Cortical activity and motor unit recruitment during a high intensity endurance exercise protocol in normothermic and heated environments

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Background: Exercise physiology research is often focused on exercise protocols that highlight feed-forward mechanisms with a pre-determined intensity, in which the physiological changes are directly related to the demand that is required to perform at the desired level. Recently, a clamped rating of perceived exertion (RPE) protocol has been introduced. When beginning exercise, the initial work rate is set by feed forward mechanisms, however, power output is quickly adjusted based on anticipated needs to complete the exercise protocol, likely influenced by afferent feedback. The present study is a subset of data looking at changes occurring in neural processes and also in the periphery during a 60 min clamped RPE cycling protocol of high intensity (between hard and very hard, or RPE 16) in heated (HEAT) and normothermic (NORM) environments. We looked at differences in activity in cortical areas of the sensorimotor and corticomotor areas of the brain (Pz and Cz) using electroencephalography (EEG) and motor unit recruitment in the vastus lateralis muscle (VL) using electromyography (EMG) over the duration of the exercise protocol. The purpose of the study was to determine differences in neural activity and muscular activity during a subjective high intensity endurance exercise task in both normothermic and heated environments.

Methods: Fit, healthy males, ages 18-35 were recruited for the study (n=4). Participants were required to cycle for 60 min at an RPE 16 in either HEAT or NORM conditions (35˚C or 22˚C, respectively; 60% humidity). Two minutes of baseline EEG data were collected prior to beginning the cycle protocol. During exercise, a 60s snap shot (SS) of power output (PO), EEG and EMG data was taken every 10 minutes beginning at 4:30, 14:30, 24:30, 24:30, *etc*. (SS1, SS2, SS3, *etc*.), while the participant maintained exercising at the same RPE 16 intensity. Heart rate and RPE was recorded at the end of every snapshot.

Statistical Analysis: A two-way repeated measures ANOVA was run for changes in trial × time. Where significant differences were found, a paired t-test was run to determine significance between conditions. Significance was set at the alpha (α) level of $P \leq 0.05$.

Results: RPE was significantly different in NORM between SS1 and SS2 and SS6 ($P \leq 0.05$). No significant differences were found in RPE for the HEAT or between conditions. In NORM, all PO for SS2-SS6 were significantly different than SS1 $P \leq 0.05$). There were also significant differences between SS2 and SS3, SS4, SS5, SS6 ($P \leq 0.05$) and SS3 and SS6 ($P \leq 0.05$). PO in HEAT was only significantly different between SS2 and SS6 and SS3 and SS6 ($P \leq 0.05$). There was a significant difference between HEAT and NORM found in SS2 and SS4 ($P \leq 0.022$ and 0.03, respectively). There were no significant differences in any EMG data within or between conditions. EEG data showed significant differences in Pz α percent change from SS1 in SS2 ($P=0.048$), SS3 ($P=0.028$) and SS5 ($P=0.001$) in NORM. Cz α percent change SS1 showed significant differences between SS1 and SS3 ($P=0.041$), SS2 and SS6 ($P=0.027$) and SS3 and SS6 ($P=0.026$). No other changes were found in individual α or β bands in NORM, HEAT, or between conditions. Finally, there was significant difference in percent change from SS1 and all other SS in Pz and Cz α/β ratio in NORM and HEAT ($P \leq 0.05$). There was also a significant difference in NORM Pz and Cz change in α/β ratio between SS4 and SS6 (0.017 and 0.001, respectively). A final significant difference was found in the Pz α/β ratio in the HEAT between SS4 and SS5 ($P=0.03$). No changes were found between NORM and HEAT for α/β ratio in either Pz or Cz.

Conclusions: Although high intensity exercise with a clamped RPE shows a significant decrease in power over time, especially in normothermic conditions, no significant differences were found for any changes in motor unit recruitment, or β bands within the EEG. A significant change in α bands in both the sensori and motor cortices during exercise suggests changes in cortical activity that may be resultant from demands necessary to perform the exercise task, though whether the changes in cortical activity are feed forward or backward is indiscernible. Finally, heat does not seem to have a large affect on either performance or physiological alterations that occur during the high intensity, clamped RPE exercise task.