DOES EXERCISE AFFECT COGNITIVE PERFORMANCE DIFFERENTLY IN MEN AND WOMEN

by

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Abstract

There are known sex differences between men and women when completing memory tasks. Men are better at completing the mental rotations task and women are better at the object search tasks. Previous studies suggest that small bouts of exercise can have an effect on cognition. The current study examined the effects of exercise on certain cognitive tasks. The mental rotations test measured spatial ability and the object array task measured object memory. Three different types of exercise were examined, including cardiovascular, stretch, and resistance training. Each of these different exercise types can have different benefits for an individual. This study is important because physical fitness is a main part of life. Going to the gym or a workout session is not the only way to be physically fit, but it can include; walking to a destination, taking the stairs, walking a dog, or doing stretches in the morning. Exercise is all around and accessible in many different forms. The present study found that exercise decreased performance on the cognitive tasks when exercise was included. The study concluded that participants that exercised regularly had similar or worse spatial ability and object memory performance to those who regularly exercised.

Does Exercise Affect Cognitive Performance Differently in Men and Women

Many people know that exercise is necessary for keeping a body in shape. However, what they may not know is that it is also necessary for keeping the mind in shape. There are different studies that look at how physical exercise can help improve cognitive functions. This is a topic of interest because physical activity is something that is attainable for people. Whether it is a small amount or large amount of exercise it can be beneficial for a person's health. The majority of these studies have investigated the effects of exercise on reducing age-related cognitive decline in older adults. Older adults seem to have more cognitive deficits than younger adults and this could be why there are more studies that focus on the older age group. There are different forms of exercise that can be beneficial; such as cardiovascular, stretching, and resistance training. Cardiovascular exercise has been previously recommended as a beneficial form of exercise. These different forms of exercise all have different effects on cognitive processes.

The Effects of Exercise on Different Age Groups

Research investigating exercise and its effects on cognition are typically broken into three different categories; young, middle-age, and old. Few studies investigating the cognitive benefits of exercise have included younger participants because the older population can have memory deficits that exercise may improve. Younger participants are not displaying cognitive deficits to the extent as the older population are. Some studies have shown that exercise can enhance cognition (Shay & Roth, 1992; Voss et al., 2019). There are other studies in which involving young and older subjects are compared, there is a larger improvement from exercise in the older groups. (Hötting, Holzschneider, Kauschke, Schmidt, Reer, & Röder, 2012; Hawkins, Capaldi, & Kramer, 2013; Shay & Roth,1992). A study was done in Taiwan that included undergraduate and graduate students; this study did not include an older adult population. The study examined brain activation using an EEG while participants completed visuospatial tasks and a cardiovascular exercise endurance task. The main results of this experiment showed that the cardiovascular group had faster reaction times than the control group Wang, Shih,& Tsai (2016). However, there were few other differences between the exercise and control group. This could be because young subjects may have less room for improvement on cognitive tasks. Younger participants do not experience as many deficits and this could be why they do not show much improvement on cognitive tasks. The current study will be looking at college aged students to determine if a specific exercise regimen improves performance on cognitive tasks.

Another study that examined 48 undergraduate participants (33 female) were asked to memorize a paragraph and then tested on their long-term memory recall of the paragraph (Labban & Etnier, 2011). Participants were randomly assigned to one of three groups; exercise prior to recall group, exercise-after group, or the control group. Participants performed a single bout of moderate intensity exercise on a cycle ergometer. Results indicate that both of the exercise prior and exercise-after groups had increased recall, but the exercise-prior group had the best recall.

Research investigating middle-age subjects has focused on enhancing cognitive deficits with exercise. The age range of middle-aged adults is 30 to 50 years old. Studies have found that middle-aged groups improve more on cognitive processes after exercise than young groups, but the old groups have the greatest difference (Shay & Roth, 1992). One study focused on the effects of exercise on a middle-aged population for their experiment. They looked at how stretching and cycling exercises effects cognitive tasks (Hötting et al., 2012). This study also included a six-month period of interventions training. The results show that both types of exercise are beneficial to different memory tasks.

Another avenue of research investigated the effects of exercise on age-related cognitive decline. There are multiple studies that look at different forms of exercise and how it can help different parts of the brain and, in turn, help different functions of memory. In one study, the participants ages ranged from 63 to 82 years and they were part of a 10-week aquatics class. The main results showed that the 10-week aquatic intervention group improved their performance on cognitive tasks than the control group (Hawkins, Capaldi, & Kramer (2013). Another study that investigated an older population of people included 60-80-year olds Voss & colleagues 2019). The group of 34 participants had to complete two biking conditions: the lighter version without resistance and then the moderate with resistance condition. After the exercise was completed, they underwent a fMRI brain scan while completing a memory task. The participants showed more activity in the parts of the brain that collect and share memories when performing working memory task. They saw an increase in activity in the medial temporal, parietal cortex, and the prefrontal cortex. The adults that showed increased activity when they underwent the brain scan, also did better on the working memory test. Voss et al., (2019)

Intervention and non-intervention studies, Pre-test and Post-test regimens

Intervention studies involve exercise training before cognitive testing in an experiment. This can include a pre-test to examine an individual’s fitness level to place them in the correct intervention training group. This exercise can last a month, six months, or a year. The activity can be performed for 30 minutes to an hour. Intervention studies can have impacts on people who do not frequently exercise because they experience a new routine. Hötting and colleagues (2012) incorporated participants that had only been exercising two times a month in the past five years. The participants were mostly sedentary, and the intervention study provided an exercise routine. This intervention includes a pre-test of physical fitness by an incremental step test and once they moved on in the study participants had to complete 60 minutes of session twice a week. Participants had to complete 48 sessions which rounded to seven months. They found that the cycling and stretching exercise groups had better results on cognitive tests than the control group. There was improvement on the attention task in the stretching group while episodic memory recognition scores were improved in the cycling group.

Many intervention studies have conflicting results. The level of intensity of the exercise is one of the determining factors. Higher intensity workouts can cause fatigue in an individual and depending on how much time they exercise may cause a decline on cognitive tests Tomporowski (2003); Tomporowski & Ellis (1986). A study done by Gupta and others had participants exercise either two, five, ten, or fifteen minutes (Gupta, Sharma, & Jaspal 1974). They then had to complete arithmetic problems right after they exercised. Results demonstrate that people who exercised in the two- or five-minute groups had a significant improvement on arithmetic problems. The participants in the ten to fifteen-minute groups had a significant decrease in completion of the arithmetic problems.

Short bouts of exercise before completing a cognitive task can improve performance after or during a task. One study examined three different conditions; exercise before exposure to a task, exercise after exposure to a task, and a control group. The control group rested for thirty minutes and then were exposed to the stimuli, rest, and then had to recall what the stimuli were. Labban & Etnier, (2011). Both of the training groups recalled more than the control groups, but the pre-training exercise group enhanced recall significantly more than the control group. Exercise in general seems to have a positive effect on completing tasks. An animal study examined the effect of forced exercise in rats Radahmadi, Alaei, Sharifi, & Hosseini, (2015). The animals were placed into five different groups; control group, sham exercise, exercise then rest,

rest then exercise, and lastly the exercise-exercise group. The rest period was 21 days so the rest-exercise group would rest for 21 days and then exercise for 21 consecutive days. The results show that the exercise-exercise group had the greatest improvement in short, mid, and long-term memory. The rest-exercise group only improved on mid and long-term memory. Thus, the timing of when exercise occurs may influence cognitive performance.

Forms of Exercise in the Present Study

There are different forms of exercise that affect the body differently and each of these exercises may have different effects on memory. For instance, stretching and cardiovascular exercises can have different effects on certain cognitive tasks.

Stretching is the act of extending a limb and muscle. Yoga is a popular choice for stretch exercise. In one study, cardiovascular exercise and stretching were examined to determine which form of exercise enhanced cognitive functions Hötting et al., (2012). Stretching condition affects cognitive tasks of attention, executive functions, and spatial reasoning. Cardiovascular exercise was tested by using a cycling test. The cardiovascular condition did not show as much improvement as the stretch/coordination condition. Hötting et al., (2012).

Cardiovascular exercise is when a person's heart rate increases by the activity; this can include running, jogging, walking, or swimming. Cardiovascular exercise has been shown to improve cognitive functions. Running on a treadmill may alter brain chemistry and cognitive functions involving the hippocampus. Albeck et al. 2006; Kim et al. (2010). Many studies examine the differences in cardiovascular fitness and stretching exercises and their benefits. In one study, cardiovascular/aerobic exercise was examined in young, middle-aged, and aged subjects. The participants were separated into either high or low fitness groups and then tested on cognitive tasks. The younger participants did not show a difference on cognitive tasks between the high and low fitness groups. The middle age and old participants demonstrated enhanced performance on cognitive tasks in the high fitness group Shay & Roth (1992).

Present Study

The present study examined whether or not exercise has an effect on cognitive tasks in college aged students and if there is a difference in this effect in males and females. There are studies that show that males are better at completing the mental rotations task that examines spatial ability (Geiser, Lehmann, & Eid, 2008;Vandenberg, & Kuse, 1978). There are also studies that show that females have better performance on object tasks (Saucier, Green, Leason, Macfadden, Bell, & Elias, 2002). Few studies have examined the effects of exercise in young participants and even fewer have examined differences in the effects of exercise in males and females.

The current study examined performance on the mental rotations task and object array task. This is one of the first studies to look into the effects of exercise on these tasks in males and females. My hypothesis was that exercise will enhance task performance in both sexes.

Methods

Participants

Participants included 83 students from SUNY Purchase. All of the participants were over the age of 18. The mean age of males was 21years old and females was 19 years old. The participants for the study were collected from the Introduction to Psychology Participant Pool and by flyers on the campus. Students were compensated for doing the study by receiving a class credit.

Demographics Questionnaire. Qualtrics

A survey using Qualtrics will be given to the participants of the study asking them their sex, how many times they work out per week, and what types of exercise they do. The present study will focus on sex, either male or female. Mainly looking for differences in how exercise can affect the sexes differently when performing the cognitive tasks.

Object Array Task

Participants will be given an 8 ½ x 11 sheet of paper with multiple black and white drawings of 31 symbols. The participants will study the array for 1 minute. After 1 minute, the original paper will be removed, and participants will be handed the second paper. This paper will have the same objects as the original one, except seven pairs of objects will have been moved around to different positions. The participants will be given 1 minute to circle the moved objects. After completing the second object array task they will be given a third piece of paper, now having 14 objects in different spots then the first paper they were given. The participants will be given 1 minute to circle the objects that have been moved on the third piece of paper. The participants will then complete the MRT and will be given the fourth piece of paper and now have to circle the new objects for 1 minute. The fourth paper will contain 17 of the symbols from the first paper and 14 new symbols. Participants performance on the object array task will be measured as the number of symbols correctly circled minus the number of objects incorrectly circled. The maximum score for each paper is 14, because 14 objects will be changed in each paper presented.

Vandenburg 3D Mental Rotation Task

The Vandenberg and Kuse Mental Rotations Test as previously described (Peters et al., 1995) will be used in the present study. The participants will be given a 24 question MRT. The MRT task contains a 3-dimensional black and white object that is the main object on the left.

There are also four different 3-dimensional black and white objects on the right. There are two correctly rotated objects that match the main 3-dimensional object. The participants circle the two correctly rotated objects to get the question correct. The participants will have 4 minutes to complete the first set of 12 MRT tasks. After they have finished with the first 12, they will have a four-minute break. After the break they will again have four minutes to complete the next 12 MRT tasks. The participants will receive a score of “1” for each correct answer (correctly circling both rotated objects). The maximum score for the MRT is 24.

Materials and Procedure

The tasks were done in person, in a private Psychology lab on the SUNY Purchase campus. Participants were given an informed consent form and the demographics survey using Qualtrics. The participants completed the two cognitive tasks the Object Array Task (Levy et al., 2005) and the Vandenburg Mental Rotation Task (Peters et al., 1995). The whole experiment took 40 minutes to complete. Participants arrived at the designated lab to complete the current study. When participants arrived, they had completed the Qualtrics online demographics survey and had been given a three-digit number to use as their identifier. Participants were then directed to sit in the designated chair and were given the first part of the experiment the object array task. Participants were told they has thirty seconds to study the first page of the object array task. After the first part of the study finished participants were directed to turn the page and had another thirty seconds to circle objects that had moved from their original positions they had studied previously. Then participants were directed again to turn the page and would have thirty seconds to circle objects that have moved from the original array. When participants had finished this part of the study, they were given the next test which was the mental rotations task. Participants were asked to look at the first page which included a target figure on the left side and four rotated objects on the right. Participants were told to state if they saw that the figures on the right were rotated versions of the target stimuli on the left. Participants were then told to complete three problems on page two, the answers were given at the bottom of the page and they had to put an "X" across the correctly rotated figures to get them correct. Participants were then read the instructions for the main part of the task; they were told that they would have four minutes to do pages three and four. They were told they had to mark the two correctly rotated figures with an "X" across the box. Once the four minutes were up the participants turned their papers over and take a four-minute break. After the four-minute break was over participants had another four minutes to complete pages five and six to mark the two correctly rotated objects that matched the target stimulus on the left with an "X". Participants were then given the last part of the study which was another object array task. Participants had thirty seconds to circle new objects that were in the new array. Once participants had finished the last part of the study they were debriefed and then were able to leave the lab.

Results

The main hypothesis was that exercise will enhance task performance in both sexes. An independent samples t-test comparing the scores of the object array tasks in males. The exchange trial of the object array task which depended on being male, and the stretch exercise condition which was the exercise variable revealed to be not significant, (19) = -0.25, p = 0.81.The object exchange scores of the object array for males that exercise (M = 5.4, SD = 4.17) was not significantly lower than the object exchange scores of males that did not exercise (M = 5.83, SD = 3.26).

The object shift trial of the object array between males and the stretch exercise condition was not significant, t(19) = 0.15, p = 0.88. The object shift scores of the object array for males that exercise (*M* = 5.0, *SD* = 2.92) was not significantly lower than the object exchange scores of males that did not exercise (*M* = 4.83, *SD* = 2.17).

The object novel trial of the object array between males and the stretch exercise condition revealed a significant difference between the means of the two groups, $t(19) = -2.25$, $p = 0.04$, $d = -0.99$, 95% CI [-1.91,-0.06]. The object novel scores of the object array for males that exercise (*M* = 8.44, *SD* = 4.13) was not significant from the object exchange scores of males that did not exercise (*M* = 11.42, *SD* = 1.78).

Finally, an independent samples t-test comparing the scores of the mental rotations task between males and the stretch exercise condition revealed a significant difference between the means of the two groups, $t(19) = 0.17$, $p = 0.92$, $d = 0.05$, 95% CI [-0.82,0.91]. The mental rotations task score for males that exercise (*M* = 13.33, *SD* = 3.12) was not significant from the object exchange scores of males that did not exercise (*M* = 13.08, *SD* = 6.47).

There were independent samples t-tests run comparing the scores of the object array task between males and the resistance exercise condition. The exchange trial of the object array between males and the resistance exercise condition was not significant, $t(19) = 0.20$, $p = 0.84$. The object exchange scores of the object array for males that exercise (*M* = 5.82, *SD* = 3.89) was not significant compared to the object exchange scores of males that did not exercise (*M* = 5.5, *SD* = 3.17). The object shift trial of the object array between males and the resistance exercise was not significant between the means of the two groups, $t(19) = -0.52$, $p = 0.61$. The object shift scores of the object array for males that exercise (*M* = 4.64, *SD* = 2.87) was not significant between the object exchange scores of males that did not exercise (*M* = 5.2, *SD* = 1.99). The object novel trial of the object array between males and the resistance exercise condition revealed a non-significant difference between the means of the two groups, $t(19) = 0.19$, $p =$

0.86. The object novel scores of the object array for males that exercise (*M* = 10.27, *SD* = 2.76) was not significant compared to the object exchange scores of males that did not exercise (*M* = 10.0, *SD* = 3.94). An independent samples t-test comparing the scores of the mental rotations task between males and the resistance exercise condition revealed a significant difference between the means of the two groups, $t(19) = -0.67$, $p = 0.51$, $d = -0.29$, 95% CI [-1.15,0.57]. The mental rotations task score for males that exercise (*M* = 12.46, *SD* = 5.37) was not significantly lower than the object exchange scores of males that did not exercise (*M* = 14.0, *SD* = 5.14).

Independent samples t-test were run comparing the scores of the object array tasks in males and the cardiovascular condition. The object exchange trial was not significant between the means of the two groups, $t(19) = -0.37$, $p = 0.71$.The object exchange scores (*M* = 5.42, *SD* = 3.97) was not significant between the object exchange scores of males that did not exercise (M = 6.0, SD = 2.92). The object shift trial of the object array between males and the cardiovascular exercise condition was not significant between the means of the two groups, $t(19) = 0.03$, $p = 0.98$.The object shift scores of the object array for males that exercise (M = 4.92, SD = 2.71) was not significant between the object exchange scores of males that did not exercise (M = 4.89, SD = 2.21). The object novel trial of the object array between males and the cardiovascular exercise was not significant between the means of the two groups, $t(19) = -.63$, $p = 0.12$. The object novel scores of the object array for males that exercise (M = 9.17, SD = 3.95) was not significant between the object exchange scores of males that did not exercise (M = 11.44, SD = 1.51). Finally, an independent samples t-test comparing the scores of the mental rotations task between males and the cardiovascular exercise condition revealed a significant difference between the means of the two groups, $t(19.0) = -0.61$, $p = 0.55$, $d = -0.27$, 95% CI [-1.13,0.60].

The mental rotations task score for males that exercise (M = 12.58, SD = 5.14) was not significant between the object exchange scores of males that did not exercise (M = 14.0, SD = 5.45).

The main hypothesis was that exercise will enhance task performance in both sexes. An independent samples t-test comparing the scores of the object array task performance in females. Object exchange between females and the stretch exercise condition was not significant between the means of the two groups, $t(58) = 0.06$, $p = 0.11$.The object exchange scores of the object array for females that exercise ($M = 6.92$, $SD = 4.10$) was not significant compared to the object exchange scores of males that did not exercise ($M = 6.91$, $SD = 2.94$). The object shift trial of the object array between females and the stretch exercise condition was not significant between the means of the two groups, $t(58) = -0.15$, $p = 0.8$. The object shift scores of the object array for females that exercise ($M = 4.92$, $SD = 2.75$) was not significantly lower than the object exchange scores of females that did not exercise ($M = 5.03$, $SD = 2.85$). The object novel trial of the object array between females and the stretch exercise condition revealed a significant difference between the means of the two groups, $t(58) = 0.95$, $p = 0.35$, $d = 0.25$, 95% CI [-0.27,0.76]. The object novel scores of the object array for females that exercise ($M = 11.04$, $SD = 2.15$) was not significant between the object exchange scores of females that did not exercise ($M = 10.51$, $SD = 2.08$). An independent samples t-test comparing the scores of the mental rotations task between females and the stretch exercise condition revealed a significant difference between the means of the two groups, $t(58) = -1.54$, $p = 0.13$, $d = -0.40$, 95% CI [-0.92,0.12]. The mental rotations task score for females that exercise ($M = 8.0$, $SD = 3.71$) was not significant between the object exchange scores of males that did not exercise ($M = 9.80$, $SD = 4.91$).

The resistance exercise group and the scores from the object array task were run with independent samples t-tests. The object exchange trial of the object array between females and the resistance exercise condition revealed a significant difference between the means of the two groups, $t(58) = -2.36$, $p = 0.02$*, $d = -0.66$, 95% CI [-1.21,-0.19]. The object exchange scores of the object array for females that exercise ($M = 5.42$, $SD = 3.64$) was not significant, but did show a trend than the object exchange scores of females that did not exercise ($M = 7.61$, $SD = 3.19$). The object shift trial of the object array between females and the stretch exercise condition was not significant between the means of the two groups, $t(58) = -0.66$, $p = 0.51$. The object shift scores of the object array for females that exercise ($M = 4.63$, $SD = 2.91$) was not significant between the object exchange scores of females that did not exercise ($M = 5.15$, $SD = 2.75$). The object novel trial of the object array between females and the resistance exercise condition revealed a significant difference between the means of the two groups, $t(58) = 0.27$, $p = 0.79$, $d = 0.08$, 95% CI [-0.47,0.62]. The object novel scores of the object array for females that exercise ($M = 10.84$, $SD = 1.93$) was not significant between the object exchange scores of females that did not exercise ($M = 10.68$, $SD = 2.22$). Finally, an independent samples t-test comparing the scores of the mental rotations task between females and the resistance exercise condition was not significant between the means of the two groups, $t(58) = -1.89$, $p = 0.06$, $d = -0.52$, 95% CI [-1.07,0.03]. The mental rotations task score for females that exercise ($M = 7.5$, $SD = 3.15$) was not significant, but did show a trend than the object exchange scores of females that did not exercise ($M = 9.88$, $SD = 4.60$).

An independent samples t-test comparing the scores of the object exchange trial of the object array between females and the cardiovascular exercise condition revealed a significant difference between the means of the two groups, $t(58) = -0.35$, $p = 0.73$, $d = -0.09$, 95% CI [-

0.60,0.42]. The object exchange scores of the object array for females that exercise (*M* = 6.75, *SD* = 3.61) was not significant between the object exchange scores of females that did not exercise (*M* = 7.06, *SD* = 3.49). The object shift trial of the object array between females and the stretch exercise condition was not significant difference between the means of the two groups, *t*(58) = -0.70, *p* = 0.50. The object shift scores of the object array for females that exercise (*M* = 4.71, *SD* = 3.21) was not significant between the object exchange scores of females that did not exercise (*M* = 5.23, *SD* = 2.43). The object novel trial of the object array between females and the stretch exercise condition revealed a significant difference between the means of the two groups, *t*(58) = 1.81, *p* = 0.08, *d* = 0.47, 95% CI [-0.05,0.18]. The object novel scores of the object array for females that exercise (*M* = 11.3, *SD* = 1.88) was not significant between the object exchange scores of females that did not exercise (*M* = 10.3, *SD* = 2.23). Lastly, an independent samples t-test comparing the scores of the mental rotations task between females and the stretch exercise condition was not significant between the means of the two groups, *t*(58) = -1.41, *p* = 0.23. The mental rotations task score for females that exercise (*M* = 8.28, *SD* = 4.51) was not significant between the object exchange scores of males that did not exercise (*M* = 9.81, *SD* = 4.44).

Discussion

The present study reports that regular exercise does not improve spatial abilities or object memory in young men and women. Neither stretch exercise, Cardiovascular exercise nor resistance exercise had an effect on performance in the MRT and object array tasks. Our findings are consistent with a previous study that reported no effect of exercise on working memory tasks (Pontifex., et al., 2014). This study examined young participants, the mean age of 22. Participants completed a treadmill test which allowed participants to either walk or run with increases on the incline grade of 2.5% every two minutes, and then tested on cognitive tasks.

Exercise did not affect working memory on the OSPAN task, symmetry span task, or the N-back task. These results are consisting with results from the present study demonstrating that exercise did not improve working memory in the MRT and the object array task. The current study extends previous results and suggests that even exercise groups without pre training conditions did not experience enhanced task performance. Both the current study and this previous report examine college aged students. College aged students have an active lifestyle and might exercise regularly without effort and in ways they do not report, for example by walking around their campus. Nevertheless, this study confirms prior findings suggesting that exercise does not enhance cognitive performance in young subjects. Further, our study extends previous findings by examining males and females separately and investigating different forms of exercise.

One limitation of the current study is that self-report was used to identify exercise patterns. Self- report relies on participants to be truthful. Also, there are times that self-reports could be inaccurate. A future study may use an intervention study design. Using an intervention study design could have a different effect when collecting data because different forms of exercise can be executed in the lab and controlled by the experimenters. There have been studies that show that exercise enhances cognitive processes, but those prior studies were mainly performed in older adults. When older adults' complete studies that have a routine of exercise, they often have enhanced cognitive performance (Pontifex., et al., 2014). Exercise may therefore improve age-related cognitive decline in older subject, but not in young adults.

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Appendix A

Informed Consent Form

Name of Study: The Effects of Exercise, Nicotine and Exogenous Hormone Use on Object Memory and Mental Rotation in Young Men and Women

Researchers: Principal Investigators: Kathleen Beach, Ethan Sua, Lily Otto, Nadia Shadi
Sponsor: Harburger

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Purpose: We would like permission to enroll you as a participant in a research study. This study investigates how multiple variables affect cognitive performance.

Procedure: In this experiment, you will be asked to complete a personal information questionnaire. The questionnaire will ask you personal questions ranging from drug and exercise habits to questions about your hormones. After the personal information questionnaire you will be asked to complete two cognitive performance tests. All information collected will be kept anonymous. The study should take approximately 60 minutes.

Costs, risks, and discomforts: This study has minimal risks. The personal information questionnaire may evoke some discomfort from reporting any personal information that one does not wish to share. This study is not mandatory and you can opt out at any time. Your identity will not be reported and will remain anonymous.

Benefits and compensation: The general benefit of participating in scientific research is the satisfaction that comes from contributing to science and the pursuit of knowledge. If applicable, participation in this research will allow college student participants to be compensated through class credit.

Confidentiality: The results of this study may be published in a scholarly book or journal or used for teaching purposes. However, your name and other identifiers will not be used in any publication or teaching materials. Your data will never be associated with your name or any other information that would make it possible to identify you.

Refusal or withdrawal of participation: You do not have to participate in this study. If you decide to participate, you can change your mind and drop out of the study at any time without affecting your present or future interactions with the experimenters and with no loss of credit for participation.

Signature: I confirm that the purpose of the research, the study procedures, the possible risks and discomforts, as well as potential benefits that I may experience have been explained to me. All my questions have been answered. I have read this consent form. My signature below indicates my willingness to participate in this study. I understand that I may contact the chair of the Institutional Review Board if I experience any problems during this experiment or have concerns about the ethics of this research [**irb.chair@purchase.edu**].

Type in your full name as your signature:

Appendix B

Q2
Personal Information Questionnaire

Age:

Q3
Sex:

- Male
- Female
- Non-Binary

Q4
Assigned sex at birth:

- Male
- Female

Page Break

Q5
Race (Choose all that apply):

- White/Caucasian
- African-American/Black
- Mexican-American
- Asian-American/Asian
- Puerto-Rican American
- Pacific-Islander
- Middle-Eastern
- American Indian
- Other Latino/Hispanic Origin
- Other

Page Break

Q6
Relevant Background Information

What were your scores on the SAT? (Type N/A if not applicable)

Reading and Writing

Q7
Math

Q8
What was your score on the ACT? (Type N/A if not applicable)

Page Break

Q9
How many times per week do you exercise? (If none, type 0):

Display This Question:
If How many times per week do you exercise? (If none, type 0): Text Response Is Greater Than 0

Q10
How many minutes do you spend doing each type of exercise per week?

	0	15	30	45	60	75	90	105	120	135	150	Not Applicable	
Stretch Exercise (examples: yoga, a type of dance, zumba)													
Resistance Exercise (example: weight lifting)													
Cardiovascular Exercise (examples: running, swimming, biking)													

Q11
Are you currently part of a sports club, sports team or a dance program?

- Yes
- No

Page Break

Q12
Do you use (or have you used) any Nicotine products?

- Yes
- No

Display This Question:
If Do you use (or have you used) any Nicotine products? Yes Is Selected

Q13
What forms of nicotine delivery do/did you use? (Choose all that apply):

- Cigarette/Cigar Smoking
- Vaping
- E-Cig
- Hookah/Water Pipe
- Nicotine Gum
- Nicotine Patch

- Chewing Tobacco
- Other

Display This Question:
If Do you use (or have you used) any Nicotine products? Yes Is Selected

Q14
How long have you been a nicotine user? (Amount in years, months, weeks, or days):

Display This Question:
If Do you use (or have you used) any Nicotine products? Yes Is Selected

Q15
How many times a day do you use nicotine?

Display This Question:
If Do you use (or have you used) any Nicotine products? Yes Is Selected

Q16
How many times a week do you use nicotine?

Display This Question:
If Do you use (or have you used) any Nicotine products? Yes Is Selected

Q17
When was the last time you used nicotine? (Amount in minutes, hours, days, weeks, months, or years):

Page Break

Display This Question:
If Assigned sex at birth: Female Is Selected

Q18
Females Only:

What was the date of your last menstrual period? (Type N/A if you prefer not to answer):

Display This Question:
If Assigned sex at birth: Female Is Selected

Q19
Are you currently menstruating?

- Yes
- No
- Prefer not to answer

Display This Question:
If Assigned sex at birth: Female Is Selected

Q20
Do you have regular menstrual cycles?

- Yes
- No

- Prefer not to answer

Display This Question:
If Assigned sex at birth: Female Is Selected

Q21
Are you currently pregnant?

- Yes
- No
- Prefer not to answer

Page Break

Display This Question:
If Assigned sex at birth: Female Is Selected

Q22
Are you currently taking any type of birth control that uses artificial hormones including birth control pills or patch, Norplant, Depo Provera, or others?

- Yes
- No
- Prefer not to answer

Display This Question:
If Are you currently taking any type of birth control that uses artificial hormones including birth... Yes Is Selected

Q23
If so, what type and brand?

Page Break

Display This Question:
If Assigned sex at birth: Female Is Selected

Q24
Are you currently taking any type of estrogen and/or progesterone as prescription hormone therapy?

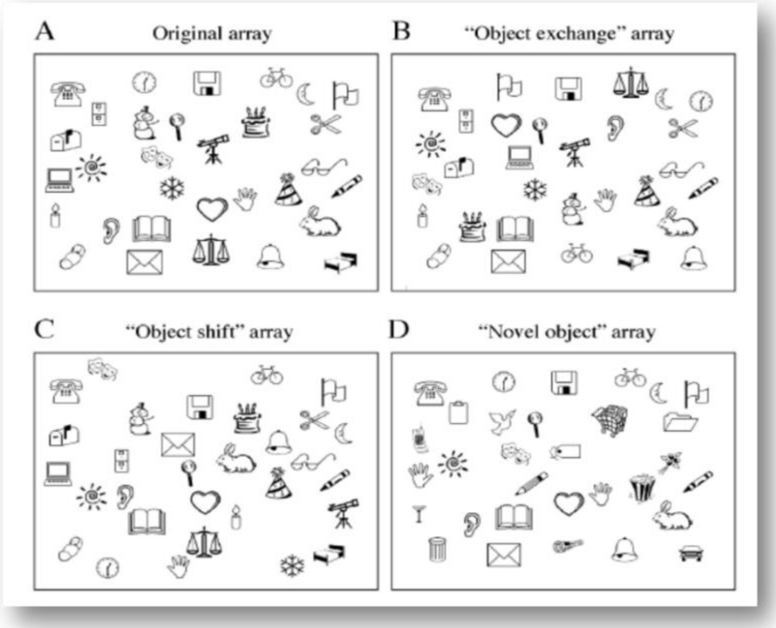
- Yes
- No
- Prefer not to answer

Display This Question:
If Are you currently taking any type of estrogen and/or progesterone as prescription hormone therapy? Yes Is Selected

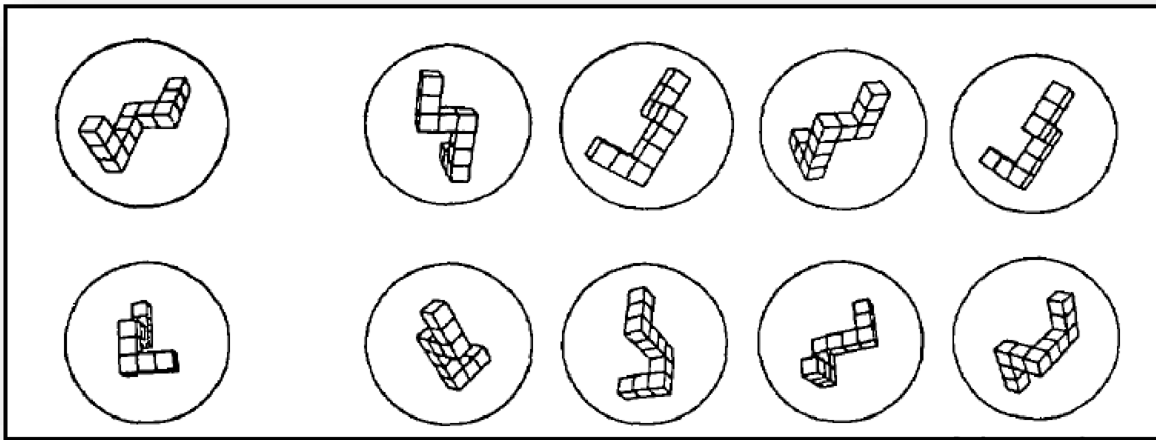
Q25
If so, what type and brand?

Page Break

Appendix C


A
Original array
B
"Object exchange" array
C
"Object shift" array
D
"Novel object" array

Appendix D



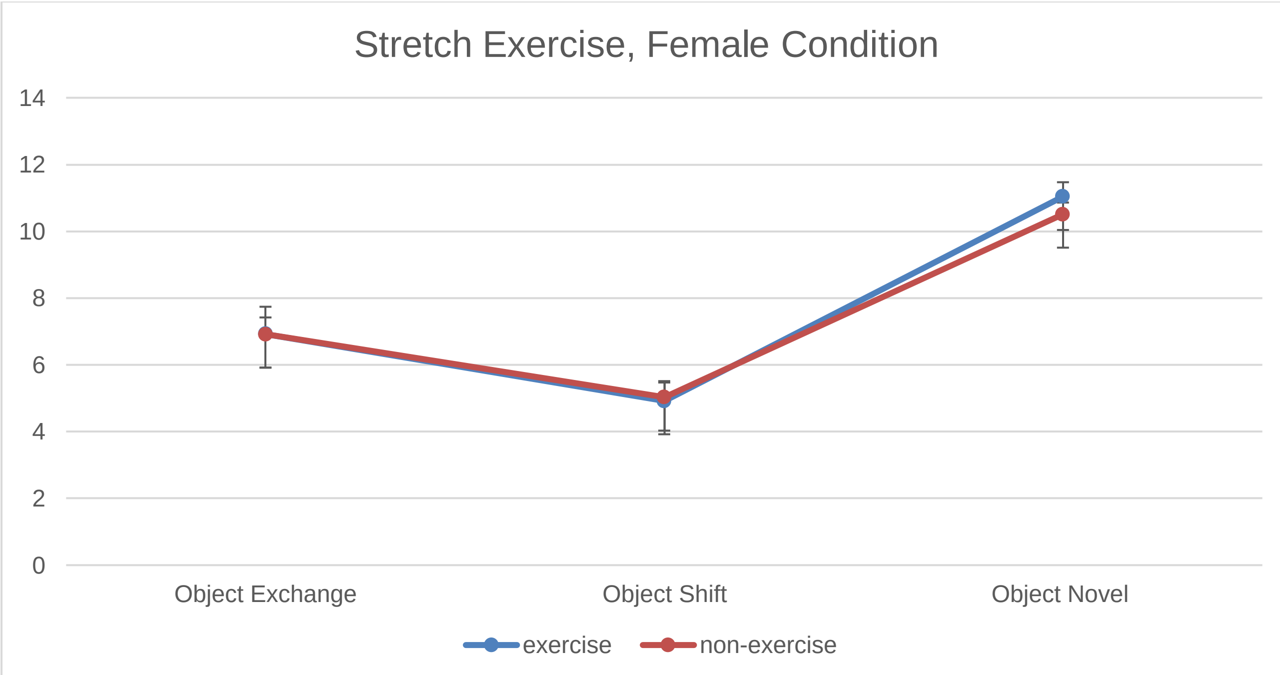


Figure 1: Mean scores of the Object Array Task in the Stretch Exercise, Female Condition

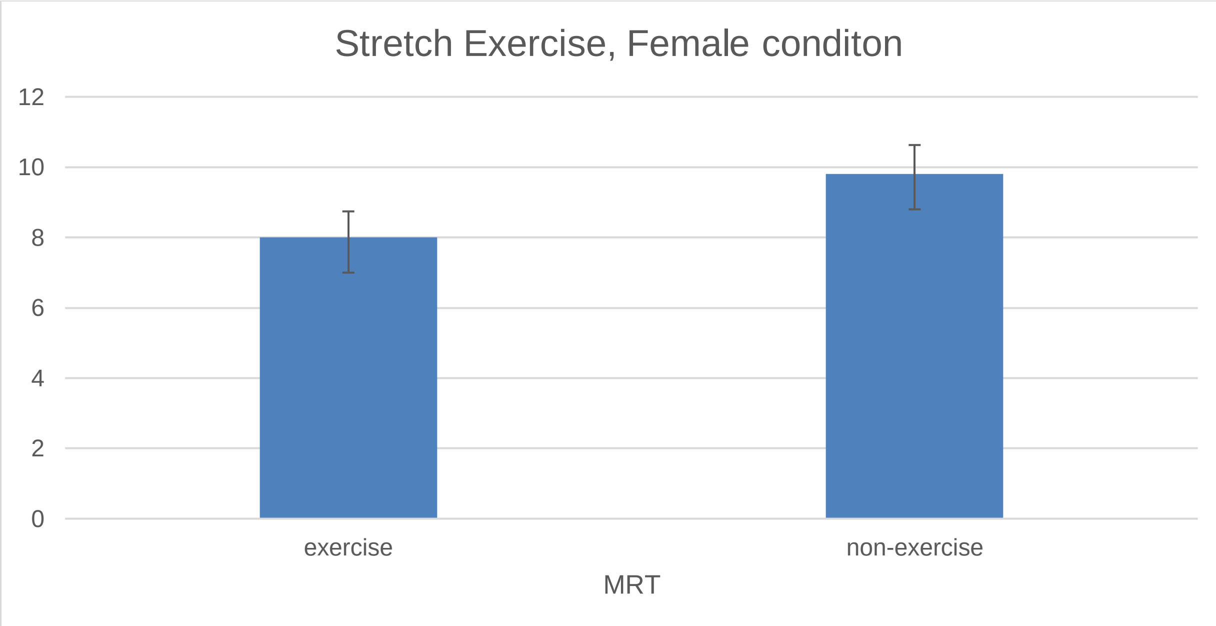


Figure 2: Mean scores of Mental Rotations Task in the Stretch Exercise, Female Condition

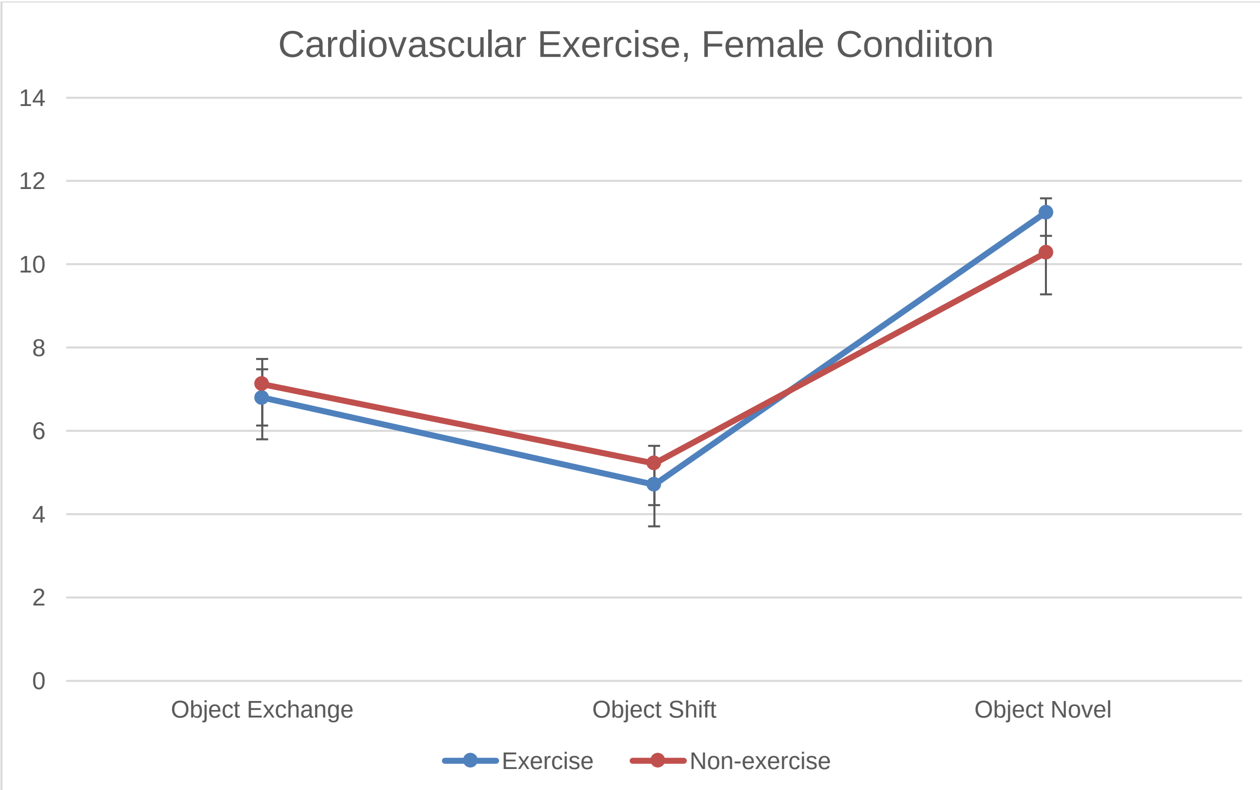


Figure 3: Mean scores of the Object Array Task in the Cardiovascular Exercise, Female Condition

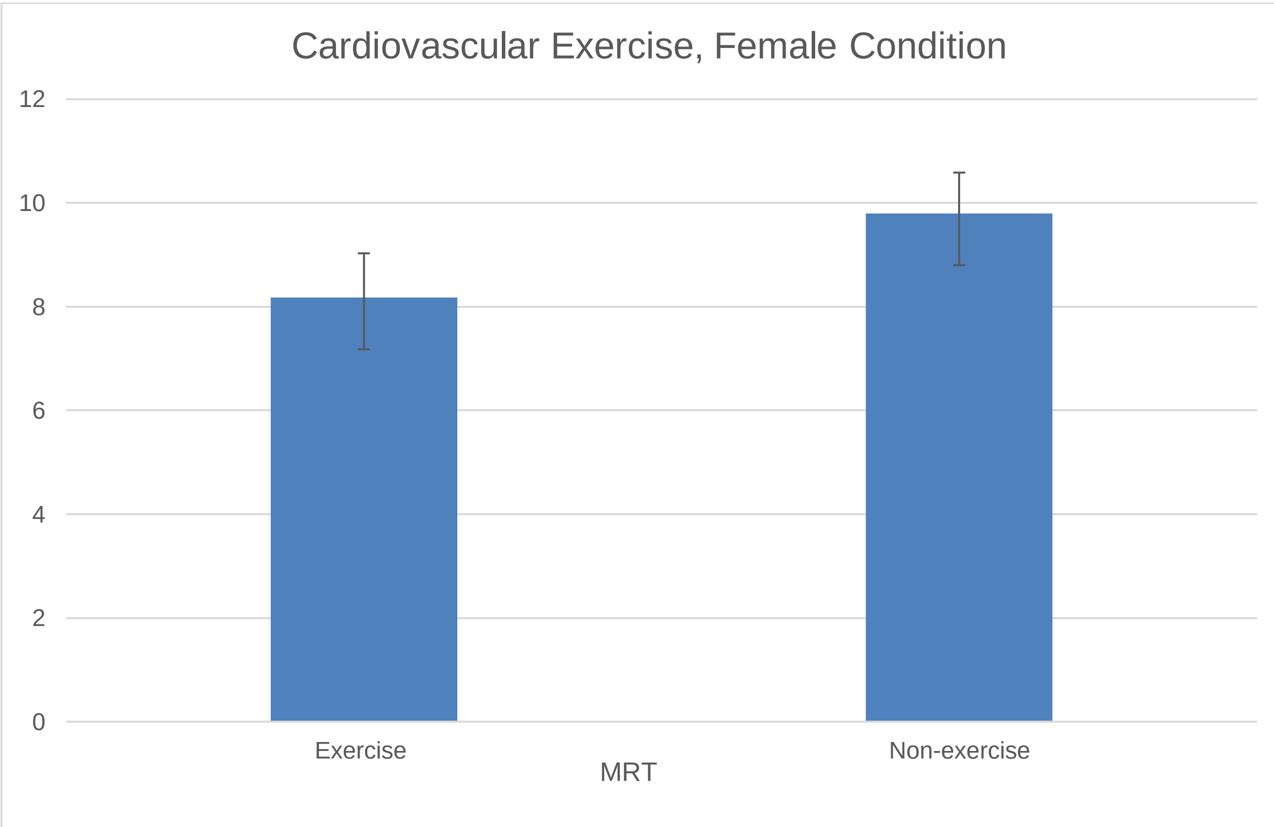


Figure 4 : Mean scores of Mental Rotations Task in the Cardiovascular Exercise, Female Condition

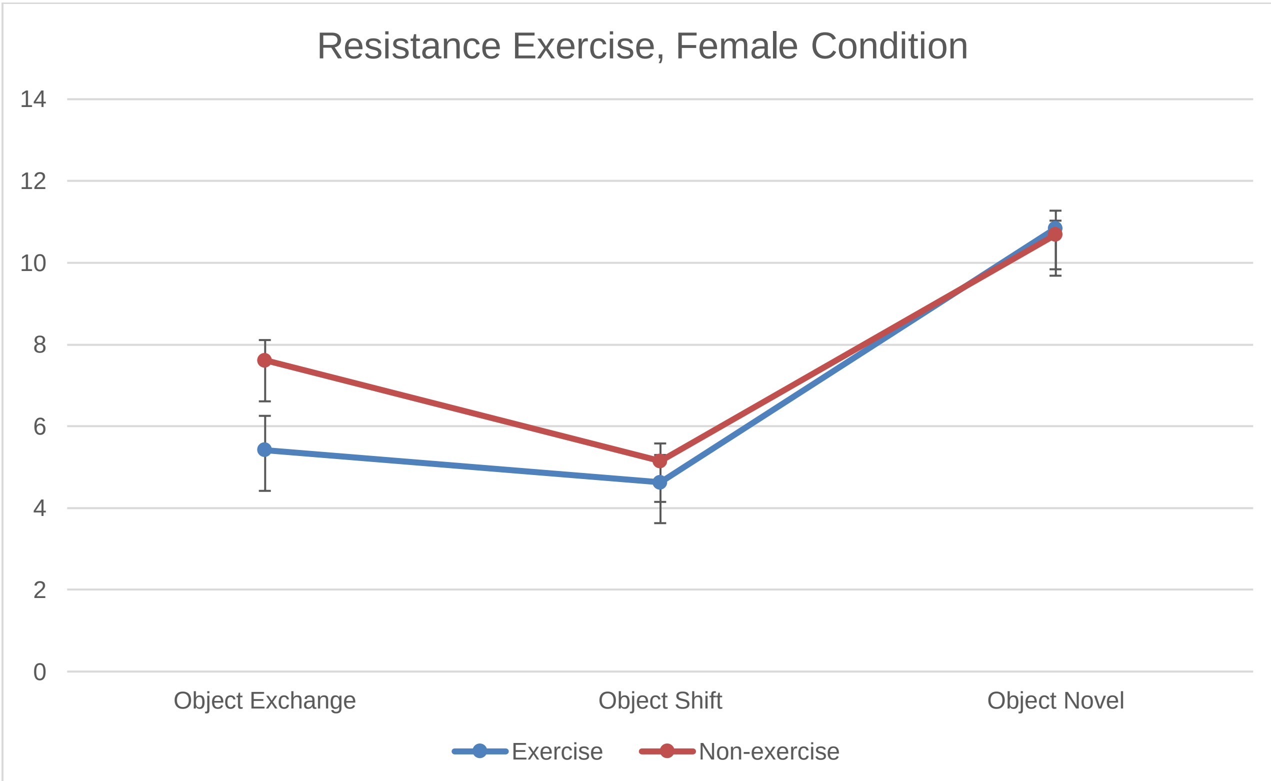


Figure 5: Mean scores of the Object Array Task in the Resistance Exercise, Female Condition

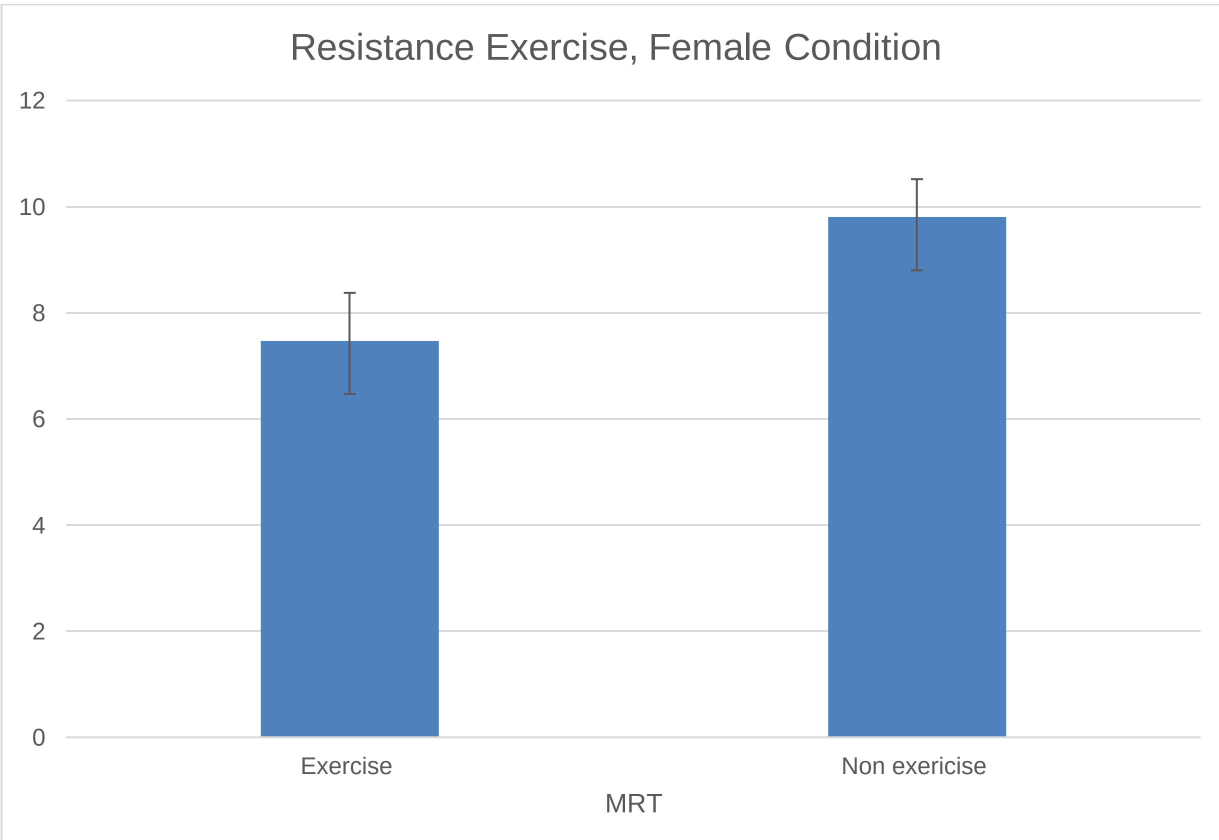


Figure 6 : Mean scores of Mental Rotations Task in the Resistance Exercise, Female Condition

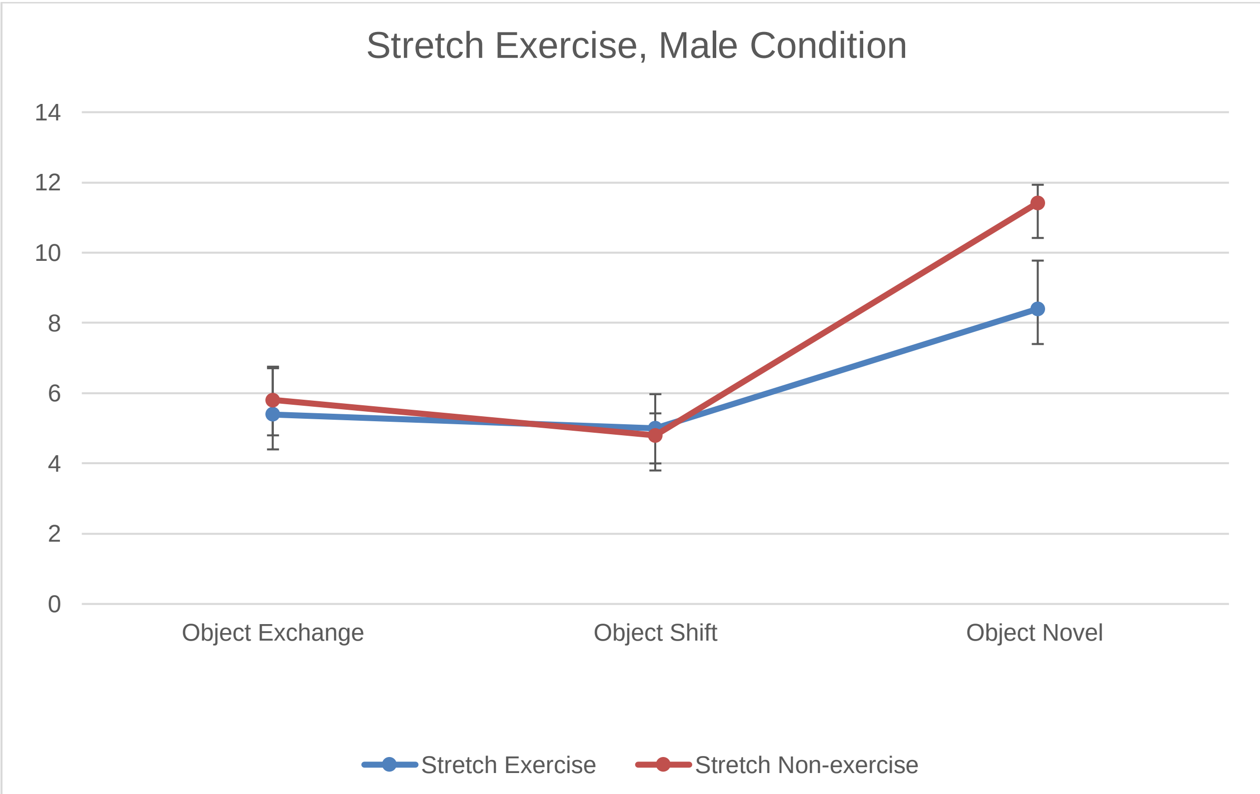


Figure 7 : Mean scores of the Object Array Task in the Stretch Exercise, Male Condition

Figure 8 : Mean scores of Mental Rotations Task in the Stretch Exercise, Male Condition

Figure 9 : Mean scores of the Object Array Task in the Resistance Exercise, Male Condition

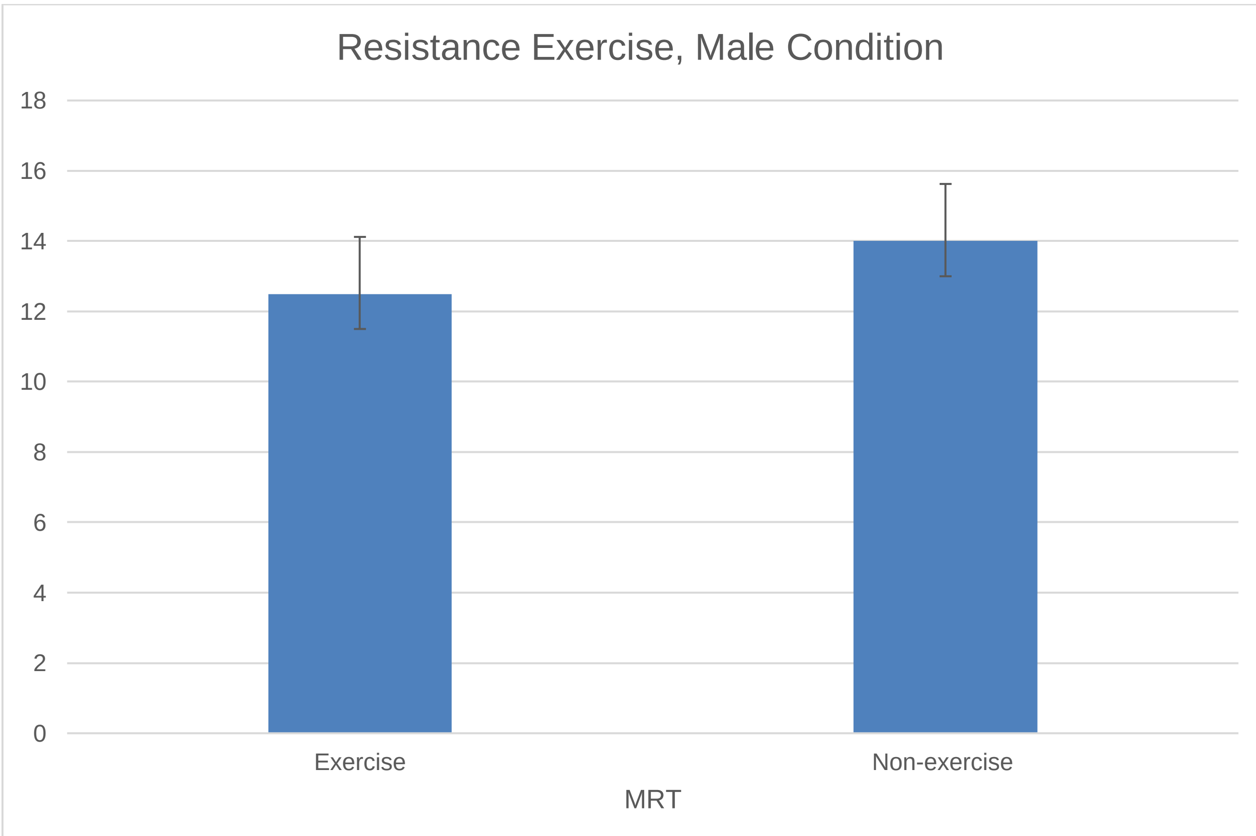


Figure 10 : Mean scores of Mental Rotations Task in the Resistance Exercise, Male Condition

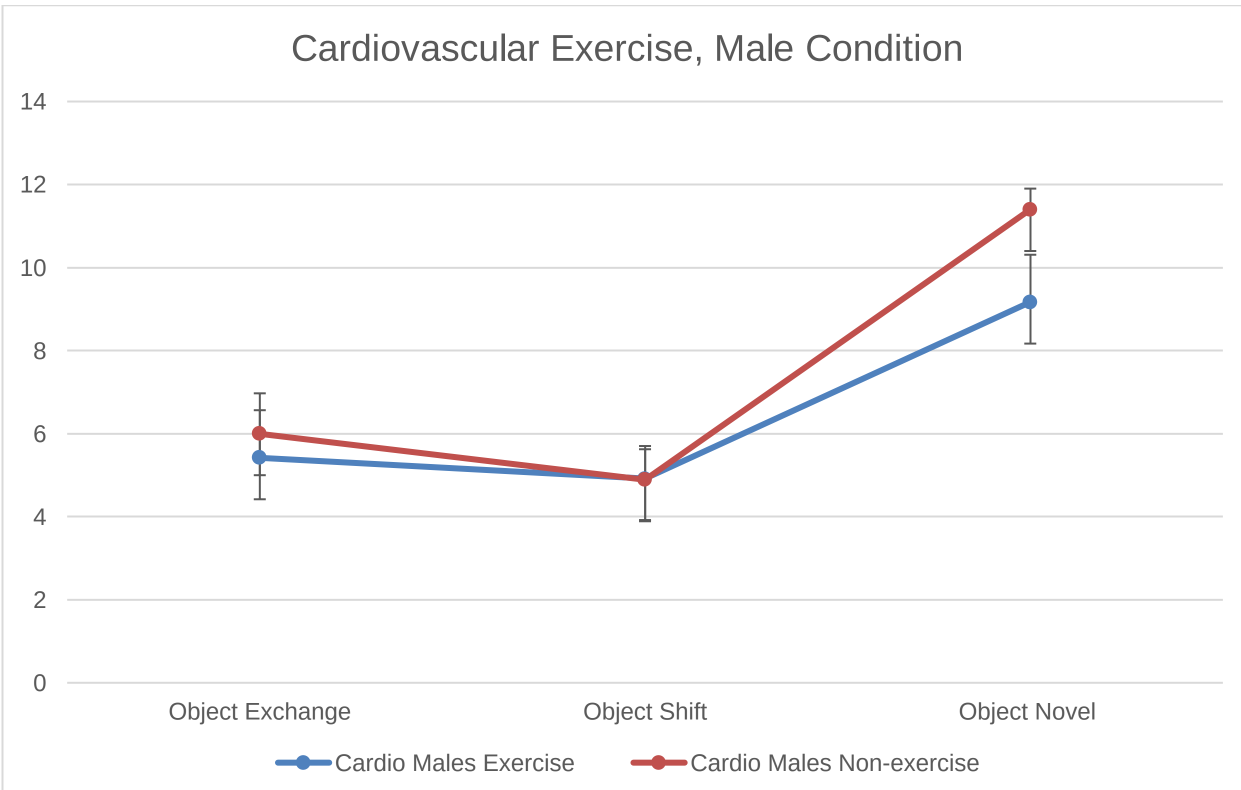


Figure 11: Mean scores of the Object Array Task in the Cardiovascular Exercise, Male Condition

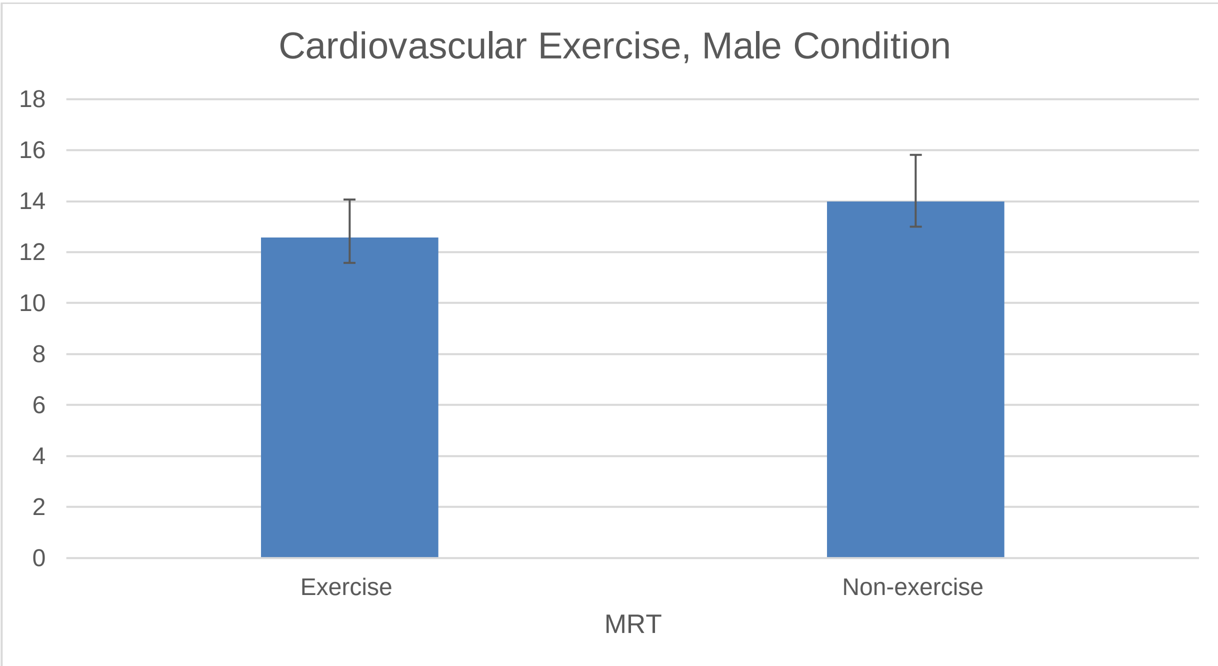


Figure 12: Mean scores of Mental Rotations Task in the Cardiovascular Exercise, Male Condition