



# Daily rhythm of skin temperature of women evaluated by infrared thermal imaging

Carlos Magno Amaral Costa<sup>a,f,\*</sup>, Danilo Gomes Moreira<sup>b,c</sup>, Manuel Sillero-Quintana<sup>c</sup>,  
Ciro José Brito<sup>d</sup>, Guilherme de Azambuja Pussieldi<sup>e</sup>, Alex de Andrade Fernandes<sup>b</sup>,  
Sergio Piñonosa Cano<sup>c</sup>, João Carlos Bouzas Marins<sup>f</sup>

<sup>a</sup> Força Aérea Brasileira (FAB), Centro de Instrução e Adaptação da Aeronáutica, Belo Horizonte, Brazil

<sup>b</sup> Instituto Federal de Educação, Ciência e Tecnologia de Minas Gerais (IFMG), Minas Gerais, Brazil

<sup>c</sup> Universidad Politécnica de Madrid, Facultad de Ciencias de la Actividad Física y del Deporte INEF, Departamento de Deportes, Madrid, Spain

<sup>d</sup> Universidade Federal de Juiz de Fora (UFJF), Departamento de Educação Física, Juiz de Fora, Brazil

<sup>e</sup> Universidade Federal de Viçosa, Campus Florestal, Minas Gerais, Brazil

<sup>f</sup> Universidade Federal de Viçosa (UFV), Departamento de Educação Física, Laboratório de Performance Humana, Viçosa, Brazil

## ARTICLE INFO

### Keywords:

Skin temperature  
Circadian rhythm  
Infrared thermography  
Cosinor analysis

## ABSTRACT

It is well known that skin temperature varies due to circadian rhythm. Although there is information available for men, little is known about women's circadian rhythm in the analysis of skin temperature (Tsk) using infrared thermography. The objective of this study is to identify Tsk variations on different body regions in women through infrared thermography during the day. The sample consisted of 20 female (mean age of  $20.5 \pm 1.3$  years, body weight of  $62.2 \pm 9.2$  kg and height of  $165.0 \pm 4.7$  cm). Oneway ANOVA for repeated measures, and Cosinor analysis was used to determine the MESOR, amplitude and acrophase of Tsk. The regions of the forearm, upper arm and anterior and posterior legs in the lower limbs, as well as the chest and scapulae in the upper limbs showed higher variability throughout the day. In general, distal regions had lower values compared with the central regions, and the pectoral region had the lowest standard deviation values. Tsk of the analyzed regions at different times show significant differences between periods of the day in young active women, showing the minimum absolute values for both Tsk in the early morning. These results highlight the need to consider the time of day when analyzing women's skin temperature. Future studies should report the time of day when the images were collected, as well as consider the circadian rhythm when making comparisons.

## 1. Introduction

Daily circadian rhythms are not only associated with a response to changes in the physical environment during 24-h, they are generated by an internal system and allow for anticipation and preparation for changes related to night-time and daytime periods (Vitaterna et al., 2001). The suprachiasmatic nucleus (SCN) located in the anterior hypothalamus is responsible for this internal circadian rhythm that comes through the transcription-translation feedback of genes that act in the nucleus neurons (Siepkka et al., 2007), resulting in circadian oscillations observed in organs and tissues such as the heart, lungs, liver, intestines, adrenal gland and adipose tissue (Garaulet and Madrid, 2009).

In order to study the physiological circadian oscillations of human body, the MESOR (Midline Estimating Statistic of Rhythm), acrophase and circadian rhythm amplitude are generally used (Refinetti et al., 2007). These indicators have been applied to identify changes driven

by the biological rhythm in measures such as the rest-activity cycle (Carvalho Bos et al., 2003), melatonin level, cortisol production and core body temperature (Tc) (Hofstra and de Weerd, 2008).

The study of Tc has important implications for determining changes in circadian rhythm due mainly to its representative capacity of biological rhythms in general (Waterhouse, Fukuda et al., 2012). The influence of circadian rhythms on Tc fluctuations are probably related to the action of the Central Nervous System (CNS) on the hypothalamic thermoregulatory centers, changing the thresholds for cutaneous vasodilation and sweating (Weinert and Waterhouse, 2007).

In participants with a normal lifestyle, the Tc has higher values between 14 h and 20 h, the acrophase around 17 h, and the bathyphase at 5 h (Krauchi and Wirz-Justice, 1994). Rectal temperature ( $T_{\text{rectal}}$ ) (Dijk et al., 2012; Monk et al., 1995; Thomas et al., 2004), axillary temperature ( $T_{\text{axillar}}$ ) (Edwards et al., 2002; Thomas et al., 2004), gastrointestinal temperature ( $T_{\text{gastrointestinal}}$ ) (Edwards et al., 2002), oral

\* Correspondence to: Carlos Magno Amaral Costa, Rua Alcobaca, 1500, Bloco 5, 504, CEP: 31255-210, Belo Horizonte, MG, Brazil.

E-mail address: [amaral.adjunto@gmail.com](mailto:amaral.adjunto@gmail.com) (C.M.A. Costa).