Efficacy of Skin Interface Temperature Using Local Ricebag For Treatment of Soft Tissue Injury

Rahmat Adnan[a], Nurhidayah Hamza, Nur Amalina Mansor, Norasrudin Sulaiman, Shariman Ismadi Ismail

[a]Sports Science Center of Studies, Faculty of Sports Science & Recreation UiTM Shah Alam 40450 , Malaysia

[b]Rehabilitation Department, Rehabilitation Department, Tengku Mizan Military Hospital Wangsa Maju Ampang Malaysia

rahmatadnan@salam.uitm.edu.my, alangr3@gmail.com

ISSN: 2231-9123

ABSTRACT

Objective**:** To determine skin interface temperature during application of cold local rice bag in acute ankle and knee injury and chronic back pain patients.Design: Repeated measures.Participants: Sixty female and male patients with acute knee and ankle injury and chronic back pain. Intervention: The cold local rice bag was applied to the injured area for 20 minutes duration. Main outcome measure: Skin interface temperature was monitored every minute during the 20-minute ice application. Result the cold local rice bag was used for acute injury: From the baseline (30.82 ^{o}C ± 0.81) the temperature dropped drastically to a mean temperature of 26.67 ^{o}C (± 2.12) after 1 minute of treatment. Subsequently, the temperature continued to drop for a period of 16 minutes (22.9 ^{o}C ± 0.73). However, the temperature then remained at a plateau for the next 2 minutes (23.0 ^{o}C ± 0.75) before slightly increasing during the remaining 2 minutes until the 20-minutes treatment was ended. At the end of the local rice bag treatment, the mean temperature recorded was 23.2 ^{o}C (± 0.83). For chronic back pain a heated local rice bag was used, where the mean temperature at baseline was 31.60 ^{o}C (± 0.67). However the temperature increased rapidly after 1 minute of treatment with a mean temperature of 34.06 ^{o}C (± 0.82). Meanwhile, the temperature was increased progressively until 15 minutes (40.05 ^{o}C ± 0.74). The temperature slightly dropped after 20 minutes of treatment, and at the end of the local rice bag treatment, the mean temperature recorded was 39.28 ^{o}C (± 0.95). Conclusion The result of this study showed significant reductions in the skin interface temperatures from the baseline until completion of the 20 minute treatment. The local rice bag had characteristics similar to that of others including cryotherapy and thermotherapy modalities. Clinically, the results indicated that the local rice bag can be applied for treatment of soft tissue injury as a viable alternative to cryotherapy and thermotherapy modalities.

Keywords: *Rice bag; skin interface; heat and cold temperature; knee and chronic back*

1. Introduction

Cryotherapy or the use of ice or cold treatment in a therapeutic setting, has become one of the most common treatments in sport medicine (Merrick et al., 1993). Cryotherapy is the use of cold compression in the treatment of acute trauma and subacute injury and for the decrease of discomfort after reconditioning and rehabilitation (Knight, 1982). Moreover, Mcgriff-Lee (2006) citing Broken and Bierman (1955) noted that for the immediate care of acute sport injuries, cryotherapy has become the most widely accepted modality. Furthermore, with ice

application, skin and subcutaneous tissue temperature will decrease immediately (Cohn et al., 1989). Bleckley et al. (2004) reviewed past studies and noted that by reducing tissue temperatures ice can reduce pain, metabolism and muscle cramps, reduce the inflammatory process and thus help recovery after trauma. In addition, blood flow can be reduced by applying cold source (Mcgriff-Lee, 2006). Risks of injury are inherent at any level of recreational and sport activities (Almekinders, 2000). One of the common acute soft tissue injury is ankle injury (Garrick & Requa, 1998). According to Lovering (2008) as reviewed by Rahmat Adnan et al. (2011), soft tissue injuries are referred to as tendon, ligament and muscle damage throughout the body. Common soft tissue injuries that normally occur include contusion or strain and sprain resulting from a blow (Rahmat Adnan et al., 2011). In addition, (Mcgriff-Lee (2006) as reviewed by Rahmat Adnan et al. (2011) showed that the effects of soft tissue injuries include pain, swelling, bruising and loss of function. Sprained tissues include a partial or complete stretching or tearing of ligaments within a joint. Ligament damage may occur when a joint sustains a substantial force, cause by a fall, sudden twist or direct impact. The degree of injury may vary from mild sprain, characterized by swelling and mild pain with minimal impact of joint junction, to a severe sprain that may be present with symptoms resembling a bone fracture. Chronic back pain is used to describe pain that occurs between the lower costal margins and the gluteal folds that persists for more than 3 months (Jackson & Simpson, 2006) According to Wright (2010) acute pain is when it only last for a few days, but when it extend for months it will be considered as chronic pain. Chronic back pain was the most frequent medical disorder in industrialized societies (Purushothaman et al., 2008). The patients who have chronic back pain have been recommended to perform several treatments including thermotherapy. Thermotherapy or heat treatment is the healing application that causes increase in body tissue temperature with the use of any material that gives heat to the body (Nadler et al., 2004). In addition, Allen (2006) proposed that thermotherapy in therapeutic heat recovery is moderately superficial and enhances blood diffusion, develops healing, recovers soft tissue extensibility, and provides pain control. Heat treatment is usually used for chronic injuries or injuries that have no inflammation or swelling. Rahmat Adnan et al. (2011) have proven that rice covered with a rib fabric has comparable characteristics with ice and hot pack, and have improved the management of soft tissue injury. In the present study ricebags are used to identify the skin interface temperature in cold and heat therapy among patients with selected soft tissue injury.

2. Materials and Methods

2.1 Study design

This study utilized a repeated measure design to investigate the reduction and elevation of skin interface temperatures during local rice bag application. Skin interface temperature was recorded at 1-minute intervals during local rice bag application within 20 minutes. The 1-minute time period was chosen to find the rate of heating (for heat therapy) and cooling (for cold therapy) treatment. It was also designed to examine the time period at which maximum cooling and heating effects take place.

2.2 Subjects

Sixty (60) subjects were involved in this study. There were divided into 2 groups comprising of 30 patients who suffered from chronic back pain and 30 patients who suffered from acute knee and ankle injuries. The target population for this study were patients of the Rehabilitation Department in Tuanku Mizan Military Hospital.

2.3 Procedure

Subjects were positioned prone lying/sitting on the couch for 10 minutes in a room with a constant temperature of 20 ºC (± 1 ºC) to stabilize skin temperature. The baseline temperature of the rice bag and skin temperature were recorded prior to the beginning of the test. Patient's injured area were wrapping with plastic wrap for ankle and knee acute injury and a towel for back injury. After applying the local rice bag, a thermocouple probe (Hanna K-type Waterproof Thermalcouple) attached to a digital thermometer (Thermometer Hanna Instrument P/N:HI 935005) was place on the skin. The temperature was recorded at every 1-minute interval within 20 minutes duration of treatment.

2.4 Data Analysis

Descriptive statistics are used to report the demographic data including gender age, height, weight and body mass index. Further, inferential statistic based on repeated measure analysis of variance was performed when three or more measures were recorded. Skin temperature at every minute of the 20 minutes of intervention were repeatedly measured to determine the changes of skin temperature during application of the ricebag. Data were analysed using the Statistical Package for Social Science (SPSS) version 19.0 with the significance level set at $p<0.05$.

3 Results

3.1 Demographic data of the participants

The means and standard deviations of the subject's age, weight, height, and body mass index (BMI) were calculated using descriptive statistics. The physical characteristics of the participants are presented in Table 1.

	Gender	N	Mean	Std. Deviation
Age (years)	Male	41	34.80	10.03
	Female	19	41.58	13.81
Height (m)	Male	41	1.72	0.03
	Female	19	1.62	0.03
Weight (kg)	Male	41	70.51	6.03
	Female	19	62.86	7.12
Body Mass Index (kg/m^2)	Male	41	23.72	1.77
	Female	19	23.78	1.94

Table 1: Demographic data of the participants

The mean (SD) age for male subjects was 34.80 (±10.03) years, while the mean age for female subjects was 41.58 (±13.81). Besides, the mean height for male subjects was 1.72 m (±0.03), while for female subjects it was 1.62 m (±0.03). However, the mean weight for male subjects was 70.51 kg (±6.03) and for female subjects it was 62.86 kg (±7.12). In this study, the female participants were older in age compared to the male participants. The height between both genders only had a minor difference which was not significant. On the other hand, both female and male participants had normal Body Mass Index (BMI).

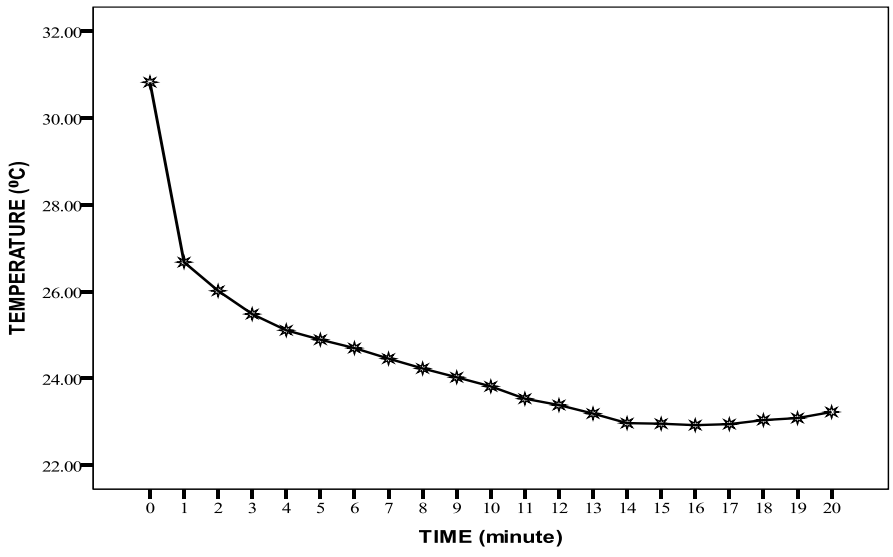
3.2 Demographic data of local rice bag

Type of rice bag	**Weight of rice bag (kg)**	**Mean temperature (^{o}C)**	**Minimum/Maximum temperature (^{o}C)**
Knee rice bag	2.4	7.0	6.9
Ankle rice bag	0.9	6.3	6.2
Back rice bag	1.7	68.5	69.8

Table 2: Weight and temperatures attained during the 20-minute application of local rice bag

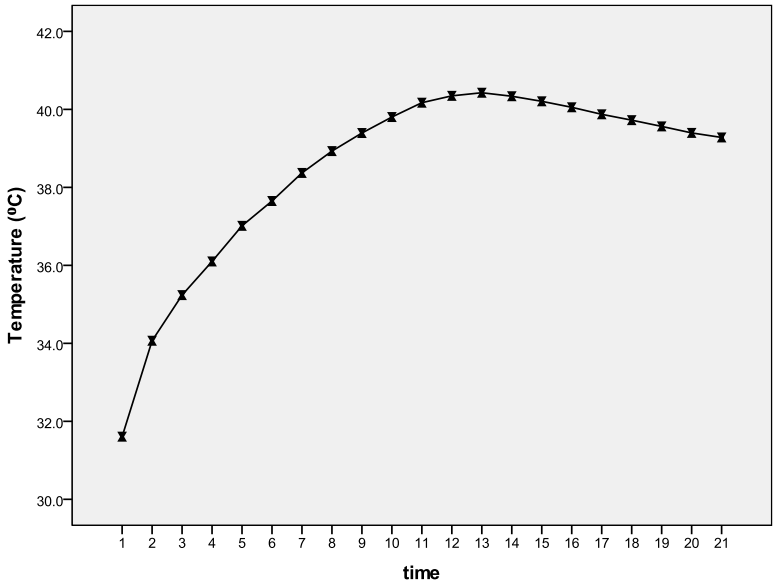
The weight of the rice bags, mean temperature of the local rice bag and the minimum temperature of the local rice bag are presented in Table 2. For knee application the weight of the local rice bag used was 2.4 kg. After cooling inside the freezer, the minimum cold temperature that could be attained was 6.9 oC. For ankle application the weight of the local rice bag used was 0.9 kg and this attained a minimum cold temperature of 6.2 oC. The weight of the rice bag used for back pain was 1.7 kg. When this rice bag was heated in a microwave oven for 5-minutes, it attained a maximum temperature of 69.8 oC. Figure

1: Skin interface temperature for acute ankle and knee injury (Cold Ricebag)



The results showed that from the baseline (30.82 ^{o}C ± 0.81) the temperature dropped drastically after 1 minute of treatment to a mean temperature of 26.67 ^{o}C (± 2.12) (Figure 1). Subsequently, the temperature drop was continuous until after 16 minutes it was 22.9 ^{o}C (± 0.73). However, the temperature remained at a plateau for 2 minutes (23.0 ^{o}C ± 0.75), before slightly increasing over the remaining 2 minutes until the end of the 20-minute of treatment. At the end of the treatment with the local rice bag, the mean temperature recorded was 23.2 ^{o}C (± 0.83). A comparison between the mean score before treatment and at 5 minutes of treatment, the skin interface temperature showed a significant decrease of 5.93 ^{o}C (± 0.62). Moreover, the mean score of skin interface temperature remained decreased at 10 minute of treatment (by 1.08 ^{o}C ± 0.27). Between 10 to 16 minutes of treatment, the last phase of the skin interface was decreased by a mean score of 0.87 (± 0.37). Lastly, from 16 minutes until 20 minutes of treatment, the skin interface temperature was slightly increased by a mean score of 0.30 (± 0.01), but with a plateau during the 17 and 18 minutes period.

Figure 2: Skin interface temperature for acute ankle and knee injury (Hot Ricebag)



The results showed that the mean temperature from the baseline was 31.60 (± 0.67) (Figure 2). However the temperature increased rapidly after 1-minute of treatment where the mean temperature for males was 34.06 ^{o}C (± 0.82). Meanwhile, the temperature increased progressively to 40.05 ^{o}C (±0.74) at 15 minutes after treatment. At 20 minutes after treatment the temperature dropped slightly. At the end of the treatment period, the mean temperature recorded was 39.28 ^{o}C (± 0.95).

4. Discussion

4.1 Skin temperature

The results of the study showed a reduction in skin interface temperature after the application of the local rice bag. Both ankle and knee injury subjects recorded a reduction in skin interface temperature from the baseline within one minute and over the 20 minutes of

treatment. Similar results were reported by Kanlayanaphotporn and Janwantanakul (2005), who observed that all modalities (ice pack, gel pack, frozen peas and mixture of water and alcohol) illustrated a similar pattern of skin interface temperature reduction, in which step reduction occurred within the first minute of the application. For ankle injury, the skin interface temperature dropped from the mean baseline temperature (29.92 ° C) until the 14th minute (23.10 ° C). After that, the skin interface temperature was slightly increased until the 20th minute of application of the local rice bag (23.38 ° C). On the other hand, for knee injury, the skin interface temperature dropped from the mean baseline temperature (31.0 ° C) until the 16th minute (22.87 ° C). Similar to ankle injury, knee injury also recorded increases in skin interface temperatures during the 20-minute treatment application (23.1° C). The findings of this study also showed that 20 minutes of local rice bag application significantly increased the skin interface temperature during treatment for chronic back pain patients. The results showed improvements in the skin interface temperature at each 1-minute interval over the 20 minutes of application. Draper et al., 2010) had also shown similar results using 3 different types of treatments using ultrasound, with increase in the screen temperature from base line until 10-minutes. In line with the hypothesis, this study provides sufficient evidence of statistically significant increase in skin interface temperature among chronic back pain patients within 20 minutes of receiving the local rice bag treatment. Moreover, this study found that the skin interface temperatures progressively increased from baseline until 15-minutes of local rice bag application, and then slightly decreased after 16 to 20-minutes. From baseline until 20 minutes the mean temperature increase was about 7.6 °C. In addition, the efficiency of superficial and deep-heating agents was demonstrated by the temperature raised in the tissues. Halvorson (1990) and Hawkes et al. (2013) had recommended that tissue temperature should be raised by at least 1°C for mild heating, 2 to 3°C for moderate heating, and 4°C or more for vigorous heating with an increase in physiological effects as tissue temperature increases.

4.2 Time of application

Kanlayanaphotporn and Janwantanakul (2005) in a study on cryotherapy modalities indicated that the mean skin interface temperature after the application of the gel pack and the ice pack was reduced significantly from 0 to 10 minute of application, and for frozen peas and mixture of water and alcohol the temperature was reduced until 13 and 8 minute of application, respectively. All four modalities tested showed a significant reduction in skin interface temperatures during the cryotherapy application. Additionally, in this study, both injuries showed decreases in skin interface temperatures from the baseline until the end of the 20-minutes of local rice bag application. This finding answers the hypothesis for this study where a significant decrease of skin interface temperature was expected after a certain period of local rice bag treatment. Nevertheless, the skin temperature decreased after a period of 16 minutes of treatment. The skin temperatures obtained persisted and then increased slightly after a 2 minute plateau. It was assumed that environmental factors such as the evaporative process at a warmer room temperature may have influenced this tiny increase in skin temperature. Besides, the local rice bag temperature retained prior to the application may have also affected the cold capacity holding during the 20-minutes of treatment. Majority of

the cold holding capacity will increase the prolonged cold capacity if the pack is well stored below negative temperatures. This knowledge is valuable in selecting a modality in a clinical setting in which the intended outcome is prolonged skin tissue cooling at a therapeutic level. On the other hand, for chronic back pain, the skin interface temperatures progressively increased from baseline until 15 minutes of local rice bag application and dropped slightly from 16 to 20 minutes of intervention. Tomaszewski et al (1992) reported slightly similar results, with the skin interface temperatures peaking at 6, 8, and 14 minutes with hydrocollator, steampack, ProHeat pack-wet, and ProHeat pack-dry applications, respectively, and then decreasing over the remainder of the 30-minute session. This study found, that the skin interface temperature with the local rice bag application was sustained in the therapeutic range during the period of treatment. The skin temperatures were raised into the therapeutic range at 11 minutes and maintain in the range until 20 minutes when the last reading was recorded. The temperature of 40.05 °C was recorded for the highest mean temperature during the 20 minutes of treatment. According to Cameron (1999), therapeutic heating should raise tissue temperature to above 38 ºC, but must be below 45 ºC to safely optimize physiologic benefits. Martins (2011) also noted that a tissue must reach a temperature of at least 40 °C to produce significant physiological effects.

4.3 Temperature of the local rice bag

The minimum temperature attained by the ankle and knee applied local rice bags was 6.2 º C and 6.9 º C, respectively. The temperature was measure immediately after the local rice bag was taken out from the refrigerator. Janwantanakul (2009) had reported that the application of 6.0 º C to 6.6 º C of cold pack was significantly more efficient in reducing the skin interface temperature than the 9.6 º C cold pack. Gage (1979) had reported that when tissue temperature drops below –10 º C, the cell matrix can be destroyed. Thus, at temperatures of 6.2 º C and 6.9 º C are unlikely to cause cell damage. Furthermore, no adverse reactions such as allergic reaction, burn or frostbite have been reported. In fact, this degree of interface temperature has been reported to provide desirable physiological responses in acute musculoskeletal rehabilitation (Chestertorn et al., 2002). In addition, tissue temperature should be maintained at approximately 10 º C to minimize the cellular metabolic rate (Sepega et al., 1988). In the present study, tissue temperature was reduced sufficiently to induce local analgesia and reduce nerve conduction velocity and cellular metabolic rate using the rice bag application. In chronic back pain patients, the study used the local rice bags that were heated in a microwave oven for 5 minutes before application. The mean temperature of the local rice bag before apply to the subjects was 68.52 ºC. In a related study by Lounsberry (2008) it was noted that the hydrocollator units kept the moist heat pack's in water maintained at between 70 and 75 ºC. Hence, the temperature of the local rice bag was considered to be within a safe range for intervention. Besides, to prevent burns from occuring, a towel will be placed between the heat pack as a protective layer (Denegar and Saliba, 2006).

4.4 Duration of the treatment

No subject had experienced any adverse reaction due to the duration of application of the local rice bags. The duration of application of the local rice bags used in this study was 20 minutes. This duration of treatment was adopted by Janwantanakul (2004) to ensure no adverse reactions from cold occurred and to maximize the efficacy of cryotherapy. In summary, the findings of this study showed that the 20-minute application of local rice bags for treating acute ankle and knee injury resulted in significant differences in skin interface temperatures. The treatment with the local rice bags for chronic back pain patients was also run over 20 minutes per session. The 20-minute per session was sufficient to provide the desired benefits of the treatment. Previous research had also shown that to achieve significant gains in tissue temperatures the treatments should last for at least 20 to 25 minutes (Lin Y and C., 2003).

5. Conclusions

The results of this study showed significance reductions in skin interface temperatures from the baseline until the end of the 20 minutes of treatment. The local rice bag had similar characteristics as cryotherapy and thermotherapy modalities. Clinically, the results indicated that local rice bags can be applied for treatment of soft tissue injury as a viable alternative to cryotherapy and thermotherapy modalities.

References

Adnan, R., Mohd Noor, Z., Abdullah Misdan, N., Tumin, S. M., Sulaiman, N., & Misdan, M. (2011). The Development of Beany/Grainy Pack to Trait Soft Tissue Injury. IEEE Colloquium on Humanities, Science and Engineering Research, 398-401.

Allen, R. J. (2006). Physical Agents Used in the Management of Chronic Pain by Physical Therapists. *Phys Med Rehabil Clin N Am*, 17, 315-345.

Almekinders, L. C. (2000). Anti-Inflammatory Treatment of Acute and Chronic Soft-Tissue Sport Injuries. *Medscape Pharmacotherapy*, 2(2).

Bleckley, C. M., McDonough, S. M., & MacAuley, D. C. (2004). The Use of Ice in the Treatment of Acute Soft-Tissue Injury. *The American Journal of Sport Medicine*, 32(1), 251-261.

Broken, N., & Bierman, W. (1955). Temperature Changes Produced by Spraying with Ethyl Chloride *Archives of Physical Medicine and Rehabilitation* 36, 288-290.

Cameron, M. H. (1999). Diathermy: The Ideal Therapeutic Heating Modality. *Journal of Orthopaedic & Sports Physical Therapy*, 29(1).

Chestertorn, L. S., Foster, N. E., & Ross, L. (2002). Skin Temperature Response to Cryotherapy. *Archives of Physical Medicine and Rehabilitation*, 83, 543-552.

Cohn, B. T., Draeger, R. I., & Jacson, D. W. (1989). The Effect of Cold Therapy in the Postoperative Managementof Pain in Patients Undergoing Anterior Cruciate Ligament Reconstruction. *The American Journal of Sports Medicine*, 17, 344-349.

Denegar C, Saliba E, & S, S. (2006). Therapeutic Modalities for Musculoskeletal Injuries. Champaign, IL: *Human Kinetics*, 119, 178-188.

Draper, D. O., Edvalson, C. G., Knight, K. L., Eggett, D., & Shurtz, J. (2010). Temperature Increases in the Human Achilles Tendon During Ultrasound Treatments with Commercial Ultrasound Gel and Full-Thickness and Half-Thickness Gel Pads. *Journal of Athletic Training*, 45(4), 333-337. doi: 10.4085/1062-6050-45.4.333

Gage, A. A. (1979). What Temperature Is Lethal for Cells? *Journal of Dermatologic Surgery and Oncology*, 5, 459-460.

Garrick, J., & Requa, R. (1998). The Epidemiology of Foot and Ankle Injuries in Sports. 29-36.

Halvorson, G. A. (1990). Therapeutic Heat and Cold for Athletic Injuries. *Physician Sportsmed*. , 18(5).

Hawkes, A. R., Draper, D. O., Johnson, W., Diede, M. T., & Rigby, J. H. (2013). Heating Capacity of Rebound Shortwave Diathermy and Moist Hot Packs at Superficial Depths. *Journal of Athletic Training*, 48(3), 000–000.

Jackson, M. A., & Simpson, K. H. (2006). Chronic Back Pain. Continuing Education in Anaesthesia, Critical Care & Pain Volume 6 4.

Janwantanakul, P. (2004). Different Rate of Cooling Time and Magnitude of Cooling Temperature During Ice Bag Treatment with and without Damp Towel Wrap. Physical Therapy in Sport, 156-161.

Janwantanakul, P. (2009). The Effect of Quantity of Ice and Size of Contact Area on Ice Pack/Skin Interface Temperature. *Physiotherapy*, 95(2), 120-125. doi: 10.1016/j.physio.2009.01.004

Kanlayanaphotporn, R., & Janwantanakul, P. (2005). Comparison of Skin Surface Temperature During the Application of Various Cryotherapy Modalities. *Archives of Physical Medicine and Rehabilitation*, 86(7), 1411-1415. doi: 10.1016/j.apmr.2004.11.034

Knight, K. L. (1982). Effects of Hypothermia on Inflammation and Swelling. *Journal of Athletic Training*, 11, 7-10.

Lin Y, & C., G. (2003). Effects of Thermal Therapy in Improving the Passive Range of Knee Motion: Comparison of Cold and Superficial Heat Applications. *Clin Rehab*, 17, 618-623.

Lounsberry, N. (2008). Therapeutic Heat: Effects of Superficial and Deep Heating Modalities on Hamstring Flexibility. Volume VII.

Lovering, R. M. (2008). Physical Therapy and Related Interventions. In P.M. Tiidus (Eds.), Skeletal Muscle Damage and Repair. United State of America: Human Kinetics.

Martins, A. (2011). Variation of Skin Temperature During and after Contrast Bath Therapy. *Rev Andal Med Deporte*, 4(4).

McGriff-Lee, N. (2006). Management of Acute Soft Tissue Injuries. *Journal of Pharmacy Practice*, 16.

Merrick, M., A.,, Knight, K., L.,, Ingersoll, C., D.,, & Potteiger, J., A. . (1993). The Effect of Ice and Compression Wraps on Intramuscular Temperatures at Various Depth. *Journal of Athletic Training*, 28(3), 236-245.

Nadler, S. F., Weingand, K., & Kruse, J. K. (2004). The Physiologic Basis and Clinical Applications of Cryotherapy and Thermotherapy for the Pain Practitioner. *Pain Physician*, 7, 395-399.

Purushothaman, B., Lingutla, K., Singh, A., Bhatia, C., Pollock, R., & Krishna, M. (2008). P123. Do Patients with Chronic Back Pain Sleep Well? *The Spine Journal*, 8(5, Supplement), 160S-161S.

Sepega, A. A., Heppenstall, R. B., Sokolow, D. P., Graham, T. J., Maris, J. M., & Ghosh, A. K. (1988). The Bioenergetic of Preservation of Limbs before Replantation. *The Journal of Bone & Joint Surgery*, 70, 1500-1513.

Tomaszewski, D., Dandorph, M. J., & Manning, J. (1992). A Comparison of Skin Interface Temperature Response between the Proheatt Instant Reusable Hot Pack and the Standard Hydrocollator Steam Pack. *Joumal oof Athletic Training*, 27, 355-359.

Wright, B. (2010). Management of Chronic Soft Tissue Pain. 25, 26-31.