

# ACUTE EFFECT OF SPEED TEST ON THE SKIN TEMPERATURE OF ELITE SOCCER PLAYERS

EFEITO AGUDO DO TESTE DE VELOCIDADE SOBRE A TEMPERATURA DA PELE DE JOGADORAS DE FUTEBOL DE ELITE

EFECTO AGUDO DEL TEST DE VELOCIDAD SOBRE LA TEMPERATURA DE LA PIEL DE JUGADORAS DE FÚTBOL DE ÉLITE

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## ABSTRACT

**Introduction:** Infrared thermography has been used in several areas, mainly in sports training, and specifically in soccer. **Objectives:** The objectives of the study were to verify the acute effect of a displacement speed test on the skin temperature of elite female soccer players, to observe pre- and post-test thermal asymmetries, and to compare responses in the anterior and posterior regions of lower limbs. **Methods:** Cross-sectional study that evaluated 17 soccer players of the 2018 Brazilian Championship. They were submitted to thermography before and 10 minutes after performing the displacement speed test. Thermographic images were collected using a FLIR® model 8 thermal imager and changes in skin temperature in the anterior and posterior regions of the lower limbs were analyzed, according to the areas of interest. Descriptive statistics were performed and mean and standard deviation of the temperatures of the areas of interest were analyzed. The normality of the data was verified, and then the Student's t test for normal paired and independent samples and the Mann-Whitney test for non-normal samples were conducted, with  $p < 0.05$  being adopted for significance level. **Results:** It was possible to observe that after the test there was an increase in skin temperature in all the regions analyzed, both on the dominant and non-dominant sides ( $p < 0.05$ ). Regarding the analysis of the anterior region, it was possible to observe a higher temperature ( $p < 0.05$ ) in the region of the tibial muscles than in the region of the quadriceps muscles. **Conclusion:** It is concluded that thermography helps to understand the thermal responses of lower limbs after applying the displacement speed test. The study shows that thermographic evaluation can guide the organization of the training session when motor tests have previously been applied, and in the detection of abnormal overloads, helping to prevent injuries. **Level of evidence IV; Therapeutic studies - Investigation of treatment results.**

**Keywords:** Thermography; Women; Control; Exercise; Soccer.

## RESUMO

**Introdução:** A termografia infravermelha tem sido empregada em diversas áreas, principalmente no treinamento esportivo e especificamente no futebol. **Objetivos:** Os objetivos do estudo foram verificar o efeito agudo da aplicação de um teste de velocidade de deslocamento sobre a temperatura da pele de atletas de futebol feminino de elite, as assimetrias térmicas pré e pós-teste e comparar respostas nas regiões anterior e posterior de membros inferiores. **Métodos:** Estudo de caráter transversal, que avaliou 17 jogadoras de futebol do Campeonato Brasileiro em 2018. Elas foram submetidas à termografia antes e 10 minutos depois da realização do teste de velocidade de deslocamento. Foram coletadas imagens termográficas por meio de um termovisor FLIR®, modelo E8, e analisadas as alterações da temperatura da pele, na região anterior e posterior dos membros inferiores, de acordo com as áreas de interesse. Foi realizada a estatística descritiva e para análise, foram usados média e desvio padrão da temperatura das áreas pretendidas. Verificou-se normalidade dos dados e, em seguida, o teste t de Student para amostras normais pareadas e independentes e o teste de Mann-Whitney, para amostras não normais, adotando-se  $p < 0,05$  para nível de significância. **Resultados:** Foi possível observar que depois do teste houve aumento da temperatura da pele em todas as regiões analisadas, tanto no lado dominante quanto no não dominante ( $p < 0,05$ ). Com relação à análise da região anterior, foi possível observar maior temperatura ( $p < 0,05$ ) na região dos músculos tibiais quando comparados com os músculos da região do quadríceps. **Conclusão:** Conclui-se que a termografia auxilia o entendimento das respostas térmicas de membros inferiores depois da aplicação do teste de velocidade de deslocamento. O estudo demonstra que a avaliação termográfica pode orientar a organização da sessão de treinamento quando há aplicação prévia de testes motores e na detecção de sobrecargas anormais, auxiliando na prevenção de lesões. **Nível de evidência IV; Estudos terapêuticos - Investigação dos resultados do tratamento.**

**Descritores:** Termografia; Mulheres; Controle; Treinamento físico; Futebol.

## RESUMEN

**Introducción:** La termografía infrarroja ha sido empleada en diversas áreas, principalmente en el entrenamiento deportivo y específicamente en el fútbol. **Objetivos:** Los objetivos del estudio fueron verificar el efecto agudo de la



aplicación de un test de velocidad de desplazamiento sobre la temperatura de la piel de atletas de fútbol femenino de élite, las asimetrías térmicas pre y post test y comparar respuestas en las regiones anterior y posterior de miembros inferiores. Métodos: Estudio de carácter transversal, que evaluó a 17 jugadoras de fútbol del Campeonato Brasileño en 2018. Ellas fueron sometidas a termografía antes y 10 minutos después de la realización del test de velocidad de desplazamiento. Fueron colectadas imágenes termográficas por medio de un termovisor FLIR® - E8, modelo E8, y analizadas las alteraciones de la temperatura de la piel, en la región anterior y posterior de los miembros inferiores, de acuerdo con las áreas de interés. Fue realizada la estadística descriptiva y para el análisis, fueron usados promedio y desviación estándar de la temperatura de las áreas pretendidas. Se verificó normalidad de los datos y, a continuación, el test t de Student para muestras normales pareadas e independientes, y el test de Mann-Whitney, para muestras no normales, adoptándose  $p < 0,05$  para nivel de significancia. Resultados: Fue posible observar que después del test hubo aumento de la temperatura de la piel en todas las regiones analizadas, tanto en el lado dominante como en el no dominante ( $p < 0,05$ ). Con relación al análisis de la región anterior, fue posible observar mayor temperatura ( $p < 0,05$ ) en la región de los músculos tibiales cuando comparados con los músculos de la región del cuádriceps. Conclusión: Se concluye que la termografía ayuda en el entendimiento de las respuestas térmicas de miembros inferiores, después de la aplicación del test de velocidad de desplazamiento. El estudio demuestra que la evaluación termográfica puede orientar la organización de la sesión de entrenamiento cuando hay aplicación previa de tests motores y en la detección de sobrecargas anormales, ayudando en la prevención de lesiones. **Nivel de evidencia IV; Estudios terapéuticos - Investigación de los resultados del tratamiento.**

**Descriptor:** Termografía; Mujeres; Control; Ejercicio Físico; Fútbol.

DOI: [http://dx.doi.org/10.1590/1517-8692202127012020\\_0060](http://dx.doi.org/10.1590/1517-8692202127012020_0060)

Article received on 07/23/2020 accepted on 10/13/2020

## INTRODUCTION

In recent years, women's soccer has seen an increase in the number of athletes at different levels and championships, mainly after the new licensing rules of the South American Football Confederation, turning it into a noteworthy sports category within the high-performance sports.

Regarding its characterization, soccer has been considered an intermittent modality as its official matches require numerous motor actions, such as accelerations/decelerations, jumps and changes of direction at different intensities, and the competitive performance of players can be influenced by the interaction of different motor skills<sup>1,2</sup>.

Over the years and with the sport's evolution, soccer has undergone changes in its dynamics, and, consequently, games have become faster<sup>3</sup>, causing displacement speed to become one of the determining skills in competitive performance. In this sense, the increase in size of the championships and in the number of games played has contributed to these changes in the competitive environment, especially in elite soccer, which means that evaluations of this motor skill are carried out regularly in order to serve as a parameter of training control.

Particularly in relation to training control parameters, different indicators have contributed to monitor the athlete's progress, and one of the resources most frequently employed to assess speed is the 30-meter displacement test proposed by Little and Williams<sup>4</sup>. In fact, it seems to be a daily practice in sports environments to apply motor tests in order to diagnose and monitor the evolution of the athlete's performance throughout the season, but a problem to be pointed out is how much these tests influence or if they can be used before the training session.

In this regard, different tools have emerged to assist in the control and monitoring of training, such as infrared thermography, which is a method of capturing images that detects changes in skin temperature<sup>5</sup>. Notably, infrared thermography has shown impressive results in different areas of knowledge, mainly in the health sciences. It can be used as an auxiliary tool in the diagnosis of diseases such as cancer, musculoskeletal injuries and even in the evaluation of clinical and aesthetic procedures, as it is a non-invasive, radiation-free and highly accurate technique<sup>6,7,8</sup>.

In the scope of sports training, specifically in the control and monitoring of training, some studies have contributed to the detection of overload and skeletal muscle fatigue in elite athletes, and also to the control and

prevention of injuries arising from sports practice<sup>9,10</sup>, however, there is no information regarding the responses on skin temperature after application of motor tests, mainly in elite female soccer athletes. Therefore, the objectives of this study are: a) to verify the acute effect of the application of a displacement speed test on skin temperature of elite female soccer athletes; b) to identify possible thermal asymmetries before and after applying the test; c) to compare skin temperature response of the anterior and posterior regions of the lower limbs of female soccer players.

## MATERIALS AND METHODS

### Research design and participants

This study is observational and involves elite female soccer players. An intentional sample was selected, and included 17 female soccer athletes, aged  $21.9 \pm 4.7$  years old on average, with a mean body mass of  $59.6 \pm 8.0$  kg, a mean fat percentage of  $16.6 \pm 3.7$ , and a mean height of  $1.64 \pm 4.9$  cm. The following inclusion criteria were observed: not having any orthopedic limitations, not using any stimulating substance and being present in the data collection.

The study was carried out in the competitive period of the adult category of the Brazilian Championship in 2018, with an average of two games per week. The athletes trained six times a week, with an average duration of 90 minutes, beginning the work with stretching exercises and general muscle warm-up, followed by a training session programmed by the technical committee.

All volunteers signed an informed consent form. The project was approved by the Research Ethics Committee under CAEE protocol number 00348818.1.0000.5404

### Data collection procedure

The athletes were submitted to the thermographic evaluation protocol before and after the displacement speed test application. The infrared images were collected using a FLIR® thermal imager, E8 model. This device has an integrated  $320 \times 240$  pixel resolution, making it possible to measure temperatures between  $-20^{\circ}\text{C}$  and  $250^{\circ}\text{C}$ , with thermal sensitivity  $<0.06^{\circ}\text{C}$ .

Before the data collection the athletes were instructed not to consume caffeine or alcohol, not to use any type of product on their skin,

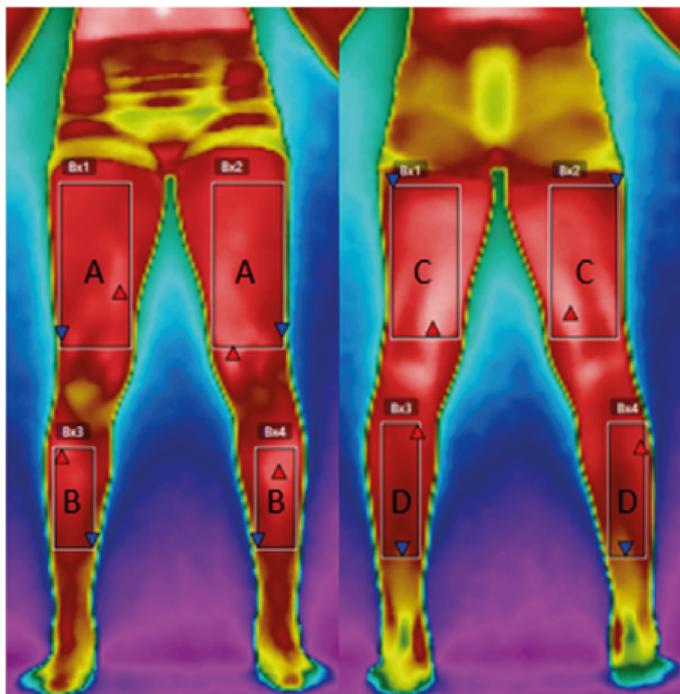
not to take any medication, and not to perform physical exercises in the 24 hours preceding data collection. They were also instructed not to apply pressure on, rub or scratch their skin at any time until the entire collection process was completed<sup>11</sup>.

For the initial collection, the thermographic camera was stabilized by placing it in the evaluation room and turning it on 20 minutes before the procedure. The athletes stayed 20 minutes in a previously prepared room, conditioned at 22°C to obtain thermal balance. They all remained in an anatomical position in front of the evaluator, on a carpet, at a distance of two meters from the thermal imager. The thermographic images were taken at the initial moment (pre) and repeated 20 minutes after the speed test application (post)<sup>12</sup>. Two images were captured, one in the anterior and one in the posterior plane. The analysis of the thermograms was performed using the Flir Tools® software, considering the areas for the following regions of interest (ROIs): quadriceps, anterior tibialis, hamstrings and calf, as shown in Figure 1.

Displacement speed was assessed using the 30-meter speed test, according to the protocol described by Little and Williams<sup>4</sup>, in which athletes should cover the total distance of 30 m as quickly as possible. All athletes were submitted to a five-minute warm-up protocol, consisting of light running and short sprints. Four pairs of photocells (Speed Test Fit® – Cefise) were positioned one meter high, the first on the starting line, the second on the 10-meter mark, the third on the 20-meter mark, and, finally, the fourth on the final 30-meter mark. Each athlete made two attempts, with a three-minute interval between each one, and the best result obtained was the one used for analysis.

### Statistical analysis

The data were presented using descriptive statistics (mean ± standard deviation), and, after verifying data normality through the Shapiro-Wilk test, they were submitted to the Student's T test for normal paired and independent samples. When data normality wasn't detected the Mann-Whitney test for non-normal samples was used. Significance level of  $p < 0.05$  was adopted for the analyses.



**Figure 1.** Regions of interest (ROIs) used for the analysis (A – quadriceps; B – anterior tibialis; C – hamstrings; D – calf).

## RESULTS

From the data obtained, the results will be presented according to the values of the skin temperature of the ROIs relative to the moment of evaluation (Table 1), thermal asymmetry (Table 2), and temperature of the anterior and posterior regions (Table 3).

Table 1 illustrates the results of the comparison of skin temperature before and after the speed test, making it possible to observe a significant increase in the ROIs temperature after the test, both in the dominant and non-dominant limbs. ( $p < 0.05$ ).

Table 2 refers to the analysis of the temperature difference between the dominant and non-dominant limbs, and it was possible to note that there was no thermal asymmetry in any of the analyzed regions, both before and after the speed test's application.

Table 3 shows the temperature of the analyzed regions (anterior and posterior) of each body segment, according to dominance. The data demonstrate that there was a significant skin temperature difference ( $p < 0.05$ ) in the leg, as the tibial region showed higher temperatures compared to the calf, both before and after the test, on both sides.

## DISCUSSION

Based on the data obtained, the present discussion will be divided into three moments. The first moment highlights the effect of the displacement speed test on the skin temperature of the lower limbs. In the second moment, the thermal asymmetry of the lower limbs will be addressed, and, lastly, the regions that most experienced changes in skin temperature will be presented.

Regarding the speed test effect on skin temperature, the data point to an increase in all analyzed regions following its application. Other studies have sought to identify skin temperature changes while and after performing various exercises, such as squatting, running, cycling, rowing and swimming<sup>13-19</sup> but the effects of specific tests on this parameter have not been identified<sup>20-22</sup>.

After the 30-meter speed test application, it was noted that there was an increase in the temperature of all the regions analyzed, both in the dominant and non-dominant limbs, differing from the results of the study by Korman et al.<sup>14</sup>, who found a decrease in skin temperature after subjecting sprinters of the Polish athletics team to a speed resistance training session, with distances ranging from 60 m to 120 m. The data may have diverged due to the analysis technique adopted, as in the study by Korman et al.<sup>14</sup>, the mean skin temperature of the lower limbs as a whole was considered, whereas in this study the analysis was performed using only the quadriceps and the hamstrings.

In a test performed on a treadmill, Merla et al.<sup>12</sup> verified the subjects skin temperature response while running, with a gradual increase in intensity. It was found that, at the end of the test, there was a skin temperature increase of approximately 0.2°C in the region of the thighs,

**Table 1.** Mean temperature of the analyzed regions and standard deviation, according to the moment of evaluation.

Limb	ROIs	Moments of Evaluation		Temperature difference (°C)
		Pre-test	Post-test	
Dominant	Quadriceps	28.6 ± 0.6	29.8 ± 0.6*	0.2
	Hamstrings	28.6 ± 0.4	29.8 ± 0.7*	1.2
	Anterior tibialis	28.6 ± 0.2	30.0 ± 0.4*	1.4
	Calf	28.3 ± 0.7	29.2 ± 0.7*	0.9
Non-dominant	Quadriceps	28.5 ± 0.6	29.8 ± 0.6*	1.3
	Hamstrings	28.7 ± 0.4	30.0 ± 0.8*	1.3
	Anterior tibialis	28.8 ± 0.3	29.9 ± 0.4*	0.9
	Calf	28.6 ± 0.5	29.5 ± 0.6*	0.9

\*  $p < 0.05$ .

**Table 2.** Mean temperature of the analyzed regions and standard deviation, according to dominance.

Moments	Analyzed regions							
	Quadriceps		Hamstrings		Anterior tibialis		Calf	
	Dominant	Non-dominant	Dominant	Non-dominant	Dominant	Non-dominant	Dominant	Non-dominant
Pre (°C)	28.6 ± 0.3	28.6 ± 0.3	28.6 ± 0.1	28.7 ± 0.1	28.6 ± 0.2	28.8 ± 0.3	28.1 ± 0.2	28.1 ± 0.2
Post (°C)	29.8 ± 0.4	29.8 ± 0.5	29.8 ± 0.6	30.0 ± 0.7	30.0 ± 0.4	29.9 ± 0.4	29.2 ± 0.6	29.5 ± 0.4

**Table 3.** Mean temperature of the anterior and posterior regions of the lower limbs and standard deviation, according to the moment of evaluation.

Moments	ROIs			
	Dominant side		Non-dominant side	
	Quadriceps	Hamstrings	Quadriceps	Hamstrings
Pre	28.6 ± 0.3	28.6 ± 0.1	28.6 ± 0.3	28.7 ± 0.1
Post	29.8 ± 0.4	29.8 ± 0.6	29.8 ± 0.5	30.0 ± 0.7
	Anterior tibialis	Calf	Anterior tibialis	Calf
Pre	28.6 ± 0.2*	28.1 ± 0.2	28.8 ± 0.3*	28.1 ± 0.2
Post	30.0 ± 0.4*	29.2 ± 0.6	29.9 ± 0.4*	29.5 ± 0.4

\*p&lt;0.05.

results that are close to those of this study (Table 1). Fernandes et al.<sup>15</sup> found an increase in the temperature of the anterior and posterior thigh and of the calf after a 60-minute session of aerobic exercise at 60% of the VO<sub>2</sub>max, results that are analogous to those found in the present study. Santa Cruz et al.<sup>22</sup> evaluated the skin temperature of handball players after an official match and found temperature variations in the region of the quadriceps (0.2°C on the right side and 0.1°C on the left side) and hamstrings (0.4°C on the right side and 0.2°C on the left side), but without statistical difference. This behavior can be explained by the orientation of blood flow towards the most active regions<sup>23</sup>, especially when it comes to maximum protocols, as was the case of the 30m test<sup>24</sup>. This information is of extreme importance in the planning of the training session that will follow the test application, since it offers the possibility to identify which regions had a higher demand and to plan the session avoiding excessive overload of those regions.

In soccer, specifically, studies have sought to verify thermal asymmetries in order to identify and prevent injuries<sup>25</sup>. Regarding the results of thermal asymmetry, it was possible to note that there was no asymmetry in any of the regions analyzed, i.e., there was no contralateral difference greater than 0.3°C, both before and after the test, indicating that there was no additional overload in none of the body hemispheres, since the differences found (0.1°C to 0.3°C) agree with the literature, which classifies asymmetry values <0.5°C as normal<sup>26</sup>. A study by Stroppa et al.<sup>27</sup> also applied thermography to professional soccer players, seeking to verify thermal asymmetries only in the knee region, and found no statistical difference between limbs, both in the anterior and posterior regions. This study is in line with our findings, which also found no statistical difference in the moments before and after the test.

Although this study did not find thermal asymmetry between the dominant and non-dominant limbs, it draws attention to the higher skin temperature in the tibial region on both sides compared to the quadriceps, both before and after the test. A study by Fernandes et al.<sup>28</sup> verified the effect of a soccer match on the skin temperature of the lower limbs, and observed that 24 hours after the match, there was an average increase of 2.2°C, together with a 561% increase in creatine kinase (CK), in comparison to the pre-match values, which indicates micro muscle

injuries. These results show that there may be a relationship between skin temperature increase in the tibial region and the activity of enzymes related to injury and/or inflammation, suggesting greater mechanical stress on this region that is responsible for stabilizing the ankle joint, especially when performing eccentric actions, which are prevalent in soccer and sprints, as is the case of the displacement speed test<sup>29</sup>.

This temperature increase in the tibial region may also be related to biomechanical factors (joint mobility, postural deviations, level of flexibility, among others). In this sense, Rodriguez-Sanz et al.<sup>30</sup> assessed the ankle flexibility of soccer players, and then subjected the athletes to an 8 km/h run on a treadmill for 15 minutes. Before and after the running protocol thermographic images were collected and it was found that the flexibility level of the ankle joint can influence temperature increase in muscles overloaded by mechanical changes in the joint. That being so, infrared thermography seems to be an important tool to monitor both training sessions and test sessions for evaluation and control, since the increase in skin temperature may indicate additional, and even abnormal, overloads that contribute to the occurrence of injuries.

## CONCLUSION

It is concluded that, after the application of the 30-meter speed test there was an increase in the temperature of all analyzed regions, which may have been caused by the orientation of blood flow towards the areas with greatest activation. After applying the test, there was no thermal asymmetry between the dominant and non-dominant limbs, but higher skin temperature increase was found in the tibial region, on both sides, compared to the quadriceps.

## Practical applications

The data presented here point to different practical applications that different members of the technical committee can use. It enables the technical team to be more attentive in the organization of the training session when there is application of speed test at the beginning of the session, mainly in relation to the region of the anterior tibial muscle. In the monitoring and control of training, thermography proved to be a tool that can help detect minimal changes in skin temperature, which may reflect a muscular overload. In addition, from the identification of thermal asymmetries, the technical committee can define which recovery procedures can be employed to minimize muscle overload and assist in injury prevention.

## ACKNOWLEDGMENT

The authors thank Espaço da Escrita – Pró-Reitoria de Pesquisa – UNICAMP – for the language services provided.

All authors declare no potential conflict of interest related to this article

**AUTHORS' CONTRIBUTIONS:** EE each author made significant individual contributions to this manuscript. AMP: Substantial contribution to the concept and design of the work, data acquisition, writing. ATT: Data acquisition and revision of the article. NAV and TMR: Data acquisition and substantial contribution to the concept and design of the work. SHB and CSH: Data acquisition and analysis. CRP: Data analysis and interpretation and critical review of the intellectual content. FCT: Writing and revision of the article. JPB: Substantial contribution to the concept and design of the work, critical review of the intellectual content and approval of the final version of the text.

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## ERRATA

In the article entitled “ACUTE EFFECT OF SPEED TEST ON THE SKIN TEMPERATURE OF ELITE SOCCER PLAYERS” authored by Andressa Mella Pinheiro, Angélica Tamara Tuono, Nathália Arnosti Vieira, Tiago Marques de Rezende, Sérgio Henrique Borin, Charlini Simoni Hartz, Carlos Roberto Padovani, Fernando Carmelo Torres, João Paulo Borin, published in *Rev Bras Med Esporte* vol.27 no.1 São Paulo Jan./Mar. 2021 DOI: [http://dx.doi.org/10.1590/1517-8692202127012020\\_0060](http://dx.doi.org/10.1590/1517-8692202127012020_0060), pages 55–59 by request of the authors.

- On page 58, line 1

Where it reads: results that are close to those of this study

Read: results that are smaller to those of this study

- On pages 57 and 58

Tables 1, 2 e 3 respectively, should be substituted for the following tables:

**Table 1.** Mean temperature of the analyzed regions and standard deviation, according to the moment of evaluation.

Limb	ROIs	Moments of evaluation		Temperature difference (°C)
		Pre-test	Post-test	
Dominant	Quadriceps	28.7 ± 0.6	29.8 ± 0.6*	1.1
	Hamstrings	28.6 ± 0.4	29.9 ± 0.8*	1.3
	Anterior tibialis	28.7 ± 0.5	30.0 ± 0.6*	1.3
	Calf	28.1 ± 0.5	29.2 ± 0.8*	1.1
Non-dominant	Quadriceps	28.7 ± 0.6	29.9 ± 0.7*	1.2
	Hamstrings	28.8 ± 0.4	30.0 ± 0.8*	1.2
	Anterior tibialis	28.8 ± 0.6	30.0 ± 0.6*	1.2
	Calf	28.1 ± 0.5	29.5 ± 0.7*	1.4

\* p<0.05.

**Table 2.** Mean temperature of the analyzed regions and standard deviation, according to dominance.

Moments	Analyzed regions							
	Quadriceps		Hamstrings		Anterior tibialis		Calf	
	Dominant	Non-dominant	Dominant	Non-dominant	Dominant	Non-dominant	Dominant	Non-dominant
Pre (°C)	28.7 ± 0.6	28.7 ± 0.6	28.6 ± 0.4	28.8 ± 0.4	28.7 ± 0.5	28.8 ± 0.6	28.1 ± 0.5	28.1 ± 0.5
Post (°C)	29.8 ± 0.6	29.9 ± 0.7	29.9 ± 0.8	30.0 ± 0.8	30.0 ± 0.6	30.0 ± 0.6	29.2 ± 0.8	29.5 ± 0.7

**Table 3.** Mean temperature of the anterior and posterior regions of the lower limbs and standard deviation, according to the moment of evaluation.

Moments	ROIs			
	Dominant side		Non-dominant side	
	Quadriceps	Hamstrings	Quadriceps	Hamstrings
Pre	28.7 ± 0.6	28.6 ± 0.4	28.7 ± 0.6	28.8 ± 0.4
Post	29.8 ± 0.6	29.9 ± 0.8	29.9 ± 0.7	30.0 ± 0.8
	Anterior tibialis	Calf	Anterior tibialis	Calf
Pre	28.7 ± 0.5*	28.1 ± 0.5	28.8 ± 0.6*	28.1 ± 0.5
Post	30.0 ± 0.6*	29.2 ± 0.8	30.0 ± 0.6*	29.5 ± 0.7

\* p<0.05.