Sex differences in thermal strain induced by a typical hiking scenario in a cool environment

Damien Fournet[1,2], Katy Griggs[1], Bernard Redortier[2], George Havenith[1]*
[1] Environmental Ergonomics Research Centre, Loughborough University, Loughborough, UK
[2] Thermal Sciences Laboratory, Oxylane Research, Villeneuve d'Ascq, France
* corresponding author: D.Fournet@lboro.ac.uk

Introduction

Most research investigating hill walking has focused on the mechanisms of accidental hypothermia with protocols involving males exposed to prolonged wet and windy environments [1]. No attention has been paid to discomfort associated with the different phases of recreational hiking in non-adverse conditions. The present study was designed to evaluate overall and local thermal strain during a typical hiking scenario and to highlight potential differences between males and females. This knowledge can be of practical importance for improved clothing requirements.

Methods

Eight males and eight females, physically active, took part in a laboratory-based 110-min simulated hike at a fixed relative intensity in a 15°C environment. The protocol was split into four main stages, a 5-min standing rest (PRE), a 60-min ascent (no wind) at 55% $\dot{V}O_{2max}$ (CLIMB), a 15-min seated rest exposed to 2.8 $m.s^{-1}$ frontal wind (SUMMIT) and a 30-min descent (no wind) at 20% $\dot{V}O_{2max}$ (DOWN). Treadmill gradient (up and down) was set at 15% and all participants wore standardised clothing (T-shirt, fleece top, trousers) and a backpack adjusted to 10% of body mass. At the different stages, nude whole-body skin temperature (T_{sk}) was recorded by infrared thermography in order to obtain mean T_{sk}, regional T_{sk} as well as population-averaged maps of whole-body T_{sk} distribution [2]. Rectal temperature (T_{re}) and heart rate (HR) were recorded throughout the whole protocol. Gross sweat loss (GSL) was calculated from pre- and post-weight measurement. Thermal sensation, wetness sensation and thermal comfort were also evaluated for the whole-body and for 11 body regions.

Results and Discussion

Sex differences were mainly observed for thermoregulatory responses and to a much lesser extent for perceptual responses. Specifically, females exhibited a significantly higher T_{re} and lower mean T_{sk} (on average 0.3°C and 0.6°C respectively) over the protocol (Figure 1). Four of the females were at the luteal phase of the menstrual cycle and the other four at the follicular phase. At SUMMIT, T_{re} dropped continuously for both groups, with a more pronounced drop in the females (p<0.05) whereas the increase in mean T_{sk} was more important during DOWN for females compared to males (p<0.05).

Regional T_{sk} displayed significant sex differences specifically located in the lower limbs and arms, being 2°C colder for females on average (p<0.01). These sex differences were less pronounced than during another experiment in the cold with unclothed female and male runners [2]. HR was 20 bpm lower for females during CLIMB (p<0.05) but similar at SUMMIT and DOWN (p=0.91). Overall thermal sensation was colder for females at PRE (*cold* vs *slightly cool*) and overall thermal comfort was worse at SUMMIT (*uncomfortable* vs *slightly uncomfortable*) compared to males (p<0.05). The last sex difference was at a regional level with males perceiving their face as wetter than females (*wet* vs *dry*) at CLIMB (p<0.05).

Similarities between sexes were observed for all other parameters. GSL was similar between groups (p=0.36). Overall thermal and wetness sensation reached similar levels at CLIMB (*warm*

and *wet*), SUMMIT (*slightly cool* and *moist*) and DOWN (*slightly warm* and *moist*) for all participants with no sex differences.

The body maps of T_{sk} showed for the first time the regional variations in T_{sk} after a clothed-exercise bout showing the contribution of active muscles during hiking as well as the discrete importance of the backpack pressure onto the skin.

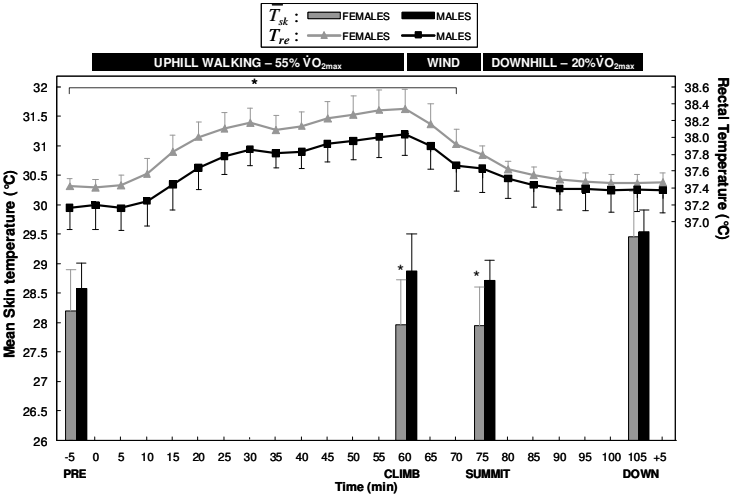

Figure 1. Evolution of rectal temperature (T_{re}, °C) and mean skin temperature ($\overline{T}_{sk}$, °C) for 8 females and 8 males with load carriage (10% body mass) during a simulated hike in a 15°C environment. *significantly different from males (p<0.05)

Over the protocol, correlation analyses indicated that face T_{sk} was a good indicator of local face sensation and it was also positively correlated with overall thermal sensation (from r = -0.65 to r = -0.85, p<0.05).

Conclusions

Our evaluation emphasizes that perceptual responses of males and females were relatively similar during hiking at a fixed relative intensity despite sex-differences in thermoregulatory responses. The exceptions in terms of perception were mainly found during the resting phases.

The limited overall and regional sex differences are not of practical importance for clothing design. Overall data yet indicate the need for a good adaptability of the clothing ensemble when facing various climates and exercise demands.

References

1. Ainslie P, Campbell I, Lambert J, McLaren D, Reilly T: **Physiological and metabolic aspects of very prolonged exercise with particular reference to hill walking**. *JSports Med.* 2005, **35(7):**619-647.
2. Fournet D, Ross L, Voelcker T, Redortier R, Havenith: **Skin temperature mapping in the cold: the role of subcutaneous fat**. *Proceedings of XIV ICEE* 2011, Nafplio, Greece.