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THE EFFECT OF HIGH INTENSITY INTERVAL TRAINING (HIIT) ON SHORT-TERM MEMORY STUDY AMONG MEDICAL STUDENT IN SEMARANG

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ABSTRACT

Background: High Intensity Interval Training (HIIT) is an aerobic exercise consisting of high intensity of physical exercise interspersed with low intensity of physical exercise. HIIT has been known that can improve cognitive function. Medical students has low physical activity that can affect on cognitive function including short-term memory. Short-term memory is important in learning process which can affect on academic performance. **Objective:** To determine the effect of High Intensity Interval Training (HIIT) on an individual's short-term memory. **Methods:** This study used quasi experimental pretest and posttest design. The research subjects were 29 female students of the Faculty of Medicine, Diponegoro University with the average age of 19-22 years with normal BMI (Body Mass Index), divided in 2 groups. Experimental group (n=14) was instructed to do 6 weeks of HIIT (3 times a week) and control group (n=15) was instructed to not to do any exercises. Short-term memory was measured with Scenery Picture Memory Test (SPMT). The significance of the data was analyzed with paired sample t-test and independent sample t-test. **Results :** A significant increase ($p<0.001$) in memory score before and after HIIT, from 18.07±1.49 to 20.21±1.37. The posttest memory score of HIIT group (20.21±1.37) was significantly ($p=0.034$) higher than the control group (18.67±2.23). Meanwhile, the memory score at the pretest between the 2 groups was no significant differences ($p=0.621$). **Conclusion:** HIIT can improves short-term memory. Further studies are needed to confirm the effect of HIIT on short-term memory with limiting the physical activity, nutritional control for each subject, and comparisons between male and female.

Keywords: High Intensity Interval Training (HIIT), Scenery Picture Memory Test (SPMT), Short-term Memory.

INTRODUCTION

Rapid technological advances have an effect on changing individual lifestyles to sedentary lifestyles. A sedentary lifestyle is a habit of individuals who are less or lazy to do physical activity.[1] According to data from Riset Kesehatan Dasar Kementrian Kesehatan Republik Indonesia (Riskesdas), there is an increase in the number of people over 10 years of age whose physical activity is less, from 26.1% (2013) to 33.5% (2018).[2]

According to the World Health Organization (WHO), the lack of physical activity causes the death of approximately 3.2 million people each year. About 20% -30% of the causes of death are due to a lack of physical activity.[3] In addition, the lack of physical activity can lead to cognitive dysfunction.[3,4,5]

Most people think that physical activity or sports take a long time. Therefore, unavailability of time or busy activities is often the main reason for not doing enough exercise. Currently, a type of exercise that is more effective and efficient and does not require a long time has been developed, namely High-Intensity Interval Training (HIIT).[6]

HIIT is a new variation of aerobic exercise, which is an exercise program by combining the high and low or moderate-intensity at certain intervals.[7] HIIT only takes about 20-30 minutes.[7,8] Therefore, this exercise can be an alternative choice for people who have a lot of activities, one of them is a medical student with a busy course schedule.

Physical activity, especially exercises, can improve cognitive abilities, including memory.[9] HIIT can increase VO2 max, even it is higher than other exercises.[10,11] In addition, there are studies that said the increase of VO2max can improve memory function.[11]

Memory has a very important role because it is needed in almost all human activities, especially in the learning process. For medical students, the role of memory is very necessary and if there is a disturbance in the memory storage process, it will impact on

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the student academics. Therefore, It is important for everyone to improve their memory skills.

The memory assessment method can be done by using the Scenery Picture Memory Test (SPMT). SPMT is a fast and effective cognitive test to assess a short-term visual memory capacity.[12]

Based on the explanation above, the researcher is interested to do a research on the effect of High-Intensity Interval Training (HIIT) on short-term memory. This research has never been conducted in Indonesia.

METHOD

This study used a quasi-experimental study with pre-test and post-test groups design. This study was conducted in the area of the Faculty of Medicine, Diponegoro University before the Covid-19 pandemic and was carried out in the house of each subjects during the Covid-19 pandemic. This study was conducted from March to May for 6 weeks.

The samples were taken by purposive sampling method based on specified criteria and divided into two groups, experimental and control group. The samples in this study were students of the Faculty of Medicine, Diponegoro University who fulfill the inclusion and exclusion criteria. The inclusion criteria of this study were physically and mentally healthy, women aged 18-22 years, normal Body Mass Index (BMI) (18.5-25 kg/m2), no anatomical abnormalities in the lower limbs, normal blood pressure, ready to be the subject of this research for 6 weeks, and ready not to do another exercise for 6 weeks. The exclusion criteria for this study were having a history of brain tumors and epilepsy, head trauma causing neurological symptoms, central nervous system infection, taking sedative drugs, suffering from psychiatric disorders, taking brain supplements, consuming alcohol, and having poor sleep quality.

The number of samples for each group was 15 people and the total of the number samples for this study was 30 people.

The independent variable in this study is *High Intensity Interval Training* (HIIT). Meanwhile, the dependent variable is short term memory. The type of data used in this study is primary data. The data collection process was carried out starting from all research subjects following the pre-test measurement of short-term memory scores using SPMT. The control group was instructed not to do any types of workout for 6 weeks. The experimental group was instructed to do HIIT workout in the morning.

The mechanism of implementing HIIT workout starts with a warm-up for 8 minutes, followed by a core movement consisting of 15-meter sprints and 15-meter jogging as many cycles as determined (3 cycles in the first week with the pulse rate 140 x/minute, 4 cycles in the second week with the pulse rate 145 x/minute, 5 cycles in the third week with the pulse rate 150 x/minute, 6 cycles in the fourth week with the pulse rate 155 x/minute, and 7 cycles in the fifth and sixth week with the pulse rate 160 x/minute), and cool-down for 1 minute. Every before and after HIIT workout, the experimental subjects' pulse rate were measured first. Before this pandemic, HIIT workout interventions were carried out in person, but, during this pandemic, it was carried out online which is monitored via video. After 6 weeks of the intervention, all study subjects were re-measured their short-term memory using SPMT via zoom.

Then, the data was processed, coded, and entered into a computer for descriptive analysis and hypothesis testing.The data normality test on the dependent variable was analyzed using the Saphiro-Wilk test. Hypothesis testing regarding the difference in short term memory before and after High-Intensity Interval Training (HIIT) workout was analyzed using a paired t-test. Hypothesis testing regarding the difference in short term memory between the control group and the experimental group were analyzed using an unpaired t-test.

RESULTS

This research was conducted from March to May 2020 with the research subjects of 30 students of the Faculty of Medicine 2017-2018 who fulfilled the inclusion and exclusion criteria and ready to take part in this research. There were 30 research subjects selected based on inclusion and exclusion criteria. The subjects were divided into 2 groups, each group consisting of 15 people. After being observed until the end of this study, the entire control group could carry out

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the research until it was finished, while in the experimental group, there was 1 research subject who could not be followed up because the subject did not reply to the researcher 's message. Therefore, the total subject of this study was 29 people.

There were 29 research subjects with an average age ± SB from the control group is 20.07±0.884 and the experimental group is 20.00±0.784. The age range in both groups was the same, it was 19 to 21 years (min-max). Meanwhile, the average of BMI (Body Mass Index) ±SB (min-max) from the control group is 22.48±1.591(19.70-24.76) and the experimental group is 21.83±2.042 (18.94-24.91). The average of heart rate before intervention ±SB (min-max) from the control group is 80.00±6.459 (71-91) and the experimental group is 80.07±6.534 (70-91). All subjects have the normal heart rate. Moreover, the average of GPA (Grade Point Avarege) ±SB (min-max) from the control group is 3.55±0.324 (2.83-3.93) and the experimental group is 3.53±0.285 (2.97-3.97). The difference in GPA was not significant with the value of p = 0.899 (unpaired T-test). Moreover, all of research subjects, either the control or experimental group did not have a history of neurological disorders, psychiatric disorders, brain tumors, epilepsy, central or systemic nervous system infections, history of consumption of sedatives or alcohol or brain supplements, history of extremity disorders, sleep disorders and no exercise routine.

The measurement of short-term memory scores was carried out using the Scenery Picture Memory Test (SPMT) for 2 times before giving treatment to the experimental group (pre-test) and after 6 weeks given treatment for High-Intensity Interval Training (post-test). The memory scores were obtained from the ability to remember images in units, so the more memory scores you get, the better the memory function will be. The following is the data obtained on short-term memory measurements using the Scenery Picture Memory Test (SPMT).

Table 1. Short-Term Memory

Short-Term Memory	Group		*p*
	Control (Average±S)	Experimental (Average±SB)	
Pretest	18,40±1,99	18,07±1,49	0,621¶
Posttest	18,67±2,23	20,21±1,37	0,034¶*
p	0,582§	<0,001§*	
Difference	0,27±1,83	2,14±1,46	0,005¶*

* Significant (p<0,05); ¶ Independent Sampel T-Test; § Paired T Test

Based on table 1, the results showed that the SPMT score at the pre-test in the experimental group was lower than the control group. However, the results of statistical tests using an unpaired T-test showed that the difference was not significant (p = 0.621). While, the results of the SPMT score at the post-test in the experimental group was higher than the control group. The results of the unpaired T-test showed a significant difference (p = 0.034).

In table 1, it can also be seen that in the experimental group there was a significant increase in SPMT scores (p <0.001; paired T-test). In the control group, there was also an increase in SPMT scores, but the increase was not significant (p = 0.582; paired T-test).

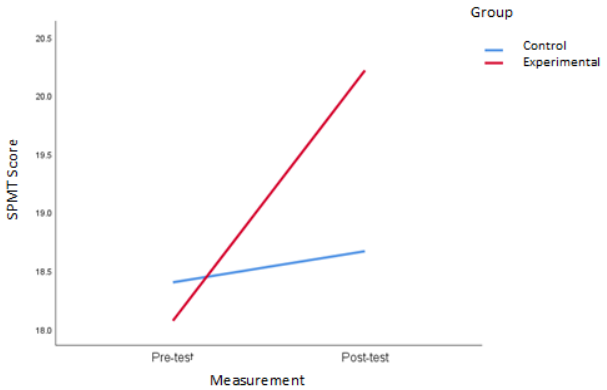

Figure 1. Diagram of SPMT score

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Based on Figure 1, it can be seen that the results of the SPMT score assessment in the experimental and control groups were increased. However, the increase of the SPMT score in the control group was not as big as in the experimental group. In the experimental group, there was a significant increase in SPMT scores ($p < 0.001$; paired T-test), while in the control group there was an insignificant increase in SPMT scores ($p = 0.582$; paired T-test). The comparison between the SPMT pre-test and post-test scores in the two research groups is shown in Figure 2.

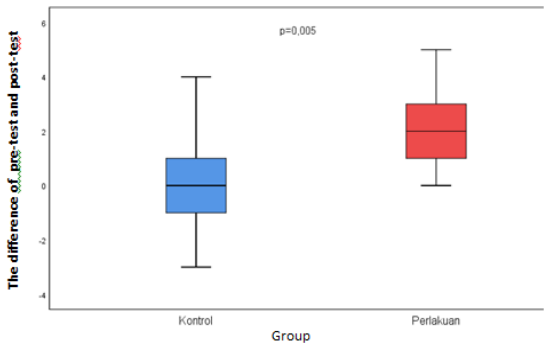

Figure 2. The difference of *pre-test* and *post-test*

In Figure 2, it can be seen that the difference between the pre-test and post-test SPMT scores in the experimental group was significantly greater than the control group ($p = 0.005$; unpaired T-test).

DISCUSSION

In this study, all subjects were women with the average age that was almost the same and the differences of GPA between the control and experimental group that was not significant so it tended to be homogeneous. With those homogeneity, in this study, the GPA did not affect the results. In addition, this research was carried out with a different procedure due to the Covid-19 pandemic. HIIT exercises are carried out online at the domicile of each research subject who is monitored via video to avoid the transmission of Covid-19. Meanwhile, the SPMT short-term memory test was carried out via application *zoom*. Even so, this research can still be done well and shows that there is a significant difference between the experimental group that was given treatment of High-Intensity Interval Training (HIIT) for 6 weeks and the control group that was not given any treatment. The pre-test and post-test short-term memory scores of the control group had an increase, but not significantly. It could be caused by an assessment of short-term memory using the same instrument, the Scenery Picture Memory Test (SPMT), according to the Zaromb and Roediger's research, there was a tendency of the increasement of the better test results in the research subjects who were given a test with the same instrument more than once.[13] Moreover, in contrast to the control group, the short-term memory scores of the pre-test and post-test in the experimental group had a significant increase. The results of this study are in accordance with the major and minor hypotheses which is the short-term memory is better in the experimental group than in the control group. In addition, short-term memory is also better after doing High-Intensity Interval Training (HIIT) exercise than before doing the exercise.

The results of this study are in accordance with the theoretical basis that stated that HIIT aerobic exercise improves a cognitive function through several mechanisms, among of them are the increasement of blood flow to the brain or Cerebral Blood Flow (CBF), including the hippocampus and prefrontal cortex which play a role in cognitive function including short-term memory.[14-16] The effect of Cerebral Blood Flow on memory through the increasement of the Cardiac Output which will increase perfusion in brain system. It is also known that getting older, so the Cerebral Blood Flow (CBF) increasingly decrease, while old age is a

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risk factor for cognitive impairment and dementia.[14,17] Other studies have shown that cerebral hypoperfusion is associated with decreased cognitive function and increases the risk of dementia.[18] This indicates that an increase in cerebrovascular function in aerobic exercise, characterized by an increase in CBF, could be a mechanism underlying the beneficial effect on cognitive function.[11] Another mechanism that may also underlie the effect of aerobic exercise on cognitive function, including memory, is an increase in VO2max. This is consistent with research conducted by Megan Hutchinson which shows that the increase in VO2max corresponds to an increase in memory score.[11] In addition, there is another mechanism, namely through the increase of Brain-Derived Neurotrophic Factor (BDNF). Brain-Derived Neurotrophic Factor (BDNF) is a neurotrophin that plays a role in neuroplasticity (synaptic formation and function) which is widely produced in the hippocampus and cortex so that it can have a positive impact on cognitive function.[11,19,20] In animal studies, there is an increase in BDNF in the hippocampus area and the cortex area after being given treatment in the form of physical exercise.[19,21] The results of animal studies have been confirmed with human subjects who also had a significant increase in serum BDNF levels.[19,22,23] A study also proved that increased BDNF can affect memory.[24-27] This indicates that the increase in BDNF may underlie the mechanisms of improving cognitive function, including memory.[25] Aerobic exercise can also cause neuroinflammatory changes, which can reduce pro-inflammatory cytokines and increase anti-inflammatory cytokines, thus preventing brain damage and can improve cognitive function. Pro-inflammatory cytokines, especially IL-6, which is a stimulator of C-reactive protein (CRP) production, can also affect BDNF levels and affect neuroplasticity. Therefore, decreased pro-inflammatory cytokines and increased anti-inflammatory cytokines are also associated with cognitive function enhancement mechanisms including memory.[19] Another mechanism that also affects memory enhancement after physical exercise is an increase in Insulin-like Growth Factor-1 (IGF-1).[28-30] IGF is a neuroprotective molecule in the brain[31] that can influence neurogenesis and modulate the formation of new neurons, including in the hippocampus, which is an area that affects memory function.[28] Therefore, an increase in IGF-1 can also be associated with a mechanism of enhancing cognitive function. including memory.

The limitations of this research are including the change in the way research is carried out offline to online which is monitored via video due to the Corona Virus Disease-19 (COVID-19) pandemic so that it cannot be observed directly, all activities of the subject, for example, nutrition and daily activities of different samples were not controlled, and also this study was only conducted on women so that it could not be compared with men. In addition, the researcher could not control the interest and mood of the study sample during the pre-test and post-test.

CONCLUSION

After 6 weeks of HIIT intervention, short-term memory in the experimental group improved higher than in the control group. In addition, short-term memory also improved after doing HIIT exercise compared to before doing HIIT exercise.

Ethical Approval

All research procedures received ethical clearance from the Health Research Ethics Commission of the Faculty of Medicine, UNDIP Semarang before conducting the research. The Ethical Clearance number is 123/EC/KEPK/FK-UNDIP/VI/2020.

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Conflicts of Interest

The authors declare no conflict of interest.

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