

## Anterior Cingulate Cortex Activates after Achievement of Obligatory Purpose

著者	Fujimoto T., Tashiro M., Chiba N., Masud M. M., Watanuki S., Ishii K., Gondoh Y.
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## VIII. 16. Anterior Cingulate Cortex Activates after Achievement of Obligatory Purpose

*Fujimoto T.<sup>1</sup>, Tashiro M.<sup>2</sup>, Chiba N.<sup>3</sup>, Masud M. M.<sup>2</sup>, Watanuki S.<sup>2</sup>,  
Ishii K.<sup>3</sup>, and Gondoh Y.<sup>4</sup>*

*<sup>1</sup>Center for Advancement of Higher Education, Tohoku University*

*<sup>2</sup>Division of Cyclotron Nuclear Medicine, Cyclotron and Radioisotope Center, Tohoku University*

*<sup>3</sup>Department of Medicine and Science in Sports and Exercise, Graduate School of Medicine,  
Tohoku University*

*<sup>4</sup>Seika Women's Junior college, Science of Early Childhood Care and Education*

### **Introduction**

After a few days of consecutive exercise, people often feel positive psychological changes not only immediately but also the next day after exercise, despite their fatigue not recovering completely. Our purpose was to study a part of the mechanism of this positive psychological change. We observed the change in regional brain activities 24 hr after four days consecutive exercise using positron emission tomography (PET) and <sup>18</sup>Fluorine-fluoro-deoxy-glucose (<sup>18</sup>F-FDG).

### **Methods**

Subjects were nine healthy male volunteers (age, 21.2±1.9 years, means ± SD). Subjects performed the intermittent exercise during four continuous days. PET scans were performed two times, before the exercise period and 24 hr after the exercise period. During the exercise period, subjects pedaled a bicycle ergometer for 90 min two times a day (total 180 min) at workloads of 55% of maximum aerobic power ( $\dot{V}_{O_{2max}}$ ). All subjects refrained from eating and drinking at least 6 hr before PET scan. Before PET scans, all subjects were requested to rest on a bed for 30 min. After <sup>18</sup>F-FDG (37 MBq) injection, subjects continued to rest for an additional 30 min. After the rest, a whole brain three-dimensional (3D) static emission scan was performed. The voxel-based statistical analysis of the relative parametric glucose metabolic rate images was conducted using the Statistical Parametric Mapping<sup>1</sup> software version 2002 (SPM2) and Matlab 6.5.1 for Windows (Math

Works, Natick, MA, USA). For statistical analysis, all pixel values were normalized to an arbitrary global mean value of 50 mg/100 ml/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 of 50 voxel minimum, in two ways (before the exercise period - after exercise 24 hr later, and 24 hr after exercise- before the exercise period). Subjects results were recorded on the Mood checklist–short form 2 (MCL-S.2), visual analogue scales (VAS) as a subjective index and critical flicker fusion frequency (CFF).

## **Results**

$^{18}\text{F}$ -FDG uptake of the left anterior cingulate cortex (ACC) was significantly higher 24 hr after exercise than before the exercise period (uncorrected,  $p < 0.001$ , Fig. 1). The fatigue VAS was significantly elevated on the 3<sup>rd</sup> and the 4<sup>th</sup> exercise days compared with the value before the exercise period ( $p < 0.01$  and  $p < 0.05$ ). Fatigue VAS, 24 hr after exercise recovered to the level before the exercise period. CFF of the 4<sup>th</sup> exercise day was significantly lower than before the exercise period ( $p < 0.05$ ), and CFF at 24 hr after exercise had declined more (Fig. 2). Pleasure score declined significantly from 2<sup>nd</sup> to 4<sup>th</sup> exercise day as compared with that of before the exercise period ( $p < 0.05$ ), and it recovered 24 hr after exercise.

## **Discussion/Conclusion**

These results demonstrated that subjects would be tired at least neurophysiologically (CFF decrease), but they would not feel much fatigue or stress psychologically 24 hours after exercise. This discrepancy on recovery between the CFF, the pleasure score, and fatigue VAS level might be related to the ACC function.

## **Reference**

- 1) Friston K. J., *Neuroimage* 4 (1996) 97.

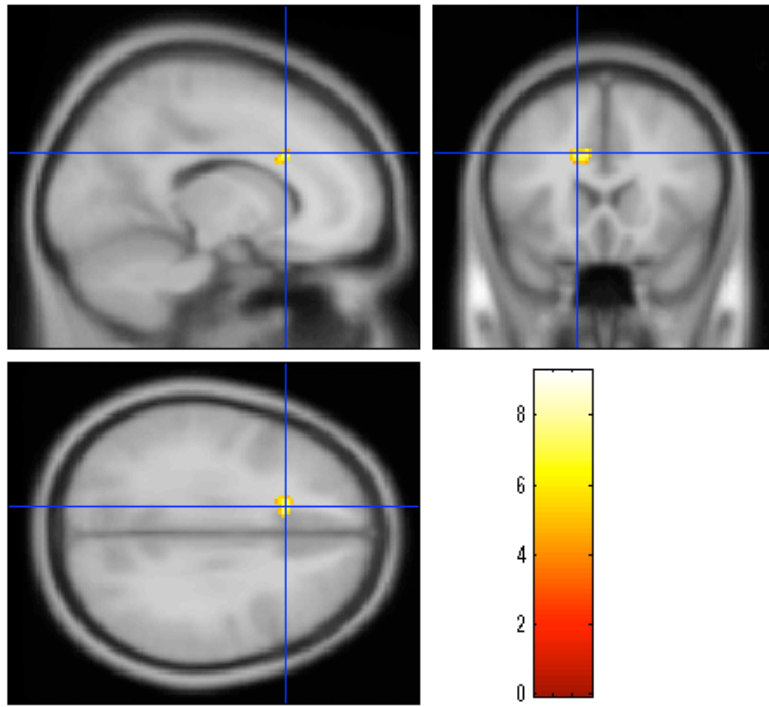


Figure 1. The  $t$ -statistics superimposed on the subject's average MR brain image. Increase in normalized  $^{18}\text{F}$ -FDG up take on left Anterior cingulate cortex (ACC) (Brodmann 32) after exercise 24 later in comparison with that of previous exercise period. Statistical threshold was set at  $P < 0.001$  (uncorrected) for height threshold and 50 voxels minimum for extent threshold. A:sagittal view, B:cornnal view, C:anxial view.

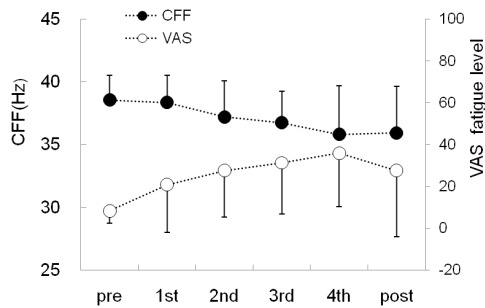


Figure 2. Change in fatigue VAS and CFF during experiment. \* $p < 0.05$  and # $p < 0.01$  vs. previous exercise period. Values are expressed as means  $\pm$  SD.

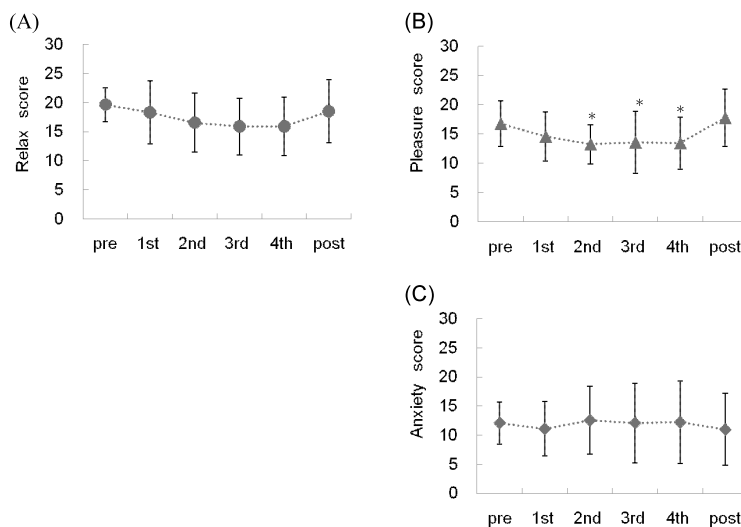


Figure 3. Change in MLC-S.2 factor scores during experiment. A; Relax score, B; Pleasure and C; Anxiety score during exercise period. Values are expressed as means  $\pm$  SD. \* $p < 0.05$  vs. previous exercise period. Number of subjects are 9.