BODY FAT PERCENTAGE AND LOWER LIMBS TEMPERATURE IN RECREATIONAL CYCLISTS DURING AN INCREMENTAL TEST

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Artigo Original

Body fat percentage and lower limbs temperature in recreational cyclists during an incremental test

Porcentagem de gordura e temperatura dos membros inferiores

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ABSTRACT: This study aimed to evaluate temperature variations on the thighs in an incremental cycling test in healthy recreational cyclists with two different fat percentages. Thirty-two male recreational cyclists were measured in height, body mass, thigh skinfold and body fat percentage, and from the body fat percentage were divided into two groups, Group 1: 16 cyclists who presented body fat percentage < 24% and Group 2: 16 cyclists who presented body fat percentage > 24%. Three thermographic photos were taken, before (Pre), just after (Post) and after 10 min (Post10) of the incremental cycling test to determine mean temperature of right and left *Vastus Lateralis, Rectus Femoris and Biceps Femoris*. Temperature variations were defined as the difference among the three moments: (i) var1 = Post-Pre, (ii) var2 = Post10-Pre and (iii) var3 = Post10-Post. Differences between groups and moments were calculated using magnitude-based inferences. Group 1 evidenced a very likely large increase in the cycling peak power output. Group 2 showed a likely and most likely moderate, large and very large increase in age, body mass and fat. Group 1 depicted a very likely to likely moderate temperature increase in the right and left *Vastus Lateralis*, *Rectus Femoris* and *Biceps Femoris* on Post10 compared to Post effort moment. Both groups depicted a very likely and most likely moderate and large temperature decrease of right and left *Biceps Femoris* on Pre compared to Post effort. Percentage of fat seems to discreetly influence skin temperature response, finding that might not be observed when we evaluate trained cyclists exhibiting different percentages of fat.

Key Words: Infrared thermography; Fat percentage; Incremental cycling test.

RESUMO: Este estudo objetivou a avaliar as variações de temperatura das coxas em um teste incremental de ciclismo em ciclistas recreacionais saudáveis com dois diferentes percentuais de gordura. Trinta e dois ciclistas recreacionais do sexo masculino foram avaliados em estatura, massa corporal, dobras cutâneas da coxa e percentual de gordura corporal, e, a partir do percentual de gordura corporal, foram divididos em dois grupos, Grupo 1: 16 ciclistas que apresentaram percentual de gordura corporal < 24% e Grupo 2: 16 ciclistas que apresentaram percentual de gordura corporal > 24%. Foram tiradas três fotos termográficas, antes (Pré), logo após (Pós) e após 10 min (Pós10) do teste de ciclismo para determinar a temperatura média do Vasto Lateral, Reto Femoral e Bíceps Femoral direito e esquerdo. As variações de temperatura foram definidas como a diferença entre os três momentos: (i) var1 = Pós-Pré, (ii) var2= Pós10-Pré e (iii) var3= Pós10-Pós. Diferenças entre grupos e momentos foram calculadas usando inferências baseadas em magnitude. Grupo 1 apresentou um provável a muito provável aumento moderado da temperatura para os Vastos Laterais direito e esquerdo, o Reto Femoral e o Bíceps Femoral no Pós10 em comparação com o momento pós-esforço. Grupo 2 mostrou aumentos provável e muito provável moderado, grande e muito grande na idade, massa corporal e gordura. Ambos os grupos descreveram uma muito provável e mais provável moderada e grande queda de temperatura do Bíceps Femoral direito e esquerdo no Pré comparado ao Pós-esforço. Percentagem de gordura parece influenciar discretamente a resposta da temperatura da pele, resultado que poderá não ser observado quando avaliados ciclistas treinados que apresentam diferentes percentagens de gordura.

Palavras-chave: Termografia infravermelha; Percentual de gordura; Teste incremental de ciclismo.

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Introduction

Increases in the metabolic rate of human beings occur with physical exercise, which, consequently, raises internal body heat[1]. Internal temperature rising is generated by metabolic energy convection into mechanical and thermal components, mainly due to the active muscle action[2], causing blood transport increasing in the skin surface[3]. This transport causes the loss of heat to the environment by thermoregulatory processes such as conduction, convection, radiation and evaporation, being changes observed on the skin surface in various activities and sport disciplines[4–6].

Skin temperature response depends on the physical activity type[7,8]. In cyclic exercises, like running or cycling, skin temperature decreases in the initial effort instants due to the deviation of blood to the active muscles. However, on rest period skin temperature deviates from muscles to the skin, thus being lost to the environment[7,9]. Contrarily, it has been noticed that skin temperature rises at the beginning of the exercise, which is followed by a decrease during the activity and an increase after the end of the exercise[9]. This seems to occur due to athlete's training level, which has already been pointed out as a skin temperature response influencing factor[9,10], as both alterations occur mainly on the regions where muscles have been elicited[11,12].

Physiological and biomechanical profile that change with the athlete's conditioning level in cyclic sports might affect skin temperature responses[11,13]. However, the percentage of body fat has also been mentioned as a skin temperature influencing factor in both during the rest and physical activity period[14,15]. It might be explained by the percentage of body fat acting as thermal insulation and reducing skin temperature[16], implying that athletes with lower percentage of body fat achieve greater decreases in it[9,10]. In fact, it has been thoroughly explained and accepted that fat percentage causes skin temperature changes, but, how it impacts on different cyclists' percentage of body fat (fat percentage < and > than 24%) with similar cycling conditioning level at a specific temperature during a cycling test has been little explored. The evaluation of temperature variation in cycling is necessary since hyperthermia is normally observed in long competitions and may affect health and performance. Thus, it is paramount to fully understand the behavior of skin temperature during cycling. This study aimed to evaluate temperature variations on an incremental cycling test in healthy recreational cyclists with two different fat percentages.

Materials and methods

Participants

Thirty-two healthy recreational[17] male cyclists volunteered to participate and were divided into two groups of 16 cyclists each: body fat percentage < and > 24% (Group 1, and Group 2, respectively) as shown in Table 1. These body fat percentages were established according to the health risk classification proposed by the American College of

Sports Medicine[18]. Based on this classification, body fat percentage < 24 was considered healthy and > 24 meant a high risk of fat percentage. Data collection was approved according to the Ethics and Research Committee of the Federal University of Amazonas (CAAE / CEP / UFAM 66458217.7.0000.5020), and all experimental procedures were conducted by the Code of Ethics of the World Medical Association (Declaration of Helsinki) for experiments involving humans. Participants provided written informed consent before data collection.

Body composition

Body mass and density have been estimated by air displacement plethysmography (BOD POD; Body Composition System, Cosmed, Rome, Italy) following the equipment-standardized technique. The percentage of body fat was determined using the Siri's equation (%G = [(4.95/D)-4.50] x 100; SIRI[19]), where "D" is the body density (D=mass/volume). Participants wore minimal fitting clothing, spandex shorts and a swim cap. To ensure quality control the equipment was calibrated on a daily basis according to supplier recommendations[20].

Cycling incremental test

Participants' body posture on the stationary ergometric bicycle (CG4 Imbrasport, Co., Porto Alegre Brazil) was adjusted, being defined as the maximum extension of the knee during cycling between 25° and 30°[9]. The incremental test started with an initial 105 W workload for 3 min and was followed by 35 W increments every 3 min until exhaustion[21]. Pedaling cadence was maintained at 60 ± 5 revolutions per minute (RPM) by visual feedback of the ergometer bicycle software (Ergo-control, CG4 Imbrasport, Co., Porto Alegre Brazil)[9]. Exhaustion was defined when the participant was no longer able of maintaining a pedaling cadence of 55 RPM[10]. Athletes' peak power output was acquired by the correction of the power output on the last testing stage completed[22].

Skin surface temperature

Each participant was evaluated by the same examiner, went through a 10 min acclimatization in a standing position, wearing swimsuits, in a controlled room with temperature set at 22 ± 3°C and relative humidity of 50 ± 15%[23], without electronic equipment near the thermographic camera and avoiding measurement noise. Participants were instructed to prevent sunbathing or UVA rays on the test day, strenuous exercise in the previous 24 h and to abstain from skin creams, consuming hot or alcoholic beverages in the 12 h prior testing[10,23]. An anti-reflective panel was positioned behind the participant during thermography photos acquisition, which minimized the effect from infrared radiation reflected by the participant on the wall, avoiding solar or electric energy irradiation[23].

Each participant took two thermography photos, one in the anterior and one in the posterior plane through a thermographic camera (FLIR T4xx series, FLIR, Luxemburgstraat, Belgium) with lens positioned parallel to the ground at 1 m away from the participant. Three test moments during the incremental cycling test were selected for thermal images analysis: (i) before the exercise, after 10 min of acclimatization in laboratory environment (Pre); (ii) just after the end of the incremental protocol after sweat removal (Post) and (iii) after 10 min rest (Post10)[9]. According to previous studies, high skin temperature alterations have been observed in these moments, denoting human body most substantial thermoregulation process changes[7,9,10].

ThermCAM Researcher Pro 2.0 software (FLIR, Luxemburgstraat, Belgium) was used to acquire average temperatures for each region of interest (*Vastus Lateralis*, *Rectus Femoris* and *Biceps Femoris*) on both, right and left sides of the body[10]. Differences between the mean temperatures of each region of interest at different moments were sides of the body. Differences between the mean temperatures of each region of interest at different moments were calculated as following: (i) var1: Post vs. Pre; (ii) var2: Post10 vs. Pre; (iii) var3: Post10 vs. Post.

Statistical analysis

All data presented normality evaluated by the Shapiro–Wilk's test, and homogeneity of the variances evaluated by the Levene's tests. Descriptive statistics was used in data analysis, means and standard deviation. Changes in age, height, body mass, body fat, thigh skinfold, peak power output between groups and the differences between moments in each group and muscle were analyzed using Standardized Mean Difference (SMD) and Effect Size (ES).

The Hopkins scale (www.sportsci.org/resource/stats) was used for their interpretation: 0-0.2 trivial, > 0.2-0.6 small, > 0.6-1.2 moderate, > 1.2-2.0 large, and > 2.0 very large[24]. Effects with 90% Confidence Interval (CI) overlapping zero and/or the smallest worthwhile change (i.e., 0.2 standardized units) were unclear. Inference and precision based on magnitude were performed to analyze the odds of true modifications being clear or trivial. The probability of finding differences between variables was solved by assessing them qualitatively through the scale: < 1%, almost certainly not; 1-5%, very unlikely; 5-25%, unlikely; 25-75%, possible; 75-95%, likely; 95-99%, very likely; > 99%, most likely. Probabilities were also calculated to identify whether the true differences were lower, similar or greater than the smallest difference or change, 0.2 x standard deviation between subjects[24]. If the chance of having higher and lower differences were both > 5%, the true difference was determined to be unclear.

Results

Table 1 depicts mean and standard deviation of age, height, body mass, body fat, thigh skinfold, peak power output and SMD, 90% CI and probabilities of comparison between groups. Group1 has evidenced a very likely large increase in the peak power output. Group2 has shown a likely and most likely moderate, large and very large increase in age, body mass and body fat.

Table 1. Mean and standard deviation of age (AGE), height (Hgt), body mass (BM), body fat (BFT), thigh skinfold (TSF), peak power output (PPO) and Standardized Mean Difference (SMD), 90% Confidence Interval (CI), Effect Size (ES) and Probabilities of comparison (PC) between Groups 1 and 2.

Variables	**Group1**	**Group2**	**Group 1 vs. Group 2**		
			SMD (90% CI)	**ES**	**% greater/similar/lower values (PC)**
AGE	28.56 ± 5.50	32.50 ± 8.45	0.73 (0.16; 1.37)	Moderate	93/6/1 (Likely)
Hgt (cm)	172.91 ± 7.28	174.58 ± 8.01	0.22 (-0.38; 0.81)	Small	64/27/9 (Unclear)
BM (kg)	72.85 ± 9.56	88.37 ± 13.86	1.23 (0.63; 1.83)	Large	100/0/0 (Most likely)
BFT (%)	16.07 ± 5.50	29.83 ± 4.13	1.68 (1.19; 2.16)	Very large	100/0/0 (Most likely)
TSF (cm)	17.63 ± 4.24	20.81 ± 5.82	0.62 (-0.04; 1.27)	Moderate	86/12/2 (Likely)
PPO ($W.Kg^{-1}$)	3.91 ± 1.04	2.92 ± 0.85	-1.09 (-1.68; 0.51)	Large	0/1/99 (Very likely)

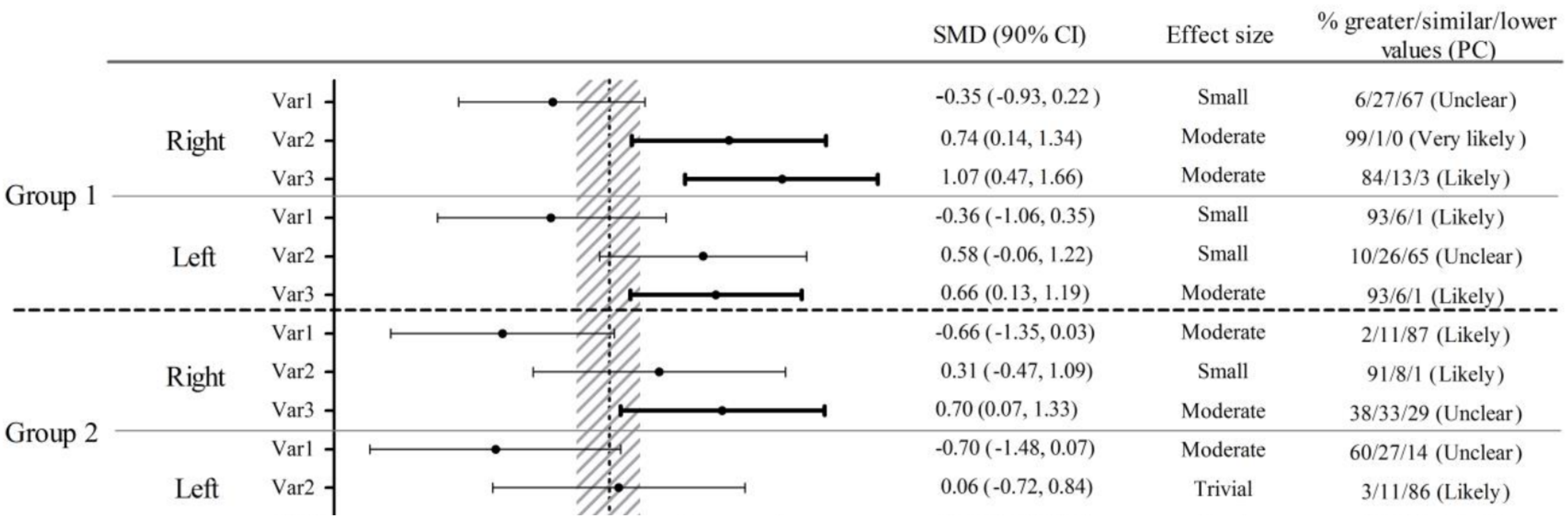
Table 2 presents mean and standard deviation of *Vastus Lateralis*, *Rectus Femoris, and Biceps Femoris* temperature of lower limbs on Pre, Post, Post10, Group 1 and 2.

Table 2. Mean and standard deviation of skin temperature of *Vastus Lateralis* (*VL*), *Rectus Femoris* (*RF*) *and Biceps Femoris* (*BF*) on both, right and left lower limbs, Group 1 and 2 on Pre, Post, Post10.

Variables	Right (R)			Left (L)		
	Pre (ºC)	Post (ºC)	Post10 (ºC)	Pre (ºC)	Post (ºC)	Post10 (ºC)
Group 1 VL	31.70 ± 1.09	31.01 ± 0.96	32.13 ± 1.13	31.21 ± 0.91	31.06 ± 0.91	32.10 ±1.14
Group 2 VL	29.94 ± 1.21	29.01 ± 1.30	30.48 ± 1.75	29.88 ± 1.07	28.77 ± 1.22	30.34 ± 1.77
Group 1 RF	31.31 ± 0.37	31.05 ± 0.97	32.23 ± 0.96	31.26 ± 0.97	31.14 ± 0.87	32.13 ± 1.08
Group 2 RF	29.96 ± 1.24	29.07 ± 1.30	30.50 ± 1.74	29.98 ± 1.18	28.91 ± 1.20	30.48 ± 1.69
Group 1 BF	31.21± 0.98	30.20 ± 1.51	31.20 ± 1.07	31.20± 0.87	30.14± 1.59	31.12 ± 1.13
Group 2 BF	30.38± 1.21	28.33 ± 1.18	29.72 ± 1.40	30.40± 1.34	28.40± 1.23	29.56 ± 1.35

Figures 1, 2 and 3 have shown SMD, 90% CI, ES and probabilities of the comparison of temperature among Post vs. Pre (var1); Post10 vs. Pre (var2); Post10 vs. Post (var3) for both groups and sides of the body on *Vastus*

Lateralis, *Rectus Femoris* and *Biceps Femoris*, respectively. Considering right *Vastus Lateralis*, Group 1 has evidenced a very likely and likely moderate temperature increase at Post10 compared to Pre and Post moments. Group 2 has shown an unclear moderate increase at Post10 compared to Post moment. Group 1 has displayed on left *Vastus Lateralis* a likely moderate temperature increase at Post10 compared to Post. Considering right and left *Rectus Femoris*, Group 1 has depicted a likely moderate temperature increase at Post10 compared to Post effort. Group 2 has shown an unclear and moderate temperature increase in the right *Rectus Femoris*. Right and left *Biceps Femoris* have shown a very likely and most likely moderate and large temperature decrease in both groups at Pre compared to Post effort. Moreover, a likely moderate increase in Group 1 has been noticed at right and left *Biceps Femoris* and Group 2 right *Biceps Femoris* at Post10 compared to Post test.



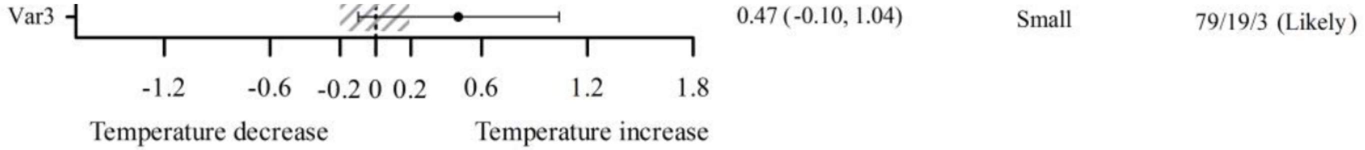


Figure 1. Temperature differences among Post vs. Pre (var1), Post10 vs. Pre (var2) and Post10 vs. Post (var3) in Groups 1 and 2 on right and left *Vastus Lateralis*. Error bars indicate 90% Confidence Interval (CI) of Standardized Mean Difference (SMD) between time points. The probabilities of the differences between the moments being greater, similar or lower are presented in percentages and classified according to these percentages (PC).

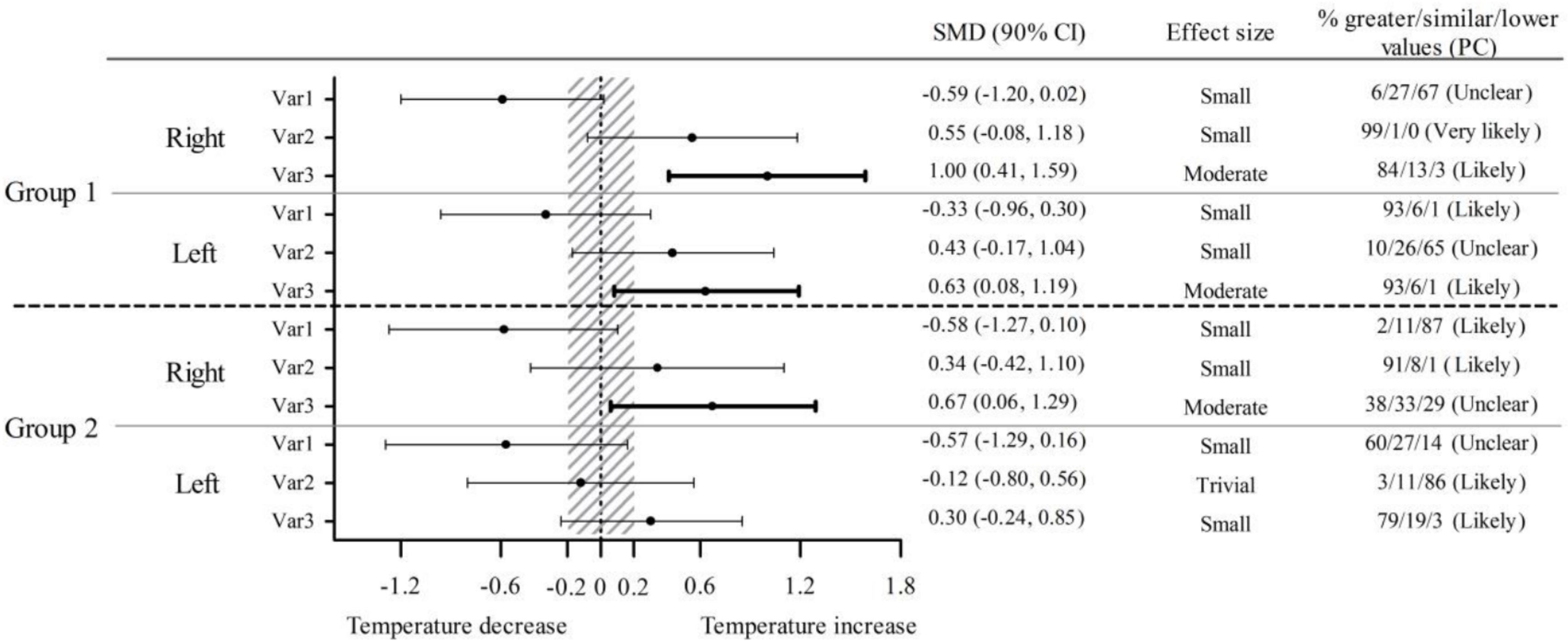


Figure 2. Temperature differences among Post vs. Pre (var1), Post10 vs. Pre (var2), Post10 vs. Post (var3) in Groups 1 and 2 on right and left *Rectus Femoris*. Error bars indicate 90% Confidence Interval (CI) of Standardized Mean Difference (SMD) between time points. The probabilities of the differences between the moments being greater, similar or lower are presented in percentages and classified according to these percentages (PC).