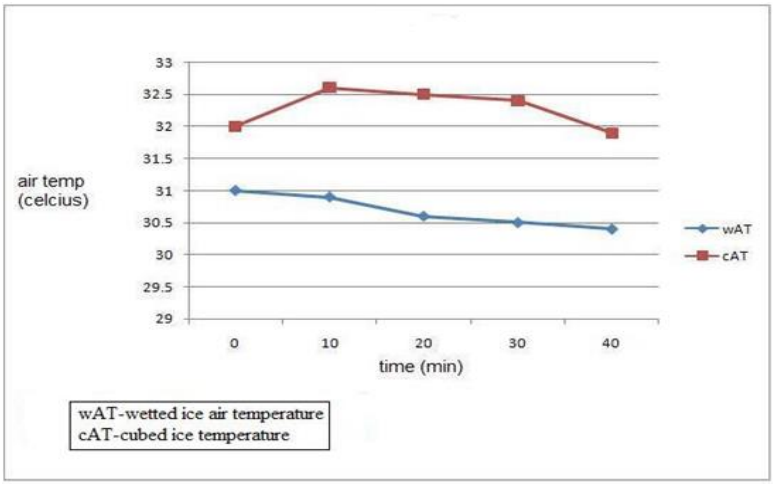

Figure 3: Mean ambient temperature during treatment with cubed-ice and wetted-ice

4.0 Discussion

The main objectives of this study include (a) comparing the efficacy between cubed-ice and wetted-ice as a cryotherapeutic agent, and (b) determining the climatic factors affecting the level of efficacy of the two cryotherapeutic agenst in the Malaysian climate. As most of the researchers did not include air temperature and relative humidity in their studies, lack of data were available on how the air temperature and relative humidity are affecting the efficacy of the cryotherapeutic agents.

The findings from this study suggested that there was a strong significant different at the level of efficacy between these two cryotherapeutic agents where cubed-ice was a better cryotherapeutic agent since it resulted in a lower surface temperature during the cooling phase compared to wetted-ice.

However, the findings of this study contradicted with earlier findings. A study by Baker et. al., 2009 in terms of surface temperature, where wetted-ice produced the greatest skin surface temperature change and cubed-ice produced the smallest change.

The Malaysian hot and humid climate affected the efficiency of the cooling agent. The effects of relative humidity and air temperature can further be seen during the cooling phase. This might be due to relative humidity and air temperature affecting the melting rates of the cooling agents.

Neverthless,the baseline and rewarming phase skin temperature for cubed-ice is higher than wetted-ice temperature. This might be due to the air temperature during the experiment for cubed-ice was higher than during the treatment with wetted-ice.

The findings from this study might be useful for first aiders, sport aiders, athletic trainers and other related professions making decision selecting the type of ice best suited during training or competitions depending on the ambient temperature and humidity. However, further studies need to be carried out on larger number of participants of both genders. Intramuscular temperature should be obtained because this is the targeted site for the cryotherapeutic treatments**.**

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References

Algafly A.A., George K.P., (2007). The Effect of Cryotherapy on Nerve Conduction Velocity, Pain Threshold, and Pain Tolerance. *British Journal of Sports Medicine.* 41:365- 369.

Allen C., Avila P., Bina J., Enwenka C.S., Konrade J., Munns S., (2002). Soft tissue thermodynamics before, during, and after cold pack therapy. *Medicine & Science In Sports & Exercise.* 34(1):45-50.

Atkinson G., Black M.A., Dawson B., Green D.J., Gregson W., Jones H., Milson J., Morton J., (2011). Influence of Cold Water Immersion on Limb and Cutaneous Blood Flow at Rest. *The American Journal of Sports Medicine*. 39(6):1316-1323.

Au K.K., Bernard L.W., Cordova M.L., Demchak T.M., Sefton J.M., Stone M.B., (2010). Cryotherapy And Ankle Bracing Effects On Peroneus Longus Response During Sudden Inversion. Journal of Electromyography and Kinesiology. 20(2):348-353.

Baker R.J., Cheatham C.C., Dykstra J.H., Hill H.M., Michael T.J., Miller M.G., (2009). Comparisons of Cubed Ice, Crushed Ice, and Wetted Ice on Intramuscular and Surface Temperature Changes. *Journal of Athletic Training*. 44(2):136-141.

Bertolini G., Busarello F., Nakayama G., Paula G., Souza F., Vieira L., (2011). Hamstrings Muscles Extensibility Gain Comparing Static Stretching With Or Without Cryotherapy. *Fisioterapia em Movimento*. http://dx.doi.org/10.1590/S0103-51502011000200006

Blake A.S., Caldwell K.A., Casa D.J., Clements J.M., Gilmer A.M., McClung J.M., Meenen P.M., (2002). Ice-Water Immersion and Cold-Water Immersion Provide Similar Cooling Rates in Runners With Exercise-Induced Hypothermia. *Journal of Athletic Training*. 37(2):146-150.

Bleakley C., Davison G.W., Gardner E., Glasgow P., Hopkins J.T., McDonough S., (2010). Cold-Water Immersion (Cryotherapy) For Preventing And Treating Muscle Soreness After Exercise. *Cochrane Bone, Joint and Muscle Trauma Group*. DOI: 10.1002/14651858.CD008262

Bleakley C., MacAuley D., McDonough S., (2004). The Use of Ice in the Treatment of Acute Soft-Tissue Injury: A Systematic Review of Randomized Controlled Trials. The American Journal of Sports Medicine.32(1):251-261.

Brucker J.B., Cordova M.L., Demchak T.J., Long B.C., Stone M.B., (2005). Exercise and Quadriceps Muscle Cooling Time. *Journal of Athletic Training*. 40(4):260-263.

Castle P., Duffield R., Green R., Maxwell N., (2010). Precooling Can Prevent the Reduction of Self-Paced Exercise Intensity in the Heat. Medicine & Science in Sports & Exercise. 42(3):577-584.

Costello J.T., Donnelly A.E., (2010). Cryotherapy and Joint Position Sense in Healthy Participants: A Systematic Review. *Journal of Athletic Training*. 45(3):306–316.

Denegar C.R., Hubbard T.J., (2004). Does Cryotherapy Improve Outcomes With Soft Tissue Injury. *Journal of Athletic Training*. 39(3):278-279.

Durrant E., Fellingham G.W., Measom G., Myrer J.W., (1997). Cold- and Hot-Pack Contrast Therapy: Subcutaneous and Intramuscular Temperature Change. *Journal of Athletic Training*. 32(3):238-241.
Edwards J.E., Garrison J.C., Ingersoll C.D., Leonard J.L., Palmieri R.M., Weltman A., (2006). Peripheral Ankle Cooling and Core Body Temperature. *Journal of Athletic Training*. 41(2):185-188.

Estona R., Jakemana J.R., Macraea R., (2009). A Single 10-Min Bout Of Cold-Water Immersion Therapy After Strenuous Plyometric Exercise Has No Beneficial Effect On Recovery From The Symptoms Of Exercise-Induced Muscle Damage. Ergonomics. 52(4):456-460.

Evers S.L., Fellingham G.W., Measom G.J., Myrer J.W., Myrer K.A., (2001). Muscle Temperature Is Affected by Overlying Adipose When Cryotherapy Is Administered. *Journal of Athletic Training*. 36(1):32-36.

Fischer J., Van Lunen B., Branch D.J., Pirone J., (2009). Functional Performance Following an Ice Bag Application to the Hamstrings. *The Journal of Strength and Conditioning Research*. 23(1):44-50.

Guadagnoli M., Holcomb W.R., Rubley M.D., Tarno J.M., Tomchuk D., (2010). The Magnitude of Tissue Cooling During Cryotherapy With Varied Types of Compression. *Journal of Athletic Training*. 45(3):230-237.

General Climate of Malaysia, http://www.met.gov.my

Hardaker N., Hobbs S., Kennet J., Selfe J., (2007). *Cooling* Efficiency of 4 Common Cryotherapeutic Agents. *Journal of Athletic Training*. 42(3):343-348.

Howatson G., Van Someren K.A., (2003). Ice Massage: Effects on exercise-induced muscle damage. *Journal of Sports Medicine and Physical Fitness*. 43:500-505.

Jungling O., Knobloch K., Meyer-Marcotty M., Vaske B., Vogt P.M., (2011). Standardized Combined Cryotherapy And Compression Using Cryo/Cuff After Wrist Arthroscopy. *Knee Surgery, Sports Traumatology, Arthroscopy*. 19(2):314-319.

Jutte L.S., Merrick M.A., Smith M.E., (2003). Cold Modalities With Different Thermodynamic Properties Produce Different Surface and Intramuscular Temperatures. *Journal of Athletic Training*. 38(1):28-33.

Prins J., Scheffers F.A., Stubbe J.H., Van Meeteren N., Van Dongen M., (2011). Feasibility And Preliminary Effectiveness Of Ice Therapy In Patients With An Acute Tear In The Gastrocnemius Muscle: A Pilot Randomized Controlled Trial. *Clinical Rehabilitation*. 25(5):433-441.