Effects of Negative Stimulation After Exercise on Frontal Asymmetry in Unregular Exercisers

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Abstract. As a signal to recognize emotion, the electroencephalogram (EEG) is used widely. Frontal asymmetry is not only related to emotion, but also affected by exercise. The purpose of our research is to explore the effects of exercise for negative emotion, and how the activity of the frontal of the college students who did not exercise regularly is. We used the frontal asymmetry between F3 and F4 channels of the alpha band. The result showed that the power of frontal asymmetry increased after exercise compared to that before exercise within 3 seconds after stimulation, and the change of the power during the 2nd second was more obvious. The activity of the frontal of the students without exercise habits can be altered by exercise. The frontal asymmetry is related to emotion, which confirms that exercise has an effect on the students without exercise habits after negative stimulation.

1. Introduction
Emotional recognition plays an important role in the study of the human emotions. In recent years, some physiological signals, such as electrocardiogram (ECG) [1], electromyogram (EMG) [2], electroencephalogram (EEG) are widely used to recognize emotion [3, 4]. In these physiological signals, we are more inclined to use EEG signals to recognize emotion, because the emotion is most closely related to the brain.

The frontal asymmetry was first analyzed by Davidson [5], which then received considerable attentions. For example, the frontal asymmetry is found to be closely related to emotions [6]. In addition, the frontal asymmetry has been used to recognize emotions [7]. Therefore, the use of frontal asymmetry to analyze negative emotions is feasible.

Some researchers have explored the effects of exercise on brain activity. The aerobic exercise can recover the amplitude of low-alpha wave after imposing the sound and mental stressors [8]. And the effect of different intensity of exercise on the asymmetry is studied by [9]. In order to study the relationship between exercise and the frontal asymmetry of alpha wave, we compared the changes of what? Before and after intensive cycling exercise for all subjects. The result showed that the asymmetry increased significantly after exercise, especially within the 2nd second after stimulation for most subjects. Then we compared the frontal asymmetry index within three seconds of post-exercise stimulation, it was shown that the asymmetry index in the 2nd second reaches its maximum. We
We conclude that for most people who do not exercise regularly, the exercise can increase the asymmetric index after negative emotional stimulation, and maximum increase at the 2nd second after stimulation. This finding poses a great potential for us to study the influence of exercise on emotion in the future.

2. Materials and methods

2.1. Experimental condition
We recruited 41 healthy college students (18-25 years; 21 male and 20 females) as subjects. The participants who did not do exercise regularly were selected out by questionnaires. Emotional stimuli selected from the International Affective Picture Stimuli (IAPS) [10]. Before and after the exercise, a total of 24 pictures of neutral, positive and negative emotion labels were used to stimulate the emotions of the subjects, and the EEG signals of all the subjects were recorded by a 32-electrode cap. The specific process is as follows:
1. Rest for a minute
2. Look at the picture for 6 seconds, each picture is separated by 24 seconds.
3. Do medium-intensity cycling for 30 minutes.
4. Rest for 20 minutes.
5. Repeat Step 2 with different pictures.

2.2. Frontal asymmetry
There are some studies on the correlation between frontal asymmetry and emotion. The current study indicates that spectral asymmetry index is able to discriminate among the effects of negative, neutral and positive emotions though human EEG [11]. These studies indicate that the left frontal is associated with positive emotions, and the right frontal is associated with negative emotions [12,13]. In addition, F3 and F4 channels are related to information processing of emotion and cognition [14]. Specifically, we calculate the asymmetry index ASM using the alpha power difference between the two electrodes of F4 and F3, as shown in Equation 1.

\[ ASM = P_{F4} - P_{F3} \]  

2.3. Analysis
After collecting EEG signals from 41 subjects, the EEG signals of 33 of them were available. For each EEG signal, 16 trails (8 before and 8 after exercise) were extracted from the data of 1 second and 3 second before and after negative picture stimulation (the data of the first second served as baseline). The reference electrodes are A1 and A2, and the sampling frequency is 250 Hz. We only use F3 and F4 electrodes to get 8-13Hz alpha wave by using filter. Then the power of each trial F3, F4 is calculated, and the ASM of each trial is calculated. 16 trails of each participant were divided before-exercise group and after-exercise group, and the average ASM of the two groups was calculated respectively.

3. Result and discussion
We used F3 and F4 electrodes to collect, preprocess, filter and de-baseline the EEG signals of 33 subjects, and calculated the power of alpha band of each trail within three seconds after stimulation. We compared ASM in 1st second, 2nd second and 3rd second before and after exercise, as shown in Figure 1.
Figure 1. ASM contrast of 33 subjects before and after exercise by negative picture stimulation. The blue line indicates before-exercise, and the orange line indicates after-exercise. The order is 1st, 2nd, 3rd after stimulation.

As it is shown in Figure 1, individual differences have a great impact on the amplitude of ASM. Within three seconds after stimulation, the fluctuation of the ASM for each participant is very clear. And there is no regularity in the amplitude change of the ASM among individuals, for example, some subjects have negative and positive ASM number after negative stimulation before and after exercise. So, we analyzed the brain activity of each subject before and after exercise. It found that for most subjects, the ASM value of negative stimulus increased significantly after exercise. In other words, left frontal activity increased compared with pre-exercise. However, there were also some subjects whose left frontal activity was weaker than that before exercise. Perhaps for a small number of people, intensity was not appropriate, and the intensity affected the changes in the brain area of the subjects. Therefore, for most subjects, the neutral intensity exercise set by the experiment is suitable for their habits, and the response after stimulation also shows that exercise has an impact on left frontal activity, which is corresponding to positive emotions. Furthermore, we can find that the ASM in the 2nd second after exercise has the most obvious effect on the above situation by comparing the ASM in the 1st second and 3rd second. Therefore, exercise has the greatest effect on the ASM value in the 2nd second after stimulation. In other words, exercise has the best effect on the emotion of negative stimulation in the 2nd second.

4. Summary
Our study analyzed changes in frontal activity after cycling for negative picture stimulation in people without exercise habits. The results showed that exercise can increase left frontal activity after stimulation for most subjects. And the effect is most obvious in the 2nd second. The activity of the left frontal is related to positive emotions, so our research shows that neutral intensity exercise has a positive impact on emotions. Specifically, the ASM value in the 2nd second after stimulation is used as a variable in the emotional classification.

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