Original Research

A Single Bout of Moderate Intensity Exercise Improves Concentration Level on Teenagers

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ABSTRACT

Background: Physical exercise has a lot of benefit for health. However, the effect of cognitive function such as concentration in teenagers has yet been known.
Aims: The objective of this study was to analyze the effect of a single bout or acute moderate intensity physical exercise on the level of concentration in teenagers.
Methods: The subjects of this study were 32 16-18 years old teenagers, divided into two groups, control (C) and exercise (E) groups. Each group consisted of 8 boys and 8 girls. The E group did a single bout of moderate exercise using ergocycle. Physical exercise duration was 15 minutes, preceded by 5 minutes of warming up and then followed by 5 minutes of cooling down exercise. The concentration level was measured using the response period to sound stimulation (in second), measured with reaction time machine pre- and post-treatment. Faster response showed better concentration level and *vice versa*. Data were analyzed using paired T test, Wilcoxon Signed Ranks Test, independent T test, and Mann-Whitney test. The significance level was 5%.
Result: There were significant differences of concentration level between pre- and post-exercise in E group (p= 0.004) and post-exercise concentration level between groups (p = 0.01). Exercise group had faster reaction time than C group (0.555±0.2 *vs.* 0.793±0.3, respectively).
Conclusion: A single bout of moderate intensity exercise can improve the cognitive function showed by increased concentration level in teenagers.

Keywords: *single bout, exercise, intensity, ergocycle, reaction time, concentration, teenager*

Introduction

Physical exercise is an organised physical activity that can improve or maintain physical fitness[1]. Based on modality, intensity, and duration, physical exercise is divided into five categories: (1) short term, light to moderate submaximal aerobic exercise that lasts 10 to 15 minutes, (2) long-term, moderate to heavy submaximal aerobic exercise whose duration 30 minutes to 4 hours, (3) incremental aerobic exercise to maximum, which intensity increases within a certain duration, (4) static exercise which involves excessive muscle contraction with minimal movement, and (5) dynamic resistance exercise, which is similar but accompanied by movement. Aerobic exercise is in category (1) and (2)[2].

The effects of physical exercise can be acute or chronic. If it is done repetitively, the effect will be chronic, just like on athletes. Meanwhile, if it is only done for once, the effect will be acute[3]. Physical exercise itself has two types of intensity, moderate and vigorous, and can be rated by quantity from the pulse interval while doing physical exercise. Moderate intensity has the pulse interval of 50-70% and vigorous intensity has an interval of 70-85%[4]. Physical exercise has several benefits for a person's body if done correctly. One of them is to improve brain function and health. The brain has neurotrophic substances, such as brain derived neurotrophic factor (BDNF) and nerve growth factor, which can be stimulated by physical exercise. This proccess cause growth and developmental effects on brain structure, including its cognitive function[5]. The purpose of this study is to prove the effect of acute moderate intensity physical exercise on the level of concentration in adolescents.

Material and Methods

This study was approved by the Ethics Commission of the Faculty of Medicine, Airlangga University (No. 81/EC/KEPK/FKUA/2019). Prior to the study, each subject has signed the informed consent and procedure forms. Information about the subject's health, such as diabetes or metabolic disease history, depression history, diet, and exercise habit were gathered.

Subject

A total of 32 subjects, consisted of 16 boys and 16 girls participated in this study. The interval of the age was approximately 16-18 years old, which was classified as teenagers or adolescents[6]. Subjects were divided into 2 groups, the control (C) group (n = 16) and the exercise (E) group (n = 16). Each group has the total of 8 boys and 8 girls. Subjects in two groups were prohibited from doing physical exercise 1 month before this study.

Before starting the treatment, the height and weight of each participant was measured using the continental scale corps instrument; the BMI (body mass index) of each subject was then calculated by dividing the subject's weight (in kg) with the square of the subject's height (in m^2). Fasting blood sugar level was examined to exclude subjects who had diabetes, a metabolic disease, which could interfere with the procedure, especially type 2 diabetes mellitus, which is influenced by poor lifestyle. Subjects were allowed to drink water only. Fasting blood sugar was checked using the EasyTouch blood glucose kit. After the examination, sweetened tea was given to all groups and 30 minutes after that, the E group started the physical exercise.

Subjects were also asked to complete a depression scale questionnaire, using the PHQ-9 Depression Scale, to ensure the subject was not under psychological pressure. A physical examination for resting heart rate and blood pressure was also conducted to ensure that there were no general abnormalities, such as tachycardia, hypertension, etc.

Exercise Protocol

The intensity was based on the maximum heart rate (HRmax). Before performing the procedure, HRmax of each subject was determined by calculating 220 minus subject's age. For example, the HRmax of 20 years old subject is 200 bpm. The moderate intensity of the physical exercise was 60% of HRmax. During exercise, the HR zone of moderate intensity was monitored with a polar heart rate device to maintain the intensity in moderate zone for each subject.

Ergocycle was used in the exercise. Subjects in the control group did not perform exercise, they were allowed to sit and relax for about 25 minutes. Meanwhile, subjects in the exercise group perfomed cycling for about 25 minutes, consisted of 5 minutes warm up, 10 minutes cycling in the moderate intensity zone[2], and 5 minutes cooling down. During warm up and cooling down, subjects performed cycling at a constant speed of approximately 50 rpm without any load. After the 5 minutes warm up, subjects were given additional loads. The female subjects were given 1,5 Kp load, and the male subjects were given 2 Kp load.

Concentration Level Test

Concentration level test was measured using Takei whole body reaction measuring equipment (TTK-1246B/09006, Japan), to observe the subjects reaction time responding to sound stimulations. The reaction time in both groups (second) were measured.

Analysis

The data were analysed with Statistical Package for Social Sciences (SPSS) version 25.0. If the data was normally distributed, the difference between pre- and post was analysed by paired T-test. Independent T-test was also performed to compare the result between 2 groups. If the data was not normally distributed, Wilcoxon Signed Ranks test was used to figure out the difference between pre- and post, while Mann-Whitney test was used to distinguish between 2 groups. The significance level was 5%.

Result

Subjects were homogenous based on the characteristic of the subjects ($p>0.05$), see table 1. The age, body mass index (BMI, fasting blood glucose (FBG), heart rate (HR), and reaction time were similar in both groups.

The pre-test reaction time was 0.9 ± 0.28 seconds in the control group and 0.81 ± 0.29 seconds in the exercise group. After exercise, the average post-test reaction time in the control group was 0.79 ± 0.30 seconds and in the physical exercise group was 0.56 ± 0.17 seconds (fig 1.).

The duration of reaction time was inversed to the level of concentration. Shorter duration of reaction time indicate a higher concentration level of the subject. Therefore, based on the data, the exercise group obtained higher level of concentration compared to the control group.

Table 1. Characteristic of the subjects

	Control group	Exercise group	p
Age (y.o)	17.81 ± 0.54	17.88 ± 0.34	0.95*
BMI (kg/m^2)	21.64 ± 1.92	21.47 ± 1.50	0.78**
FBG (mg/dL)	88.06 ± 10.67	84.94 ± 18.76	0.96**
HR-pre (bpm)	82.06 ± 10.54	79.06 ± 10.19	0.42*
ReacTime-pre (sec)	0.9 ± 0.28	0.81 ± 0.29	0.39*

y.o= years old ; BMI = body mass index ; FBG = fasting blood glucoe ; HR = heart rate ; ReacTime-pre = reaction time before intervention. Statistical analyses : *Mann-Whitney test and **independent T test.

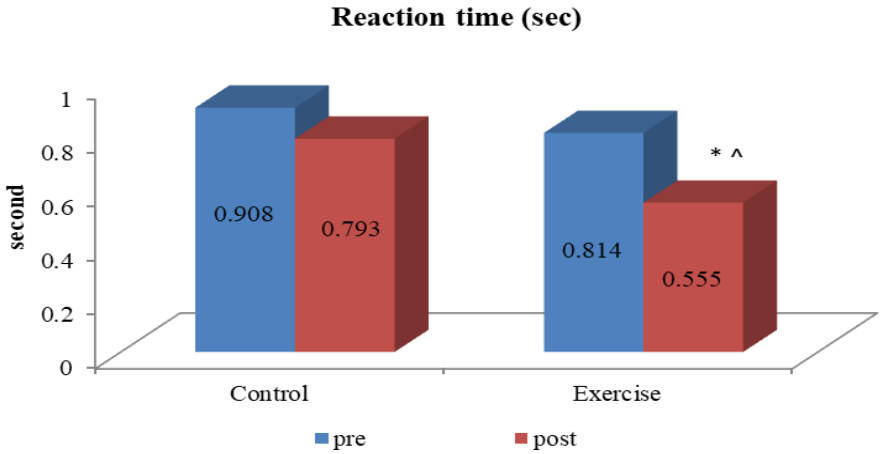

Figure 1. The pre- and post-reaction time in each group
Pre = before intervention ; post = after intervention

*: significantly different to the control group (p <0.05) using Mann-Whitney test. ^: significantly different to the pre-test data in each group (p <0.05)using Wilcoxon Signed Ranks Test (for control group) and paired t-test (for exercise group).

Discussion

Based on the current study, increase of concentration level shown by faster reaction time in physical exercise group was significant, compared to the controls. Physical exercise is an organized physical activity which increases energy consumption to improve physical fitness[7]. In this research, the physical exercise taken was in moderate intensity which has a pulse increase limit of 50-70% of heart rate reserve (HRR)[4]. It is expected that physical exercise could stimulate neurotrophic factors and neuronal growth, which can preserve the cognitive function of the brain, increase brain vascularisation, dopamine levels, and change the neurotropic factors. This process would result in a neuroprotective effect[8,9].

Previous study using ergocycle on athletes and non-athletes in adult revealed mild physical exercise intensity, approximately 40% increase in heart rate, could increase concentration with the results of increased response. However, at approximately 60% increase of heart rate, there is no significant increase in concentration results[10]. In this study however, moderate intensity of physical exercise with a 60% of HRmax improved subject concentration. This could be due to the

differences in the age and the fitness levels with the previous study.

Some studies showed that acute physical exercise could improve the executive function of the brain. Executive function was one of the functions for the concentration. The executive function played a major role in every aspect of life, especially in mental aspects. Most mental disorders experienced by a person will affect the cognitive function as well. One part of the executive function which is inhibition control had a pivotal role in concentration. By giving suppression on other stimuli, it could lead the subjects focusing on only one stimuli[11].

Several types of physical exercise such as treadmills and sprints were also tested in group of children aged 9-12 years old. Improved response accuracy can be found in some of these studies.[12,13] The accuracy of the response itself can also be measured by other tests, such as specific switch cost and correct response rate. Some studies also showed positive results showed by enhancement of executive function, especially response accuracy, after moderate intensity physical exercise of 50-70% HRmax.[14-16] This research supports the argumentation of single bout or acute of physical exercise of moderate intensity could increase concentration level in teenagers.

Conclusion

A single bout or acute of moderate physical exercise improves concentration level in teenagers. However, further research should be conducted to figure out the underlying mechanism.

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