RBFEx
ISSN Online: 2675-1372

Revista Brasileira de Fisiologia do Exercício

Original article

Effects of an official duathlon sprint competition on lower limb temperature: response according to moments and dominance

Efeitos de uma competição oficial de duathlon Sprint na temperatura dos membros inferiores: respostas segundo momentos e dominância

Angélica Tamara Tuono[1], Andressa Mella Pinheiro[1], Nathália Arnosti Vieira[2], Tiago Marques de Rezende[1], Sérgio Henrique Borin[3], Charlini Simoni Hartz[3], Carlos Roberto Padovani[4], João Paulo Borin[1]

1. Faculdade de Educação Física - Universidade Estadual de Campinas (UNICAMP), Campinas, SP, Brazil
2. Red Bull Bragantino, Bragança Paulista, SP, Brazil
3. Universidade Metodista de Piracicaba (UNIMEP), Piracicaba, SP, Brazil
4. Universidade Estadual Paulista (UNESP), São Paulo, SP, Brazil

ABSTRACT

Introduction: Infrared Thermography has contributed to detect physiological changes caused by sports with the use of skin temperature. **Objective:** To verify the lower limb temperature after a *sprint duathlon* competition. **Methods:** Seven duathletes (37 ± 8 years, 72.3 ± 6 kg, 15.7 ± 3% and 171 ± 7 cm) participated. A FLIR® E8 thermal imager (sensitivity ≤ 0.06 ° C) was used to collect images of regions of interest (ROI): quadriceps, tibialis, hamstrings, and calves before (M0), immediately after (M1) and 10 minutes after competition (M2). **Results:** The measures indicate a decrease ($p > 0.05$) in the temperature of the quadriceps, tibialis, and hamstrings in M1 compared to M0. In M2, a higher temperature is observed than in M0 in the calves, and in M1 in the quadriceps and tibial muscles. Compared to the beginning, competition resulted in a decrease in temperature immediately after in all regions, except calves, followed by an increase in the skin temperature of the analyzed ROI and did not cause asymmetries between dominant and non-dominant members. **Conclusion:** Thermography can be used in the analysis of duathletes and asymmetry between limbs and can help in the planning and organization of training in this modality.

Keywords: thermography; running; cycling; competition.

RESUMO

Introdução: A termografia contribui para detectar alterações fisiológicas causadas pelo esporte com o uso da temperatura da pele. **Objetivo:** Verificar diferenças na temperatura dos membros inferiores após uma competição de *duathlon sprint*. **Métodos:** Participaram sete duatletas (37 ± 8 anos, 72,3 ± 6 kg, 15,7 ± 3% e 171 ± 7 cm). Um termovisor FLIR® E8 (sensibilidade ≤ 0,06 °C) foi usado para coletar imagens das regiões de interesse: quadríceps, tibiais, isquiotibiais e panturrilhas antes (M0), imediatamente após (M1) e 10 minutos após a competição (M2). **Resultados:** Os resultados indicam sensível diminuição da temperatura de quadríceps, tibiais e isquiotibiais em M1 comparado a M0. Em M2, é observada uma temperatura maior que em M0 nas panturrilhas, e que em M1 em quadríceps e tibiais. A competição resultou em uma sensível diminuição, seguida de um aumento da temperatura em todas as regiões, exceto nas panturrilhas, e não causou assimetrias entre membros dominantes e não dominantes. **Conclusão:** A termografia pode ser utilizada na análise de duatletas e assimetria entre membros, podendo auxiliar no planejamento e organização do treinamento dessa modalidade.

Palavras-chave: termografia; corrida; ciclismo; competição.

Received: May 2, 2020; Accepted: July 9, 2021.

Correspondence: Angélica Tamara Tuono, Rua Olavo Bilac, 286 São Benedito 13520-000 São Pedro SP. angelicatuono91@hotmail.com

Introduction

Duathlon is a high-intensity cyclic modality composed of running-cycling--running. One of the official distances in competitions is sprint, which consists of 5 km of running, followed by 20 km of cycling and another 2.5 km of running [1,2], which depends mostly on the manifestation of skills such as anaerobic endurance, strength, speed, and coordination [3]. This modality is practiced by athletes of various levels around the world [4], which increases the need for an understanding of the organic responses, especially during competition.

Under this perspective, infrared thermography (IT) has contributed with important information for detecting physiological changes caused by sports practice according to skin temperature [5-9]. Radiation emitted by the body is interpreted as real-time images that identify thermal patterns and can provide parameters for various physiological processes, as these are almost always accompanied by an increase in local or systemic temperature. The thermal sensitivity of the camera is extremely high, often making it difficult to see a large difference in temperature when viewing images, and for this reason, careful and cautious singular analysis is required [10,11].

In fact, by using IT, some studies point toward the understanding of indicators related to injuries [9], to acute responses of muscles after simulated effort [12,13], to exercise intensity [14,15], the analysis of possible asymmetries between limbs, and the difference between muscle groups [7-9,13,16]. However, there is a lack of information related to the analysis of athletes in competition, which, in the context of training theory and methodology, brings science closer to practice, and can help to understand the sport and, consequently, the organization and planning of training.

There is a lack of information concerning the duathlon, particularly in the case of sprint distance, with regard to the impact that such a competition has on participants in relation to changes in skin temperature. Thus, the aim of this study was to verify the lower limb temperature after a sprint duathlon competition.

Methods

Sample

Seven Brazilian trained male duathletes (37 ± 8 years, 72.3 ± 6 kg, 15.7 ± 3% and 171 ± 7 cm) participated in this study during an official stage of duathlon sprint. The weekly training frequency of six days and an average of seven sessions divided between running (38 ± 5 km), cycling (110 ± 25 km) and gym weight training with a predominance of strength and power development (92 ± 13 minutes long; eight exercises per training session with four sets of five to eight repetitions with 75–85% of the maximum). Inclusion criteria were: practicing the modality for at least two years, not having any osteomioarticular lesion established within 30 days prior to collection, not to be a smoker and not to ingest any substance that changes the metabolism.

Rev Bras Fisiol Exerc 2021;20(4):443-450

This study was approved by the Research Ethics Committee under the protocol CAEE: 00348818.1.0000.5404.

Data collection procedure

The athletes were subjected to the thermographic evaluation protocol before the competition (M0), immediately after (M1) and 10 minutes after (M2).

Infrared images were obtained with a FLIR® thermal imager, model E8, integrated resolution of 320 × 240 pixels, which allows to measure temperatures between -20°C and 250°C, with thermal sensitivity of ≤ 0.06°C, accuracy of ± 2°C or ± 2% of reading and thermal sensitivity/NETD <30 mK at 30°C.

The athletes were instructed not to consume caffeine or alcohol, not to use any type of skin product, not to use any medication and not to exercise in the last 24 hours before collection. This care had a verbal confirmation immediately before the beginning of the evaluations. They were also instructed not to press, rub or scratch the skin at any time until the entire data collection process was completed [17]. All measurements were performed in the morning.

The thermographic camera was positioned in the assessment room and turned on 20 minutes before the start of data collection for stabilization. After that, the athletes stayed for 20 minutes in this room (temperature 21 ± 0.3 ° C and humidity 75 ± 4.9%) for the thermal balance to occur [12]. All participants remained in anatomical position before the evaluator on a carpet and at a distance of two meters from the camera which was maintained perpendicular to the regions of interest (ROI). Two images were captured, one anterior and one posterior, and were considered as ROI: quadriceps (A), tibialis (B), hamstrings (C) and calves (D), as shown in Figure 1. All images were processed using an emissivity factor of 0.98 to obtain human skin temperatures. The Rainbow pallet was used with scale fix to 21°C-34°C. The thermogram processing software FlirTools® was used for image storage, processing and analysis. All images were analyzed by an experienced and qualified professional.

Statistical analysis

After data collection, information was initially processed with mean and standard deviation values, and normality was verified with the Shapiro-Wilk test. Pearson Correlation was then used for analysis between muscle groups and ANOVA One-Way repeated measures for comparison of variables according to assessment moments. A value of $p < 0.05$ was adopted as level of significance.

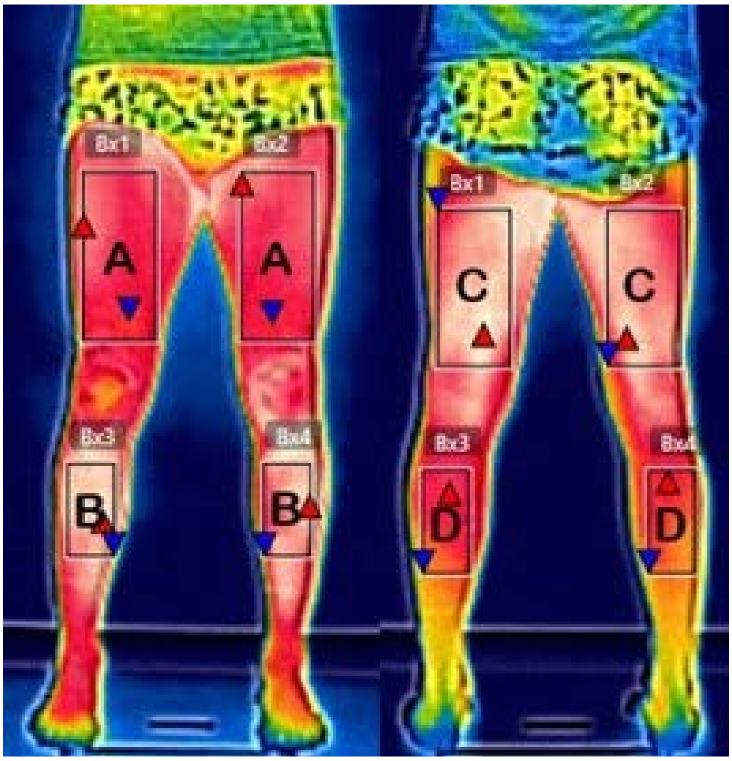

Figure 1 - Regions of Interest (ROI) considered for analysis: A = Quadriceps; B = Tibialis; C = Hamstrings; D = Calves

Results

The results are presented in two moments. In the first moment (Table I), the average temperature of the ROI and the difference between the three assessment moments, and next (Table II), the relation between temperature and the dominance of limbs during the three assessment moments.

Table I shows the mean and standard deviation of ROI temperature in Celsius and the respective difference between the three assessment moments. There was a sensitive decrease in temperature for M1 compared to M0 in all regions except calves. In M2, a higher temperature is observed than in M0 in the calves, and in M1 in the quadriceps and tibial muscles ($p < 0.05$).

Table I - Mean and standard deviation of ROI temperature according to each assessment moment and difference between moments

ROI	Moment			Difference between moments			
	M0	M1	M2	Δ (°C) M0-M1	Δ% M0-M1	Δ (°C) M0-M2	Δ% M0-M2
Quadriceps	31.4 ± 0.4	31.1 ± 1.2	31.8 ± 1.0*	0.3	0.9	0.4	1.2
Tibialis	31.6 ± 0.4	31.5 ± 1.1	31.7 ± 0.9*	0.1	0.3	0.1	0.3
Hamstrings	32.0 ± 0.4	31.8 ± 0.7	31.9 ± 1.1	0.2	0.6	0.1	0.3
Calves	32.1 ± 0.4	32.5 ± 0.8	32.5 ± 0.8*	0.4	1.2	0.4	1.2

*$p < 0.05$

Table II presents mean and standard deviation values of temperature (°C) and the differences between dominant and non-dominant limbs for each assessment moment. There is a thermal equilibrium in all ROI and moments, except for the tibialis musculature in M0, where there is a higher temperature in the dominant limb.

Table II - Mean and standard deviation of temperature in ROI and difference in °C between dominant and non-dominant limbs according to the moments

ROI	Dominância	Assessed moments		
		M0	M1	M2
Quadriceps	Dominant	31.3 ± 0.4	31.1 ± 1.3	31.7 ± 1.2
	Non-dominant	31.4 ± 0.4	31.2 ± 1.1	31.9 ± 0.9
Tibialis	Dominant	31.8 ± 0.4*	31.6 ± 1.2	31.7 ± 1.0
	Non-dominant	31.3 ± 0.5	31.5 ± 1.1	31.6 ± 1.0
Hamstrings	Dominant	32.1 ± 0.2	31.8 ± 0.8	32.0 ± 1.1
	Non-dominant	32.0 ± 0.4	31.7 ± 0.8	31.9 ± 1.1
Calves	Dominant	32.1 ± 0.4	32.1 ± 0.6	32.4 ± 0.7
	Non-dominant	32.2 ± 0.4	31.8 ± 0.6	32.5 ± 0.9

*$p < 0.05$

Discussion

Based on the proposed objective, which aimed to analyze the effect of an official competition on the skin temperature of the duathletes lower limbs, this discussion points in two directions: 1) the temperature behavior of the skin between the ROI, and 2) the asymmetries between dominant and non-dominant limbs at the moments assessed.

Particularly in the first moment, the percentage variation (Δ%) stands out, with a decrease in temperature in M1 ($p > 0.05$), compared to M0 in the quadriceps, tibial and hamstring muscle groups, and soon afterwards in M2, a sensitive increase ($p > 0.05$) in the temperature of the same muscle groups. This behavior seems to corroborate the detailed review by Marins et al. [18] on the application of thermography in this sport, as well as the findings by Tanda [5], who analyzed middle runners in two types of treadmill competitioning, with gradual and constant loading, and noted that in both situations skin temperature showed a slight decrease during the first minutes of exercise and soon thereafter a significant increase. The conclusion is that the decrease in temperature was related to the effort-induced skin vasoconstriction, and the subsequent increase to vasodilation caused by the thermoregulation process. These results are similar to those found in the present study. Korman et al. [6] analyzed elite sprinters before, during and after a speed endurance training session and also found similar results, noting a decline in lower limb skin temperature in the early moments of the session, followed by stabilization and sensitivity increase in the following minutes.

Another highlight in this context is the temperature of the muscle groups of the resting duathletes. Other findings in the literature [6,18,19] have lower scores compared to the data presented here. According to Marins et al. [20], reference values for active men while resting indicate: 29.7°C for quadriceps, 30.2°C for tibialis, 30.2°C for hamstrings and 29.9°C for calves, which puts the values shown in the present study above the expected in all muscle groups, suggesting that athletes have already started the race with prior physiological alteration. Sillero-Quintana et al. [10], who evaluated more than 200 athletes, show that temperatures equal to or higher than 31.9°C while resting indicate the presence of an inflammatory process and/or possible injury. It should be noted that out of the four ROI analyzed in this sample, three were close to or above this value (tibialis = 31.6°C; hamstrings = 32.0°C; calves = 32.1°C).

A high volume regarding the distance of the competition can be seen when considering the information on the training performed. When it comes to running, Bourdon et al. [21] and Rios et al. [22] state that high training volumes are directly associated with inflammation or injury.

As for the asymmetry between dominant and non-dominant limbs, only one situation - tibialis while resting (M0) - was found in which the dominant limb showed higher temperature (0.5°C), which should lead to a more thorough follow-up as this asymmetry may be an early sign of lesion or overload [18]. Regarding the remaining three ROI, no asymmetry was found at any of the three assessment moments, as it is considered a normal condition according to Marins et al. [18] and Corte et al. [9], who state that asymmetries lower than 0.4°C as not being clinically important. Other studies that analyzed the thermal asymmetry between dominant and non-dominant limbs in modalities such as professional soccer [9,19], sub13 and sub15 soccer [16], women's soccer [23], futsal [7], volleyball [13] and handball [8] also observed asymmetries lower than 0.4°C, which allowed them to consider clinically normal conditions for their respective athletes.

The lack of monitoring of some factors that can influence changes in skin temperature, such as weather conditions and sample number, can be considered as limitations of this study.

Conclusion

The duathlon sprint competition resulted in a decrease in temperature immediately after the competition in all regions except the calves, followed by an increase in the skin temperature of the analyzed ROI, in addition to not causing asymmetries between dominant and non-dominant limbs. Thus, the thermography can be used in the analysis of duathletes, specifically regarding the asymmetry between the dominant and non-dominant limbs, giving clues about information that can help in the planning and organization of the training of athletes in this modality.

Conflict of interest
No conflict of interest with relevant potential

Financing source
This study was financed in part by the Coordenadoria de Esporte e Lazer da Prefeitura Municipal de São Pedro/SP.

Author's contributions
Conception and design of study: Tuono AT, Borin JP; **Acquisition, analysis and/or interpretation of data:** Tuono AT, Pinheiro AM, Padovani CR, Borin, JP; **Drafting the manuscript:** Tuono AT, Pinheiro AM; **Revising the manuscript critically for important intellectual content:** Tuono AT, Pinheiro AM, Vieira NA, Rezende T, Borin SH, Hartz CS, Padovani CR, Borin JP.

Acknowdgements
The authors thank *Espaço da Escrita, Pró-Reitoria de Pesquisa*, UNICAMP for the language services. Thanks to the athletes and the municipal administration of São Pedro, São Paulo, Brazil.

References

1. Ronconi M, Alvero-Cruz JR. Respuesta de la frecuencia cardíaca y consumo de oxígeno de atletas varones em competiciones de duatlón *sprint*. Apunts Med Esport 2011;46(172):183-8. doi: 10.1016/j.apunts.2011.02.008

2. Confederação Brasileira de Triathlon. Site CBTri. [cited 2020 Jan 2]. http://www.cbtri.org.br. Atualizado em 2020

3. Hottenrott K. ed. El entrenamiento del Duatlón. Badalona, Espanha: Paidotribo; 2017.

4. International Triathlon Union. Site ITU. [cited 2020 Jan 2]. https://www.triathlon.org/

5. Tanda G. The use of infrared thermography to detect the skin temperature response to physical activity. J Phys Conf Ser 2015;655(1):1-10. doi: 10.1088/1742-6596/655/1/012062

6. Korman P, Straburzynska-Lupa A, Kusy K, Kantanista A, Zielinski J. Changes in body surface temperature during speed endurance work-out in highly-trained male *sprint*ers. Infrared Phys Tech 2016;78:209-13. doi: 10.1016/j.infrared.2016.08.003

7. Santos RMC, Souza ES, Silva SJ, Arruda JRL, Santa Cruz RAR. Análise termográfica dos esforços no futsal. Coleç Pesqui Educ Fís [Internet]. 2017 [cited 2021 Jun 26];16(1):15-22. Available from: https://www.fontouraeditora.com.br/periodico/upload/artigo/1296_1505737539.pdf

8. Santa Cruz RAR, Araújo VA, Sousa PAC, Arruda JRL. Perfil termográfico de atletas de handebol após um jogo oficial. Rev Movimenta [Internet]. 2018 [cited 2021 Jun 21];11(1):12-9. Available from: https://www.revista.ueg.br/index.php/movimenta/article/view/6429

9. Corte ACR, Pedrinelli A, Marttos A, Souza IFG, Grava J, Hernandez AJ. Infrared thermography study as a complementary method of screening and prevention of muscle injuries: pilot study. BMJ Open 2019;5:1-5. doi: 10.1136/bmjsem-2018-000431

10. Sillero-Quintana M, Fernández-Jaén T, Fernández-Cuevas I, *et al.* Infrared thermography as a support tool for screening and early diagnosis in emergencies. J Med 2015;5(6):1223-8. doi: 10.1166/jmihi.2015.1511

11. Corte ACR, Hernandez AJ. Termografia médica infravermelha aplicada à medicina do esporte. Rev Bras Med Esporte 2016;22(4):315-9. doi: 10.1590/1517-869220162204160783

12. Merla A, Mattei PA, Di Donato L, Romani GL. Thermal imaging of cutaneous temperature modifications in runners during graded exercise. Ann Biomed Eng 2009;38:158-163. doi: 10.1007/s10439-009-9809-8

13. Morais NA, Araújo VA, Carvalho LS, Sousa PAC, Santa Cruz RAR. Respostas termográficas dos esforços em atletas de voleibol. Corpoconsciência [Internet]. 2017 [cited 2021 Jun 20];21(2):8-14. Available from: http://cev.org.br/biblioteca/respostas-termograficas-dos-esforcos-em-atletas-de-voleibol/

14. Balci GA, Basaran T, Colakoglu M. Analysing visual pattern of skin temperature during submaximal and maximal exercises. Infrared Phys Tech 2016;74:57-62. doi: 10.1016/j.infrared.2015.12.002

15. Silva AG, Albuquerque MR, Brito CJ, Oliveira SAF, Stroppa GM, Sillero-Quintana M, Marins JCB. Resposta térmica da pele ao exercício em remoergômetro de alta versus moderada intensidade em homens

fisicamente ativos. Rev Port Ciênc Desporto 2017;17:125-37. doi: 10.5628/rpcd.17.s4a.125

16. Cogo WT, Nogueira PHR, Silva AG, Marins JCB. Perfil térmico de membros inferiores de jogadores de futebol de categoria de base. Revista Brasileira de Futebol [Internet]. 2017 [cited 2021 Jun 20];10(2):4-24. Available from: http://cev.org.br/biblioteca/perfil-termografico-dos-membros-inferiores-jogadores-futebol/

17. Pinto TWS, Guimarães ASP, Barreto TC, Santa Cruz RAR. Alterações termográficas na musculatura abdominal após exercício estático e dinâmico em jovens ativas. Rev Perspectiva [Internet]. 2018 [cited 2021 Jun 20];3(1):11-19. Available from: http://sys.facos.edu.br/ojs/index.php/perspectiva/article/viewFile/189/186

18. Marins JCB, Fernandez-Cuevas I, Arnaiz-Lastras J, Fernandes AA, Sillero-Quintana M. Applications of infrared thermography in sports: a review. Rev Int Med Cienc Act Fís [Internet]. 2015 [cited 2021 Jun 21];15(60):805-24. Available from: http://www.termografia.ufv.br/wp-content/uploads/Marins--2015-Applications-of-Infrared-Thermography-in-Sports.-A-Review.pdf

19. Marins JCB, Fernandes AA, Moreira DG, Silva FS, Costa CMA, Pimenta E. Thermographic profile of soccer players' lower limb. Rev Andal Med Deport 2014;7(1):1-6. doi: 10.1016/S1888-7546(14)70053-X. (b)

20. Marins JCB, Moreira DG, Cano SP, Quintana MS, Soares DD, Fernandes AA, *et al*. Time required to stabilize thermographic images at rest. Infrared Phys Tech 2014;65:30-5. doi: 10.1016/j.infrared.2014.02.008. (a)

21. Bourdon PC, Cardinal M, Murray A, Gastin P, Kellman M, Varley MC, *et al*. Monitoring athlete training loads: consensus statement. Int J Sport Physiol 2017;12(2):161-70. doi: 10.1123/IJSPP.2017-0208

22. Rios ET, Rodrigues FC, Rocha LF, Salemi VMC, Miranda DP. Influência do volume semanal e do treinamento resistido sobre a incidência de lesão em corredores de rua. Revista Brasileira de Prescrição e Fisiologia do Exercício [Internet] 2017 [cited 2021 Jun 21];11(64):104-9. Available from: http://www.rbpfex.com.br/index.php/rbpfex/article/view/1086/889

23. Stroppa GM, Silva AG, Moreira DG, Cerqueira MS, Fernandes AA, Bouzas JCM. Análise da temperatura da pele em joelhos de jogadoras de futebol profissional. Revista Brasileira de Futebol [Internet] 2017[cited 2021 Jun 21];8(2):36-42. Available from: https://rbf.ufv.br/index.php/RBFutebol/article/view/225