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Comparison of the Effect of Aerobic and Resistance Exercise on Short Term Memory on Health Adults
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Background: Exercise is known to improve the cognitive function, including short-term memory. Exercise can induce structural and functional changes of the brain, i.e. synaptic plasticity. Exercise is categorized into two groups: aerobic exercise and resistance exercise. Studies have shown that both groups of exercises can improve short-term memory function. Objective: This research is aimed to compare the effect of aerobic and resistance exercise on short-term memory on healthy adults. Methods: Participants were given the choice to be admitted into either group, aerobic or resistance. Short-term memory (forward digit span) were measured before and after the intervention. Results: There were 20 male participants (mean age 22.95 ± 5.33) complete the intervention. There was no significant difference in the short-term memory function on both groups, aerobic (p=0.058) and resistance (p=0.206). However, an increase of short-term memory score average was observed in both groups, 6.6 to 7.2 in the aerobic group and 6.5 to 6.9 in the resistance group. There was no difference in short-term memory when the comparison was made between the two groups (p=0.628). Conclusions: This study showed that exercise could increase the short-term memory function, although insignificant, in health male adults. Key Words: exercise, short-term memory, aerobic, resistance

INTRODUCTION
Exercise is defined as planned, structured and repetitive physical activity that has the objective of improvement or maintenance of physical fitness. The term “exercise” is often confused with the word “physical activity”. Physical activity refers to all body movements by the skeletal muscle that results in energy expenditure. Exercise, apart from maintaining physical fitness, is also a known environmental factor that is able to influence the brain’s cognitive function. This is caused by the change in synapse plasticity along with structural and functional changes of the brain induced by exercise. The form of plasticity change includes the increase of substantia grisea volume in the hippocampal area and frontal lobe, which are the center of memory storage. The aforementioned increase might be due to increased blood flow to the brain during exercise that leads to micro-structural changes in the brain. A systematic analysis shows that 52 hours of regular exercise, defined as minimal exercise for 30 minutes at moderate intensity on at least three days a week for the last three months, could increase short-term memory function.

Short-term memory, as one of the bodies functions affected by exercise, is defined as a cognitive system that is used to store sensorial events, movements and cognitive information for a relatively short amount of time. An individual is able to store 7 to 12 pieces of information for a short time (a few seconds up to minutes) using short-term memory. There are various methods that can be used to measure the short-term memory capacity of an individual. Those methods include Digit Span (forward and backward span), letter digit span task and word span. Digit Span is one of the most used methods to assess short-term memory due to its simple procedure and low variability compared to the other methods of measurement. The reason for the low variability is because humans are often exposed to a series of random numbers (date, phone number, time, sports match results) daily.
Based on the fact that exercise can affect human memory capacity, this study was done to directly compare the effect of aerobic and resistance exercise on short-term memory. The subjects in this study were gathered from the same population and exercised simultaneously for 18 weeks, compared to previous studies which conducted the same study acutely or investigated the difference of the effect by comparing different individual studies.²

**METHODS**

**Study Design**

Participants were given the choice to self-select the group they wanted to be admitted in, aerobic or resistance. Group A represented aerobic exercise and group B represented resistance exercise. Outcome measures were collected at T1 (baseline) and T2 (after the exercise intervention of both groups). Data collection and study intervention were conducted across different gym facilities. Ethical approval was granted by the University of Tanjungpura ethical committee (6245/UN22.9/TA.00.03/2019). Conventionally, blood lactic acid level was measured to confirm its formation as a product of resistance or synonymously anaerobic exercise. But due to limited resources, blood lactic acid level of the resistance group was not measured.

**Participants**

**Inclusion and Exclusion Criteria**

Participants were screened and recruited by a public advertisement. The inclusion criteria included being healthy (adapted from the PAR-Q+ 2014), leading a sedentary lifestyle (no engagement in any type of exercise for more than 30 minutes, three times per week, for the past 3 months), male, aged 18 to 45 years old. The exclusion criteria included rejection of participation, history of addictive substances, brain trauma, brain tumor, current smoker, education level below senior high school, consumption of caffeine within the last eight hours and alcohol within the last 24 hours before the Forward Digit Span (FDS) was conducted.³

**Orientation and Pre-Test**

Participants were gathered for an orientation on how the research will be conducted. Each participant signed an informed consent and completed preliminary questions to rule out the exclusion group. Those included were given the FDS (Table 1) to test short-term memory. Ten participants in the aerobic group were given calculations (HR_{estimated max} = \frac{1}{2} \times \frac{3\times intenity desired}{1220\text{-}age}) to control the intensity of the exercise within the range of light to moderate to avoid potential injuries and over-exhausting the body.⁴ The target duration of exercise is 52 hours of accumulated exercise.⁵

**INTERVENTION**

**Aerobic**

Participants from the aerobic group exercised on treadmill with a target of at least 52 hours of exercise within 18 consecutive weeks. The recommended frequency was three, 60-minute sessions per week that totaled to at least 52 hours by the end of the intervention period. The intensity of the exercise itself was adapted to the capabilities of each participant, ranging from light to moderate (57-63% for light and 64-76% for moderate) by heart rate measurements.⁶ The range of intensity chosen was to accommodate the participant’s fitness level and to avoid injuries by suggesting the previously sedentary participants to exercise vigorously. Heart rate was measured using the M3 smartwatch. Warming up, stretching and cooling down were not included as part of the exercise.

**Resistance**

Participants from the resistance group weight-lifted with a variety of options including free weights, machines, and body weight with a target of at least 52 hours of exercise over 18 consecutive weeks. The recommended frequency was four, 49-minute sessions per week that totaled to at least 52 hours by the end of the intervention period.
The required weight was adapted to the capabilities of each participant. Participants’ capabilities were determined by the amount of weight able to be lifted fully one set (8-12 repetitions of the same move). Alternatively, bodyweight exercises were also accepted. Warming up, stretching and cooling down weren’t included as part of the exercise.

**Post-Test**
Participants that completed the program were tested for their short-term memory using the FDS test within a week after completion. Data collected was compared and analyzed.

**Sample Size**
A recent meta-analytical review reported that the mean of human short-term memory score has not changed significantly in 85 years (mean 6.56, SD 1.22). Using these values, with 0.05 significance level and 95% power, 10 participants were required per group to demonstrate the effect size.

**Statistical Analysis**
SPSS V.19 was used for analysis with statistical significance set at p<0.05. Shapiro-Wilk test (p<0.05) was used to assess assumptions of normality on all baseline variables, while Levene’s test was used to determine homogeneity.

To establish the effect of each exercise group, Wilcoxon signed rank test was performed because of the abnormality of baseline variables. For the primary analysis of study outcomes, group differences were analyzed using the 2-sample independent t-test.

**RESULTS**

**Participants Characteristics**
The participants characteristics (sex, age and occupation) were similar between groups. Participants were all male and had a mean age of 22.95 (±5.33). Twenty five percent stated they were entrepreneurs and 75% were university students. There were no significant differences between-groups in baseline short-term memory score (P = 0.628). The mean of the aerobic group short-term memory score was 6.6 (±0.70) while the resistance group was 6.5 (±1.27).

**Primary Analysis**

*Between-Group Difference in Short-Term Memory Function*
The performance of each participant before and after the 18 weeks intervention is shown in Table 1. Short-term memory score increased in both exercise groups with the median scores of the aerobic group ranging from 6.6±0.699 to 7.2±0.422 (p=0.058) and the resistance group ranging from 6.5±1.269 to 6.9±0.876 (p= 0.206). Table 2 shows the result of the independent t-test done to compare the effect of exercise on both groups and resulted with P=0.628 showing that there was no significant difference between exercise groups on short-term memory function.

**Secondary Analysis**

*Short-Term Memory Difference within Aerobic Group*
Forward Digit Span results (P=0.058) increased in the aerobic group. There was increase in the mean of the forward digit span test (mean increase=0.6, 95% CI), indicating an improved, although insignificant, performance within the aerobic group.

*Short-Term Memory Difference within Resistance Group*
Forward Digit Span results, as shown in Table 4, increased in the resistance group (P=0.206). There was an increase in the mean of the forward digit span test (mean increase=0.3, 95% CI), indicating an improved, although insignificant, performance within the resistance group.
### DISCUSSION

This study examined the difference of short-term memory between aerobic and resistance exercise groups. To the best of our knowledge, this is the first study that directly compares the effect of long-term exercise between aerobic and resistance exercise. The duration of this study is also longer compared to its predecessors that lasts up to four weeks. The results support previous works in this area on young and healthy or cognitively impaired elderly participants. However, in the current study, secondary analysis demonstrated only modest changes within individual exercise groups.

The findings of the present study were consistent with previous studies that have reported increases in short-term memory function in response to long term exercise in healthy adults.

Modest short-term memory changes were observed in the aerobic group, which aligns with several past studies on long term (minimum four months) aerobic exercise that showed an increase in short-term memory function. Research by Moreau claimed that exercise is not an effective way to increase short-term memory function as there were no significant increase in the participant’s working memory function, which is closely linked to short-term memory. However, it was suspected that the results were due to indirect cognitive assessment, through behavioral observation, rather than the usual memory tests. The age of the participants was also on cognitive peak, making further significant changes hard to be acquired.

The protective effect of the working memory on elderly female participants aged 65-75 were observed after 52 weeks of resistance exercise and affirmed that even non-regular exercise could produce the same protective effect as the regularly exercised group. A more recent study by Moreau, et al. did not show any significant improvement in terms of short-term memory function, hence it was unable to establish a clear correlation between the exercise and short-term memory function increase. It was suspected that inconsistency of the type of resistance exercise could affect the results of the study. Iuliano, et al. also supported the two previously mentioned studies’ findings that resistance exercise did not show a significant change in short-term memory function.

In this study, changes in short-term memory score were observed, although not significant.
One of the factors that could induce these changes is high baseline scores, which leaves no room for improvement. Previous studies stated that changes were easier to be observed when the baseline was relatively low compared to the general average (7 ± 2). The time of the day the post-test was conducted can influence the results as different studies tested their participants at different time of the study. The human study showed that conducting the short-term memory evaluation a week after exercise intervention still present’s notable improvement of short-term memory function. Meanwhile another study on male rats (Rattus norvegicus), which conducted the evaluation 21 days after the last exercise session, did not show any improvements. A similar number of post-tests on human subjects have not been completed. Therefore, it can only be assumed that the effect of exercise on short-term memory lasted for seven days.

**CONCLUSION**

In summary, improvements on short-term memory function occurred in both aerobic and resistance exercise groups, although not significant. Perhaps conducting similar research comparing the effect of a different type of resistance exercise would help us determine its significance before comparing to aerobic exercise. A recurring short-term memory test could also be done during the intervention time to measure if there were improvements in short-term memory function.

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