

# The Efficacy Of Prolonged Cooling Using Phase Change Material For Enhancing Recovery Following A Marathon

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## ABSTRACT

**PURPOSE:** Athletes often utilize cryotherapy interventions following exercise to mitigate muscle damage, inflammation and feelings of soreness. The literature has shown only small benefits from cryotherapy on accelerating recovery from exercise. The practical utility of modalities such as cold water immersion is questionable. Phase change material (PCM) packs can provide prolonged cooling while simultaneously allowing the wearer to continue with activities of daily living and, thus, is a more practical alternative to other cryotherapy modalities. The aim of this study was to test the efficacy of a single prolonged cooling treatment using PCM following completion of a marathon on soreness, strength, muscle damage and inflammation on the days after running a marathon. **METHODS:** Twenty-four participants (8 male, 16 female) completed a marathon and were randomized to receive the post-race intervention (3 h of 15°C PCM covering the quadriceps) or recover without an intervention (control). Soreness, knee extension strength, vertical jump height, creatine kinase (CK), and high sensitivity c-reactive protein (hsCRP) were recorded at baseline, 1, 2, and 3 days following the marathon. **RESULTS:** Soreness increased following the marathon ( $P < 0.0001$ ) in both groups, but was lower in the PCM group (treatment effect  $P = 0.028$ ) and resolved faster (treatment by time  $P < 0.044$ ; D3 soreness:  $1.1 \pm 0.9$  PCM vs  $2.7 \pm 1.6$  control). Strength decreased following the marathon in both groups ( $P < 0.0001$ ) with no difference between groups. Although not significant, by Day 3 strength recovered more in the PCM ( $98.6 \pm 15.6\%$ ) vs. control group ( $90.4 \pm 7.6\%$ ). PCM had a beneficial effect on jump height (treatment effect  $P = 0.037$ , treatment by time  $P = 0.031$ ); over the 3 days post-race, jump height averaged  $101 \pm 10\%$  of baseline in PCM treatment versus  $89 \pm 10\%$  in the control condition ( $P = 0.037$ ). CK and hsCRP increased over time (both  $P = 0.0001$ ) peaking on D1, with no difference between groups. **CONCLUSIONS:** Prolonged post-marathon PCM cooling accelerated resolution of soreness and recovery of vertical jump performance, but had no effect on other indices of damage or inflammation. PCM cooling is a practical, wearable cryotherapy modality that can facilitate recovery following excessive exercise stress. [susan@nismat.org](mailto:susan@nismat.org)

## BACKGROUND

- Traditional cryotherapy modalities, such as cold water immersion (CWI), are commonly used to accelerate recovery following exercise, but are limited in the duration of application and have limited effectiveness on soreness and no effect on strength
- Phase change material (PCM) packs can prolong the duration of cooling to the musculature, comparable with 15 min of 15°C CWI, for 3 hours (Kwiecien et al 2019)
- We have previously shown that PCM can:
  - ❖ accelerate recovery following eccentric exercise in recreational (Kwiecien et al 2018) and trained athletes (Kwiecien et al 2020), without compromising the adaptive response that protects against damage following a subsequent bout of eccentric exercise (Kwiecien et al 2020)
  - ❖ accelerate recovery in professional soccer players (Brownstein et al 2019; Clifford et al 2018)

## OBJECTIVES

- To test the efficacy of a three hour PCM cooling treatment on recovery of pain, strength, jump height, muscle damage and inflammation following a marathon
- Hypothesis:** Prolonged PCM cooling will reduce post-marathon pain, accelerate recovery of strength and limit blood markers of muscle damage and inflammation

## METHODS

- Thirty participants (Table 1) completed a marathon run (26.2 miles) and were randomized to either receive:
  - 1. Intervention:** 3 h of 'frozen' 15°C PCM applied directly to the skin covering the quadriceps (participants began the intervention within  $1:20 \pm 0:34$  hours of finishing the marathon)
  - 2. Control:** recover without an intervention



**Figure 1:** Participant displaying frozen and melted PCM

# METHODS

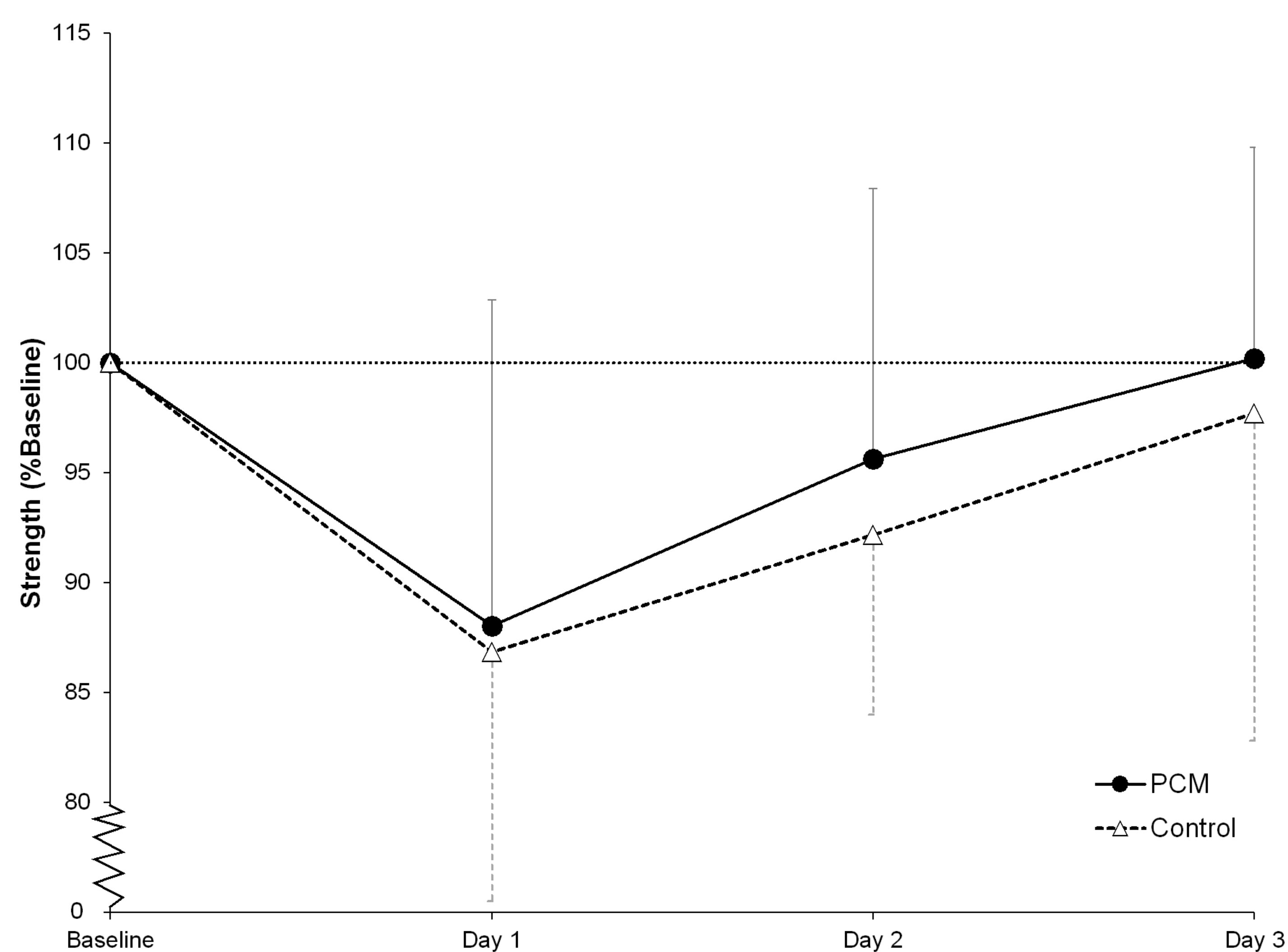
**Table 1:** Participant characteristics and marathon completion times. Note: Values are mean  $\pm$  SD. Finish times are reported as hour: minutes (h:mm).

| Treatment                        | n         | Age (years)                | Height (cm)                      | Weight (kg)                     | # Previous Marathons      | Expected Finish Time            | Actual Finish Time              |
|----------------------------------|-----------|----------------------------|----------------------------------|---------------------------------|---------------------------|---------------------------------|---------------------------------|
| PCM                              | 15        | 36 $\pm$ 8                 | 170.9 $\pm$ 10.0                 | 67.1 $\pm$ 11.5                 | 3 $\pm$ 6                 | 4:21 $\pm$ 0:42                 | 4:23 $\pm$ 0:53                 |
| Female                           | 9         | 35 $\pm$ 9                 | 164.6 $\pm$ 6.7                  | 60.5 $\pm$ 6.7                  | 4 $\pm$ 6                 | 4:16 $\pm$ 0:43                 | 4:29 $\pm$ 0:51                 |
| Male                             | 6         | 37 $\pm$ 8                 | 180.3 $\pm$ 5.8                  | 77.1 $\pm$ 10.1                 | 10 $\pm$ 7                | 3:34 $\pm$ 0:22                 | 3:40 $\pm$ 0:20                 |
| Control                          | 15        | 33 $\pm$ 9                 | 167.9 $\pm$ 11.5                 | 69.1 $\pm$ 14.4                 | 6 $\pm$ 7                 | 3:59 $\pm$ 0:40                 | 4:11 $\pm$ 0:48                 |
| Female                           | 10        | 31 $\pm$ 8                 | 162.3 $\pm$ 7.4                  | 62.8 $\pm$ 12.3                 | 3 $\pm$ 7                 | 4:26 $\pm$ 0:46                 | 4:29 $\pm$ 0:58                 |
| Male                             | 5         | 36.6 $\pm$ 9               | 179.0 $\pm$ 10.4                 | 81.7 $\pm$ 9.5                  | 2 $\pm$ 2                 | 4:11 $\pm$ 0:36                 | 4:13 $\pm$ 0:47                 |
| <b>Total</b>                     | <b>30</b> | <b>34<math>\pm</math>8</b> | <b>169.4<math>\pm</math>10.7</b> | <b>68.1<math>\pm</math>12.9</b> | <b>5<math>\pm</math>6</b> | <b>4:10<math>\pm</math>0:42</b> | <b>4:17<math>\pm</math>0:50</b> |
| <b>Between group comparisons</b> |           | P = 0.338                  | P = 0.454                        | P = 0.689                       | P = 0.143                 | P = 0.169                       | P = 0.543                       |

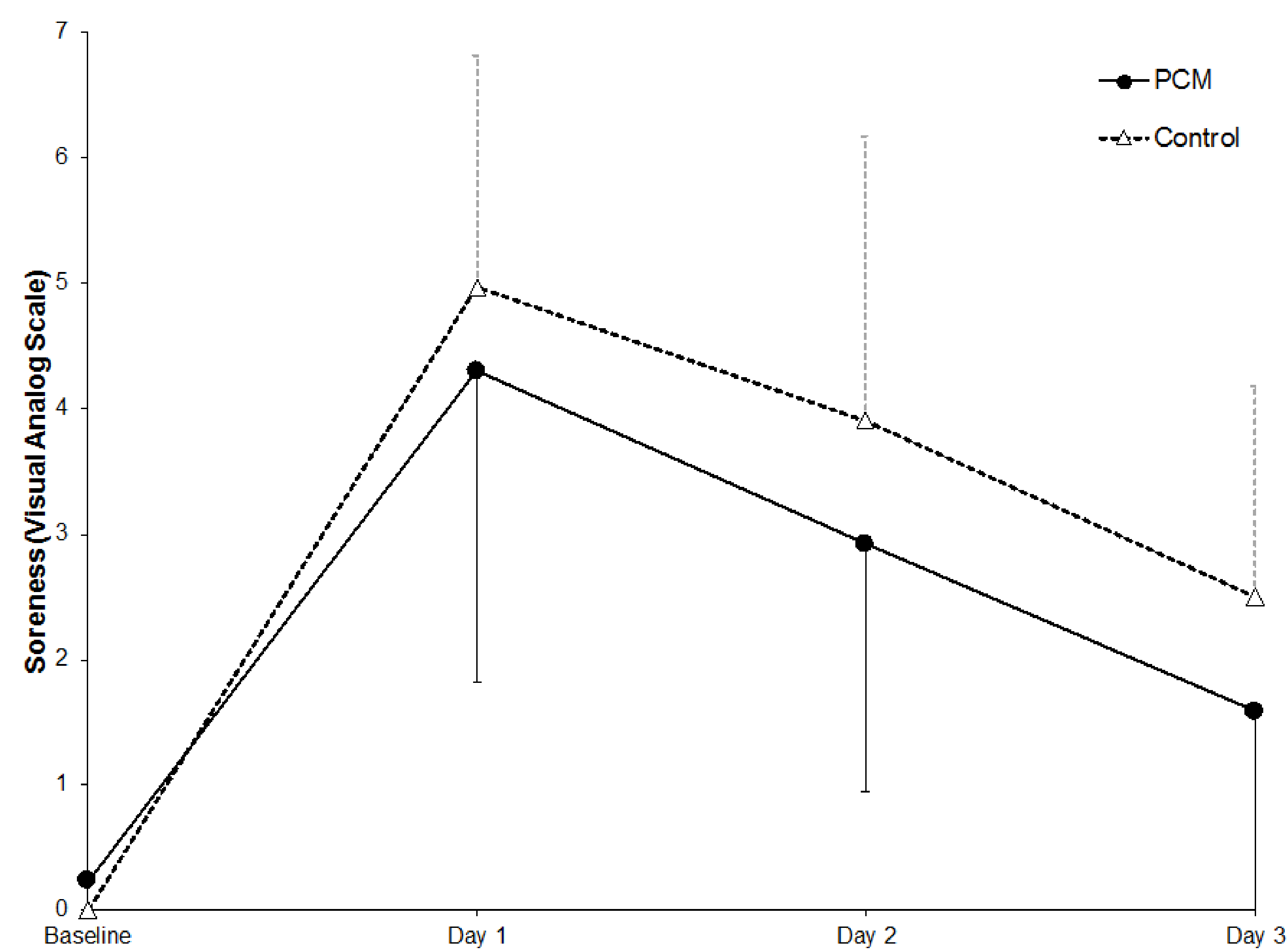
Variables were recorded at baseline, 1, 2, and 3 days following the marathon:

- pain, knee extension strength, vertical jump height (Counter Movement Jump – CMJ), Creatine Kinase (CK), and high sensitivity C-Reactive Protein (hsCRP)

# RESULTS

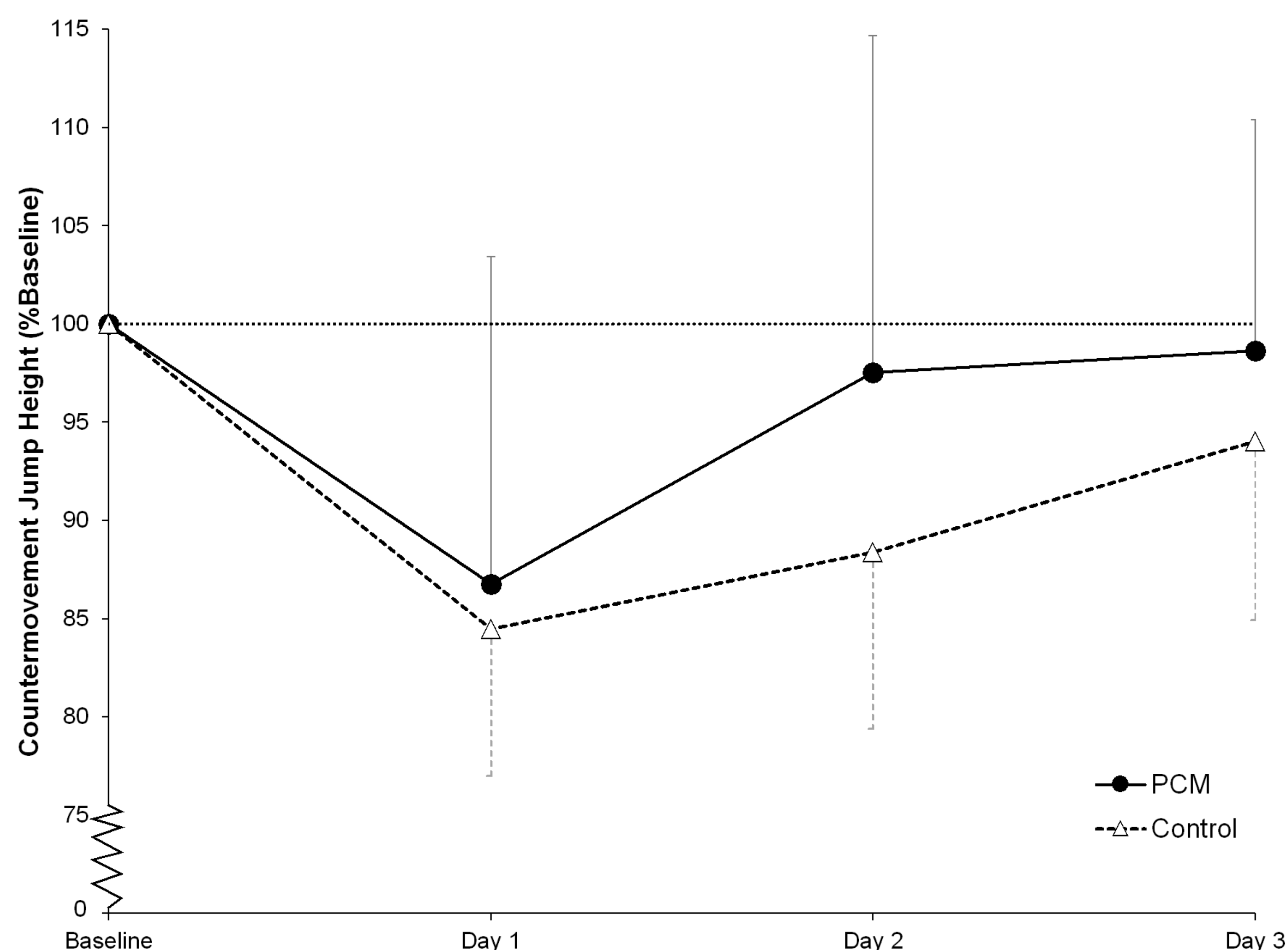


**Figure 2:** Isometric strength loss of the quadriceps (presented as a percentage change from baseline strength loss) for the PCM treatment and control groups before and on the three days following the marathon. Values are mean  $\pm$  SD. Strength was reduced over the 4 days after the marathon ( $P < 0.0001$ ), with no difference between groups.



**Figure 3:** Subjective reports of quadriceps soreness on a 0-10 scale (0 = no discomfort, 10 = too painful to squat to 90°) for the PCM treatment and control groups before and for three days following the marathon. Values are mean  $\pm$  SD. Soreness following the marathon was increased in both groups ( $P < 0.0001$ ).

# RESULTS



**Figure 4:** Percentage change from baseline in countermovement jump (CMJ) height for the PCM treatment and control groups before and for three days following the marathon. Values are mean  $\pm$  SD. Following the marathon, CMJ height was impaired in both groups ( $P < 0.0001$ ), but was not different between treatments.

|                    | CK (U·L <sup>-1</sup> )            |                                    | hcCRP (ug/ml)                         |                                       |
|--------------------|------------------------------------|------------------------------------|---------------------------------------|---------------------------------------|
|                    | PCM                                | Control                            | PCM                                   | Control                               |
| <b>Baseline</b>    | 119 $\pm$ 70<br>(2.00 $\pm$ 0.28)  | 169 $\pm$ 138<br>(2.11 $\pm$ 0.31) | 1.03 $\pm$ 0.82<br>(-0.07 $\pm$ 0.26) | 0.77 $\pm$ 0.34<br>(-0.15 $\pm$ 0.17) |
| <b>Day 1</b>       | 893 $\pm$ 471<br>(2.87 $\pm$ 0.30) | 841 $\pm$ 372<br>(2.87 $\pm$ 0.24) | 7.72 $\pm$ 5.28<br>(0.79 $\pm$ 0.31)  | 7.38 $\pm$ 4.56<br>(0.80 $\pm$ 0.27)  |
| <b>Day 2</b>       | 419 $\pm$ 289<br>(2.51 $\pm$ 0.35) | 547 $\pm$ 363<br>(2.64 $\pm$ 0.31) | 3.63 $\pm$ 1.89<br>(0.51 $\pm$ 0.22)  | 4.27 $\pm$ 2.29<br>(0.56 $\pm$ 0.28)  |
| <b>Day 3</b>       | 328 $\pm$ 193<br>(2.42 $\pm$ 0.32) | 378 $\pm$ 416<br>(2.36 $\pm$ 0.47) | 2.26 $\pm$ 1.12<br>(0.30 $\pm$ 0.24)  | 4.23 $\pm$ 5.80<br>(0.43 $\pm$ 0.39)  |
| <b>Time Effect</b> | $P < 0.0001$                       | $P < 0.0001$                       | $P < 0.0001$                          | $P < 0.0001$                          |

**Table 2:** Response of indices of muscle damage (serum Creatine Kinase; CK) and inflammation (high sensitivity C-Reactive Protein; hsCRP) in the blood before (baseline) and for 3 days (Day 1, 2, and 3) after the marathon run in the PCM and Control groups. Values are mean  $\pm$  SD. Note: Values are presented as absolute value (log transformed value).

## DISCUSSION

- The marathon led to decreases in muscle function, increases in perceptions of soreness, and increases in blood markers of muscle damage (CK) and inflammation (hsCRP)
- Thus, there was sufficient damage from the marathon to detect a benefit from the PCM cooling intervention
- Contrary to the hypothesis, and unlike our previous work, there was no difference in the rate of recovery between the local PCM treatment and control groups
- Although non-significant, strength, soreness, and CMJ height returned to baseline quicker in the PCM treatment group
- The findings of the present study are in agreement with the only other study to have previously investigated the effectiveness, or lack thereof, of cryotherapy on recovery following a marathon (Wilson et al 2018)
- Notably, the damage response in the present study was greater than that reported by Wilson et al (2018)

## CONCLUSION

- Prolonging the duration of cooling by administering local cooling to the quadriceps for 3 hours following a marathon run **does not** enhance recovery, likely because the local PCM cooling is not a large enough cryotherapy stimulus to negate the thermal load induced by the marathon
- Following strenuous, metabolically stressful exercise, using cryotherapy for successful recovery should be concomitant with the amelioration of voluntary activation and core temperature

### References:

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