TEMPERATURE VARIATION OF THE QUADRICEPS FEMORIS MUSCLE EXPOSED TO TWO FORMS OF CRYOTHERAPY BY MEANS OF THERMOGRAPHY

ORIGINAL ARTICLE

Alberito Rodrigo de Carvalho[1]
Daiane Lazzeri de Medeiros[1]
Francieli Tibes de Souza[1]
Grazieli Francine de Paula[1]
Patrícia Mantovani Barbosa[1]
Paula Renata Olegini Vasconcellos[1]
Márcia Rosângela Buzanello[1]
Gladson Ricardo Flor Bertolini[1]

1. Laboratory of Studies of Injuries and Physiotherapeutic Resources of the State University of Western Paraná (Unioeste), Cascavel Campus – Paraná.

Mailing address:
Gladson Ricardo FlorBertolini
Rua Universitária, 2.069, Colegiado de Fisioterapia, Jd. Universitário
85819-110 – Cascavel, PR
Caixa Postal 711.
E-mail: gladson_ricardo@yahoo.com.br

ABSTRACT

Introduction: Cryotherapy is any form of therapeutic application of cold which decreases the temperature of tissues. Objective: To compare the variations in surface temperature of the quadriceps muscle at three different times when exposed to two forms of cryotherapy: ice bags or bags containing a mixture of ice and water. Material and Methods: The study involved 18 subjects, aged between 18 and 25 years, of both sexes. In each volunteer, ice cryotherapy on the left thigh and a mixture of ice and water on the right thigh was simultaneously applied for 15 minutes to the quadriceps femoris region. The temperature was measured by a thermograph and the following moments were recorded: before cryotherapy, immediately and 5 and 30 minutes after removal of the modality of cryotherapy. Results: Both cryotherapy methods were effective to decrease the temperature of the quadriceps and the mixture of ice and water was able to induce a lower temperature compared to the modality which used ice only. The cooling for both modalities lasted for at least 15 minutes after the removal of ice and surface temperature had been restored at pre application 30 minutes after removal. Conclusion: Both methods promoted a reduction in temperature that lasted at least 15 minutes, and 30 minutes after the with drawal the temperature was reestablished to normal levels. However, the mixture of ice and water produced cooling more remarkable than the ice alone.

Keywords: cryotherapy, thermography, cooling agents.

INTRODUCTION

Since ancient Greece cryotherapy is therapeutically used aiming the tissue cooling, local analgesia, edema decrease, reduction in the inflammatory process, of the blood flow, of the intramuscular metabolic rate, of the velocity of nervous conduction as well as minimization of tissue damage caused by hypoxia[1,2].

During the application of cryotherapy, a first initial phase of cold is observed. The second phase is of pain or discomfort, and the third of analgesia or anesthesia. The fourth phase produces reflex vasodilation or deep paralytic phase. Theses phases last approximately three minutes each, depending on the used modality[3]. The decrease in the local blood flow occurs when the tissue temperature reaches 13.8°C. Analgesia occurs at 14.4°C. If the cooling reaches temperature below 10ºC, there is total blocking of the transmissions of the nervous impulse[4].

Currently, cryotherapy is a widely used technique in physiotherapy and there are many modalities, such as the use of ice bags, ice bags mixture (a mixture of ice and water), and immersion in cold water, among others. However, the differences in the cooling capacities of the distinct modalities of cryotherapy still cause questioning, since it is crucial to know the cooling effect of each of them so that the clinical response of the therapy is optimized to the maximum[5].

Thermography is a diagnostic image exam of great sensitivity, totally fast, safe and painless, with no ionizing radiation, contact or contrast. A special camera is able to acquire long infrared radiation emitted by the human body; hence, it is possible to measure the temperature of the skin surface and design an image of the thermal distribution. In order to have this exam performed, the used environment should be acclimatized with temperatures between 22-25ºC. Acclimatization and thermal stabilization of the patient should occur for 10 to 15 minutes[6-8].

Thus, the present study tried to identify through thermography which, between two cryotherapy modalities commonly used in the clinical environment, causes more remarkable decrease in temperature, being the aim to compare the superficial temperature variations of the quadriceps femoris muscle, in three distinct moments, when exposed to two cryotherapy modalities: ice bags (I) or ice bags with ice and water (I+W).

MATERIAL AND METHODS

The sample was by convenience and non-probabilistic, composed of 18 university students aged between 18 and 25 years, from both genders. The two cryotherapy modalities, ice bags (I) and bags with the ice and water mixture (I+W), were applied in all individuals, and the I+W modality was applied on the right quadriceps and the I modality on the left quadriceps. The application duration for both was of 15 minutes and they were simultaneously applied. The protocols were performed in the Study Laboratory of Injuries and Physiotherapeutic Resources of the Unioeste Physiotherapy Clinic. The research was approved by the Ethics in research Committee of Unioeste under the file 479/2010-CEP.

Initially, the subjects were submitted to a triage evaluation for identification data record as well as analysis of possible unfavorable factors to the participation in the research. The volunteers who presented systemic, vascular or locomotor diseases, or presented hypersensitivity to cold were not included.

Both modalities were applied with a plastic bag containing: in the I+W modality – 760g of ice + 240g of water; in the I mo-

dality – 1kg of ice. Measures were confirmed using a Techline Digital Bal 150pa scale.

The images were obtained with a Therma CAM® E320 portable infrared thermographic camera, with 320 x 240 *pixels* resolution, 4x digital zoom, thermal sensitivity of –0.10ºC to 25ºC, and ± 2ºC precision for data thermographic analysis. The data thermographic analysis was performed with the aid of the Therma CAM™ Quick Report program– version 1.1. The thermography was used to measure the superficial temperature of the quadriceps femoris muscles of both lower limbs, simultaneously, and was presented in Celsius degrees.

The thermographic images were analyzed having an 8cm point of the superior corner of the patella as reference point on the quadriceps. The laboratory remained acclimatized at a 24ºC temperature 12 hours before the procedure. On the day of the cryotherapy application, the volunteers were submitted to 15 minutes of acclimatization in the collection environment, wearing suitable clothes (*shorts*), leaving the quadriceps exposed, and doors and windows were closed. Movements close to the individuals who remained seated were avoided, no contact with the region under study was made, and the individuals were told to perform the minimum movement as possible.

After that period, the first thermographic record was made (AV1). Subsequently, the two cryotherapy modalities were simultaneously applied on the individual, with the aim to minimize the application bias. Immediately after, 15 and 30 minutes after the removal of the cryotherapy modalities, the second (AV2), third (AV3) and fourth (AV4) records, respectively, of both thighs were performed.

Statistical analysis was performed by the Kolmogorov-Smirnov test for normality. Comparison between data of the right and left quadriceps was made using the Wilcoxon test. Friedman with Dunn's post-test was used to compare the pre-cryotherapy immediatelyafter,15 and 30 minutes post-application moments within each modality. The significance level was of $p < 0.05$.

RESULTS

In the comparisons between right and left quadriceps at the different record moments, which evidenced which of the modalities was able to cool down the muscle more, significant difference was not found in the AV1 moment ($p = 0.1969$), indicating hence homogeneity. However, immediately after (AV2, $p = 0.0017$), 15 (AV3, $p = 0.0013$) and 30 minutes (AV4, $p = 0.001$) after the cryotherapy removal, there were significant differences between the modalities (table 1) and the I+W modality induced to significantly lower cooling.

Concerning the right (I+W) and left sides (I), comparing AV1 with AV2 and AV3, significant differences were found ($p < 0.05$), indicating significant decrease of temperature, while for the comparison between AV1 and AV4 no significant difference was found between records ($p > 0.05$), suggesting hence that there was restoration to the pre-application values. When AV2 and AV3 were compared, no significant differences were observed ($p > 0.05$), indicating maintenance of the temperature decrease reached. However, there was significant difference with the evaluation after 30 minutes (AV4, $p < 0.05$), presenting return of the temperature to initial levels. In the comparison between AV3 and AV4, there was no significant difference ($p > 0.05$) (table 1).

Table1. Results obtained both for variations between mean temperatures , in Celsius degrees (ºC), observed for each modality (ice + water – I+W) and ice – I), at the different recording moments (pre-cryotherapy – AV1; immediately after – AV2, 15 – AV3; and 30 minutes – AV4), and application sites (right quadriceps – R Quad, and left quadriceps– L Quad; right – R, and left – L).

	AV1		AV2		AV3		AV4	
Site	R Quad	L Quad	I+W (R)	I (L)	I+W (R)	I (L)	I+W (R)	I (L)
Tpt ºC	29.66	29.56	8.00╫*	9.84*	22.18╫*	22.77*	25.17╫▲	25.68▲

╫ Significant difference compared on the left side at the same evaluation moment.
* Significant difference when comparing with the pre-cryotherapy moment of the respective side.
▲ Significant difference when comparing with the post-immediate momentof the respective side.

DISCUSSION

This study demonstrated that the two cryotherapy modalities were efficient in decreasing the quadriceps femoris temperature and that the ice and water mixture was able to induce to lower temperature compared with the modality which used ice only. The cooling process for both lasted for at least 15 minutes after the ice removal and the superficial temperature was restored to the pre-application levels at 30 minutes after the removal.

Enwemeka *et al.*[1] evaluated the temperature of the quadriceps muscle at 1, 2 and 3cm of depth, before, during and after 20 minutes of treatment with ice bag. The results presented significant skin temperature decrease from eight minutes of treatment. After the therapy, the temperature at 1cm rapidly increased, returning to the basal levels. Conversely, there was temperature decrease at the 2 and 3cm depth, since the deeper tissues lost heat favoring the reheating of the superficial tissues.

In agreement with that, Myrer*et al.*[9] e Mac Auley[10] observed that the intramuscular temperature continues to decrease after the end of the cryotherapy. Tomchuk *et al.*[11]also observed that the intramuscular temperature remained decreasing from 2ºC to 3ºC after 10 minutes after ice removal, before gradually increasing to basal levels.

According to the literature, it is supposed that the deeper tissues are one of the heating sources used to reheat the superficial tissue. In this study, the deep tissues possibly continued to cool down after the cryotherapy removal due to the gradual increase of surface temperature of the muscle. However, since the thermograph is not able to record differences in depth, it is suggested that further studies which evaluate temperature in many depths are carried out, confronting hence the data evaluated by thermography.

The cold modalities with distinct thermodynamic properties produce different intramuscular temperatures, some with more remarkable effects than others, being alteration in the physical status the most important of them.Some absorb heat by conduction and let the water produced by the ice melting evaporate, absorbing hence more heat from the surface[12]. The interaction between cooling and subjacent tissues surface is important in the determination of the treatment efficiency, supporting the hypothesis that wider contact area and attachment to the tissue influence on the therapeutic effect[4]. Based on this hypothesis, it could be inferred that the I+W modality could produce more cooling than I alone, a result which has been observed.

Similarly to the results previously mentioned here, Dykstra *et al.*[13] verified that the therapy with ice and water was more

capable of cooling the gastrocnemius muscle after 20 minutes of application than ice cubes or crushed ice. Such fact may have occurred due to the increase of the contact of the wet ice and the skin, since the water inside the package adapts better to the treatment area than ice. Contrasting such view, Janwantanakul[14], using an ice bag with different sizes and weight, verified that the contact area size did not alter the level of cooling of the tissues.

Another aspect which interferes in the heat transfer is the thermal capacity of each material; that is, specific heat[12]. Kanlayanaphotporn and Janwantanakull[15] studied the application of four cryotherapy modalities: ice pack, water and frozen alcohol mixture, gel pack and frozen peas, and observed that the ice pack and water and alcohol mixture were more efficient in reducing tissue surface temperature. It can be explained by the high specific heat in the ice pack and water and alcohol mixture, offering higher capacity of superficial cooling.

Due to the cryotherapy clinical importance added to other factors such as tissue thickness and thermoregulation in different life stages can influence on the temperature alterations[16], further studies which use populations with age extremes and pathological alterations should still carried out.

CONCLUSION

Both modalities promoted temperature reduction which lasted for at least 15 minutes; and after 30 minutes from removal of the modalities, the temperature was reestablished to normal levels. However, the ice and water mixture produced higher cooling than the ice alone modality. Thus, clinically speaking, there may be difference between the application of ice bags or ice and water mixture.

All authors have declared there is not any potential conflict of interests concerning this article.

REFERENCES

1. Enwemeka CS, Allen C, Avila P, Bina J, Konrade J, Munns S. Soft tissue thermodynamics before, during, and after cold pack therapy. Med Sci Sports Exerc 2002;34:45-50.
2. Brancaccio N, Klein AA, Böettche GA, Colla PHS, Machado DM, Moser GR, et al. Análise de lesão muscular em ratos treinados e sedentários submetidos a crioterapia. Fisioter Mov 2005;18:59-65.
3. Vasconcellos LPWC. Noções de crioterapia. Perspect Médicas 1998;9:22-8.
4. Bleakley C. McDonough S, Macauley D. The use of ice in the treatment of acute soft-tissue injury: a systematic review of randomized controlled trials. Am J Sports Med 2004;32:251-61.
5. Knight KL. Crioterapia no tratamento das lesões esportivas. São Paulo: Manole, 2000.
6. Andrade Filho ACC. Teletermografia: princípios físicos, fisiológicos e fisiopatológicos da produção da imagem e suas indicações na clínica de dor e reabilitação. Acta Fisiátrica 1999;6:55-9.
7. Brioschi ML, Macedo JF, Macedo RAC. Termometria cutânea: novos conceitos. J Vasc Bras 2003;2:151-60.
8. Brioschi ML, Yeng LT, Pastor EMH, Colman D, Silva FMRM, Teixeira MJ. Documentação da síndrome dolorosa miofascial por imagem infravermelha. Acta Fisiátr 2007;14:41-8.
9. Myrer JW, Myrer KA, Measom GJ, Fellingham GW, Evers SL. Muscle temperature is affected by overlying adipose when cryotherapy is administered. J Athletic Train 2001;36:32-6.
10. Mac Auley DC. Ice therapy: how good is the evidence? Int J Sports Med 2001;22:379-84.
11. Tomchuk D, Rubley MD, Holcomb WR, Guadagnoli M, Tarno JN. The magnitude of tissue cooling during cryotherapy with varied types of compression. J Athl Train 2010;45:230-7.
12. Merrick MA, Jutte LS, Smith ME. Cold modalities with different thermodynamic properties produce different surface and intramuscular temperatures. J Athl Train 2003;38:28-33.
13. Dykstra JH, Hill HM, Miller MG, Cheatham CC, Michael TJ, Baker RJ. Comparisons of cubed ice, crushed ice, and wetted ice on intramuscular and surface temperature changes. J Athl Train 2009;44:136-41.
14. Janwantanakul P. The effect of quantity of ice and size of contact area on ice pack/skin interface temperature. Physiotherapy 2009;95:120-5.
15. Kanlayanaphotporn R, Janwantanakul P. Comparison of skin surface temperature during the application of various cryotherapy modalities. Arch Phys Med Rehabil 2005;86:1411-5.
16. Jutte LS, Merrick MA, Ingersoll CD, Edwards JE. The relationship between intramuscular temperature, skin temperature, and adipose thickness during cryotherapy and rewarming. Arch Phys Med Rehabil 2001;82:845-50.