THE EFFECT OF L-MENTHOL ON THERMOREGUALTION AND SENSATION DURING EXERCISE IN WARM AND HUMID CONDITIONS

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INTRODUCTION

L-menthol ($C_{10}H_{20}O$; molecular weight, 156), a cyclic terpene alcohol produced from mint oils or prepared synthetically (Eccles, 1994), is perhaps best known for the cool sensation it elicits when applied to the skin. This raises the possibility of using such solutions to increase thermal comfort in some working and sporting scenarios. However, before this is recommended, it is important to determine the effect of l-menthol on thermoregulation.

L-menthol elicits its cool sensation by acting on sensory neurons (Jort *et al.,* 2003). Specifically, it acts through TRPM8, a highly sensitive cold receptor located on the cell membrane of sensory neurons (McKemy *et al.,* 2002; Peier *et al.,* 2002). TRPM8 is normally activated by temperatures ranging from 8°C to 28°C (Jort *et al.,* 2003) resulting in cool sensations (Peier *et al.,* 2002). If l-menthol stimulates cold receptors bringing about a cool sensation, it may also affect body temperature regulation by initiating heat loss defence mechanisms, and consequently impair athletic performance (Gonzalez-Alonso *et al.,* 1999) or increase the risk of heat illness. In such a case, any perceptual advantage gained from a cooler sensation would be more than offset by impaired performance. Additionally, some individuals experience feelings of discomfort (Cliff & Green 1994; Eccles 1994) and irritation with l-menthol application (Gillis *et al*. 2008). Therefore, before l-menthol can be recommended as a perceptual intervention, it must be proven to have no ill effects on thermoregulation and sensation. The primary aim of this research was to determine the effect of 0.2% l-menthol on thermoregulation and perception during exercise in the heat.

It was hypothesised that during exercise there will be no difference in skin temperature, deep body temperature or thermal perception between the l-menthol and Control conditions.

METHODS

A counter-balanced repeated measures design was employed. Eight volunteers were recruited from the University of Portsmouth student population. Participants were healthy, non-heat acclimated males between the ages of 18 and 40 years with a mean (standard deviation) age, height and weight of: 23 (2.26) years, 180.9cm (8.2) and 77.7kg (9.6) respectively. This study received approval from the University of Portsmouth Ethics Committee and all participants provided written informed consent.

Participants visited the Environmental Laboratory on three occasions. On their first day they were asked to complete a peak power test. On the second and third day they completed a 115 minute experiment in the heat. Over the latter two days, which were separated by 24 hours, each participant underwent two conditions: spraying with a solution containing a concentration of 0.2% wt/wt l-menthol suspended in water with less than 3.0% surfactants or spraying with a

solution containing exactly the same type and concentration of surfactants, but without l-menthol. Both solutions were applied (100mL/application) using a manual spray bottle. All participants wore long sleeved breathable shirts, along with footwear, socks and shorts.

Prior to the first trial participants were asked to perform a peak work (W_{peak}) test on a cycle ergometer to allow investigators to determine low ($W_{35\%}$) moderate ($W_{45\%}$) and high ($W_{70\%}$) intensity workloads. During each experimental condition participants cycled on a Monark cycle ergometer. They entered the environmental chamber (31°C, 70% relative humidity) at time zero and sat on the cycle ergometer for 10 minutes. From the 10th to the 20th minute participants performed warm-up exercise at $W_{35\%}$. They then sat resting from the 20th to the 55th minute. At the 55th minute participants began cycling at $W_{45\%}$ for a total of 40 minutes until the 95th minute. At the 95th minute participants cycled at $W_{70\%}$ until they completed the remaining 15 minutes of the experiment, or until failure. Participants were sprayed with either the l-menthol or control solution at the 35th, 50th and 95th minutes. See Figure 1 for a timeline of the experimental protocol.

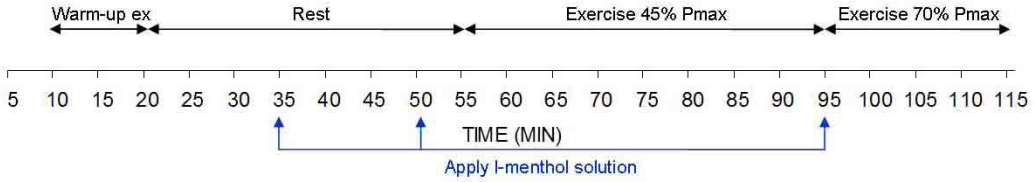

Figure 1. Experimental Timeline.

Participants reported their thermal comfort (TC), thermal sensation (TS) and rate of perceived exertion (RPE) using visual analogue scales every 10 minutes. Subjective reports of irritation were obtained with participants choosing from the following descriptors; burning, skin abrasions, stinging/pricking, itching, tingling, numbness, ache, pain (Cliff and Green, 1994).

Deep body temperature (T_{re}) was measured using a rectal thermistor. Skin temperature (T_{sk}) was measured by fixing thermistors to the left side of the body at the chest (T_{chest}), medial inside forearm ($T_{forearm}$), medial thigh (T_{thigh}) and calf (T_{calf}) (Ramanathan NL, 1964). Mean skin (MST) (Ramanathan, 1964) and body temperature (MBT) (Colin *et al.*, 1971) were then calculated. Heart rate (HR) was measured using a heart rate monitor (Polar, Finland).

The normality of data was tested using the Kolmogorov-Smirnov test. Within subject analysis of Time and Condition was undertaken using a parametric repeated-measures analysis of variance (ANOVA) using a statistical software package (SPSS 15). MST, T_{re} and MBT data were compared at the time points: 5, 15, 25, 35, 45, 55, 65, 75, 85 and 95 minutes. TS, TC and HR data were compared at time points 8, 15, 25, 38, 45, 55, 65, 75, 85 and 97. *Post-hoc* pair-wise comparisons were used to detect the direction of any significant effects. The alpha level for all statistical tests was set at $P<0.05$. All figures present data until the 97th minute, or the last time point when all participants were exercising.

RESULTS

All data sets tested were normally distributed. Data from one participant (participant 3, Control group) was excluded from the analysis of T_{re} and MBT due to an incomplete data set. Participant

numbers fell during the period of high intensity exercise (97min+) due to exhaustion; therefore, these data are not included in the current analysis.

No significant differences were observed between conditions in HR T_{sk} and MST. T_{re} was significantly higher (P=0.032) at some time points in the l-menthol condition (Figure 2) but the absolute difference was less than 0.1°C. MBT was significantly higher (P=0.031) at some time points in the l-menthol condition (Figure 3) but the absolute difference was less than 0.1°C.

No significant difference was observed between conditions in TC; however, TS in the l-menthol condition was significantly lower (participants felt cooler) than in the Control condition at minute 38 (P=0.030), 65 (P=0.030) and 75 minutes (P=0.020) (Figure 4). All participants noted some form of irritation between the 38th and 75th minute of the l-menthol condition, but with the exception of one participant's description of tingling, no irritation was reported in the Control condition.

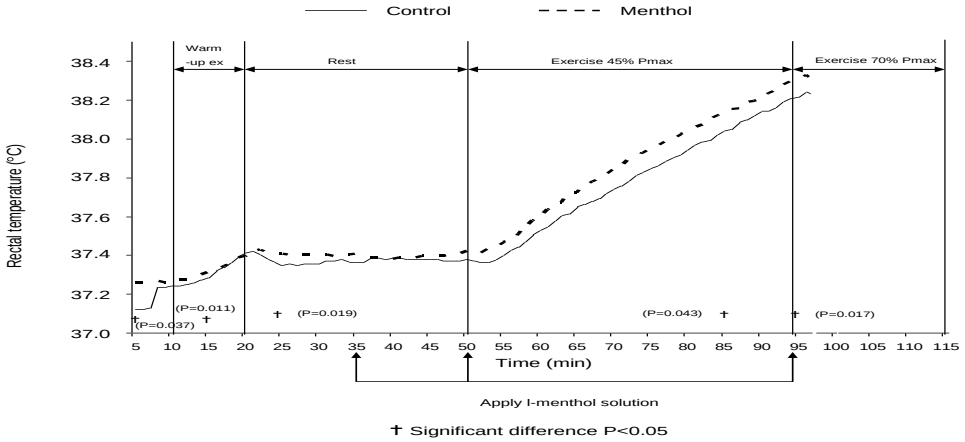

Figure 2. Rectal temperature during the l-menthol and Control conditions (n=7)

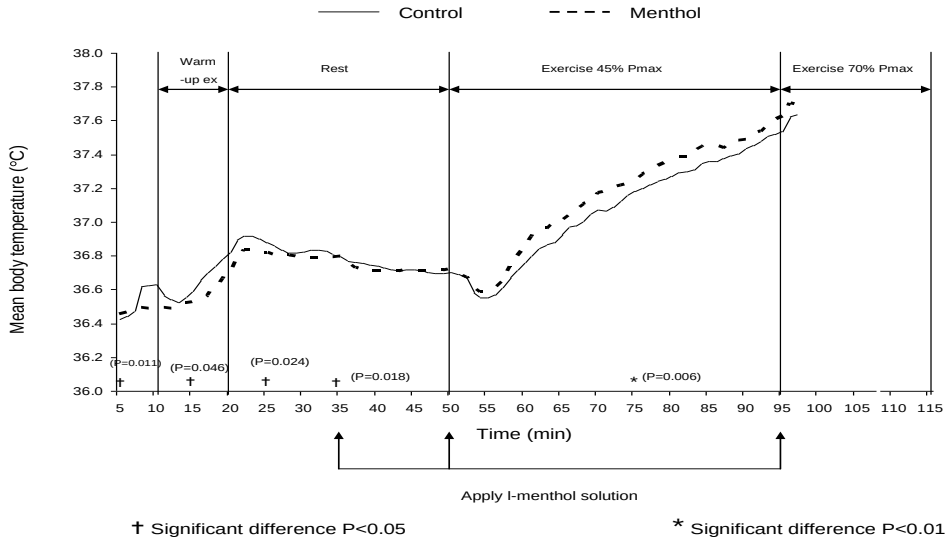

Figure 3. Mean body temperature during the l-menthol and Control conditions (n=7)

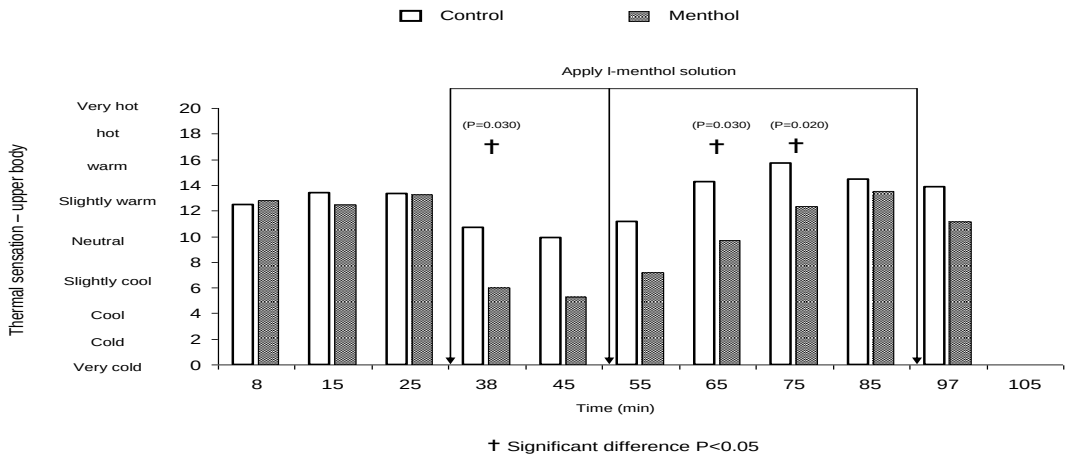

Figure 4. Average thermal sensation of the upper body during the l-menthol and Control conditions (n=8)

DISCUSSION

Although the difference in T_{re} and MBT between conditions was statistically significant at some time points, some of these times preceded the application of either solution. In any case, the absolute differences in T_{re} and MBT between conditions were small and probably of no practical significance. The hypothesis that there would be no difference in thermoregulation during exercise in the heat between the l-menthol and Control conditions is supported.

There was also a dissociation between TC and TS in the l-menthol condition; with participants feeling cooler but not more comfortable. All participants noted feelings of irritation at some point during the l-menthol trial. Some authors have suggested that along with cold receptor activation, l-menthol may also activate pain fibres (Eccles 1994). Thus, the benefit provided to TS by the application of l-menthol appears to be negated by the irritation it causes. Whether this is the case with weaker l-menthol solutions is currently being investigated.

These findings raise the possibility of using an l-menthol solution to enhance sensation and perhaps performance in sports ranging from shooting, where comfort and concentration are important, to endurance events, where the drive to exercise can be attenuated by high temperatures (Nybo & Nielsen, 2001).

It is concluded that in the conditions of the present experiment, the application of a solution containing 0.2% l-menthol did not, in general, have a significantly detrimental impact on the ability to thermoregulate when compared to a Control solution without l-menthol. Although l-menthol caused participants to feel cooler, they were no more comfortable; probably because of feelings of irritation.

ACKNOWLEDGEMENTS

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