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ABSTRACT

Purpose: The purpose of this study was to investigate if exercise in the form of moderate intensity interval training affected memory by comparing the performance of number of words recalled after the implementation of an exercise condition and a control condition.
Methods: The investigators tested a total of 20 participants. All participants completed an informed consent document prior to testing. Participants had three minutes to memorize a list of 15 words. This was followed by either 15 minutes of interval training or 15 minutes of sitting in a controlled environment. All participants participated in both the control and experimental conditions. A paired samples t-test was used to determine statistical significance.
Results: The participants were able to recall an average of 11±3 words in the control condition and an average of 9±4 words in the exercise condition. The results showed no statistical significance between control and exercise performance ($p=0.10$), nor was there any statistically significance difference in the performance between genders.
Conclusion: The study results show there was no effect on cognitive function performance (specifically short term memory) from moderate intensity interval training. This study failed to confirm that moderate intensity interval training evokes cognitive function benefits equivalent to those demonstrated in previous studies on continuous moderate intensity aerobic exercise and high intensity

interval training. Future studies should consider the effect of varying duration and intensity of the interval training to find a possible correlation.

INTRODUCTION

College is a major transition period for most college students. Students become more independent with their academics, food choices, and time utilization. Much of an average college student's time is used to engage in sedentary activities like sitting in a classroom, studying, watching television, or surfing the internet. About 33% of college students lead sedentary lifestyles (Quartiroli & Zizzi, 2012). And if not engaging in these activities, work, social obligations, or extra-curricular activities can take up additional time. Within the college-age population, absence of exercise or irregular exercise is commonly due to a lack of time. As the typical college student is constantly immersed in a very time consuming academic schedule, finding the extra time to engage in physical activity proves to be very challenging. A recent study showed that during college, especially during the first two years, physical activity decreased and body weight increased in college students (Hajhosseini et al., 2016). Another study showed that 75% of the college population engaged in moderate intensity exercise and 59% engaged in vigorous intensity exercise at least semi-regularly. Despite the participation in physical activity, 50% of those that engaged in physical activity do not meet the minimum ACSM exercise requirements (American College Health Association, 2015). Thus, a majority of college students participate in exercise, but not enough to receive full health benefits. A form of exercise called interval training can be a very beneficial type of exercise for the college age population due to its efficiency, along with other reasons. Interval training is different from traditional continuous training because instead of maintaining a constant intensity for a specific amount of time, the individual alternates between low, moderate, and high intensities. One study showed that interval training can improve cardiovascular function, quality of life, efficiency, aerobic fitness, and exercise adherence (Gayda, Dominique, & Said,

2016). It is common for college students to have busy schedules that do not offer any time to fit in one to two hours at the gym, so interval training is an efficient alternative to achieve daily exercise. Interval training can be completed in as little as ten minutes or more if desired. This smaller time frame can encourage college students who want to exercise, but cannot afford to lose an hour of their time.

Along with the efficiency of time, interval training is speculated to improve cognitive functioning, which could also serve to benefit college students. A recent study found that interval training can improve the ability of the brain to transition from thinking about one concept to the other, or thinking about two concepts simultaneously, when performed regularly for at least seven weeks (Venckunas et al., 2016). Along with the accessibility and cognitive benefits of interval training, the time-efficient aspect of it can be another reason that college students may be attracted to this form of exercise.

According to the National College Health Assessment (NCHA), only 20.9% of students engage in physical activity 5-7 days a week, with 23.6% of students reporting zero physical activity in the past 7 days (American College Health Association, 2015). Many students assume that taking time off from studying to exercise will harm their academic performance, but based upon the previously cited research, it can be speculated that exercising can be beneficial for academics, specifically memory retention. It has been shown in recent research that four primary factors affect physical activity behavior in college students. These include professional factors, cognitive factors, social factors, and environmental factors (Venckunas et al., 2016). Of these, cognitive factors with the independent variable of self-efficacy were observed to be the primary reason college students participated in physical activity (Young, Sturts, Ross, 2015). Two recent studies supported that high intensity interval training can improve cognitive function (Alves et al. 2014; Tsukamoto et al., 2016). There is far less research and conflicting results reported regarding the effects of moderate intensity exercise on cognitive function (Peiffer, Darby, Fullenkamp, & Morgan, 2015; Tsukamoto et al., 2016). The wide multitude of cognitive

benefits associated with interval training suggests it is a worthwhile method of exercise for college students anywhere.
On average, a typical aerobic exercise bout can take anywhere from 30 minutes to an hour depending on the individual's regimen, this may deter the average college student from participating in physical activity solely due to their time constraints. But interval training may exhibit the same cognitive benefits associated with aerobic exercise, in as little as 10 or 20 minutes. This may be observed as a more appealing and feasible option for the average college student with time constraints. Thus, eliminating the negative environmental factors; previously deemed by recent studies, to be amongst the primary factors deterring college students from participating in physical activity. Thus, the purpose of this study was to further investigate if exercise in the form of moderate intensity interval training affects memory function. It was hypothesized that moderate intensity interval training (intermittent bouts of walking and running) would have a positive effect on memory retention.

MATERIALS & METHODS

Overview of the Study

This study targeted college-aged individuals, ages 19-22, with no known attention deficit disorders, cognitive dysfunctions, or acute musculoskeletal injuries. Also, any individuals deemed "high risk" by ACSM guidelines were not eligible to participate. Interested individuals contacted the investigators of the project via the email address or phone number listed on the advertising materials. Investigators then responded to interested individuals to initiate a health screening process to ensure eligibility . Participants were given an electronic copy of the *American College of Sports Medicine (ACSM) Health/Fitness Facility Pre-participation Screening Questionnaire* and requested that individuals complete the form and return it to the investigator. This questionnaire identified any major signs/symptoms/conditions that contraindicated exercise for an individual and consequently excluded the individual from participation in the research study. After investigators reviewed the questionnaire and ensured that it was safe for the individual to participate, the investigators contacted the individual to set up an

appointment for them to report to the testing facility. Participants were asked to arrive at the testing location having done the following: completed a three-hour fast (no food or beverage, with the exception of water), avoided the use of nicotine for at least four hours, and avoided strenuous exercise for at least 24 hours. Participants wore athletic shoes and loose comfortable clothing.

Data Collection

Upon arrival to the testing site, participants were given the opportunity to express any questions or concerns regarding their involvement in the study and the investigators provided any further necessary information for the study. After all question/concerns were addressed by the investigators, participants were asked to sign two informed consent documents. One form was given to the investigator and the other consent form was given to the participants for their records. All procedures were approved by the Georgia College Institutional Review Board. Participants were also given an identification code to protect their confidentiality that was used by the investigators to perform a cross-sectional study, randomly placing subjects into one of the two test conditions. The even identification codes underwent the control condition for their first visit and the exercise condition their second visit, while the odd identification codes underwent the experimental condition first and the control condition their second visit.

Exercise Condition: The participants arrived to the testing facility at their specified date and time. The participants had their blood pressure taken for baseline measurements. The participants were then seated in a quiet area and given a list of 15 random words. The participants had 3 minutes to memorize the words. After the 3 minutes, the participants went to the track and performed a 1.5-minute walking warm-up followed by participation in moderate intensity interval training. The participants alternated running for 2 minutes and walking for 1 minute for a total of 12 minutes. An investigator was stationed at each corner of the track where the participants were performing interval training. One investigator had a stopwatch and instructed the participants when to switch from

walking to running and vice versa. The participants walked and ran at their own pace while staying at moderate intensity. Participants' intensity was monitored using the Borg Rating of Perceived Exertion (RPE) where the participants rated their perception of effort, fatigue, and physical exertion based on a 6 to 20 scale. According to ACSM guidelines, moderate intensity is rated between 12 to 14 on the Borg RPE scale. After the interval training, the participants performed a 1.5- minute walking cool down. Then the participants returned to the quiet area, were timed for 3 minutes, and asked to write down as many words as they could recall from the list of 15 words during the 3-minute time frame. One of the researchers calculated how many words the participants recalled and recorded the data, while the participants completed cool down stretching and follow-up blood pressure measurements. Participants were required to stay on site until their blood pressure returns to approximately resting levels. Participants were then dismissed.

Control Condition: The participants arrived at the testing facility at their return specified date and time. In order to standardize procedures as performed in the exercise condition, participants had their baseline blood pressure assessed. Participants then sat in a quiet classroom and were given a list of 15 words to memorize in 3 minutes. They were allowed 3 minutes to memorize the 15 words then remained seated for 15 minutes in the classroom. Once the 15 minutes passed, the participants were timed for 3 minutes and asked to write down as many words as they could recall from the list of 15 words during the 3- minute time frame. One of the researchers calculated how many words the participant recalled and recorded the data from the second recall. Participants were then dismissed.

Statistical Analysis

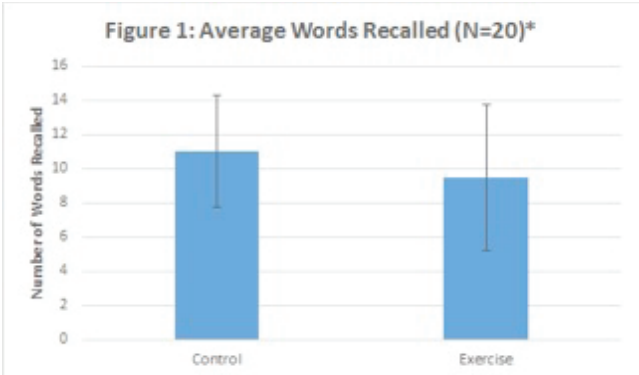
All data collected were analyzed using Statistical Package for the Social Sciences (SPSS) version 22. Descriptive statistics (mean ± SD) were calculated for the dependent variable, number of recalled words. Dependent t-tests were performed to compare the control and experimental scores between the two groups. Statistical significance was set at $p<0.05$.

RESULTS

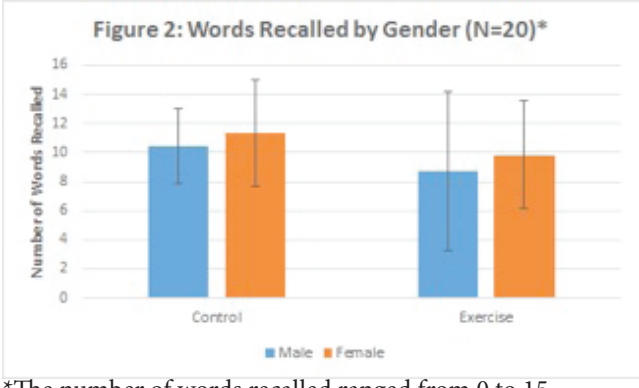
There were a total of 20 college students that expressed interest in this study and none were dismissed due to any exclusionary criteria. No adverse events occurred during any of the individual tests and participants verbally confirmed keeping the requested RPE parameters while exercising. All the participants were between ages 18 and 22 with 35% (n=7) of the volunteers being male and 65% (n=13) being female.

Of the 15 possible words to recall, the participants recalled an average of 11±3 words in the control group and 9±4 words in the exercise group. However, these results were not statistically significantly different. Figure 1 below provides a visual representation of the average words recalled between the control and experimental groups.

By gender, the average words recalled in the control group were 10±3 words by males and 11±4 words by females. In the exercise group, the average words recalled were 9±5 words by males and 10±4 words by females. Figure 2 below provides a visual representation of these results. The paired samples t-test did not indicate any statistical significance between exercise and cognitive function (p=0.10) and the independent samples t-test did not show any statistical significance between exercise and cognitive function between genders. By gender, the average words recalled in the control group were 10±3.



*The number of words recalled ranged from 0 to 15.



*The number of words recalled ranged from 0 to 15.

DISCUSSION

The purpose of this study was to further investigate if exercise in the form of interval training affects memory function. It was hypothesized that interval training that included intermittent bouts of walking and running would have a positive effect on memory retention. Due to no statistically significant findings revealed by the paired samples t-test comparing testing conditions, or the independent samples t-test comparing gender performance; the research hypothesis was rejected.

Past studies have shown that acute continuous moderate intensity exercise improves cognitive function (Alves et al., 2012; Yanagisawa, et al., 2010) and others have indicated that high intensity interval training also improves cognitive function (Alves et al., 2014). These past studies used the Stroop test (Stroop, 1935) to

measure cognitive function. The present study was based upon the successful results of the previous studies and sought to investigate if moderate intensity interval training could also benefit cognitive performance using a list of 15 randomly generated words rather than a Stroop test. Contrary to the hypothesis of the present study, the results indicated that cognitive function was not enhanced by low-moderate intensity interval training. This could be due to a lack of a consistently controlled environment (noise disturbances at testing site), small sample size, and the use of a different assessment of cognitive ability. The word list might not be as indicative of cognitive function as the Stroop test has proven to be, which could have skewed the results.

A possible explanation as to why the results of the present study did not agree with studies previously published could be the level of hydration of the participants. It is clearly seen that dehydration impairs the cognitive function of the brain (Cian et al., 2000; Cian, Barraud, Melin, & Raphel, 2001). Tomporoski in 2003 found that submaximal aerobic exercise greatly increased cognitive function, but during continued bouts of extended, strenuous exercise leading to dehydration both information processing and memory cognition were compromised. Participants in this study were advised to hydrate before arriving to the testing site, as advised by ACSM guidelines, but there were no measures taken to ensure proper hydration levels among the participants. Differing levels of starting hydration levels as well as selected intensity could have influenced how quickly the participants became dehydrated. Hydration status could be a possible factor that affected the results of the present study; however, no participants visually or verbally expressed signs of dehydration at any point of the data collection process.

The results of the study did not indicate that interval training had any statistically significant effect on cognitive function; this may be attributable to several limitations. These limitations include the homogeneous nature of the physical activity patterns of the sample population, the setting in which the study was conducted, and the subjectivity of the RPE sale used to measure exercise intensity. Through the implementation of a convenience sample selection

of participants, the sample population may have served as a limitation to this study. According to a recent statistic, only 49% of the general population is considered physically active, however, 55% of the subjects tested were enrolled in the exercise science major and consequently likely to have a much higher level of physical activity than the general population. Therefore, a testing sample mainly composed of exercise science majors, who are known to be exponentially physically active; limits the applicability of the findings to the general population.

The testing environment limitations included factors such as the disturbance of the testing setting, resultant from sporting events occurring, on occasion, at the same time as the conduction of both exercise and controlled trials. The lack of consistency in the testing environment may have impeded the participant's mental concentration in the controlled setting, and potentially tampered with the reliability of the exercise setting. Finally, the RPE scale may serve as a limitation affecting the measurement of intensity during the exercise trials. Although the participants reported their RPE values during the experiment were within the requested range, the subjectivity of the RPE scale creates the potential for participant variability, which in turn potentially limits the validity of data collected. Future studies investigating interval training on memory function should seek to overcome these limitations. Adaptations including, a testing environment that may be easily controlled, additional objective methods for the measurement of exercise intensity (i.e. heart rate), the recruitment of a larger sample size, and the selection of participants in such a way that ensures variety of physical activity patterns of the testing sample. Additional studies should also be conducted to further investigate interval training and mental cognition; specifically addressing the possible effects of interval training on long term memory, which was not addressed in this study.

Although there were no statistically significant findings from the research conducted, there are still ways in which the findings can be applied clinically. It can be inferred that interval training does not affect cognitive functioning, specifically memory, in college age individuals, but future studies can expand upon the

present study by implementing certain changes. They could focus more on differences within the genders and how they respond cognitively to interval training. Along with this, future studies could change the modality of interval training used, or the duration and intensity. A more extensive population could be examined, instead of using just college students, to improve validity and accuracy within the results. After accumulating the results of our study, other studies could place a greater emphasis on determining what types of exercise, instead of interval training, affect cognitive function in individuals.

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