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Research Article

The Effects of Massage, Iastm and Foam-Rolling on Skin Thermal Adaptations of Muscles of Different Perimeter and Subcutaneous Fat in Young Basketball Players

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Abstract

Aim: Skin temperature adaptations have been used as an indirect way of assessing hemodynamic and metabolic changes following the application of various physiotherapy techniques. This study aimed to examine the thermal skin responses (thermal buildup and retention rate) to massage, instrument-assisted soft tissue mobilization (IASTM) and foam-rolling procedures applied on tissues of different subcutaneous fat and perimeter measurements.

Materials and Methods: Ten (10) young basketball players received three treatments (one per week) of either massage, IASTM and foam rolling for 15 minutes on their quadriceps and gastrocnemius muscles. A thermometer was used to assess skin temperature immediately before and after the therapeutic application and every 1 minute after that until it returned to the baseline value.

Results: The application of massage and IASTM led to a more significant increase in skin temperature compared to the foam-rolling application for both muscles tested. IASTM led to a significantly higher retention of elevated temperature, and this adaptation was substantially longer in the gastrocnemius than in the quadriceps muscle. Differences in subcutaneous fat and muscle perimeters does not appear to affect the increase and retention of the skin temperature.

Conclusions: Soft-tissue techniques can increase and retain the skin temperature of muscles with bigger and smaller perimeters. These adaptations were more evident after the application of massage and IASTM applications.

Keywords: *Massage; IASTM; Foam Rolling; Skin Temperature*

Introduction

Increased skin temperature reflects to some extent the increased blood circulation of the underlying tissues as well as a significantly increased metabolic rate [1-3]. Based on the above, skin surface temperature responses to various stimuli have been associated with corresponding adjustments in the blood circulation and metabolism of the underlying tissues and have been used as an indirect way of assessing hemodynamics and metabolic changes after the application of various physiotherapy techniques [3]. In this context, the application of various soft tissue techniques such as massage [4,5], as well as the application of special electrotherapeutic techniques such

as radiofrequency, have significantly increased skin temperature which, depending on the medium applied, has been maintained above the original measurement for a significant period (approximately 1 hour).These changes have been attributed to a) increased friction by manual therapy applications, b) transfer of thermal energy, c) the production of profound thermal energy and d) increased blood circulation and increased transfer of hot blood to superficial tissues [6,7].

In recent years, innovative treatment techniques for myofascial release and treatment with specific equipment have been developed, such as instrument-assisted soft tissue mobilization (IASTM) and foam rolling, which, in addition to the release of myofascial adhesions and restrictions, can also launch significant vascular changes such as an increase in blood circulation and skin temperature [8-10].

In particular, IASTM procedures and self-massage techniques utilizing foam rolling are innovative therapeutic approaches that can significantly increase joint range of motion (ROM), reduce the sensitivity of myofascial trigger points and improve patient functionality [11,12]. The effect of soft tissue techniques on skin temperature was investigated in a study by Fousekis., *et al.* [8] that aimed to determine the effect of three different angle applications of the ERGON technique on the skin surface temperature of the hamstrings. The results showed that this therapeutic intervention, regardless of the angle of application, can lead to a significant increase in temperature (2 - 3 ^{o}C) from the initial measurements that lasted for 75 minutes after the end of the application.

However, the methodological designs of all the above studies have significant disadvantages that threaten the validity of their findings. In particular, the above studies did not take into account the morphological characteristics of the structures they evaluated and, in particular, did not categorize their applications according to the thickness of the underlying skin tissues, which is likely to be an important factor in enhancing metabolic adjustments following the application of such techniques.

Specifically, since the subcutaneous fat that acts as an insulating material and the transverse diameter of the underlying muscle tissue are directly related to both the mass for the production of thermal energy as well as the vascular-lymphatic network for the transport of warm blood to the surface of the skin, the thicknesses of these subcutaneous tissues should be considered important factors that could directly affect both the elevation and retention of skin temperature. In this context, the present study aims to evaluate the thermal effects of massage, IASTM and foam-rolling applications on the surface temperature of tissues of different body fat and muscle perimeter with the aim of indirectly evaluating the physiological adaptations of surface tissue cellular metabolisms.

Methods

The sample of the study consisted of ten (10) basketball players, aged 15.55 years, with a body weight of 73.27 kg and a height of 1.74 meters, who had not suffered any injuries and did not suffer from any disease that could affect skin temperature. All the participants were informed about the objectives of the research and the day and time of the measurements and signed a written consent to participate voluntarily in the measurements and the research procedures. The measurements were performed in the Therapeutic Exercise and Sports Rehabilitation Lab of the Department of Physiotherapy at the University of Patras. The B-K Medical Ultrasound Mini Focus 1402 was used to measure fat and the perimeter of the quadriceps and gastrocnemius muscles in both the right and left lower extremities.

The lengths of the quadriceps and gastrocnemius muscles were calculated in each participant, and the mean of the distances were marked. After these points were spotted, a 10 × 20 prefabricated rectangles (which had three vertically-aligned holes with 4 cm between them) was placed there to provide a standard thermal assessment of the three points for all participants. The superficial skin temperature of the involved muscles was recorded at these three points with a manual wireless infrared leather surface thermometer (Thermocouple 01500A3). This specific surface thermometer has a measurement accuracy of ± 0.3^{o}C between 20.0 - 42.5^{o}C, with ± 0.2^{o}C improved accuracy between 36.0 - 39.0^{o}C [7]. The same measurements of the surface temperature using the same methodology were performed on the non-dominant lower limb (not the treated limb), which served as the control. The temperature measurements were performed every minute until the surface temperature reached pre-treatment levels.

Participants received three treatments (one per week), which included a 15-minute application of either classical massage, IASTM or foam rolling on the dominant limb's quadriceps and gastrocnemius area (using the non-dominant limb as control), followed by the evaluation of the skin's thermal adaptations before and after each intervention. The massage interventions consisted of effleurages, kneading, petrissages and deep local frictions applied by experienced clinical physiotherapists who were members of the University lab. The IASTM applications were based on the procedures of the ERGON IASTM technique (ERGON IASTM, Athens-Greece) and were applied by certified ERGON IASTM providers. For the foam rolling procedure, the athletes performed self-mobilization, focusing on either the anterior side of the femur (quadriceps) or the posterior side of the tibia (gastrocnemius), using a commercially available foam roller (diameter: 8 cm; Blackroll AG, Bottighofen, Switzerland) according to the manufacturer's instructions.

For the descriptive statistical analysis, the continuous variables were expressed in the form of mean, standard deviation and median. To investigate the effect of a categorical variable on a quantitative variable, one-factor variance analysis (one-way ANOVA) was used. To investigate the effect of two categorical variables on a quantitative variable, the analysis of variance to two factors (two-way ANOVA) was used. To study the relationship between two continuous variables, the Pearson or Spearman index was used, depending on whether the assumption of normality applied. The Sapiro-Wilk test was initially used to test the normality condition. In the case of non-acceptance of the hypothesis, the graphic representations of "Normal Q-Q plot," "Detrended Normal Q-Q plot" and "Box Voyage" were studied. A paired t-test was used to examine differences in temperature adaptations between the quadriceps and gastrocnemius muscles. SPSS 25 software was used for statistical data processing, and the minimum value of the level of statistical significance, the p-value, was set at 5%.

Results

Tables 1 and 2 present the descriptive data for muscle perimeter and subcutaneous fat, as well as the differentiation and retention of temperature data per therapeutic intervention and treatment area of the intervention and control extremities.

Quadriceps (n=10)				Gastrocnemius (n=10)			
Muscle Perimeter		Subcutaneous Fat		Muscle Perimeter		Subcutaneous Fat	
Treated side (mean, cm)	Non-treated side (mean, cm)	Treated side (mean, cm)	Non-treated side (mean, cm)	Treated side (mean, cm)	Non-treated side (mean, cm)	Treated side (mean,cm2)	Non-treated side (mean, cm)
7.52	7.466667	2.611111	2.755556	5.933333	5.9	2.166667	2.244444

Table 1: *Muscle perimeter and subcutaneous fat data of the quadriceps and gastrocnemius muscles in young basketball players (N=10).*

Treatment Interventions	Quadriceps (N=10)					Gastrocnemius (N=10)				
	Treated side (D)		Non-treated side (D)		Temperature retention (min)	Treated side (D)		Non-treated side (D)		Temperature retention (min)
	Mean (°C)	Std. Deviation	Mean (°C)	Std. Deviation	Mean	Mean (°C)	Std. Deviation	Mean (°C)	Std. Deviation	Mean
Massage	2.51	0.40	0.13	0.11	86.7	3.62	0.23	0.13	0.13	113.0
IASTM	1.88	0.27	0.19	0.09	101.3	1.71	0.36	0.19	0.13	144.9
Foam roller	1.59	0.88	0.08	0.25	60.7	1.30	0.75	0.08	0.13	72.8

Table 2: *The differentiation and retention of increased temperature data per therapeutic intervention and treatment area of the intervention and control extremities in young basketball players (N=10). D=Differentiation.*

The one-way ANOVA test showed a significant difference in temperature change between the three groups for both the quadriceps (F = 6.44, p = .005) and the gastrocnemius (F= 61.53, p < .001) of the limb that received therapy. A post hoc analysis using the Bonferroni criterion for the quadriceps showed that the mean temperature change in the foam roller intervention group (mean = 1.59, sd = .882) was less than the corresponding massage group change (mean = 2.51, sd = .407, p = .005). No significant difference was observed between IASTM and massage.

Regarding changes in gastrocnemius temperature, a post hoc analysis, also using the Bonferroni criterion, showed that the mean temperature change in the foam roller group (mean = 1.305°C, sd = .752) was less than the corresponding change in the massage group (mean = 3.625°C, sd = .230, p < .001). In addition, the mean temperature change in the IASTM intervention group (mean = 1.710°C, sd = .360) was smaller than the corresponding change in the massage group (mean = 3.625°C, sd = .230, p < .001). In the case of intervention in the muscles of the unaffected limb, the adaptations of the surface temperature of the skin were minimal and without significant clinical differences between the three intervention groups.

The results also showed a significant difference in temperature retention between the three groups for both the quadriceps (F = 4229.200, p < .001) and the gastrocnemius muscles (F (2) = 63,315, p < .001). Specifically, for the quadriceps, the mean duration of temperature maintenance in the foam roller intervention group (mean = 60.7 min) was shorter than the corresponding duration of the IASTM group (mean = 101.30 min, p < .001). Moreover, the mean duration of temperature maintenance in the foam roller intervention group (mean = 60.7, min) was shorter than the corresponding duration in the massage group (mean = 86.7 min, p < .001). In the IASTM intervention group, the mean duration of temperature maintenance (mean = 101.30) was longer than the corresponding duration of the massage group (mean = 86.70, p < .001). For the gastrocnemius, the mean duration of temperature maintenance in the foam roller intervention group (mean = 72.80) was shorter than the corresponding duration in the IASTM group (mean = 144.90, p < .001), while the mean duration of temperature maintenance in the foam roller intervention group (mean = 72.80) was shorter than the corresponding duration of the massage group (mean = 113.00, p < .001). In the IASTM intervention group, the mean duration of temperature maintenance (mean = 144.90) was longer than the corresponding duration in the massage group (mean = 113.00, p < .001).

The evaluation of the correlation between the change in temperature and the body fat values and muscle perimeters for each intervention method (massage, IASTM, foam roller) showed that the temperature changes were not related to either the value of fat or the perimeter of the muscles (p> 0.05). Table 3 presents all the combinations of correlation testing between muscle perimeter/subcutaneous fat value and quadriceps/gastrocnemius muscle, as well as the significance values for each control between all possible pairs of intervention groups.

Treatment intervention	Quadriceps perimeter ~ Temperature retention time	Gastrocnemius perimeter ~ Temperature retention time	Quadriceps fat ~ Temperature retention time	Gastrocnemius fat ~ Temperature retention time
Foam roller	rs = .031 (p = 0.933)	rs = -0.218 (p = 0.546)	rs = 0.006 (p = 0.986)	rs = -0.261 (p = .466)
IASTM	rs =0 .183 (p = 0.613)	rs = 0 .122 (p = 0 .736)	rs = -0.168 (p = .643)	rs = 0 .320 (p = 0.367)
Massage	rs = 0.037 (p = 0.920)	rs = -0.147 (p = 0 .685)	rs = 0 .144 (p = 0 .692)	rs = 0.491 (p = 0 .150)
Foam roller vs. IASTM	p = 0 .772	p =0 .850	p = 0.741	p = 0 .263
Foam roller vs. Massage	p =0 .992	p = 0.490	p =0.795	p = 0.131
Massage vs IASTM	p =0 .780	p = 0.610	p = 0.555	p = 0.704

Table 3: *Correlation data regarding changes in temperature and the body fat values and muscle perimeters for each intervention method (massage, IASTM, foam roller).*

Comparisons regarding the retention time of the quadriceps and gastrocnemius surface temperatures by type of intervention showed significant differences in favor of the gastrocnemius. Specifically, the results of the pairwise control t-test showed a) a statistically significant difference in temperature retention time between the quadriceps (M = 60.7, SD = 10.04) and the gastrocnemius muscles (M = 72.8, SD = 7.96) in the foam roller group (t = 3.105, p = .013), b) a statistically significant difference in temperature retention time between the quadriceps (M = 101.3, SD = 11.26) and the gastrocnemius muscles (M = 114.9, SD = 21.31) in the IASTM group (t (9) = 5.689, p < .001) and c) a statistically significant difference in temperature retention time between the quadriceps (M = 86.7, SD = 9.33) and the gastrocnemius muscles (M = 113, SD = 10.04), in the massage group (t (9) = 9.741, p < .001).

Discussion

Classical soft-tissue techniques like massage, as well as novel techniques like IASTM and foam rolling, constitute important therapeutic approaches that are gaining ground in modern therapeutics due to their efficacy in a) releasing myofascial adhesions and restrictions, b) decreasing muscle spasms and pain, c) increasing joint ROM and d) improving patients' functionality. However, despite the critical evidence in the literature on the usefulness of such techniques in improving patients' health, important physiological adaptations such as skin temperature adaptations after the application of such techniques remain unsupported. Few studies to date have evaluated skin temperature after the application of classical massage [4], and even fewer the corresponding effects of the IASTM techniques [8] and foam rolling. Such approaches have been reported to increase skin temperature, which is a significant adjustment that reflects increased blood flow and lymphatic circulation to the underlying tissues. Nevertheless, no study has comparatively evaluated the physiological effects of applying massage, IASTM and foam-rolling techniques on skin temperature. Furthermore, no study has assessed the impact of the above methods on the adjustments (increase and maintenance of time) of skin temperature in tissues of different perimeter and fat in amateur adolescent basketball players. To narrow this research gap, we examined the effectiveness of massage, IASTM and foam-rolling techniques applied to the quadriceps and gastrocnemius muscles of young basketball players in increasing and maintaining skin temperature.

The results of the present study showed a significant increase in skin surface temperature after the application of soft tissue techniques to the quadriceps and gastrocnemius muscles. These adjustments were significantly greater after massage and IASTM techniques compared to foam rolling. More specifically, the application of massage on the quadriceps for 15 minutes led to a 2.5°C increase in the surface temperature of the skin, while in the gastrocnemius muscle the increase was 3.5°C. The application of IASTM techniques increased the surface temperature of the quadriceps and gastrocnemius muscles by 1.88°C and 1.71^{0}C and foam rolling by 1.59°C and 1.30°C, respectively. These findings confirm other research findings that have shown that the application of massage techniques to the vastus lateralis muscle led to an increase in both local temperature and heart rate [4] and that the IASTM technique can significantly increase the hamstring muscle's skin temperature [8]. The foam-rolling also raised the temperature but not to the levels of the other two therapies can be attributed to massage and IASTM techniques being more aggressive approaches. Furthermore, these techniques, when applied by a therapist with special equipment, can increase vascular circulation and better reach targeted deeper tissues and vessels compared to foam rolling, which is a myofascial compression process performed by the athlete him/herself in a more generalized pattern of execution.

In addition to the findings of an increase in surface temperature, the results of the present study showed significant differences in the maintenance of elevated temperature between the three techniques in the quadriceps and gastrocnemius muscles. In particular, the application of IASTM led to an increase in the surface temperature of almost 2°C, which was maintained above the initial levels for about 100 and 145 minutes for the quadriceps and gastrocnemius, respectively. These results support findings from Fousekis., *et al.* [8], who reported a significant 2 - 3°C increase in temperature in the hamstrings' skin after the application of Ergon techniques that was maintained for 75 minutes after the application of the Ergon IASTM technique.

What is interesting is that there is a significant difference in the elevated temperature retention between the quadriceps and gastrocnemius muscles in the foam roller, IASTM and massage groups. A possible explanation for the above finding could be the size of the muscle surface. Specifically, we can assume that the gastrocnemius muscle, having a smaller transverse diameter compared to the quadriceps, underwent a greater mobilization of its vascular and nervous plexus, resulting in a significantly greater vascular response and adaptation

to compression stimuli than did the quadriceps, which is a quite larger muscle. In addition, the considerably larger surface of the quadriceps compared to that of the gastrocnemius favors the greater exchange of thermal energy with the environment and, therefore, the faster reduction of its surface temperature.

The research does not show a correlation of subcutaneous fat and the perimeter of the intervention muscles with increased skin temperature retention. These specific results cannot be compared with other studies, as there is no corresponding research that has evaluated similar approaches. The absence of significant subcutaneous fat differentiation can be attributed to the presence of small subcutaneous fat differences between the quadriceps and the gastrocnemius muscles in the athletes of our study, rendering them incapable of enabling significant thermal adjustments of superficial tissues.

The results of the present research should be evaluated in light of its significant methodological limitations. The most important limitation is that its research design was based not on random but on convenience sampling of young athletes. Furthermore, the participants were healthy with no pathologies, and their number may be considered small; however, this limitation is offset by the significant homogeneity in the participants' physical characteristics.

Despite these limitations, the increase in surface temperature, as well as its maintenance after the application of myofascial techniques, is of particular clinical interest to physiotherapists given that an increase in tissue temperature by 1°C brings relief and increases the metabolic rate in the area and an increase by 2 - 3°C will help reduce pain and muscle spasms. In comparison, an increase by 3 - 4°C can cause changes in tissue permeability and increase the elasticity of collagen tissues, which can lead to better tissue function as well as the prevention of musculoskeletal injuries. Moreover, the increased temperature leads to an increase in the permeability of the vessels and their oxygenation.

Conclusions

The application of soft tissue techniques can increase and maintain the surface temperature of the quadriceps and gastrocnemius muscles for a significant period. The application of massage technique and IASTM lead to a significantly more substantial increase in surface temperature compared to foam rolling. The IASTM technique leads to a substantially longer duration of maintenance of the surface temperature compared to the other two therapeutic interventions for both the quadriceps and the gastrocnemius muscles. Fat and muscle circumference do not seem to affect the change in local temperature and its maintenance time.

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