

Hot Environments Decrease Exercise Capacity While Elevating Multiple Neurotransmitters Independent of Humidity

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1 INTRODUCTION

The purpose of this study was to test the hypothesis that different neurotransmitters and hormones are presented at exercise fatigue in hot temperatures with differing relative humidities (RH).

2 METHODS

Eight trained male athletes performed a graded maximum oxygen uptake (VO₂max) test in five different environmental conditions: 21°C/20% RH (Normal); 33°C/20% RH (Hot 20%), 33°C/40% RH (Hot 40%), 33°C/60% RH (Hot 60%), and 33°C/80% RH (Hot 80%). Blood samples were taken pre- and post-exercise and analyzed for noradrenaline (NA), adrenaline (ADR), dopamine (DA), serotonin (5-HT), 5-hydroxyindoleacetic acid (5-HIAA), and prolactin (PRL). Weight, oral temperature and skin temperature were recorded pre- and post-exercise. Heart rate was monitored continuously throughout exercise.

3 RESULTS

Compared to Normal, Hot 20%, Hot 40% and Hot 80% had lower VO₂max levels ($P < 0.05$). Pooling data across all five conditions, NA ($P < 0.0001$), PRL ($P < 0.0001$), 5-HT ($P = 0.002$), 5-HIAA ($P = 0.029$), and DA ($P = 0.016$) levels were affected by exercise, with the levels each being significantly associated with performance time. However, ADR did not show any significant effect between pre- and post-exercise ($P = 0.187$).

4 DISCUSSION

The main findings of this study were two aspects. First, hot-wet condition (Hot 80%) and hot-dry

conditions (Hot 20%, Hot 40%) have similar negative effects on VO₂max performance. This is in a protocol with a relative short duration – “in real” life – e.g. a prolonged competition the negative effect of high humidity on thermoregulation would be expected to aggravate hyperthermia and hence have a larger effect on VO₂max and performance. Second, irrespective of thermal status, NA, DA, PRL, 5-HT, and 5-HIAA are associated with the performance time of the VO₂max protocol. Although the finding of neurotransmitters being impacted by exercise fatigue in heat is not a new concept, this is one of the first laboratory studies to systematically investigate the effects of hot temperature and different humidities on multiple neurotransmitters simultaneously. The effects of a hot environment on aerobic performance have been well documented, but the specific influence of relative humidity on performance and on the physiological response to exercise remains largely unexplored. Although exercise capacity at moderate intensity in a warm environment is progressively impaired as the relative humidity increases, the present investigation demonstrated that VO₂max was generally lower in hot conditions than in Normal and there were no differences across humidity levels. There was a significant effect of time for NA, PRL, 5-HT, 5-HIAA, and DA concentrations after exercise in the five different conditions. The levels of NA, DA, PRL, 5-HT, and 5-HIAA were strongly associated with exercise time, suggesting that the duration and/or intensity of exercise had an important influence on neurotransmitter levels irrespective of environmental conditions. High correlation of NA, DA and 5-HT with performance time of VO₂max provides support for the hypothesis that central fatigue should be determined by the collaboration of the different neurotransmitter systems, with the most important role possibly being for the catecholamines DA, NA, and 5-HT in high temperature.

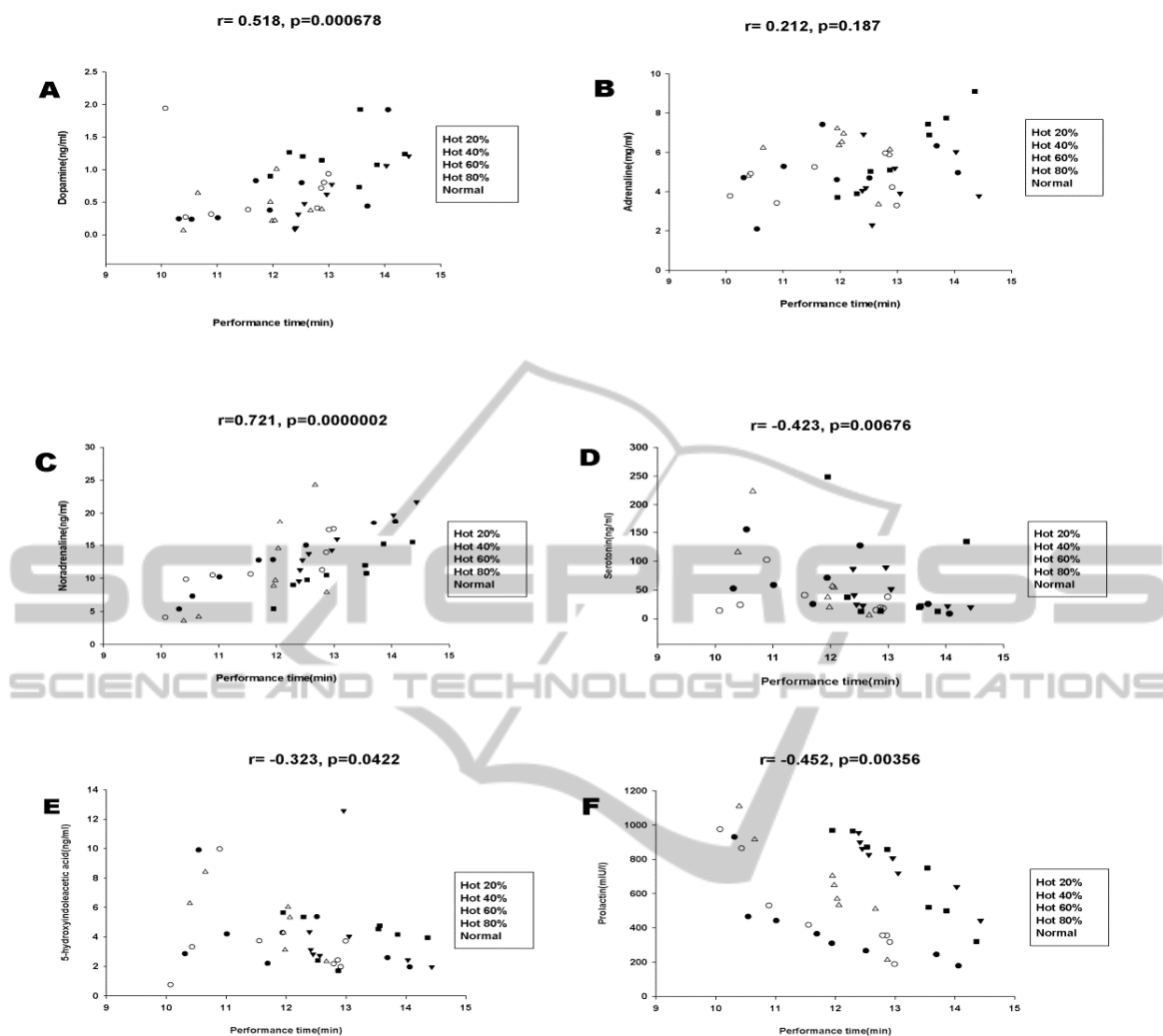


Figure 1: Relationships between performance time versus post-exercise concentrations of Dopamine (A), Adrenaline (B), Noradrenaline (C), Serotonin (D), 5-hydroxyindoleacetic acid (E) and Prolactin (F).

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