VIII. 3. Regional Brain Activity at Different Exercise Intensity

Fujimoto T.¹, Itoh M.², Tashiro M.², Musud M.², Ishii K.¹, Targino Rodrigues dos Santos², and Watanuki S.²

¹Department of Medicine and Science in Sports and Exercise, Tohoku University Graduate School of Medicine,
²Division of Nuclear Medicine, Cyclotron and Radioisotope Center, Tohoku University.

Introduction

Exercise often involves emotional changes. At higher exercise intensity, we easily get to exhaustion, but could also get refreshed at the same time. In addition we retain the sense of heavy exercise for a relatively long time. Therefore, we hypothesized that at higher exercise intensity, brain regions involving long-term memory within the limbic system as well as the motor area could be activated. The purpose of this study was to examine the regional brain metabolism induced during bicycle exercise at different intensity.

Methods

Regional brain activity was detected by positron emission tomography (PET) and glucose-tracer 18F-fluorodeoxyglucose (FDG) in 7 male volunteers (22.9 ± 1.6 year, VO2max 46.2 ± 2.2 ml/kg-min). Each subject cycled at 3 different workloads (30%, 55% and 70% VO2max) using a bicycle ergometer on three separate days with an interval of more than two days. FDG (59 ± 11.2 MBq) was injected 5 minutes after the beginning of exercise and total exercise time was 35 minutes. PET emission scan started approximately 45 min after the termination of exercise using an SET2400W whole-body tomography system, (Shimadzu Co, Japan), with an intrinsic spatial resolution of 3.9 mm. The tomography system has 32 rings of BGO crystals separated by axial intervals of 3.15 mm covering an axial field of 20 cm. Transmission scan followed the emission scan, using a ⁶⁸Ge/⁶⁸Ga rotating external line source for correction of tissue attenuation. For statistical analysis, all brain images were anatomically normalized by mathematical calculation including linear and non-linear transformation to minimize inter-subject anatomical
variation using Statistical Parametric Mapping (SPM99)\textsuperscript{1,2}. Brain images were smoothed using 16mm filter to improve signal to noise ratio. All pixel values were normalized to an arbitrary global mean value of 50 mg/100ml/min by ANCOVA, in order to exclude the effects of inter-subject variability in global cerebral glucose metabolism. A paired t-test was applied to each voxel; only voxel clusters were kept with voxels corresponding to p<0.001 in a single test and cluster size 10 voxel minimum, in one way (55% - 30%, 70% - 55%, 70% - 30%).

**Results**

As compared to exercise at 30% \( \dot{VO}2_{max} \), exercise at 55% \( \dot{VO}2_{max} \) activated a distinct region in the thalamus (Fig. 1A). As compared to exercise at 55% \( \dot{VO}2_{max} \), exercise at 70% \( \dot{VO}2_{max} \) activated regions in the superior frontal gyrus, the right superior temporal gyrus, the cingulate gyrus and the left brainstem (Fig. 1B). As compared to exercise at 30% \( \dot{VO}2_{max} \), exercise at 70% \( \dot{VO}2_{max} \) activated areas in the right insula, the left caudate, the bilateral cingulate gyrus and the left cerebellum (Fig. 1C). There was no marked increase in the regional brain activity of primary motor area relative to exercise intensity.

**Discussion/Conclusion**

These results clearly show that the brain regions related to emotion and memory were more activated at higher exercise intensity. These areas making projections to each other may subconsciously make episode memory of the exercise experience at higher exercise intensity. Exercise of higher intensity may be beneficial for pathophysiological states in which brain activity involving emotion or memory is down regulated, such as depression or amnesia.

**References**

Figure 1A shows brain activity between 55% VO2max - 30% VO2max exercise.
Figure 1B shows brain activity between 70% VO2max – 55% VO2max exercise.
Figure 1C shows brain activity between 70% VO2max – 30% VO2max exercise.