THE EFFECT OF SKIN SURFACE MENTHOL APPLICATION ON RECTAL TEMPERATURE DURING PROLONGED IMMERSION IN COOL WATER

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INTRODUCTION

Immersion in cool water (< 30ºC) may lead to hypothermia, regardless of the individual's activity status (Choi et al., 1996). At 27ºC room air, spread of menthol on the skin surface stimulates cold-sensitive afferent pathways (Hensel and Zotterman 1951, Shafer et al., 1986), provoking local cutaneous vasoconstriction and body heat conservation, at rest (Tajino et al., 2007). However, it is still unknown whether application of menthol could protect body heat content during prolonged immersion in cool water. The purpose of the present study was to investigate the effect of skin surface menthol application on rectal temperature response during 60-min immersion in 24ºC water preceded by exercise. It was hypothesized that menthol application before exercise would slow rectal temperature decrease during immersion in 24ºC, mainly through more peripheral vasoconstriction, higher oxygen consumption ($\dot{V}O_2$) and faster start of shivering thermogenesis.

METHODS

Fourteen healthy male subjects (age: 21.4±2.7 years, maximal oxygen uptake ($\dot{V}O_2max$): 44.9±5.0 $ml \cdot kg^{-1} \cdot min^{-1}$ and body fat: 9.9±2.8 %) participated in this study. Two experiments, one with (MEN) and one without (CON) menthol application were conducted following random and counterbalanced order. Each experiment was performed at the same time of day, at least 3 hours after a light meal. After the subjects emptied their bladder, their body mass was measured

(Bilance Salus, Milano) and a thermistor (Yellow Springs, USA) was placed in the rectum, at a depth of 13-15 cm from the sphincter. Moreover, thermistors (Yellow Springs, USA) were placed on forearm and fingertip and secured with adhesive tape.

The experimental protocol consisted of cycling (Lode, Groningen, Holland) at 50% of individual maximum heart rate (HRmax= 220-age) so long as to reach 38ºC in rectal temperature (Tre) and was immediately followed by whole body immersion in stirring water of 24ºC; this temperature difference (38-24ºC) was expected to allow faster thermoregulatory responses during immersion. In MEN condition, exercise was preceded by application of 4.6 gr menthol per 100 ml of water on the skin all over the body. During immersion, Tre, vasoconstriction index (derived by the proximal distal skin temperature gradient; Tsk_{diff}:), $\dot{V}O_2$ (MedGraphics, CPX-D, USA), shivering (electromyographic activity) and HR (Polar S-810, Finland) were measured. In addition, thermal sensation (0: very cold - 7: hot) was reported every 5 minutes. All experiments were conducted at similar environmental conditions of temperature (25.0±1.0^{o}C) and relative humidity (46.2±4.3%).

RESULTS

In MEN condition, all subjects felt colder than in CON condition (Table 1) and. Tre reduction was significantly smaller from 15th to 60th min of immersion (Fig. 1) Moreover, the proximal distal skin temperature gradient showed a significant condition x time interaction ($p<0.001$) and it was higher in MEN, from the 45th to 60th min of immersion (Fig. 2).

Table 1. Oxygen consumption ($\dot{V}O_2$), ventilation ($\dot{V}E$), heart rate (HR), shivering threshold and thermal sensation during immersion in menthol (MEN) and control (CON) condition. Values are means ± SD.

	Menthol	Control	p value
$\dot{V}O_2$ ($ml \cdot min^{-1}$)	511±135	441±120	0.00
$\dot{V}E$ ($l \cdot min^{-1}$)	20.2±12.13	13.4±4.81	0.02
HR ($beats \cdot min^{-1}$)	73±9	68±9	0.00
Shivering threshold (ºC)	-0.25±0.29	-0.62±0.32	0.00
Thermal sensation	2.15±1.18	3.44±1.61	0.00

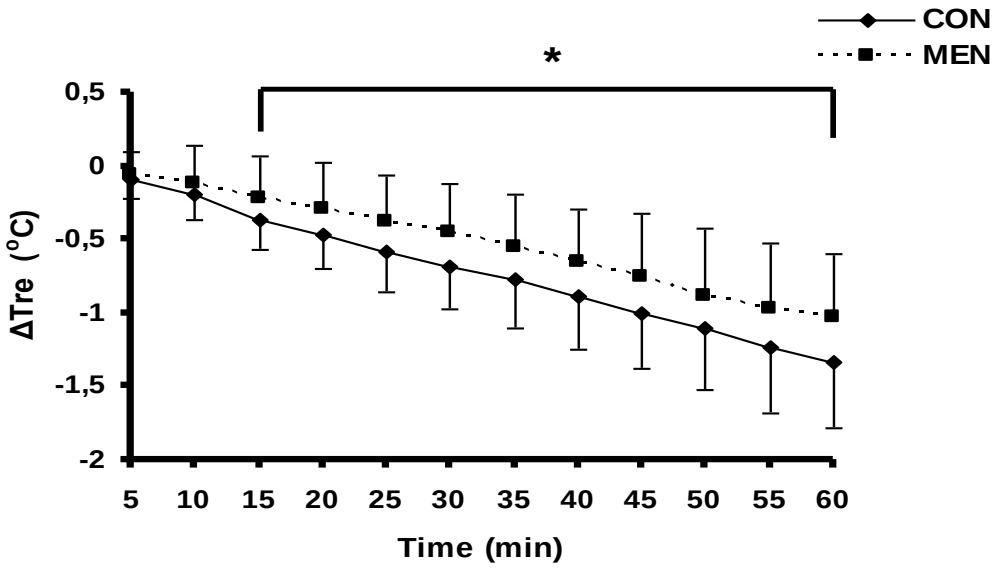

Fig. 1. ΔTre (changes from last exercise values) decrease during 60-min immersion in control (CON) and menthol (MEN) condition. Values are means ± SD. * Significant differences between conditions, $p \leq 0.01$.

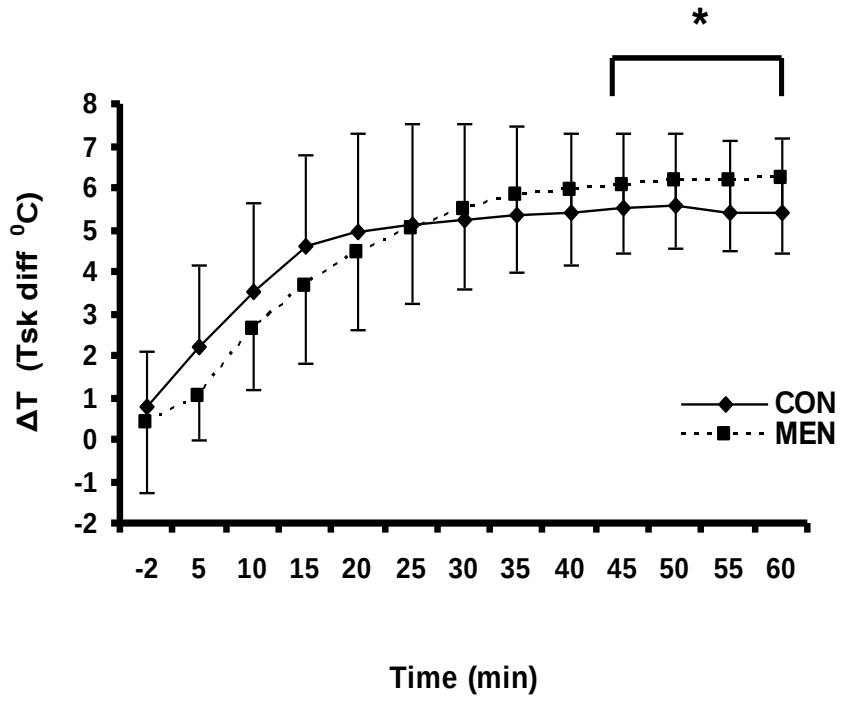

Fig. 2. Changes in forearm-fingertip difference (ΔTsk_{diff}), during 60-min immersion in control (CON) and menthol (MEN) condition. Values are means ± SD. * Significant differences between conditions, $p \leq 0.05$.

In addition, $\dot{V}O_2$, $\dot{V}E$ and HR during immersion were greater in MEN condition (Table 1). On the contrary, the initiation of rise in $\dot{V}O_2$ (considered as an index of non shivering thermogenesis occurred at smaller drop of Tre in MEN than in CON condition (Fig. 3). Shivering initiated at smaller drop of Tre (ΔTre) in MEN than in CON condition (Table 1).

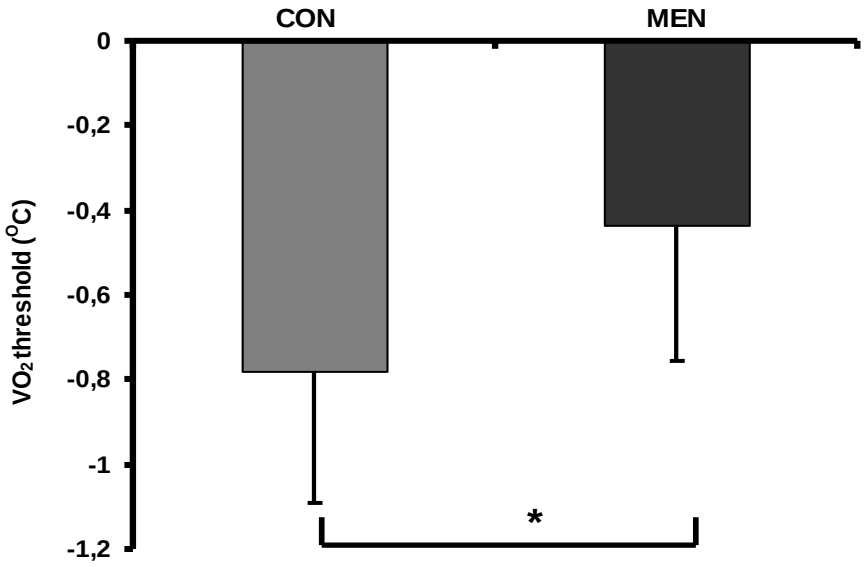

Fig.3. Drop at Tre at which initiation of systematic rise in $\dot{V}O_2$ occurred ($\dot{V}O_2$ threshold) during 60-min immersion in control (CON) and menthol (MEN) condition. Values are means ± SD. * Significant differences between conditions, $p \leq 0.01$.

CONCLUSION

Skin surface menthol application seems to induce a deceleration of Tre decrease during 60-min immersion in cool water of 24ºC. The smaller drop in rectal temperature after menthol application is probably the outcome of more vasoconstriction, higher non-shivering thermogenesis and earlier onset of shivering thermogenesis.

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