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Original Article

The Effect of Plyometrics and Aerobic Exercises on Short-Term Memory

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Abstract

Background : Person's desire to exercise is still a major problem in the realm of health, especially in indonesia. Lack of exercise affects brain structure, which is a smaller hippocampus volume in people who are not actively exercising. A shrinking hippocampus will affect a person's short-term memory abilities, so doing plyometrics and aerobic exercises can be a solution to these problems because exercise can be easily done for health and increased cognitive abilities. The aims of this study was to examine the effect of plyometric and aerobic exercises on short-term memory
Methods : This is a quasi-experimental study involving 54 students of the Medical Faculty of Diponegoro University, aged between 15 and 25 years. Subjects were selected by random allocation method. Subjects participated in the measurement of short-term memory before and 6 weeks after exercise. Subjects were divided into three groups, namely the plyometrics, aerobic and the control groups. The statistical analysis uses One-Way ANOVA.
Results : The SPMT (Scenery Picture Memory Test) pre-test assessed the memory function of participants. The pre-test SPMP score in the aerobic, plyometric and control groups were 14.94 ± 1.765, 14.83 ± 1.724 and 14.86 ± 2.423 respectively. However, the statistical tests shows that the difference was not significant (*p*= 0.986; One-Way ANOVA). On the other hand, the post-test SPMT score at in the control, plyometric and aerobic groups were 14.78 ± 2.647, 19.50 ± 1.295 and 17.00 ± 1.749 respectively. The results of the One-Way ANOVA test showed that the difference was significant (*p*<0.001).
Conclusion : Plyometrics and aerobic exercises improve short-term memory of Medical students of Diponegoro University. The most significant improvement was found in the plyometrics group.

Keywords : Aerobic exercise; plyometrics exercise; short term memory.

INTRODUCTION

Person's desire to exercise is still a major problem in the realm of health, especially in Indonesia. Basic Health Research in 2018 shows that only 25% of the population aged 10 years and overdo exercise.[1] A study from the Boston University School of Medicine in 2012 shows that lack of exercise affects brain work, in which smaller hippocampusin prefrontal cortex were found among people who do less excercise. This is supported by previous study conducted by Scott McGinnis, *et al*, stating that the brain has parts such as mind and memory control (prefrontal cortex and medial temporal cortex).[2] Memory is a component of cognitive[3] and a person's ability to store and retains some information, which can be recalled later.[4] In connection with physical activity, it was reported that there was an increase in BDNF (Brain Derived Neurotrophic Factor) expression in the hippocampus and peripheral cortex, thus correlating with improved memory function better.[5]

A study conducted by Meszler from the Institute of Sport Sciences and Physical Education, University of Pécs in 2019 on Pylometrics training, shows significant results at 6th week in improving fitness and cognitive function.[6–8] Athletes, thereby, produce greater muscle strength and a direct effect on the performance.[6–8] It is different from aerobic exercise, most people in Indonesia are more aware of its benefits only as a fitness exercise.[9] Therefore, researchers want to examine and compare the effects of plyometrics and aerobic exercises on cognitive functions. Cognitive examination focused on short term memory.

METHODS

This study used an experimental design with pre and post–test designs involving three parallel groups. The participants of this study were students who met Inclusion criteria including active students of the Medical Faculty of Diponegoro University Semarang for the 2017, 2018 or 2019 academic years, male, between 15 and 25 years old, body mass index between 18 and 25 kg/m^2, normal blood pressure, doing no other sports and comply with study procedure for 6 weeks. Exclusion criteria included history of brain injury or head trauma, heart disease, anemia, leg injuries, varicose veins on extremities, consumption of neurotropic or brain supplements, refractive errors of the eye, and mental conditions. The research was conducted for 6 weeks between 24th July and 04th September 2020. Participants were randomly allocated (simple random sampling) into three groups consisting of control, plyometrics and aerobic groups. Participants of the intervention group (plyometrics and aerobic groups) who did not comply with the six weeks exercises were excluded. The total number of samples was 54 people involving 18 people for each group. This study was conducted at the Physiology Laboratory of the Medical Faculty of Diponegoro University.

The tools used involved agility ladder, sphygmomanometer, stopwatch, and writing instruments. The materials used were questionnaires and SPMT as reliability test. The exercise comparison was then linked to short-term memory as measured by SPMT. Its test method can be used quickly and effectively against short-term visual memory screening.[10]

Participants who had signed the informed consent were selected into three groups. The control group was not given any treatment and did not do any sports for 6 weeks; The first intervention group was given plyometric exercises agility ladder for 6 weeks with increasing sets each week. The movement in one set involved side shuffle, straddle hops, bunny hops, and lateral jump lunge for 10 minutes. Between the first and second week, the subjects got 2 sets with an additional 1 set every 2 weeks. Exercises were conducted two times a week. The exercise site has been mutually agreed upon at the Diponegoro Military Command IV Shooting Field, Semarang. Compliance with the subjects was obtained through education at the beginning before conducting the research assisted by supervisors. Training supervision was carried out by a supervisor who is an athlete trainer, while assessment with SPMT was carried out by the main researcher. The second intervention group was given aerobic exercise involving shuttle run 20 meters for 6 weeks. An additional set was conducted every 2 weeks with 3 sets from the first to the second week, then two additional sets every two weeks. The different additions between plyometric and aerobic sets are due to balance loads. The determination that the load was balanced was calculated based on the subject's heart rate in 1 set.

Short-term memory was measured using the SPMT before and 6 weeks after the intervention. The measurement was conducted by showing the subjects with an image of a room containing 23 objects. Participants were asked to memorize these objects within 1 minute. A forward digit span test was then carried out to outwit individuals up to 7 digits. They were asked to name the object that has been seen and memorized earlier. The criteria for good memory is when individuals are able to name a minimum of 12 objects correctly.[10]

This study has obtained ethical permission from the KEPK (Health Research Ethics Commission) Faculty of Medicine, UNDIP with No. 45 / EC / KEPK / FK-UNDIP / IV / 2020.

Data were analayzed using the Shapiro-Wilk normality test to determine the data distribution. The hypothesis about the different SPMT scores between groups before and after exercises was tested using the paired sample t-test as the data were normally distributed (p> 0.05). Furthermore, the hypothesis about the different pre-test and post-test between groups was tested by One-

Way ANOVA test as the data were normally distributed (p <0.05). The Bonferroni Post-Hoc test was performed to compare the results between the control and intervention groups. The difference between groups was tested using the Kruskal Wallis test and followed by the Bonferroni Post-Hoc test. Data analysis used software of the Statistical Product and Service Solutions (SPSS) Version 26.

RESULTS

Based on the figure in diagram 1, participants were allocated into three groups consisting of 18 participants for each group. For 6 weeks, there was a routine follow-up and there were twice exercises each week, boththe plyometrics and aerobics groups. The post-test with SPMT was also given at the end of the study to 54 research subjects. No subject was dropped out during the study.

Based on table I, the average age of the research subjects was 20.22 ± 0,925 with the youngest and oldest ages are 18 and 22 years old respectively. Subjects had an average height of 171.19 ± 6,420 cm and body weight of 63.98 ± 7,442kg. The average subject's body mass index is of 22 kg / m^2. None of the subjects have history of injury or postural abnormalities.

Based on SPMT measurements on table II, the SPMT pre-tests scores of aerobic, plyometric and control groups were 14.94 ± 1.765, 14.83 ± 1.724, and 14.86 ± 2.423 respectively with p 0.986, which is not significant as the p-value is <0.05. On the other hand, The SPMT post-test scores of control, plyometric and aerobic groups were 14.78 ± 2.647, 19.50 ± 1.295, and 17.00 ± 1.749 respectively with p <0.001.

Based on figure 1, thereis an increased SPMT score in the plyometric and aerobic groups (p <0.001), which showed a significant result. However, there is no significant SPMT score (p=0.707) between pre-test and

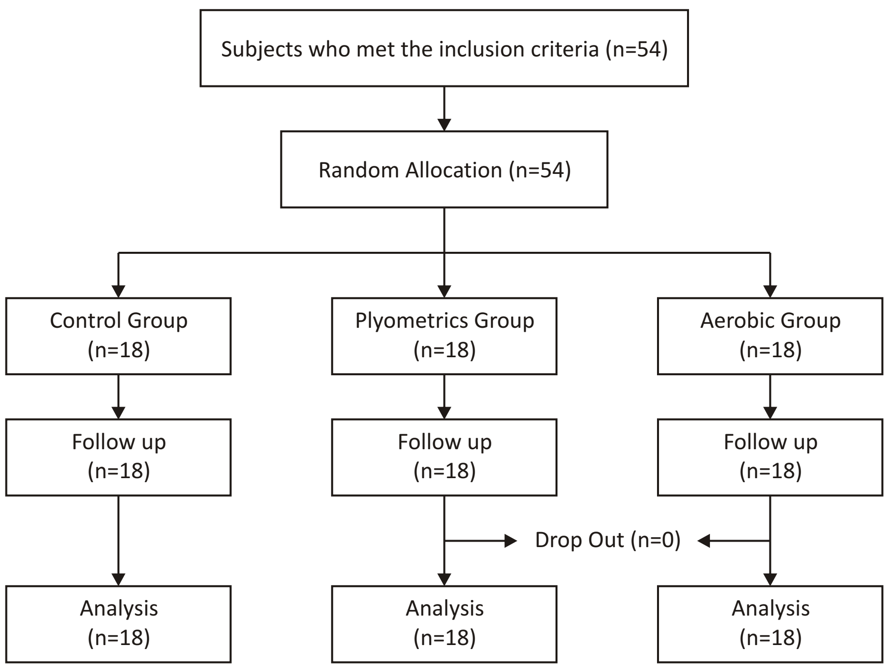

Diagram 1. Consort Diagram

TABLE 1
Description of Research Subject

Variable	N	Minimum	Maximum	Mean	Std. Deviation
Age	54	18	22	20.22	.925
Height	54	150	187	171.19	6.420
Weight	54	50	81	63.98	7.442
IMT	54	18	25	22	1.9420

TABLE 2
SPMT Memory Score

Measurement Time	Skor SPMT			$p^{§}$
	Control (n=18) Average ±SD;	*Plyometrics* (n=18) Average ±SD;	Control (n=18) Average ±SD;	
Pretest	14.86 ± 2.423; 14.50	14.83 ± 1.724; 15.00	14.94 ± 1.765; 15.00	0.986§
Post-test	14.78 ± 2.647; 15.00	19.50 ± 1.295; 19.50	17.00 ± 1.749; 17.00	<0.001§*
p¶	0.707¶	<0.001¶*	<0.001¶*	
Difference	-11 ± 1.231; 0.00	4.67 ± 1.237; 4.00	2.06 ± 1.211; 2.00	<0.001¥*

*Significant ($p < 0,05$); §One–Way ANOVA; ¶Paired–Samples T test; ¥Kruskal Wallis

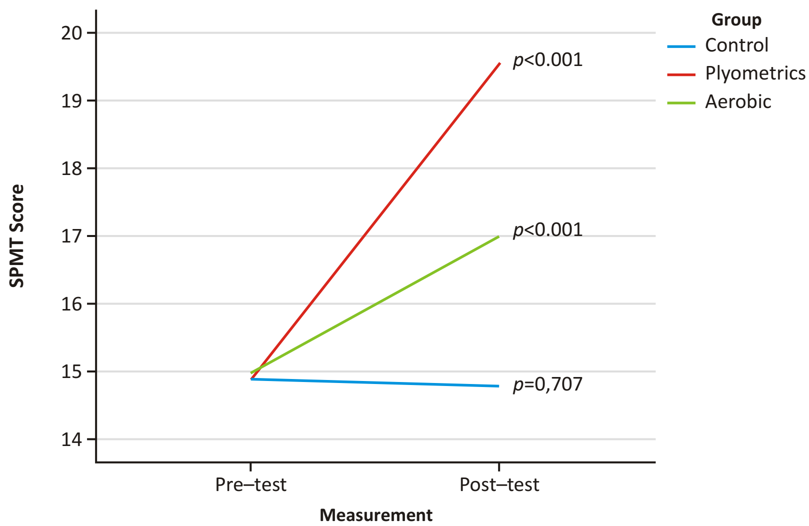

Figure 1. SPMT Memory Score difference at Pre-test and Post-test (*p*-value <0.05)

post-test in the control group.

DISCUSSION

The Annals of Applied Sport Science states that the physiological adaptation response starts after undergoing exercise 2 times a week for 6 weeks. Physiological adaptations occur in the form of endurance and strength adaptations, which is related to strengthening joints, tendons and ligaments while increasing focus, coordination and cognitive performance, one of which is memory. No subject drops out in this study, all subjects comply with the research until completion.[11,12]

The averaged age was 20,22 ± 0,925years old. Age affects person's storage capacity. When people get older, their memory can drop. Short-term memory can drop at the age of 30 to 90 years old. It is linked to hippocampus volume which shrinked affecting cognitive function, particularly memory.[13,14] The ideal parameter of height and weight is very important in this study because it will give normal body mass index (BMI) score. The BMI score can affect individuals ability performing exercise, both plyometrics and aerobic, heightened the risk of injury.[15] The BMI score in this research was 22 kg/m^2 which is considered normal and met the inclusion criteria for this study. Before the study, majority of subjects did not do routine sports and exercise. Subjects in the treatment group only did the mandated[6] weeks exercises while the control group did not do any exercise. Thus bias results can be avoided since all subjects are in the same condition.[16]

Significant results were obtained in the treatment group, both in the plyometrics and aerobic groups. This is supported by previous research conducted by Kirk I Erickson, *et al*. stating that there was an increased short-term memory among subjects with aerobik exercise compared to those without exercise on the Corsi Block Tapping Task (computerized recall test).[17] Their study shows an increased volume of hippocampus among subjects doing regular exercise due to smooth blood supply to the brain and production of new brain cells. The increased cerebral blood supply occurs due to increased cardiac output, arterial baroreflex and chemoreflex control. The increased hippocampal volume was also associated with an increased BDNF levels which was an effect of the increased anterior hippocampal volume. It shows an increasedcognitive function, particularly memory among those doing sports.[5,17,18]

The results are more significant among subjects doing plyometrics exercise than those doing aerobic exercise. This is in accordance with the research conducted by Kang Sungwoo showing that plyometrics exercise is effective in increasing neuromuscular response as more explosive movements can develop greater strength in a shorter period of time. This is evaluated using Rate of force development (RFD) to examine explosive strength and neuromuscular function with maximum strength development in minimal time.[19]

A good neuromuscular response is closely related to improved cognitive function. It is supported by previous study by Yael Netz, *et al*. explaining that exercises with repetitive movements and a lot of coordination movements result in greater muscle strength and concentration.[20] Furthermore, it will affect metabolic processes in the brain which in turn increasing neuroplasticity of the brain improving cognitive function. Exercises involving a lot of learning and memorization, new skills and movement patterns and maintaining attention can help to improve working memory, attention, and overall executive abilities in comparison with exercises involve single movement or movement pattern from beginning to end.[11,20] This study might be better if conducted longer than 6 weeks so the more significant development of prefrontal cortex can be examined. In addition, a more sophisticated tools such as fMRI may be used to detect the increased volume of pre frontal cortex during the study. A study by Kirk Erickson shows that doing sports in a year increases hippocampus volume and protects diminishing hippocampus volume due to aging. Increased volume means improved memory function and higher BDNF (Brain Derived Neurotrophic Factor) serum. The fMRI was used to clearly observe the increased hippocampus volume every six months.[17]

In conclusion, the six weeks plyometrics and aerobic exercises have a positive effect on short-term memory function in which the results are better among subjects doing plyometrics. However, no improved short-term memory is noted among subjects in the control group. Plyometrics and aerobics could be an alternative to keep body fit and to improve cognitive function, especially short term memory. The easy movement of plyometrics and aerobics can be done any time. Plyometrics and aerobics could be exercised among those aged 15–25 years old with normal range of BMI without history of ankle and knee injuries nor posture abnormalities. Future research may be better conducted with a longer study duration with a more sophisticated tools such as fMRI to examine brain development.

REFERENCE

1. Riset Kesehatan Dasar (Riskesdas). 2018;44(8):1–200. Available from: http://www.depkes.go.id/resources/download/infoterkini/materi_rakorpop_20 18/Hasil Riskesdas 2018.pdf doi: 10.1088/1751–8113/44/8/085201
2. Weisser B. Lack of physical activity. Dtsch Arztebl Int. 2015;112(33–34):563. https://doi.org/10.3238/arztebl.2015.0563b
3. Alpkaya U. The effect of physical activity on social physique anxiety and academic achievement in the 8th grade secondary school students. Univers J Educ Res. 2019;7(3):707–12. https://doi.org/10.13189/ujer.2019.070309
4. Mortimer JA, Ding D, Borenstein AR, Decarli C, Guo Q, Wu Y, *et al.* Changes in brain volume and cognition in a randomized trial of exercise and social interaction in a community-based sample of non-demented chinese elders. J Alzheimer's Dis. 2012;30(4):757–66. https://doi.org/10.3233/JAD-2012-120079
5. Cowan N. Working Memory Underpins Cognitive Development, Learning, and Education. Educ Psychol Rev. 2014;26(2):197–223. https://doi.org/10.1007/s10648-013-9246-y
6. Sherwood L. Fisiologi Manusia Dari Sel ke Sistem. Edisi 8. octavianus Herman; Mahode, A.Agung, Ramadhani D, editor. Jakarta: EGC; 2010. 170–176 p.
7. Franchi M V, Monti E, Carter A, Quinlan JI, Philip J, Reeves ND, *et al*. Counteracting muscle ageing with plyometric muscle loading. Switzerland: Frontiers in Physiology Specialty; 2019. 1–26 p. https://doi.org/10.3389/fphys.2019.00178
8. Meszler B, Váczi M. Effects of short-term in-season plyometric training in adolescent female basketball players. Physiol Int. 2019;106(2):168–79. https://doi.org/10.1556/2060.106.2019.14
9. Booth FW, Roberts CK, Laye MJ. Lack of exercise is a major cause of chronic diseases. Compr Physiol. 2012;2(2):1143–211. https://doi.org/10.1002/cphy.c110025
10. Takechi H, Dodge HH. Scenery picture memory test: A new type of quick and effective screening test to detect early stage Alzheimer's disease patients. Geriatr Gerontol Int. 2010;10(2):18390. https://doi.org/10.1111/j.1447–0594.2009.00576.x
11. Makhlouf I, Chaouachi A, Chaouachi M, Othman A Ben, Granacher U, Behm DG. Combination of agility and plyometric training provides similar training benefits as combined balance and plyometric training in young soccer players. Front Physiol. 2018;9(NOV):1–17. https://doi.org/10.3389/fphys.2018.01611
12. Aghajani R, Hojjati Z, Elmiyeh A. The Effects of Plyometric and Resistance Training on Explosive Power and Strength of Young Male Volleyball Players. Ann Appl Sport Sci. 2014;2(1):45–52. https://doi.org/10.18869/acadpub.aassjournal.2.1.45
13. Blasiman RN, Was CA. Why is working memory performance unstable? A review of 21 factors. Eur J Psychol. 2018;14(1):188–231. https://doi.org/10.5964/ejop.v14i1.1472
14. Catinas O. Exploring the effects of ageing on short-term memory performance. Am J Sports Med. 2017;Vol. 8:1–25. https://doi.org/10.13140/RG.2.2.32019.32808
15. Radcliffe, James C.; Farentinos RC. High-Powered Plyometrics. Barnard M, editor. J Hum Kinet. 2017;34:1–297.
16. Kinser PA, Robins JL. Control group design: Enhancing rigor in research of mind-body therapies for depression. Evidence-

based Complement Altern Med. 2013;Vol. 23:1–10. https://doi.org/10.1155/2013/140467

17. Erickson KI, Voss MW, Prakash RS, Basak C, Szabo A, Chaddock L, *et al*. Exercise training increases size of hippocampus and improves memory. Proc Natl Acad Sci U S A. 2011;108(7):3017–22. https://doi.org/10.1073/pnas.1015950108
18. Hopkins ME, Davis FC, VanTieghem MR, Whalen PJ, Bucci DJ. Differential effects of acute and regular physical exercise on cognition and affect. Neuroscience [Internet]. 2012;215:59–68. Available from: http://dx.doi.org/10.1016/j.neuroscience.2012.04.056 doi: 10.1016/j.neuroscience.2012.04.056
19. Kang S. Difference of neuromuscular responses by additional loads during plyometric jump. J Exerc Rehabil. 2018;14(6): 960–7. https://doi.org/10.12965/jer.1836428.214
20. Netz Y. Is There a Preferred Mode of Exercise for Cognition Enhancement in Older Age? ––A Narrative Review. Front Med. 2019;6(March):1–10. https://doi.org/10.3389/fmed.2019.00057