Effects of Environmental Temperature on Aerobic Training Adaptations

Katherine Marshall, Robert Shute, Megan Vande Hei, Dustin Slivka
University of Nebraska at Omaha, School of Health and Kinesiology, Omaha, NE

Exercise Physiology Lab

ABSTRACT

BACKGROUND: Previously we have demonstrated acute effects of endurance exercise in different environmental temperatures. However, training within these temperatures has not been examined. The purpose of this study is to determine the effect of exercise training in different environmental temperatures on aerobic capacity, body composition, heart rate, sweat rate, core, and skin temperature. **METHODS:** Thirty-six recreationally trained males made 18 visits to the lab and performed a 3-week cycling training protocol in either a 7°C, 20°C, or 33°C environment. Aerobic capacity, body composition, heart rate, sweat rate, core, and skin temperature were measured before and after the acclimation period. During the 3-week acclimation training protocol heart rate, power output, temperature, and sweat rate were measured. **RESULTS:** In 33°C compared to 20°C subjects, VO_{2peak} ($p = 0.02$) and power output ($p < 0.001$) were greater for 20°C subjects following training, whereas core temperature ($p = 0.036$), skin temperature ($p < 0.001$), sweat rate ($p < 0.001$), and heart rate ($p = 0.036$) were higher in 33°C subjects. Body composition improved in both conditions ($p < 0.001$). In 7°C compared to 20°C, VO_{2peak} ($p < 0.001$), body composition ($p < 0.001$), core temperature ($p < 0.001$), sweat rate ($p = 0.05$), and power ($p < 0.001$) improved in both conditions following training. Skin temperature was lower in 7°C ($p < 0.001$). **CONCLUSIONS:** These data indicate that physiological stress produced from exercising in 33°C environments inhibits performance measures. Whereas, 7°C environments allow for greater aerobic performance and training outcomes.

INTRODUCTION

- It is well documented that regular aerobic training produces improvements in aerobic capacity, heart rate, power output, body composition, and thermoregulation.
- We have previously demonstrated that different environmental temperatures have acute effects on endurance exercise capacity.
- The effects of environmental temperature on a 3-week, short-term aerobic training performance measures remain unknown.
- The purpose of this research was to determine the effect of exercise training in different environmental temperatures on aerobic capacity, body composition, and thermoregulation.

METHODS

- Thirty-six recreationally trained, college-aged males (age = 24 ± 5 years, height = 179 ± 7 cm, weight = 86 ± 21 kg) visited the lab for 18 trials over the course of 3 weeks.
- The trials were completed in either a 7ºC, 33ºC, or 20ºC environment.
- Visits 1 and 18: subjects performed a VO_{2peak} on the cycle ergometer and body composition was assessed via hydrostatic weighing.
- Visits 2 and 17: subjects performed a 1 hour tolerance trial in their assigned temperature at 50% of watts associated with VO_{2peak}.
- Visits 3-16: subjects cycled on a cycle ergometer for 1 hour at a RPE of 15 in an environmental chamber in their assigned temperature.
- Stats: 2-way ANOVA (Trial x Temp), $p<0.05$ considered significant.

IMPACT OF 33°C

Table 1. Participant Descriptive Characteristics

	Temperature			
	33 °C		20 °C	
	Trial			
Measurement	Pre-training	Post-training	Pre-training	Post-training
VO_{2peak} (ml · kg^{-1} · min^{-1})	37.4 ± 1.4	39.2 ± 1.8	39.4 ± 2.8	44.2 ± 2.5*
Power (W)	115.7 ± 6.7	141.1 ± 7.7	119.3 ± 6.8	151.8 ± 8.5*
Body Fat (%)	22.0 ± 2.1	20.9 ± 2.3†	20.7 ± 4.9	19.6 ± 4.8†
Heart Rate (bpm)	152.6 ± 4.7	140.4 ± 4.6*	141.4 ± 4.6	127.2 ± 3.2

Data are mean ± SE. *, $p < 0.05$ between temperatures. †, $p < 0.05$ from pre-training

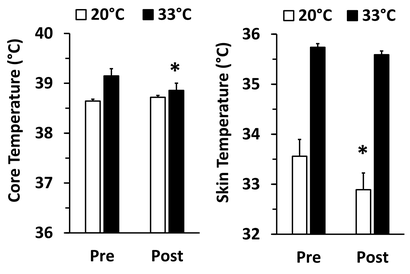

Figure 1. 33°C Core and Skin Temperature (°C). Pre-training and post-training core and skin temperature in 33°C and 20°C groups. Data are mean ± SE. *, $p < 0.05$ from pre-training of the same temperature. †, $p < 0.05$ from 20°C.

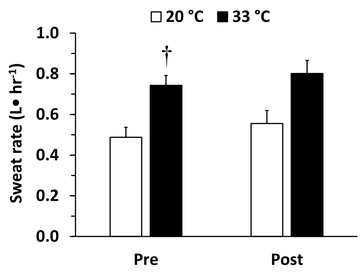

Figure 2. 33°C Sweat Rate (l·hr^{-1}). Pre-training and post-training in 33°C and 20°C groups. Data are mean ± SE. *, $p < 0.05$ from pre-training of the same temperature. †, $p < 0.05$ from 20°C.

- Performance measures of VO_{2peak} and power were lower overall in 33°C environment compared to 20°C and greater strain was placed on the cardiovascular system in the heat.
- Classical core temperature acclimation in the 33°C environment.
- Reduced skin temperature in 20°C but not 33°C.
- Sweat rate was higher in 33°C compared to 20°C regardless of training status.

IMPACT OF 7°C

Table 2. Participant Descriptive Characteristics

	Temperature			
	7 °C		20 °C	
	Trial			
Measurement	Pre-training	Post-training	Pre-training	Post-training
VO_{2peak} (ml · kg^{-1} · min^{-1})	40.8 ± 1.8	45.5 ± 2.3†	39.4 ± 2.8	44.2 ± 2.5†
Power (W)	131 ± 7	167 ± 6†	119.3 ± 6.8	151.8 ± 8.5†
Body Fat (%)	21.7 ± 2.1	20.7 ± 2.1†	20.7 ± 4.9	19.6 ± 4.8†
Heart Rate (bpm)	147.4 ± 4.4	129.1 ± 2.8	141.4 ± 4.6	127.2 ± 3.2

Data are mean ± SE. *, $p < 0.05$ between temperatures. †, $p < 0.05$ from pre-training

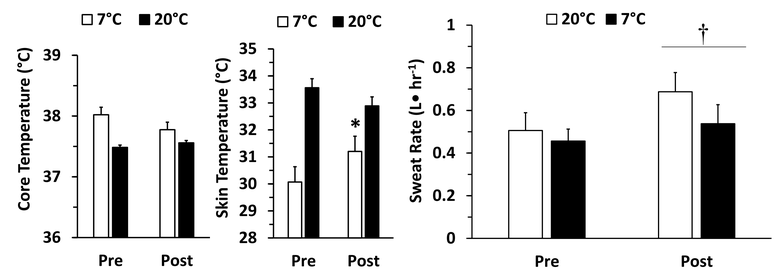

Figure 3. 7°C Core and Skin Temperature (°C). Pre-training and post-training core and skin temperature in 20°C and 7°C groups. Data are mean ± SE. * $p < 0.05$ from pre-training of same temperature.

Figure 4. 7°C Sweat Rate (l·hr^{-1}). Pre-training and post-training in 7°C and 20°C groups. Data are mean ± SE. †, $p < 0.05$ from pre-training.

- Classical acclimation was evidenced by increased skin temperature in 7°C but not 20°C.
- Sweat rate improved with training regardless of temperature.

CONCLUSIONS

- Performance measures were dampened in the 33°C environments due to the effects of heat stress, whereas there were no differences between the 7°C and 20°C environment.

- The research was funded by the Department of Defense United States Army Medical Research and Materiel Command (DOD USAMRMC: W81XWH-15-2-0075).