COGNITIVE AND MANUAL PERFORMANCE FOLLOWING INTERVAL VS. CONTINUOUS EXERCISE IN THE COLD

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INTRODUCTION

Both cognitive and manual performance are altered in extreme environments.[1, 2] In particular, cold ambients decrease manual dexterity via decreasing finger and/or forearm temperature.[3, 4] Cognitive function, on the other hand, has received variable results depending on the mode and duration of cooling, as well as the testing criteria.[5-7]

It is well documented that interval (INT) and continuous (CONT) exercise result in different patterns of blood flow and heat exchange in both heat[8] and cold.[9] Exercise can improve finger temperature[10, 11] and manual dexterity[12, 13] in the cold, but the type of exercise (interval vs. continuous cycling, matched for energy expenditure) has never been evaluated under this paradigm. Thus, we sought to evaluate how mode of exercise affects body temperature, manual dexterity, and executive function in 5°C air.

METHODS

Fourteen right-handed, apparently healthy males (21 ± .5 years) volunteered for the current investigation. They were of average fitness (45 ± 5 ml/kg/min) and body fat (14 ± 4 %) Volunteers reported to the laboratory on four occasions. The first two visits elicited anthropometric and fitness parameters for each person. During these initial sessions, volunteers practiced the performance tests a minimum of four times to minimize any learning effect. The Purdue Pegboard (dominant hand task and bimanual task) was chosen to measure manual dexterity and the Stroop Color Word Test (SCWT) was chosen to measure executive function. Both versions of the Purdue Pegboard (PP) assess fine motor manipulation. Volunteers were asked to rapidly and sequentially place small cylindrical pegs into the board for 30 seconds. Both the PP and SCWT tests are reliable and valid and have been used in similar studies.[5, 13-17]

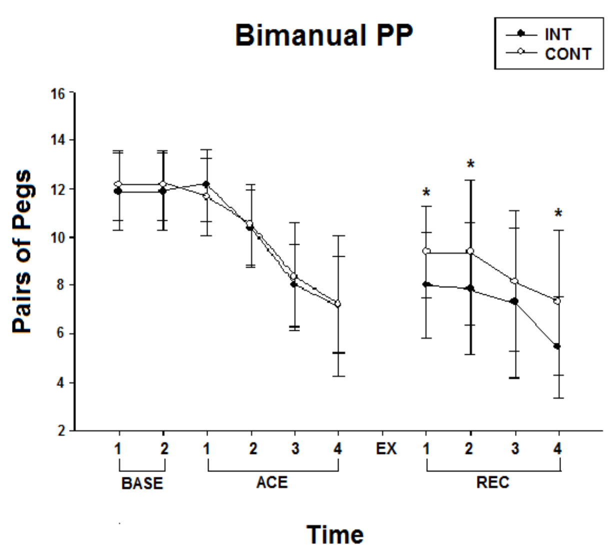
Following the familiarization sessions, volunteers underwent two trials: interval (INT) or continuous (CONT), separated by at least 72 hours. Participants completed both conditions, in random order. Volunteers arrived at the laboratory, voided, and inserted a rectal thermistor (YSI-401) 13 cm beyond the anal sphincter. They were outfitted with skin thermistors on the chest, tricep, thigh, calf, forearm, and distal fourth finger as previously described.[13, 18] The hand remained bare but the volunteers were dressed in a polypropylene crewneck shirt and trousers, socks, and cold weather boots. Following a baseline period in thermoneutral air, the volunteers entered the 5°C environmental chamber and were seated for 90 minutes in mesh-nylon chairs. They then completed 30 minutes of either INT or CONT exercise on a Monark cycle ergometer, matched for 50% of their maximal oxygen consumption. The interval session consisted of ten bouts of 90 seconds of pedalling at 60 revolutions per minute, followed by 90 seconds of static rest. During the continuous session, volunteers pedalled at 60 revolutions per minute for all 30 minutes. To ensure equal caloric expenditure between conditions, expired air samples were assessed. Following the exercise bout, volunteers were seated for the remaining 60 minutes. The details of the methodology and data collection are listed below.

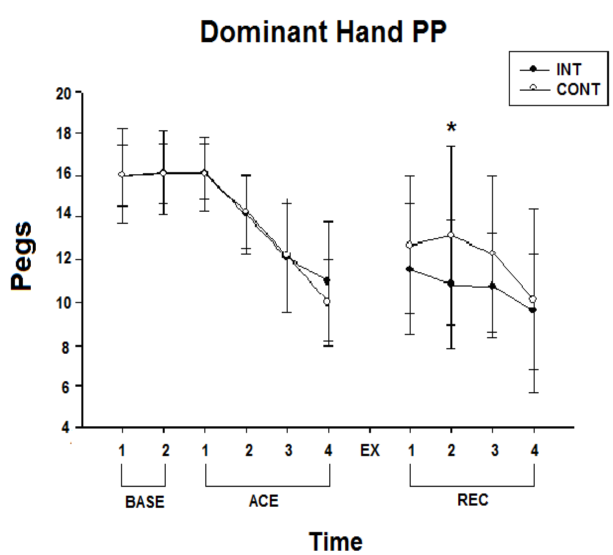
	Thermoneutral BASE	Resting Cold Exposure ACE	Exercise EX	Recovery REC
Purdue Pegboard	1 2	1 2 3 4		1 2 3 4
Stroop Test	BASE	ACE		POST-EX REC
Temperatures	1	1 2 3 4 5 6 7	1 2 3 4 5 6	1 2 3 4 5 6

RESULTS

A 2 (condition) by 10 (time) repeated measures analysis of variance was also conducted for the bimanual PP task. There was a strong trend toward significance for condition (p=.057) as well as a significant main effect for time (p=.000) and a significant condition by time interaction (p=.006). Subsequent post-hoc analysis via paired samples t-tests revealed significant performance differences following interval and continuous exercise. In particular, statistical significance was achieved at the following time points: REC-1 (p=.002), REC-2 (p=.018), and REC-4 (p=.007). A trend towards significance was noted at REC-3 (p=.132).

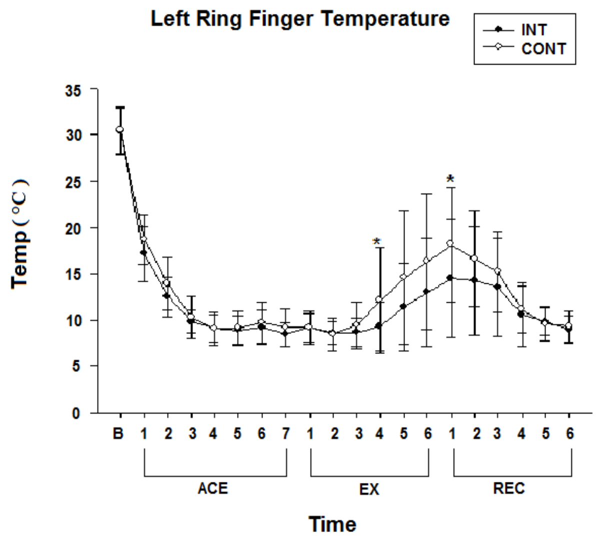
A 2 (condition) by 10 (time) repeated measures analysis of variance was conducted for the dominant (right hand only) PP. There was no main effect for condition (p=.244). However, there was a significant main effect for time (p=.000) as well as a condition by time interaction (p=.005). Subsequent post-hoc analysis via paired samples t-tests revealed better performance with continuous exercise than interval exercise during the recovery period (REC-2; p=.012). There were also trends toward significance at REC-3 and REC-4 time points (p=.124 and p=.066, respectively).

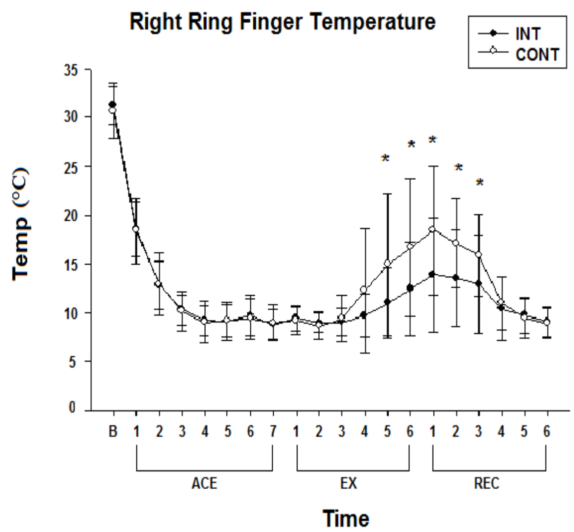




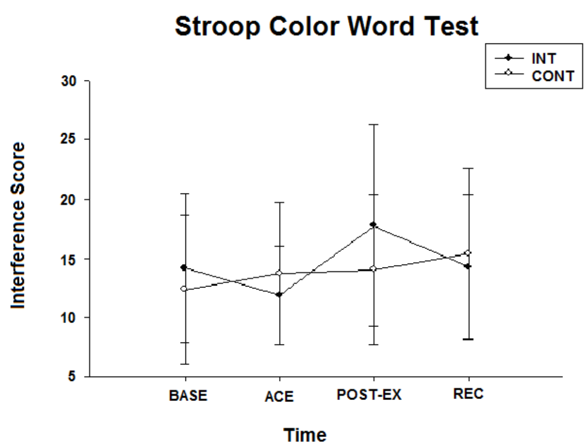
For the left ring finger, a main effect was found for group (p=.014) and time (p=.000) as well as a significant group by time interaction (p=.000). Subsequent post-hoc analysis via paired samples t-tests revealed that continuous exercise resulted in significantly warmer finger temperatures at EX-4 (p=.044; power=.533) and REC-1 (p=.021; power=.486). Trends toward significance were found at EX-3 (p=.181), EX-5 (p=.074), EX-6 (p=.062), REC-2 (p=.058) and REC-3 (p=.058).

For the right ring finger, a main effect was found for group (p=.046) and time (p=.000) as well as a significant group by time interaction (p=.000). Subsequent post-hoc analysis via paired samples t-tests revealed that continuous exercise resulted in significantly greater finger temperatures at EX-5 (p=.029), EX-6 (p=.020), REC-1 (p=.016; power=.667), REC-2 (p=.005; power=.708), and REC-3 (p=.001). A trend towards significance was also found at EX-4 (p=.061).

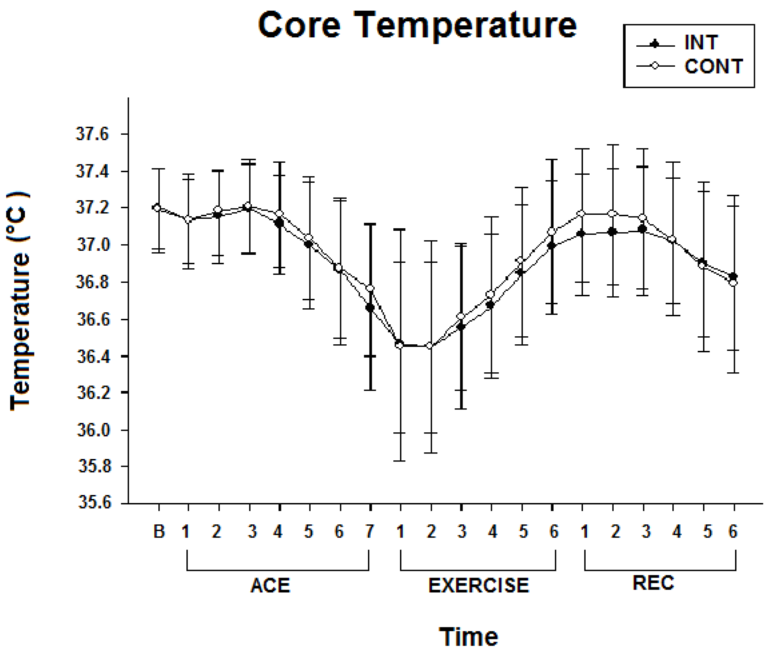




A 2 (condition) by 4 (time) repeated measures analysis of variance was conducted for the SCWT interference score. There was no main effect for condition (p=.647) or time (p=.117), and there was no group by time interaction (p=.117).



A 2 (condition) by 20 (time) repeated measures analysis of variance was conducted for all body temperature sites. For core temperature, a main effect for condition was not found (p=.540). However, a main effect for time was expected and achieved (p=.000) but no condition by time interaction was found (p=.965)



The other skin temperature sites (chest, tricep, thigh, calf, and forearm) all displayed a main effect for time (p=.000) but no main effects for condition (p>.16) or condition by time interaction (p>.24). A significant correlation was also found between average skin temperature and average dominant (right hand) PP scores over time (r=.754 for CONT and r=.740). This is in line with previous work.[3,4]

CONCLUSIONS

These data suggest that continuous exercise is more efficient at increasing finger temperature, and thus manual dexterity in the cold. Further, bimanual dexterity is significantly elevated throughout the hour recovery period from continuous exercise compared to recovery from interval exercise. Although manual performance eventually returns to pre-exercise levels, we suggest that continuous cycling can increase finger temperature to a point where performance is aided immediately post-exercise. It is important to note that core temperature and mean skin temperature were not different between conditions, and finger temperature was the strongest predictor of dexterity performance (r=.75), which is in agreement with previous work.[9, 20] It is hypothesized that central hemodynamics may be altered following continuous cycling and this may cause the increase in finger temperature (and thus enhanced PP performance). This information is important to both the military and civilian populations who must perform both fine and gross motor tasks in cold ambients.

Rapid cognitive processing assessed via the Stroop Test does not seem to be altered in the cold, relative to room temperature performance. In other words, neither the mechanism of arousal or distraction was present. Ishizuka et al (2007) reported similar results using the cold pressor test.[5] However, in the current investigation, there was a nonsignificant trend (p=.117) such that interval cycling may result in more efficient and rapid processing. The SCWT has been likened to vigilance tests in which a large cognitive demand is required for a brief period of time.[21] During INT, the increased anaerobic demand as well as the starting and stopping could have increased brain chemicals and thus broke the monotonous cycle and increased processing speed relative to continuous cycling. This mechanism could be studied further.

In conclusion, CONT is significantly better at increasing manual dexterity in the cold because it is results in greater finger temperatures compared to INT. However, INT seems to be superior in increasing cognitive performance under the same conditions.

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