University of Victoria | Graduate Studies

Notice of the Final Oral Examination
for the Degree of Doctor of Philosophy

of

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MSc (Louisiana State University, 2012)
BKin (University of Calgary, 2008)

"The impact of rate of thermal acquisition on cerebral oxygenation and haemodynamics, cerebral neural function, perceptual decision-making, and salivary cortisol concentration"

Department of Exercise Science, Physical and Health Education

Wednesday, April 17, 2019
1:00pm
Clearihue Building
Room B007

Supervisory Committee:
Dr. Lynneth Stuart-Hill, Department of Exercise Science, Physical and Health Education, University of Victoria (Supervisor)
Dr. Olav Krigolson, Department of Exercise Science, Physical and Health Education, UVic (Member)
Dr. Patrick Neary, Department of Kinesiology and Health Studies, University of Regina (Outside Member)

External Examiner:
Dr. Ronald Byrd, Department of Education, Southern Arkansas University

Chair of Oral Examination:
Dr. Natia Frank, Department of Chemistry, UVic

Dr. David Capson, Dean, Faculty of Graduate Studies

Abstract

This study examined the effects of rapid and uncompensable core temperature (Tc) acquisition on cerebral oxygenation and haemodynamics, cerebral neural function, decision-making, and rate and magnitude salivary cortisol appearance. Fourteen male subjects (mean age, 33.6 ± 12.1 years) performed an incremental treadmill exercise test to a termination criterion in a control session (CON) and an experimental session (PPE). The incremental treadmill exercise test protocol included an initial 5-minute stage at 3.5 mph and a 0% grade, the second stage was 5-minutes at 3.5 mph at 4% grade, the third stage was 50-minutes at 3.5 mph and an 8% grade, and the final stage was 1-hour at 3.5 mph and a 12% grade. The Instrumentation included a near-infrared spectroscopy (NIRS) monitor, MUSE EEG monitoring system, Equivital integrated physiological monitoring system, Tc capsules, and salivary cortisol oral swabs and ELISA kit for salivary analysis. Important physiological results were significant differences in the physiological strain index (PSI) at all common points of measurement. Important cerebral oxygenation and haemodynamics results were a plateau in left-side prefrontal cortex (PFC) O_2Hb and tHb at roughly Tc 38°C in both CON and PPE, 80% of TTT in CON, and 60% of TTT in PPE. Additionally, there was higher left-side PFC activation during PPE as indicated by a significant decrease in TSI % from start to end of exercise and double the decrease in TSI % per minute in PPE when compared to CON. There were no significant differences during the CON session. An analysis of frontal theta EEG power results showed a significant decrease when comparing pre- and post-exercise values during a Go/No-go test in PPE ($F(1,13) = 6.069$, $p = 0.027$)). There was also a significant difference when evaluating incorrect responses between pre- and post-exercise values in PPE ($F(1,13) = 12.785$, $p = 0.0014$)); these differences were not observed during CON. There was also a difference in the rate of cortisol appearance (CON = 0.002 μg dL-1 min-1; PPE = 0.018 μg dL^{-1} min^{-1}). In the PPE condition, mean cortisol values between start of exercise and the measurement point associated with Tc 38°C and between the start and end of exercise during PPE were significantly different ($p \leq 0.01$). Lastly, there was a significant difference ($p \leq 0.05$) between magnitude of cortisol values at the termination between CON and PPE. These data suggest that rapid and uncompensable Tc acquisition during PPE caused an altered cerebral oxygenation and haemodynamic response in the left-side PFC when compared to CON. The left PFC could be working harder to prevent fatigue in PPE. This could have implications for cognitive processes during and/or following exercise in the heat while wearing PPE. These data also suggest rapid and uncompensable Tc acquisition results in decreased cognitive control. This could have implications for individuals whose occupation requires PPE and critical decision making while experiencing rapid Tc heat storage. Lastly, these results show a difference between PPE and CON in regards to rate and magnitude of salivary cortisol appearance, potentially affecting individuals chronically exposed to acute heat stress. Increased acute cortisol concentration decreases anabolic response, cognitive performance, and mood states. The chronic effects of increased cortisol concentration are many: largely related to atherosclerosis development and subsequent cardiovascular disease. Additional issues include anthropometric, endocrine, metabolic, and haemodynamic disturbances. This study makes a strong argument for the rate of thermal acquisition factor. CON and PPE differences in PSI at all measurement points provides justification and support for the changes in other variables. Rapid and uncompensable Tc acquisition needs to be taken into account, as it potentially puts the lives of employees who wear PPE and those around them at risk.