THE EFFECTS OF EXERCISE ON MENTAL COGNITION

An Undergraduate Research Scholars Thesis

by

AMANDA MOCKAITIS

Submitted to the LAUNCH: Undergraduate Research office at
Texas A&M University
in partial fulfillment of requirements for the designation as an

UNDERGRADUATE RESEARCH SCHOLAR

Approved by
Faculty Research Advisor: Richard B. Kreider, PhD

May 2021

Major: Kinesiology

RESEARCH COMPLIANCE CERTIFICATION

Research activities involving the use of human subjects, vertebrate animals, and/or biohazards must be reviewed and approved by the appropriate Texas A&M University regulatory research committee (i.e., IRB, IACUC, IBC) before the activity can commence. This requirement applies to activities conducted at Texas A&M and to activities conducted at non-Texas A&M facilities or institutions. In both cases, students are responsible for working with the relevant Texas A&M research compliance program to ensure and document that all Texas A&M compliance obligations are met before the study begins.

I, Amanda Mockaitis, certify that all research compliance requirements related to this Undergraduate Research Scholars thesis have been addressed with my Research Faculty Advisor prior to the collection of any data used in this final thesis submission.

This project did not require approval from the Texas A&M University Research Compliance & Biosafety office.

TABLE OF CONTENTS

Page

ABSTRACT

The Effects of Exercise on Mental Cognition

Amanda Mockaitis
Department of Health & Kinesiology
Texas A&M University

Research Faculty Advisor: Richard B. Kreider, PhD
Department of Health & Kinesiology
Texas A&M University

Like many other Kinesiology experiments, the relationship between exercise and mental clarity has been researched in many different settings. However, few researches have been conducted on determining a specific type of exercise, anaerobic or aerobic exercises, that shows the best positive increase on mental clarity. This series of manuscripts dives into the ins and outs of exercise as it relates to mental clarity to best narrow down exercises that show the most improvements. Three manuscripts are written on different subjects that all relate to each other in an overarching theme, mental clarity. These manuscripts were broken down to reveal the most important aspects of each type of exercise, anaerobic and aerobic exercise, while also linking the direct effect of exercise on mental clarity. The types of exercises were measured using their biological effects on the brain and the body. Further research was done in the exercise and mental clarity abstract to determine the correlation between the biological effects on the brain and mental improvement in certain brain areas. These manuscripts support the feasibility to conduct further research in this field and what important areas to focus on. Because there is substantial research supporting the theory that exercise improves mental clarity, new topics such

as specific exercises is important to discover. This new research can shed a new light on ways to improve mental clarity for children and adults of all ages.

DEDICATION

To my friends, family, and instructors who supported me throughout this research process.

ACKNOWLEDGEMENTS

Contributors

I would like to thank my faculty advisor, Dr. Kreider, for their guidance and support throughout the course of this research.

Thanks also go to my friends and colleagues and the department faculty and staff for making my time at Texas A&M University a great experience.

Finally, thanks to my parents for their patience, encouragement, and love.

The data, methods, and results analyzed/used for Systematic Review and Meta-Analysis Investigating Moderators of Long-Term Effects of Exercise on Cognition in Healthy Individuals was provided by the original contributors: Ludyga, S., Gerber, M., Puhse, U., Looser, V. N., & Kamijo, K and were published in 2020.

The data, methods, and results analyzed/used for Effect of Yoga on Cognitive Abilities in Schoolchildren from A Socioeconomically Disadvantaged Background: A Randomized Controlled Study was provided by the original contributors: Chaya, M. S., Nagendra, H., Selvam, S., Kurpad, A., & Srinivasan, K. and were published in 2012.

The data, methods, and results analyzed/used for Effect of Aerobic Exercise on Cognition in Younger Adults: A Randomized Clinical Trial was provided by the original contributors: Y., MacKay-Brandt, A., Lee, S., McKinley, P., McIntyre, K., Razlighi, Q., Agarunov, E., Bartels, M., & Sloan, R. P. and were published in 2019.

All other work conducted for the thesis was completed by the student independently.

Funding Sources

This work was made possible with no funding necessary. Its contents are solely the responsibility of the author and do not necessarily represent the official views of the various copyrighted databases that are complying with the research.

NOMENCLATURE

BMI	Body Mass Index
VO_2Max	Maximum Rate of Oxygen

1. INTRODUCTION

Mental clarity has the potential to be dramatically affected by different types of exercise. If individuals were to participate in anaerobic exercises and others were to participate in aerobic exercises, the individuals who performed aerobic exercises would achieve more mental clarity compared to the anaerobic performed subjects.

1.1 Exercise and Mental Clarity

There are many reasons to exercise, whether that is to reduce the risk of disease, lose weight, or prevent depression. In British Columbia, researchers found that aerobic exercise boosted the size of the hippocampus while anaerobic exercises did not have to same results (Godman, 2014). The hippocampus is responsible for verbal memory and learning. When performing cardio exercises, your heart rate increases and with this increased heart rate comes increased breathing. As you breathe, more oxygen is taken into the bloodstream and delivered to the brain (Charvat, 2019). Once the oxygen reaches your brain, this causes the production of neurons that increase brain volume.

1.1.1 Aerobic vs. Anaerobic Exercises

While all exercise is beneficial in some way to the body, some exercises are more helpful to target specific characteristics. Aerobic exercises focus more on blood flow and increased oxygen intake which can be beneficial in improving mental clarity. Studies on humans and animals have shown improvements in cognitive health being linked to aerobic exercises such as running and cycling (Gomes-Osman, 2018). When an individual participates in some form of aerobic activity, his/her blood starts pumping at an increased rate, causing oxygen to reach the brain and the body faster than if the individual was stagnant. This increased speed of oxygen

transport “boosts the number of blood vessels and synapses, increasing brain volume, and decreasing age-related brain atrophy” (Gomes-Osman, 2018). The location of these effects occurs in brain areas that are associated with problem solving and thinking.

However, anaerobic exercises focus more on “low-intensity mind-body exercises…and resistance training” (Gomes-Osman, 2018). These anaerobic exercises work the heart in a different way, but can show cognitive improvements. As more studies are being conducted, anaerobic exercise has become more interesting when thinking about its association with mental clarity. A study conducted by a group of researchers found that collectively, the studies illustrate a positive effect of a specific anaerobic exercise, yoga, in areas of the brain such as the amygdala, hippocampus, prefrontal cortex, and other areas of the brain (Gothe et al., 2019, 105). While anaerobic exercises do not always require intense blood flow and oxygen intake, there is more focus on the internal feeling of the body which can positively increase an individual’s mental clarity.

1.2 References

Charvat, M. (2019, January 7). Why Exercise Is Good for Your Brain. Psychology Today. https://www.psychologytoday.com/us/blog/the-fifth-vital-sign/201901/why-exercise-is-good-your-brain

Godman, H. (2014, April 9). Regular Exercise Changes the Brain to Improve Memory, Thinking Skills. Harvard Health Publishing. https://www.health.harvard.edu/blog/regular-exercise-changes-brain-improve-memory-thinking-skills-201404097110

Gomes-Osman, J. (2018, May 2). What Kinds of Exercise are Good for Brain Health? Harvard Health Publishing. https://www.health.harvard.edu/blog/what-kinds-of-exercise-are-good-for-brain-health-2018050213762

Gothe, N. P., Khan, I., Hayes, J., Erlenbach, E., & Damoiseaux, J. S. (2019, December 26). Yoga Effects on Brain Health: A Systematic Review of Current Literature. *Brain Plasticity*, *5*(1), 105-122. 10.3233

2. SYSTEMATIC REVIEW AND META-ANALYSIS INVESTIGATING MODERATORS OF LONG-TERM EFFECTS OF EXERCISE ON COGNITION IN HEALTHY INDIVIDUALS

In this literature review, exercise and mental cognition will be discussed and related to each other in a variety of ways.

2.1 Introduction

There have been few findings on the maintenance and promotion of individuals without mental disorders and good cognitive function. Good cognition is a key function in the roles of an individual's everyday life. Adults that possess good cognitive cognition and clarity are linked to having better job performance and higher success in their careers. As these adults get older, a high level of cognition also helps to decrease mortality and the inevitable cognitive decline.

Exercise is an important and simple characteristic in an individual's life. While it does require effort and time, exercise can be done virtually anywhere in the world and is cost-affective. More and more studies have recently been done to discover how exercise is related to cognitive function. Some findings have addressed the changes that exercise can have on mental clarity, such as an improved memory and increased attention.

When exercise is looked at by itself, there is a relationship with increased cardiovascular health, mobility, and overall fitness increase. There are numerous benefits that exercise can bring but when it is specifically compared to mental cognition and clarity, the findings are interesting. In this literature study that is being examined, experiments were conducted in the past to determine how effective exercise is on mental clarity. These studies found that certain exercise types, such as endurance and quick paced exercises, improved different areas of

cognition. For example, the endurance exercises that were tested implied that there were greater influences on cognition in general compared to resistance exercise. However, increased endurance exercises led to smaller effects on attention compared to coordinated exercises.

2.2 Methods

Individual differences, such as sex and age, were examined as well as exercise type and intensity of exercises. The qualitative (exercise type) and quantitative (intensity) variables were used as independent variables for the effects of cognitive function. On top of this, the literature review investigated the type of effect (general or domain-specific) exercise has on cognitive function by comparing these exercises with attention and memory.

The study design included information on the certain type of control group because a previous literature review had exampled the control groups effects compared to the group completing exercise. Subpoints were taken out of the data analysis and placed into their own section such as exercise type, intensity, exercise dose, and other potential cofounders. The researches also categorized the type of exercise as either coordinative, endurance, or resistance exercise while the mixed exercise included components of all of these exercise types. Intensity was set as low, moderate, and high based on the previous literature reviews, objective intensity, and subjective responses that participants gave.

2.3 Results

In this literature review, 25,479 records were reviewed to determine potentially eligible articles. In total, 80 articles met full eligibility requirements for this review and were used to analyze data. A subgroup analysis was performed on the different domains as seen in Table A.1. The researchers found that complex attention, executive function, and memory were significantly affected by exercise. On top of this, all exercise types and intensities had a higher effect on

cognitive function in the female participants except coordinative exercise and low to moderate intensity.

2.3.1 Age, Sex, and Exercise Differences

When looking at the differences in age and sex with exercise, no overall effect could be predicted when considering all of the variables. There did contain a higher effect in children and adolescents compared to adults when measuring moderate intensity. When examining duration of exercise, the effect size increased with a longer duration compared to a shorter duration. However, when comparing exercise types such as mixed and coordinative exercise, coordinative exercise what the only type that was correlated with a high positive effect size.

2.4 Discussion

The findings from this literature review were small but significant. Exercise had a positive effect on cognition and mental clarity in healthy individuals. Furthermore, long term exercise (endurance) had smaller cognitive improvements in healthy participants compared to the populations with cognitive deficits. This result goes to show that more research needs to be completed to determine different exercises that can best optimize cognitive function.

Overall, the effect of exercise on cognition was general rather than domain-specific even when examining different exercise types. When specifically looking at attention, there was greater improvements when exercise was applied to the variable. With this analysis, a relationship can be indicated that exercise long-term can benefit general cognitive function which can lead to an improvement in job performance and academic ability.

The type of exercise and intensity was found to influence an individual's cognitive ability. Exercise type and more specifically coordinated exercises had the greatest influence in cognitive ability. For the other exercise types examined: endurance, resistance, and mixed

exercise, there was no difference in cognitive function, as seen in Figure A.1. This information is helpful to best understand the most effective influence on cognitive ability and how to better understand the relationship between exercise and mental clarity. The relationship with coordinative exercise and cognition should be treated as a relationship only because there could be a causation that intervenes with the two. This specific exercise type requires the participant to use more cognition to complete this exercise compared to the other exercise types.

When looking at intensity and duration of exercise, longer or shorter durations of exercise improved cognitive ability. This explains that intensity has no direct effect on cognition in the study. Because of this, questions can be introduced to further this research such as the differences between aerobic and anaerobic exercise. Aerobic exercise involves a greater blood oxygen level and therefore requires a higher intensity training. Anaerobic exercise however does not need much oxygen to complete and is therefore less intense than aerobic exercises. If the findings of the literature are correct, then aerobic and anaerobic exercise should have the same relationship on mental cognition when looking at intensity.

2.5 References

Ludyga, S., Gerber, M., Puhse, U., Looser, V. N., & Kamijo, K. (2020). Systematic Review and Mata-Analysis Investigating Moderators of Long-Term Effects of Exercise on Cognition in Healthy Individuals. Nature Human Behaviour, 4, 603-612. https://doi-org.srv-proxy2.library.tamu.edu/10.1038/s41562-020-0851-8

3. EFFECT OF YOGA ON COGNITIVE ABILITIES IN SCHOOLCHILDREN FROM A SOCIOECONOMICALLY DISADVANTAGED BACKGROUND: A RANDOMIZED CONTROLLED STUDY

In this study, yoga and physical activity were compared to determine the best cognitive improvement by using a variety of criteria.

3.1 Introduction

Yoga is an anaerobic exercise that focuses on different aspects of fitness. On top of fitness, yoga also has potential to have a cognitive benefit because of the amount of concentration needed to successfully participate in the exercise. In the past couple of years, yoga has become more interesting in researchers minds to determine the amount of cognitive benefit when this exercise is performed. Within pediatric populations, yoga has provided a diverse variety of benefits such as mental health, physical fitness, cardiopulmonary positive impacts, and behavior and development.

While many studies have been conducted using children as participants, there are methodical flaws. Because the sample sized taken to perform some of these studies was small, it is hard to generalize the study to apply it to the entire population. On top of this, many of these studies were not randomized which could have caused biased results.

In the study that is being examined in this journal today, the effects of three months of yoga were compared to physical exercise to determine the most effective cognitive performance. The participants included children aged 7-9 years of age with a less fortunate socioeconomic class that attend school. In order to control the experiment in the best way while also following

the participants school requirement of daily physical exercise, the researchers chose to compare yoga exercises to physical exercise.

3.2 Methods

This study was located in Bangalore, India where the researchers obtained verbal consent from 200 participants and their primary caretakers. The participants were required to meet a certain level of criteria: having no prior chronic illness or handicaps physically or mentally. Along with these criteria, the researchers required that the participants were not undernourished and had a healthy body mass index (BMI) or weight to height ratio.

A randomized-controlled design was used to conduct this study by randomly assigning each participant to one of the two study groups. This randomization was done through a computer so that the researchers could not have any input or bias towards the study.

The data analysis was carried out using the SPSS statistical analysis software. Each study group was analyzed separately using t-tests and were then compared using a two-way analysis of covariance with the baseline cognitive score of the participants as the covariant.

To estimate the change in cognitive effect over the three and six months, the regression coefficient of the baseline cognitive function scores were analyzed. This value was then compared with the experimental value of the cognitive change after three and six months. While some of the scores on the cognitive test were not normally distributed, scores were transformed and used in the analysis. Statistical significance of rejecting the null hypothesis was used by determining $\alpha < 0.05$ as significant.

3.2.1 Experimental Design

To complete the experiment, each participant participates in their required exercise, yoga or physical activity, for 45 minutes at the same time in the afternoon but in different locations on

the school property. In order to ensure the participants were completing the exercises properly, each group was monitored by certified instructors that have a great deal of knowledge in the field of exercise.

Over three months, the participants in the yoga study group were taught various stretching exercises, sun salutations, meditation, posture exercises, and breathing exercises. The physical activity study group performed stretching and aerobic exercises over the course of the study time. The participants cognitive functions were analyzed after the three months was exercise were up and this study was performed again after a three-month summer break of the participants not performing any organized physical activity.

A variety of baselines were collected to gather information on the participants socioeconomic level, educational experience, body composition measurements, and their initial cognitive function assessment.

3.3 Results

While there were 259 participants examined, 59 of the participants did not meet the criteria due to a variety of reasons including age, lack of birth certificates, not showing up to appointments, and leaving the school. At the beginning of the study, 193 participants completed the cognitive baseline out of 200 and 180 participants completed the three-month check-up cognitive assessment. The results determined that there were no significant differences in socioeconomic status, cognitive baseline tests, or body mass index (BMI) between the two study groups. The education experience statistics determined that a majority of the parents of the participants were employed with a mean income of around 3,875 Indian rupees which is equivalent to around $86 in the United States. When looking at the other educational

characteristics that was screened in the beginning, one-third of the participants mothers were uneducated.

Body composition characteristics were collected and the means were found for each measurement. Of the 200 participants, 50% were boys with a total mean age of around 7.69 for both genders. The height of the participants was calculated to have a mean of around 1.21 meters and a mean weight of 20.6 kg. While there were no significant differences on the cognitive measures of the two study groups after the study was completed, there were interesting findings when looking at each group independently.

3.3.1 Impact of Collected Data on Participants

As seen in Table B.1, participants in both groups showed increased improvement in cognitive function in the specific areas of vocabulary, comprehension, arithmetic, and object assembly. Other cognitive functions such as analogies were only significantly different in the physical activity group after the three-month mark. The yoga group specifically improved their cognitive understanding and function in block design at both checkpoints and coding at the six-month checkpoint.

When analyzing the data as a whole, this study had a greater amount of improvements than what was initially expected in all categories of cognitive function. More specifically, the improvement in the individual cognitive tests was a good amount greater than the estimated cognitive increase that was calculated through the regression coefficient taken from the baseline cognitive scores.

3.4 Discussion

While the study showed that there was a significant improvement in the cognitive function for both study groups after the exercise was finished, there was no significant group

difference. Yoga is known to ease emotions and an individual's state of mind so it is understood that yoga had a better improvement in the cognitive sections of attention and the visual and spatial abilities. The findings from the study correlate to findings in other pieces of literature that explain the cognitive benefits of yoga.

This study has various strengths such as displaying an effective randomized design and providing the two study with proper, professional instruction. While the study had its strengths, there were also limitations that could potentially factor into the results. For instance, because the school required physical activity for each of their students, the study was required to provide exercises for each group instead of having one true control group that was performing no exercises. On top of this, by choosing school children to be participants could also be a limitation due to the lack of control the researchers have on the activities the participants choose to engage in outside of school. Some participants could be taking part in more physically engaging activities on top of this study which could skew the data in some way.

Overall, the findings of the study were significant in determining the specific aspects that yoga and potentially other anaerobic exercises can have on cognitive function. This study has the ability to be a solid stepping stone to determining more information on understanding cognitive function. While this study did not have a generalized sample that can be applied to the whole world, researchers in other locations have the ability to recreate this study to determine if their findings correlate to this study.

3.5 References

Chaya, M. S., Nagendra, H., Selvam, S., Kurpad, A., & Srinivasan, K. (2012). Effect of Yoga on Cognitive Abilities in Schoolchildren from a Socioeconomically Disadvantaged Background: A Randomized Controlled Study. THE JOURNAL OF ALTERNATIVE AND COMPLEMENTARY MEDICINE, 18(12), 1161-1167. DOI: 10.1089/acm.2011.0579

4. EFFECT OF AEROBIC EXERCISE ON COGNITION IN YOUNGER ADULTS: A RANDOMIZED CLINICAL TRIAL

The objective of this article is to determine the improvements of cognitive function in young adults through the use of aerobic exercise.

4.1 Introduction

While there have been many studies on exercise and cognition done in the past, these studies involved the use of elderly participants. In this study, an analysis of the effects of aerobic exercise on the cognition of young adults was conducted. It is important to look at a research study and apply it to all age groups so that the overreaching conclusion of a multitude of studies is generalizable to the world population as a whole. On top of this, many young adults are in the phase of their lives that require a high level of mental clarity, so studies that look at the effects of exercise on cognition in their age group would be beneficial to learn from.

In past studies conducted on elderly participants, there have been a significant amount of results that explain how aerobic exercise effects attention, processing speed, memory, executive function, and working memory. With every study, there are also negative conclusions that developed at the end; however, specifically for elderly participants, executive function contained the strongest effects. The goal of the current study being examined was to reach further to a greater population size of individuals aged 20-67 in a randomized controlled trial.

By including exercise in these young adult participants daily regime, the cognition could potentially make a difference as the participants get older and enter into the cognitive-decline stage of their life. With that in mind, cognitive domains also differ between age ranges, so different aspects of cognition will be affected in aerobic exercise.

The researchers conducting this study hypothesized that aerobic exercise would have increased improvements in cognition at this younger age range, but the effects would not be as significantly different compared to elderly participants. Aerobic exercise has numerous body mechanism improvements such as increased gray matter volume (associated with better cognitive function) and cortical thickness (associated with general intelligence) in the frontal, temporal, and cingulate cortex of the brain.

4.2 Methods

The study was designed with a randomized, parallel-group, single blind clinical trial over the course of six months with participating individuals in the age range of 20-67 with below median aerobic capacity. During these six months, participants were asked to perform a variety of tasks involving aerobic exercises and stretching control condition to relate it to cognition and brain structure. Each participant was assigned to one of two conditions in which the placement was randomized and concealed until a participant was eligible and ready to participate.

The participants were asked to travel to their closest YMCA in New York City three times a week for two weeks to participate in nonaerobic related activities. Once the participants were assigned randomly to their groups (aerobic or stretching/toning), they determined their schedule and exercised individually, attending four sessions a week for 24 weeks. No matter the condition group a participant was placed in, the exercises were structured the same with 10-15 minutes of warm-up and cool down, and 30-40 minutes of workout.

Within the aerobic conditioning group, participants selected from a list of aerobic activities. For weeks 1-2 the participants trained at 55-65% of their maximum heart rate and in the next couple the weeks increased their heart rate to 65-75% of their maximum heart rate. For the remainder of the weeks, the participants exercised using 75% of their maximum heart rate.

The stretching and toning group engaged in a variety of exercises to improve core strength and flexibility.

4.2.1 Assessments

Cognitive function and aerobic capacity were assessed 3 times: before group selection, after 12 weeks, and after 24 weeks (the end of the study). Cognitive tests included the Wechsler Test of Adult Reading to estimate IQ. These tests were validated using factor analysis of the baseline test data to determine standardization. Various other cognitive tests were used to determine executive function (Modified Rey Auditory Verbal Learning Test), language (Animal naming and the Controlled Oral Word Association Test), attention (the 2 and 7 test), and working memory (WAIS-III letter-number sequencing). For aerobic capacity, maximum oxygen uptake was measured as well as maximum heart rate. Body composition measurements were also taken each visit as well as everyday function tests (Timed instrumental activities of daily living tasks) and cortical thickness.

4.3 Results

After the data was analyzed from the experiment, a couple significant findings were established. The researchers found that BMI decreased significantly in the aerobic exercise trial and aerobic capacity increased. On the other hand, the participants BMI did not change enough to be significant in the stretching trial.

4.3.1 Cognitive Function Improvements

For the cognitive processes, the researchers found that executive function specifically improved in a significant way during aerobic exercise. The researchers moderated this variable finding by age and found that the participants aged 60 had a higher level of increase in executive function than the 40-year-old participants. The variables that were not associated with age, such

as cortical thickness, showed a significant increase in the aerobic exercise group specifically in the left frontal region of the brain.

4.4 Discussion

From the results, there were significant findings that can be discussed. One major finding was that executive function in adults was greatly increased by aerobic exercise as seen in Figure C.1. While executive function did improve for all age ranges, there was differences between the ages which explains that aerobic exercise improves age-related declines in executive function rather than increase performance in those with no decline. Also associated with executive function was an increased oxygen uptake to suggest that cognitive improvement mechanisms are related to aerobic capacity as seen in Figure C.2.

The original purpose for this study was to determine what cognitive domains were affected by aerobic exercise and relate it to the numerous articles of studies presented with elderly participants. This study concluded that executive function is a primary cognitive domain that is affected during age decline which is seen in both the younger and older age groups.

Cortical thickness was also measured to determine its association with aerobic exercise. The results determined that the effect of cortical thickness did not differ by age. Cortical thickness is important in general intelligence and it is important to maintain a relatively thick cortical membrane throughout life. As individuals get older, cortical thickness tends to decrease. Aerobic exercise, from this study, has been found to reduce the decline of cortical thickness, allowing the individuals minds to stay sharper for longer.

The participants body mass index (BMI) gradually reduced due to its association with aerobic exercise in all ages. On top of this, the results of this study showed that there was an increased gray matter volume in the elderly population compared to the younger population

when aerobic exercise was in effect. Gray matter helps to improve cognitive function, so the elderly population benefited more from aerobic exercise in this specific instance.

With any study, there were limitations that reduced its effectiveness to statistical significance. One limitation included a small sample size that made the study difficult to generalize to the whole population. Reasons for this small sample size can vary between studies, but this particular study struggled with their dropout rate between the screening and group placement. With a larger sample size, larger effects could have been seen in changes within cognitive domains. Another limitation of this study was the duration of the exercise. Future studies should aim to focus on conducting data over a longer period of time than six months to determine if there is a long-lasting aerobic exercise effect on cognition.

Overall, the researchers found an increased improvement in executive function and cortical thickness when aerobic exercise is placed on participants in the age range of 20-67. These findings are strong and the study is able to be replicated to determine more information on overall brain health and exercise for adults of all ages.

4.5 References

Y., MacKay-Brandt, A., Lee, S., McKinley, P., McIntyre, K., Razlighi, Q., Agarunov, E., Bartels, M., & Sloan, R. P. (2019, February 26). Effect of aerobic exercise on cognition in younger adults: A randomized clinical trial. Neurology, 92(9), e905-e916. 10.1212/WNL.0000000000007003

5. CONCLUSION

Throughout this literature review of different studies that relate exercise to mental clarity and cognition, there is a major theme that is present. No matter the exercise (aerobic or anaerobic), there are cognitive benefits that differ in the domains of cognition.

Anaerobic exercise, as seen in the study about yoga, determined that exercises that require more focus or concentration, have a additive benefit on attention and visual spatial abilities. Because yoga does require more concentration and less oxygen to the brain, it would be a reasonable assumption to conclude attention is improved.

When looking at aerobic exercise, improvements have been found both biologically and mentally. Executive function is a cognitive domain that aids individuals in the planning process, working memory, focusing attention, and time management. Through the use of aerobic exercise, individuals blood begins to pump at a faster rate, allowing oxygen to travel to the brain quicker and in a greater volume. Because of this, the individuals performing aerobic exercise are able to perform better on cognitive tests. With the mental improvements, there are also biological improvements. Cortical thickness is positively associated with general intelligence. If aerobic exercise helps to increase and reduce decline of cortical thickness over time, individuals are able to maintain their cognition for a longer period of time.

While there were limitations to each study, there was a general consensus that exercise does improve mental cognition in some way or another. More research needs to be done to gain more insight on the effectiveness of each exercise, but these studies are a good stepping stone into the world of exercise.

Originally, when I decided to write a literature review on exercise and mental cognition, I wanted to determine which type of exercise (aerobic or anaerobic) would have the greatest effect on cognitive improvements. After having completed the research, I have determined that there are so many different aspects to cognition that it cannot be looked at as one general term. This is important to note because each exercise has benefits on different aspects of cognition.

It will be interesting to see in the near future more studies that are being done on cognition. Exercise is such a broad term and it will be beneficial for other researchers to narrow down their studies to just one anaerobic exercise and compare it with another to determine if there are different cognitive improvements within anaerobic or aerobic exercises.

APPENDIX A: SYSTEMATIC REVIEW AND META-ANALYSIS INVESTIGATING MODERATORS OF LONG-TERM EFFECTS OF EXERCISE ON COGNITION IN HEALTHY INDIVIDUALS

Table A.1: Descriptive Statistics for Continuous Moderators of the Effect of Exercise on Cognitive Function

Moderator	M	s.d.	Min	Max
Intervention duration (weeks)	21.4	13.4	4.0	52.0
Frequency (week)	2.8	1.2	1.0	5.0
Session duration (min)	53.9	26.1	10.0	180.0
Age (years)	47.9	28.9	4.4	82.3
% Female participants	60.5	23.3	0.0	100
Effects for outcome (n)	3.7	2.1	1.0	9.0
PEDro score	6.7	1.2	4.0	10
Year of publication	2013	6	1989	2019
Study group size (n)	54.4	64.3	7.5	292

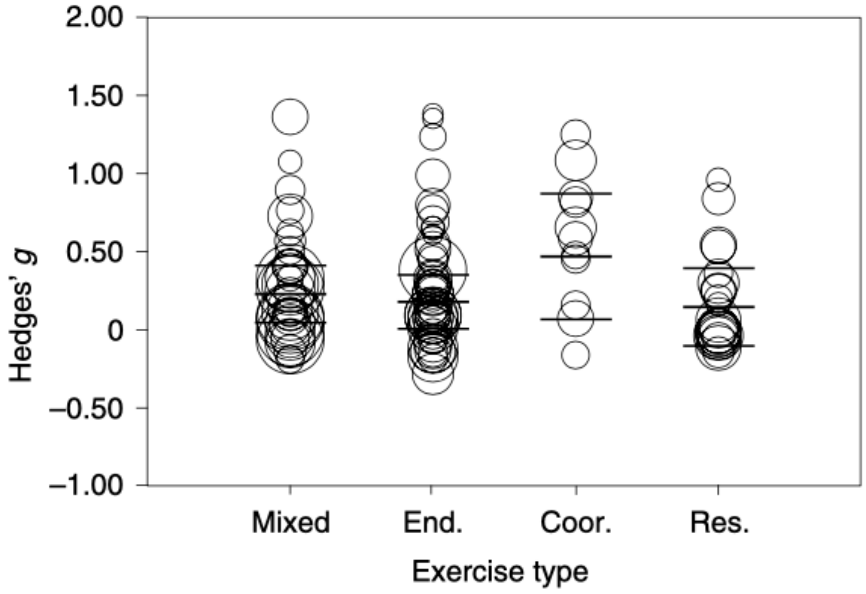

Figure A.1: Effect of Different Types of Exercise on Cognitive Function

APPENDIX B: EFFECT OF YOGA ON COGNITIVE ABILITIES IN SCHOOLCHILDREN FROM A SOCIOECONOMICALLY DISADVANTAGED BACKGROUND: A RANDOMIZED CONTROLLED STUDY

Table B.1: Cognition Scores of Children in Study Groups at Baseline, After 3 Months, and After 6 Months

Cognition Measures	Yoga Group	Physical Exercise Group
Comprehension		
Baseline	7.1 ± 2.8	6.9 ± 2.6
After 3 months	7.7 ± 2.2	7.9 ± 2.6
After 6 months	8.7 ± 2.0	8.4 ± 2.4
Arithmetic		
Baseline	5.4 ± 1.9	5.2 ± 1.9
After 3 months	5.9 ± 1.9	5.9 ± 2.0
After 6 months	6.2 ± 1.7	6.3 ± 1.7
Analogies		
Baseline	6.6 ± 3.1	6.5 ± 3.6
After 3 months	7.2 ± 3.6	7.5 ± 3.4
After 6 months	9.0 ± 3.2	8.6 ± 2.9
Vocabulary		
Baseline	13.4 ± 4.9	13.3 ± 4.6
After 3 months	14.7 ± 4.0	14.9 ± 3.8
After 6 months	14.9 ± 3.9	15.9 ± 3.6
Block Design		
Baseline	5.9 ± 3.3	6.2 ± 3.4
After 3 months	7.1 ± 4.9	6.9 ± 4.6
After 6 months	9.7 ± 7.6	8.1 ± 5.9
Object Assembly		
Baseline	4.5 ± 2.6	4.1 ± 2.3
After 3 months	5.7 ± 3.6	5.3 ± 3.4
After 6 months	6.6 ± 3.8	5.8 ± 3.3
Coding		
Baseline	32.1 ± 8.2	32.8 ± 7.5
After 3 months	33.5 ± 8.4	34.2 ± 8.5
After 6 months	35.1 ± 8.5	34.3 ± 7.9

APPENDIX C: EFFECT OF AEROBIC EXERCISE ON COGNITION IN YOUNGER ADULTS: A RANDOMIZED CLINICAL TRIAL

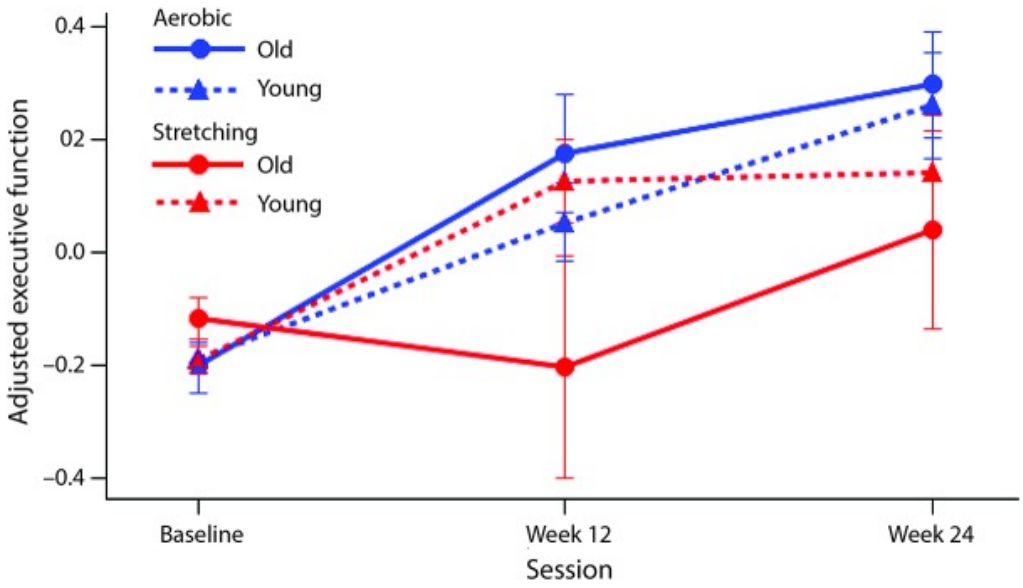

Figure C.1: Change in Executive Function with Aerobic Exercise

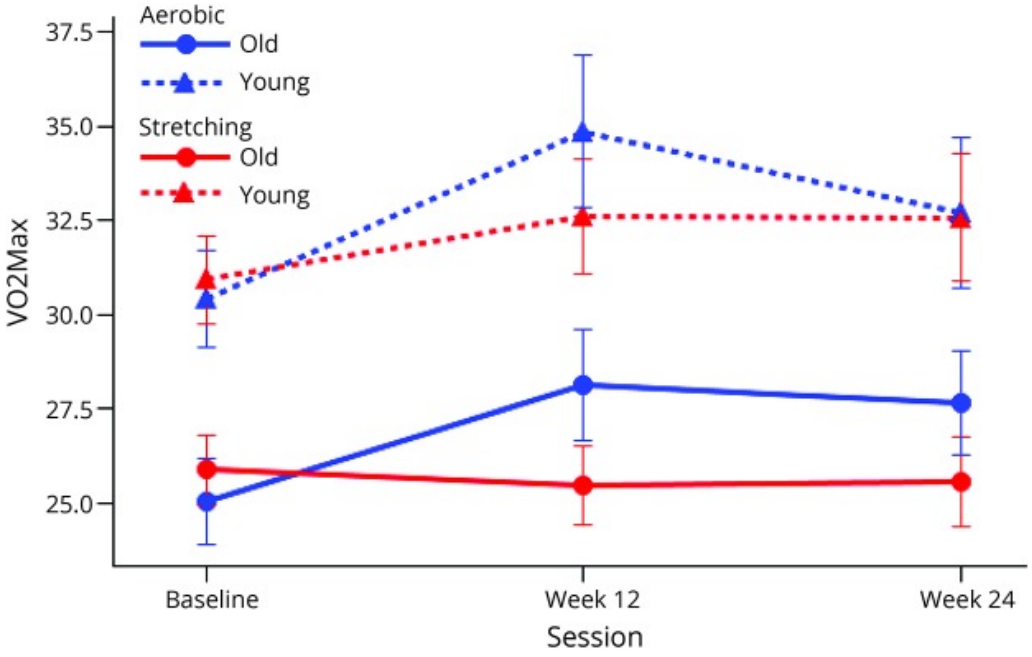

Figure C.2: Change in Aerobic Capacity with Aerobic Exercise