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Effect of acute cooling recovery on vertical jump and reaction time

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Abstract
Background: Athletes are required to compete without a sufficient recovery due to a limited resting time between bouts of exercise. Cryotherapy has been used for recovery for exercise performance. We tested a hypothesis that a 10-min cooling recovery for the lower body would enhance recovery for vertical jump exercise performance as well as reaction time following the 30-sec Wingate anaerobic test.
Methods: 11 Healthy male subjects visited a total of three times including a familiarization visit. Following the 10-min rest, vertical jump and reaction time trials were performed before and after a traditional 30s-anaerobic Wingate test (WAnT). Following 10-min recovery period with or without a cooling suit for lower body, this procedure was repeated one more time. Two-way repeated measures ANOVA was utilized to analyze jump performance and reaction time.
Results: Time to reaction and time to take-off during reaction time test were not changed throughout the entire test and no differences between recovery modes were found ($p>0.05$ for all). After 10 min recovery, vertical jump performance was partially recovered in both recovery groups. However, there was no effect of cooling recovery relative to the control counterpart ($P<0.05$ for all).
Conclusion: Data from the current study show that 10-min acute cooling would not improve subsequent vertical jump and reaction time performance following fatigued exercise. Further investigation regarding the effects of cooling on various functional performances is warranted.

Keywords: reaction time, vertical jump, acute cooling, fatigue

1. Introduction
Athletes are required to compete without a sufficient recovery due to a limited resting time between bouts of exercise. When the adequate recovery is not given following an intense exercise, it would lead to a decrease in performance level during the subsequent bouts of exercise [1]. Therefore, it is important to investigate effective and safe recovery strategies to maintain exercise performance in the subsequent bouts.
Cryotherapy has been used for recovery for exercise performance. Most experiments have focused on the long-term recovery effects (1-48 hrs) of cryotherapy, very little is known for the short-term recovery effects (≤1 hr) of the therapy between bouts of intense exercise [2].
The primary aim of the present experiment was to assess the effectiveness of acute lower body cooling between bouts of high intensity exercise. We hypothesized that a 10-min cooling recovery for the lower body would enhance recovery for vertical jump exercise performance as well as reaction time following the 30-sec Wingate anaerobic test.

2. Materials and Methods
2.1 Experimental protocol
The current study was approved by the institutional review board (IRB) at Jeonbuk National Universtiy (JBNU 2019-07-014-003). 11 healthy male subjects (25.4 ± 1.4 yrs., 79.2 ± 3.2 kg, 178.2 ± 1.7 cm) were included in the present investigation. Once subjects arrived, a cycling warm-up exercise was performed. Following the 10-min rest, vertical jump and reaction time trials were performed. Then, subjects completed a traditional 30s-anaerobic Wingate test (WAnT). Then, vertical jump and reaction time were again measured. This protocol was repeated one more time. During the next visit, subjects performed an identical procedure except for the recovery modality (i.e., control vs. cooling recovery). A representative protocol is shown in Figure 1.

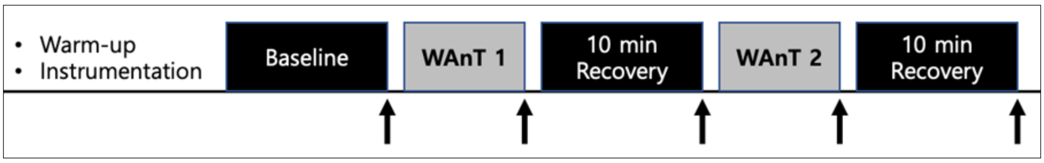


Fig 1: Experimental protocol, WAnT, Wingate Anaerobic Test, arrows indicate vertical jump and reaction time measurement

2.2 Vertical jump

Vertical jump height was calculated based on flight time (TKK-5414, TAKEI, Japan). Three jumps were averaged to determine vertical jump height for each subject. Arm swing was restricted by placing both hands on their shoulders.

2.3 Reaction time

Reaction time was assessed as previously described [3]. Briefly, subjects were instructed to escape a force platform in response to visual recognition of a light emitted in front of subjects. The software (KwonGRF) started recording ground reaction force (GFR) once the light emitted. Data from two reaction time trials were averaged.

2.4 Statistical analysis

All data are shown as the mean ± SE. Two-way repeated measures ANOVA was utilized to analyze jump performance and reaction time, which was then followed by Tukey post hoc analysis. Statistical significance was set at $P<0.05$ (Prism 8.3, GraphPad).

3. Results

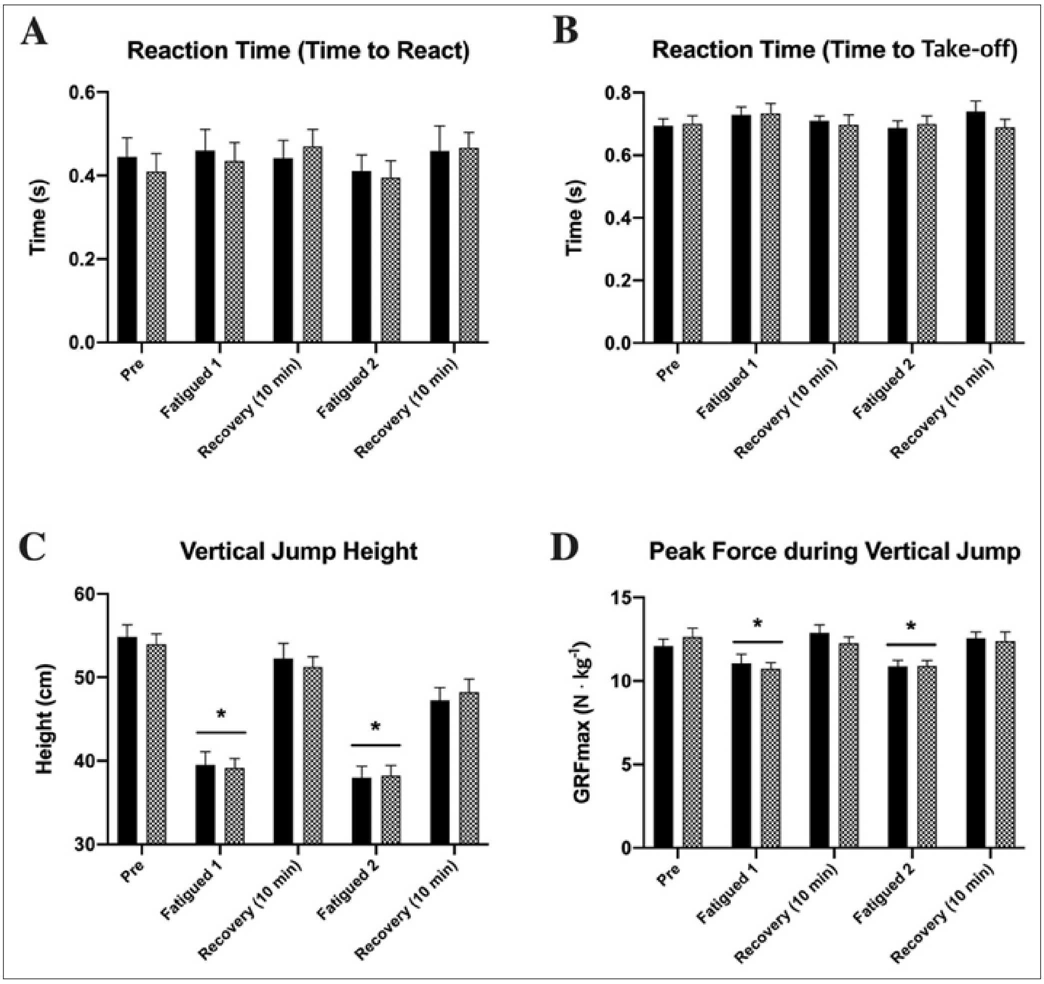
3.1 Reaction time

Reaction time was not changed following WAnT when compared with the baseline. Thus, no recovery was observed. Overall, time to reaction and time to take-off during reaction time test were not changed throughout the entire test and no differences between recovery modes were found (Figure 2A and B).

3.2 Vertical jump performance

As expected, vertical jump performance was significantly reduced following WAnT. Also, only partial recovery was found in response to 10 min recovery. Following the second WAnT, vertical jump performance was reduced further. After 10 min recovery, vertical jump performance was partially recovered (Figure 2C). However, there was no effect of cooling recovery relative to the control counterpart.

We also analyzed ground reaction force during vertical jump. As expected, ground force during vertical jump was significantly decreased following WAnT. Interestingly, peak force was fully recovered after 10 min recovery period. However, no differences in peak force during vertical jump was observed (Figure 2D).



*$P<0.05$ vs. baseline. Data is shown as mean ± SE.

Fig 2: Vertical jump and reaction time

4. Discussion
In the present experiment, we assessed whether the acute cooling recovery following strenuous exercise could have a positive effect on the subsequent vertical jump performance. As opposed to our hypothesis, the data showed no detectable recovery effect on jump performance and reaction time. The effectiveness of acute cooling as a recovery strategy should be studied further.

The acute local cooling has been extensively studied for its effectiveness on exercise performance [2]. The general consensus is that acute cooling over working muscles reduces exercise capability due to (1) muscular contraction speed [4], (2) muscular force [5], and (3) neuromuscular properties6. In this line, our laboratory recently showed that acute cooling recovery for 10 min between bouts of the WAnT blunts neuromuscular activity (i.e., frequency) and exercise performance [7]. Similarly, Cross *et al*. showed that ice immersion for 20 min decreases vertical jump performance and shuttle run speed in soccer and football players [8].

Acute cooling is shown to have positive effects on recovery under mechanisms such as changes in sensory perception [9, 10] and pain reduction [11-13]. Cooling can induce local analgesia and elevate thresholds for pain receptor [9], allowing for recovery time and subsequent exercise performance. Some peripheral stimuli, such as cooling and heating, influence distintive sets of neurons that cause pain transmission [2].

We hypothesized that acute cooling between bouts of high intensity exercise would lead to elevation in pain receptor threshold, which consequently plays a positive role in post exercise recovery by reducing pain sensation after the WAnT. However, data from the current study show that 10-min acute cooling would not improve subsequent vertical jump and reaction time performance following fatigued exercise. Further investigation regarding the effects of cooling on various functional performances is warranted.

5. Funding sources
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