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Different physiological responses but similar thermal perceptions for males with various body fatness during cold air exposure

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Introduction

There is no consensus regarding the potential effect of body fatness on subjective responses to cold at rest [1,2]. Most studies have examined overall sensation and comfort with no attention to regional values or the influence of exercise on thermal perception. The present study aimed at exploring overall and regional perceptual responses of males, varying in body fat content (%BF) in association with their physiological responses, specifically regional skin temperatures (T_{sk}).

Methods

Twenty healthy and semi-nude males sat for 60 minutes on a stool with limited motion. The resting phase was followed by a 30-min exercising phase at 100W on a cycle ergometer. Both phases were performed in a 10°C, 50% RH climatic chamber. Three distinct categories of body fat percentage (%BF), but similar fitness level, were arbitrarily created (Low Fat (**LF**): 5-10%, Medium Fat (**MF**): 10-15% and High Fat (**HF**): 15+) with a total range varying from 7 to 40 %BF. Skinfold thickness was assessed at 24 locations. Regional T_{sk} and mean T_{sk} were measured by infrared thermography at different stages of the protocol [3] together with oxygen uptake ($\dot{V}O_2$) by the Douglas bag method. Rectal temperature (T_{re}), finger tip blood flow (Laser Doppler flowmetry) and heart rate were monitored throughout the whole protocol. Thermal sensation (TS) and comfort (TC) were evaluated for the whole-body (overall) and 11 different body regions (local).

Results and Discussion

Physiological responses differed between the three body fat groups. Mean T_{sk} was significantly colder for **HF** compared to **MF**, and in turn **LF** (Figure 1). Dynamics of T_{re} were different between the groups ($p < 0.05$), especially with a drop of 0.4°C at rest for **LF** on one hand and the larger rise of T_{re} during exercise for **HF** on the other (Figure 1). Heat dissipation was favoured for **LF** with a higher risk of hypothermia in the case of prolonged exposure at rest and it was specifically more impeded for **HF** whilst metabolic heat production was increased. $\dot{V}O_2$ did not differ between groups at all stages ($p = 0.55$).

Regional T_{sk} was significantly different between the groups as observed by population-averaged body maps of absolute T_{sk} . However, normalised maps revealed consistent patterns in the T_{sk} distribution. Between subjects, %BF and local skinfold thickness were negatively correlated with mean T_{sk} and regional T_{sk} (from $r = -0.50$ to $r = -0.93$, $p < 0.05$) in line with LeBlanc [4]. Within subjects, local skinfold thickness did not however explain the variability of regional T_{sk} over the body.

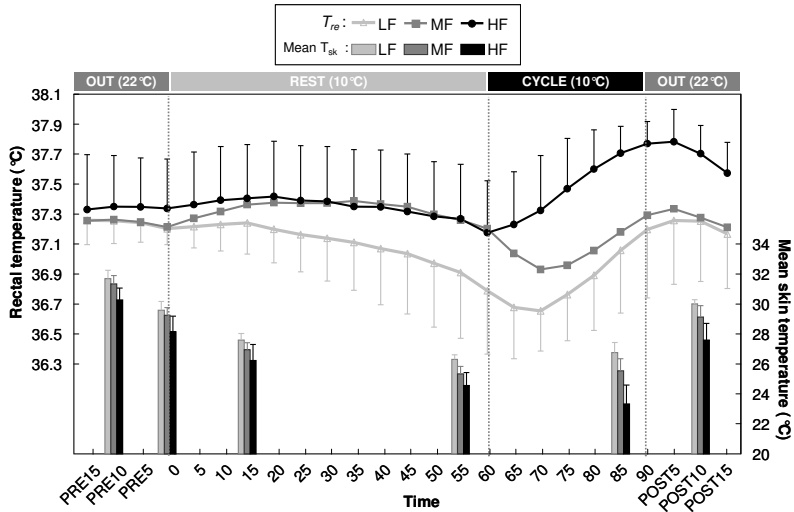


Figure 1. Evolution of rectal temperature (T_{re}) and mean skin temperature (mean T_{sk}) at the different stages of the inactive (seated) and active (100W cycling) exposure in a 10°C environment for three groups of males with varying body fat percentage (LF: 5-10% MF: 10-15% HF: 15+). Overall body fat effect on mean T_{sk} and interaction effect (time*body fat) on mean T_{sk} and T_{re} ($p<0.05$)

Overall perceptual responses were similar between body fat groups. There was no relationship between overall TS, TC and %BF. Dynamics of overall TS and TC tracked dynamics of mean T_{sk} at rest but not during exercise. Overall perceptual votes always followed the worst local thermal votes during passive cooling, in agreement with others [5]. This was however not true at the end of exercise.

Local thermal votes (TS and TC) were similar between groups and there was also no correlation with local T_{sk} between subjects. The only exception was found for the hand TS, perceived significantly warmer for HF compared to MF and LF ($p<0.05$) but only at the end of exercise. This could be associated with the early rise observed in cutaneous blood flow for HF followed by a rise in hand T_{sk} , significantly larger and sooner for HF during exercise. Extremities have been shown to be a specific region for heat loss in overweight individuals [6].

Conclusions

Despite different physiological responses (mean T_{sk} , local T_{sk} , T_{re}), participants with higher body fat had similar perceptual responses than their leaner counterparts.

Interestingly, there were clear consistencies between groups for T_{sk} patterns and this may in part contribute to the similar thermal votes.

Skinfold thickness explained between subjects but not within subject differences in T_{sk} .

The study also confirms the contribution of body fatness in heat dissipation during passive body cooling (seated rest) and exercise-induced mild hyperthermia (cycle ergometry).