CENTRAL COMMAND HYPOTHESIS: FROM CEREBRAL PREFRONTAL CORTEX TO BLOOD VESSELS OF SKELETAL MUSCLE

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Abstract

The central mechanism controlling the cardiovascular system during exercise was first proposed by Zuntz and Geppert (1886) and Johansson (1895) 130 years ago and termed cortical irradiation by Krogh and Lindhard (1913) and later central command by Goodwin et al. (1972). Central command is defined as a descending signal serving feedforward control of the cardiovascular system in association with motor command. Unfortunately, central sites responsible for generating central command and descending pathways to the autonomic nervous system are not known. According to the findings obtained from decerebrate animals, we hypothesized that the cerebral cortex is not essentially important for generating central command but may trigger a central command generator within the brain stem and that, taking account of a time delay (several seconds) in the effector responses, in advance activation of the cerebral cortex prior to the onset of exercise is necessary for rapid circulatory control. To test the hypothesis, we measured oxygenations of both prefrontal cortex and skeletal muscle (as index of regional tissue blood flow) during one- or two-legged cycling exercise using near infrared spectroscopy. In advance oxygenation of the prefrontal cortex was observed approximately 5 s prior to the onset of voluntary exercise with arbitrary start not only in a restrained laboratory condition (Matsukawa et al. 2015) but also in a freely-moving condition. However, when exercise was forced to start by cue, such oxygenation of the prefrontal cortex was absent. When comparing the cardiovascular responses, arterial pressure and peripheral resistance were more decreased at the onset of exercise with arbitrary start than with cued start, although there were significant but small differences in the cardiac responses. Concomitant greater increases in femoral blood flow and muscle oxygenation in non-exercising leg were observed at the onset of arbitrary one-legged exercise (Ishii et al. 2016). Based on the temporal relationship and characteristics, it is suggested that the in advance activation of the prefrontal cortex may play a role in triggering generation of central command, which may contribute to vasodilatation of muscular blood vessels.

Keywords: Central command, Cerebral prefrontal cortex, Voluntary exercise, Skeletal muscle vasodilatation,

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