Influence of Cold-Water Immersion on Limb and Cutaneous Blood Flows Following Exercise

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ABSTRACT

Cold-water immersion is a commonly employed treatment to facilitate recovery from exercise-induced muscle damage. Benefits may partly arise from reduction in limb blood flow, however no study has comprehensively investigated the influence of different degrees of cooling on femoral blood flow responses following exercise. **PURPOSE:** To determine the influence of cold (8 ºC) and cool (22 ºC) water immersion on lower limb and cutaneous blood flow following exercise. **METHODS:** Twelve males (25±1 years) completed a continuous cycle exercise protocol at 70% VO_{2max} until a rectal temperature of 38 ºC was attained. In a randomized order, subjects were then placed in a semi-reclined position and hoisted into either 8 ºC or 22 ºC water to the iliac crest for 10-min or rested (Control). Rectal and thigh skin temperature, deep and superficial muscle temperature (T_m), thigh and calf skin blood flow (laser Doppler flowmetry) and superficial femoral artery blood flow (duplex ultrasound) were measured prior to and after 30-min immersion. Vascular conductance was calculated for cutaneous and femoral flow and mean arterial pressure. Data were analyzed using repeated measures ANOVA. Cutaneous data is presented as % of pre-immersion. **RESULTS:** Compared with Control, femoral artery conductance was reduced to a similar extent in both immersion conditions (Cold, 1.58 ± 0.13; Cool, 1.76 ± 0.20; Control, 2.38 ± 0.22 AU·ml·min^{-1}mmHg, p <0.01). When compared to control, thigh (-72.07 ± 3.43 %; Cool, -61.05 ± 5.73 %; Control, -21.85 ± 8.04 %, p<0.01) and calf skin conductance (Cold, -65.41 ± 7.09 %; Cool, -53.62 ± 4.50 %; Control, -28.48 ± 7.39 %, p<0.01) was similar between immersion conditions. The greatest reduction in T_m occurred at a depth of 1cm and was dependent on the condition (Cold, 31.10 ± 0.48 ºC; Cool, 33.96 ± 0.38 ºC; Control, 36.22 ± 0.31 ºC, p <0.01). Deep T_m (3cm) decreased over the recovery period, with the magnitude of T_m decrease dependent on the condition (Cold, 35.52 ± 0.2 ºC; Cool, 36.00 ± 0.15 ºC; Control, 36.91 ± 0.09 ºC, p<0.01). **CONCLUSION:** A core temperature load of similar magnitude induces similar reductions in femoral and skin blood flows, irrespective of the lower body being immersed in cold or cool water. Cold-water may be more effective in the treatment of exercise-induced muscle damage by virtue of a greater reduction in T_m.

INTRODUCTION

- Cold-water immersion is a commonly employed treatment to facilitate recovery from exercise-induced muscle damage
- Proposed mechanisms include: 1) ↓ local tissue temperature, 2) ↑ vasoconstriction of skeletal muscle arterioles, 3) ↓ inflammation, metabolism, pain and oedema.
- Cold (8°C) and Cool (22°C) water immersion induce similar reductions in whole limb blood flow at rest, however, blood flow to the skin is greater in cold water suggesting that colder temperatures may cause greater reductions in muscle blood flow (1)
- Vascular responsiveness to sympathetic stimulation is reduced during exercise (2) and heat stress (3), consequently the effects of cold water immersion on muscle blood flow following exercise may differ compared to rest.
- No previous studies have evaluated the blood flow response to post exercise cold-water immersion using contemporary techniques.
- It was hypothesised that Cold (8 °C) and Cool (22 °C) water immersion would induce similar changes in cutaneous and limb blood flow following exercise

METHODS

- Twelve recreationally active men (mean ± SE: age, 25.54 ± 1 years); consented to immersion at 8 ºC and 22 ºC, randomly assigned on separate days.
- Rectal (T_{rec}), skin (T_{skin}; thigh) and intramuscular temperatures (T_m; vastus lateralis) were measured.
- Laser Doppler flowmetry was used to measure thigh and calf cutaneous blood flow
- Superficial femoral artery blood flow was measured using duplex ultrasound
- Blood pressure was used to calculate vascular conductance (flow / pressure).
- Participants cycled at 70% VO_{2max} until a rectal temperature of 38°C was attained.
- Participants were immersed (20-25 cm) semi-reclined up to the level of the iliac crest, for a 10-min period or remained seated (Control).
- Responses were monitored post exercise, pre-immersion and for 30-min post-immersion.
- A two-factor (condition x time) within-participants general linear model (GLM) was undertaken to determine any treatment differences between conditions. *Post hoc* analyses were performed using Newman-Keuls multiple contrasts. The α level for evaluation of statistical significance was set at $P < 0.05$. All data presented as means ± SE.

RESULTS

Temperature
- Similar decrease in T_{rec} between conditions (P > 0.05)
- Decreased thigh T_{skin} in cooling vs. Control (P < 0.001)
- Decreased thigh T_{skin} in 8ºC vs. 22ºC (P < 0.001)
- Decreased T_m at 2 cm depth in cooling vs. Control (P < 0.01)
- Decreased T_m at 2 cm depth in 8ºC vs. 22ºC (P < 0.01)

Blood Flow
- Decreased FVC and CVC in cooling vs. Control (P < 0.01).
- Similar decrease in FVC and CVC in 8ºC and 22ºC (P > 0.05)

Blood Pressure
- Increased MAP in 8ºC vs. 22ºC and Control (P < 0.05)
- Similar decrease in MAP between 22ºC and Control (P > 0.05)

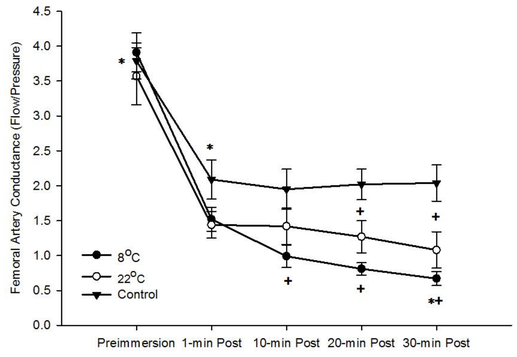

***Figure 1**. Femoral artery vascular conductance (FVC)*

* Significantly different to baseline (rest)
\+ Significantly different between cooling condition and Control

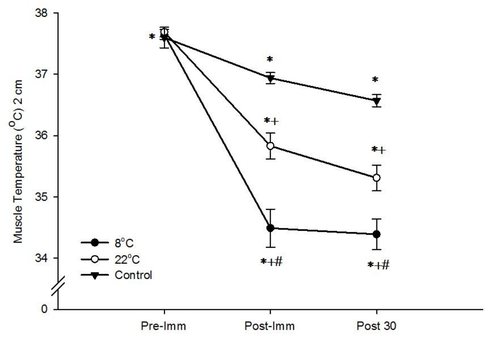

Figure 3. *Local muscle temperature*

* Significantly different to baseline (rest)
\+ Significantly different between cooling condition and Control
\# Significant difference between cooling conditions

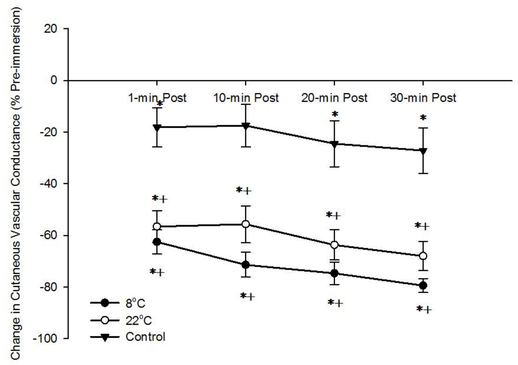

***Figure 2**. Thigh (below) cutaneous vascular conductance (CVC)*

* Significantly different to baseline (rest)
\+ Significantly different between cooling condition and Control

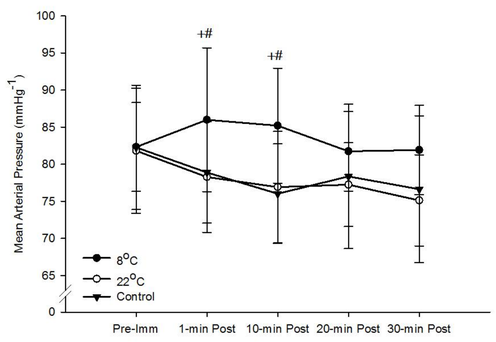

***Figure 4.** Mean arterial pressure*

\+ Significantly different between cooling condition and Control
\# Significant difference between cooling conditions

CONCLUSION

- **Cold (8°C) and Cool (22°C) water immersion promote similar reductions FVC and CVC following exercise, hence similar reduction in muscle perfusion**
- **Cold water immersion causes greater reductions in muscle temperature.**
- **Colder water may be more effective in the treatment of exercise-induced muscle damage by virtue of a greater reduction in muscle temperature.**

References

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