Spring 5-11-2020

Physical Activity and its Impact on Cognitive Development

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Physical Activity and its Impact on Cognitive Development

A Synthesis Project

Presented to the

Department of Kinesiology, Sport Studies, and Physical Education

The College at Brockport

State University of New York

In Partial Fulfillment

of the Requirements for the Degree

Master of Science in Education

(Physical Education)

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by

William Holland

Date

May 10, 2020

THE COLLEGE AT BROCKPORT

STATE UNIVERSITY OF NEW YORK

BROCKPORT, NEW YORK

Department of Kinesiology, Sport Studies, and Physical Education

Title of Synthesis Project:

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Cathy Houston-Wilson 5/11/2020

Instructor Approval Date

Accepted by the Department of Kinesiology, Sport Studies, and Physical Education, The College at Brockport, State University of New York, in partial fulfillment of the requirements for the degree Master of Science in Education (Physical Education).

Cathy Houston-Wilson 5/11/2020

Chairperson Approval Date

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Abstract

The educational system largely is associated with academic assessments and sitting at a desk or on a computer for a majority of the school day. Another part of the education system that is often overlooked is caring for the child health and wellbeing. Education is more than tests and homework and can be facilitated by other methods that don't encourage a sedentary lifestyle. The purpose of this synthesis project is to determine what impact physical activity can have on cognitive development, cognitive function and overall brain health. Results have shown that even a single bout of exercise can have a positive impact on cognitive function. The research analyzed for this synthesis project has revealed a great deal of evidence that suggests that cognitive development is positively impacted by physical activity.

Chapter 1 – Introduction

It is known that regular physical activity is part of maintaining a healthy lifestyle. It is also known that movement and physical activity can enhance one's learning as well. "Participation in physical activity has been associated with the reduction of a number of physical (for example, cardiovascular disease, colon and breast cancer, and obesity) and mental (for example, depression and anxiety) disorders across the adult lifespan" (Khan & Hillman, 2014, p. 58). There is plenty of evidence to show different benefits from physical activity, but there is one particular benefit that often gets left out or forgotten about. Maintaining brain health and plasticity is an important health goal to have. (Smith, 2014) Smith defines plasticity as the ongoing state of the nervous system and its ability to change. She also cites cerebral blood flow and its correlation with physical activity and how it can maintain brain plasticity which could be a factor in determining cognitive development among adolescents.

Recently a meta-analysis determined that there was a positive relation between physical activity and cognitive performance in children aged 4-18 years. This meta-analysis was measured in 8 categories including perceptual skills, intelligence quotient, achievement, verbal tests, and mathematical tests. (Hillman et al., 2008). This particular study found that physical activity improved cognitive performance during the above mentioned tests providing us with some data that there could be a correlation. Hillman and his colleagues also address an interesting question on why there isn't more experimental research on the matter. If there is a correlation then why isn't more being done to discover how and why this happens?

Statement of the Problem

Physical activity is mostly assumed to have a very physical response in our bodies. The neurological and cognitive impacts are often overlooked when speaking about physical activity or exercise.

Purpose of the Study

The purpose of this synthesis project is to review the literature on how physical activity can impact cognitive development.

Operational Definitions

1. **Cognitive Development:** The construction of thought processes, including remembering, problem solving, and decision-making, from childhood through adolescence to adulthood. (Encyclopedia of Children's Health, 2020)
2. **Physical Activity:** Any bodily movement produced by skeletal muscles that requires energy expenditure. (World Health Org. 2020)

Research Questions

1. To what extent does physical activity impact cognitive development?
2. How often do you need to exercise in order to improve cognitive function?

Delimitations

1. All articles in the synthesis project were selected due to their relevance in physical activity and cognitive development.
2. Mainly this study will be looking at adolescence. Also more specifically this project is going to look into what types of cognitive impacts occur as well as what type of physical activity triggers which result.
3. All articles in this synthesis project were peer reviewed and full text.

4. All articles in this synthesis project were published between 2009 and 2020.

Chapter 2 – Methods

The purpose of this chapter is to review the methods used to find literature on how physical activity can impact cognitive development. The studies collected for this synthesis were located using the EBSCO database from The College at Brockport's Drake Library. Within the EBSCO database the following databases were searched: SPORTDiscus and Academic Search Complete. Within these databases a total number of 10 articles met the criteria for inclusion as part of the critical mass within this literature review. In order for an article to meet the criteria for selection in this synthesis it must have been published between 2009-present, this will provide the synthesis with the most up to date and current information available. Other criteria for selection included scholarly and peer reviewed articles that were full-text. Having scholarly and peer reviewed articles provides more validity within the articles and better overall quality. Other articles or sources selected as part of this literature review provided context about the topic, background information and supplemental information to complete the review. All articles and sources are appropriately cited in the reference section of this paper.

In order to gather valuable articles for this synthesis certain keywords and phrases were used when searching the data-base. The first keyword searched from the Academic Search Complete database was "physical activity + cognitive development" that resulted in 1775 hits. The same keywords were used in the Sportdiscus database which yielded only 359 hits. Of the 2134 hits only articles that had a positive measurable correlation between cognitive development and physical activity were used resulting in only 2 articles used. The keywords "physical activity + cognitive development" were the first keywords used due to its relevance to the topic. Next the keywords "exercise + cognitive development" were used in the Academic Search Complete database that resulted in 1146 results. The same keywords were used in the

Sportdiscus database which came up with 321 hits. The keyword “exercise” replaced physical activity only in an attempt to not miss any articles speaking on the same topic using different keywords. Only articles that had a meaningful cognitive development measurement were used. Of the 1467 hits only 1 article was used. Lastly the keywords “aerobic exercise + cognitive development” were used in the Academic Search Complete database which resulted in 94 hits. The same keywords were used in the Sportdiscus database which resulted in only 15 hits. Most of the research to this point has led this synthesis project to search out a specific type of exercise found to help improve cognitive development. The only articles that were used were articles that had a meaningful way to measure cognitive development after aerobic exercise. Of the 109 hits 7 articles were used.

Articles that were selected for use in this synthesis were scholarly and peer reviewed articles that were full-text. Also when selecting articles for use in this synthesis it was important that each article selected had valuable information related to physical activity and its impact on cognitive development. Specific criteria were used in order to be a part of the literature review. All of the articles selected were based on the articles relevance to physical activity, exercise and even more specific aerobic exercise and its impact on cognitive development or performance. Participants in the studies reviewed were measured on different cognitive development tasks. Some participants were measured before or after physical activity and then tested while others were identified as being fit or unfit before the test began.

For this synthesis a total number of 10 articles were used to compile data on the topic of physical activity and its impact on cognitive development or performance. Articles came from a variety of journals including Journal of Teaching in Physical Education, Biology of Exercise, Journal of Fundamentals of Mental Health, Pediatric Exercise Science, American Psychological

Association, Journal of Human Kinetics volume 36, Journal of Human Kinetics, and Advanced Exercise Sports Physiology Vol.24. The critical mass for this synthesis is comprised of X number of participants. Within the 10 articles used for the literature review there was a total of 1681 total participants in this synthesis. There were 1612 children aged 3-18 years old and 69 adults aged 19-54. Data were analyzed using the following methodologies for the studies under review. For a majority of the studies ANOVA, MANOVA, and rANOVA were used to analyze different measures of cognitive data compared to physical activity and exercise. Some statistical information was also organized using SPSS software. Other forms of data analysis consisted of Cronbach Coefficient Alpha, Two-Tailed Pearson Correlation, Greenhouse-Geisser, and Wechsler Intelligence Scale for Children-Revised.

Chapter 3 - Literature Review

The purpose of this chapter is to review the literature on how physical activity impacts cognitive development and function. This section will address questions such as does physical activity impact cognitive development and for who? This section will also address what types of physical activity are best in relation to cognitive development and cognitive function. It was found best to organize this synthesis chapter by discussing who is impacted then move onto how and to what extent physical activity can affect cognitive development and function and what type of physical activity is best.

Charles H. Hillman is a leader on this very topic. He has taken part in many research reviews as well as studies that examine the correlation between physical activity and cognitive development. In one such study in 2008, Hillman did a meta-analysis on older adults and analyzed the fitness training effect on this group compared to the control group who did not partake in the fitness training. The training lasted for 10 weeks and in each of the four categories tested (executive, spatial, controlled, and speed) the experimental group showed gains while the control group did not. This could suggest that exercise and physical activity have an effect on cognitive development.

Hillman did not stop there, in 2009 he continued his research but this time he focused on pre-adolescent children. He separated the participants into two groups. They used the FITNESSGRAM test to determine groups. They ranked the participants and determined which participants would be considered lower-fit or higher-fit. He used the Eriksen Flanker Test which requires the participants to respond quickly to an array of letters. The participants would respond by selecting a button with their right or left thumbs depending on which side the letter was on. The results showed that children who were considered higher-fit had a better response time as

well as better accuracy. This study potentially challenges traditional education practices and is a great example of how physical activity or being physically fit has a positive correlation with cognitive development.

In 2014 Naiman Khan teamed up with Charles Hillman to review literature on physical activity and brain function. The purpose of this review was to point out how physical activity, particularly aerobic activity, at a young age can improve brain health over time. This review goes into specific reasons why this might occur. For example, children were examined again by levels of fitness and the higher-fit children had higher hippocampus volumes compared with the lower-fit children. The hippocampus deals with memory and relation. Another example found in this review is results found from an MRI when trying to determine executive control of children that were higher-fit compared with lower-fit children. The functional MRI was used to monitor blood flow throughout the brain. Khan and Hillman concluded that "evidence from fMRI studies suggests that that physical activity may influence the modulation of neural circuitry supporting executive control in prepubertal children" (Khan & Hillman, 2014, p.143). This review suggests that physical activity throughout childhood could have a positive effect on brain tissue loss over time. The current evidence suggests that physical activity, specifically aerobic activity, can be helpful in improving brain health over time.

Cognitive Development

Cognitive development is best described as the construction of thought processes, including remembering, problem solving, and decision-making, from childhood through adolescence to adulthood (Encyclopedia of Children's Health, 2020). "Cognitive function is a variety of functions such as perception, attention, memory, learning, and executive function." (Ando et al., 2016, p.17). Although similar they are not exactly the same. Cognitive development

refers to the journey from adolescence to adulthood whereas cognitive function is referring to the ability to execute a task such as learning or paying attention.

Adolescence Cognitive Development

There are a number of reasons why physical activity has a positive role in childhood development. There are the obvious motor development and function benefits from being physically active but there are other benefits as well (Wright 2019). Wright's research was conducted at a Head Start Agency in the Midwestern-United States. The purpose of this study was to identify the relationship between physical development and school readiness. Data was collected in the core developmental scales listed in Teaching Strategies GOLD (TS. GOLD). These scales included physical, social–emotional, language, cognitive, and literacy development. From here two-tailed Pearson correlations were conducted to analyze the information from the TS GOLD. The results of this study concluded that there was a significant positive correlation between the physical development portion and the other school readiness categories.

According to Haapla, fewer than 20% of children meet the recommendations for physical activity a day. The purpose of his review was to find the relationship between cardiorespiratory fitness and cognitive function and academic achievement. His review on physical activity and cognitive development separated children that were deemed fit and children that were deemed unfit by terms of their cardiovascular fitness. This review suggests that children that have higher levels of cardiovascular fitness have better inhibitory control. Haapala refers to inhibitory control as a "higher order mental processes that are related to the control of attention, behavior and emotions and involves mainly the neural networks in the prefrontal and parietal cortices" (Haapala p.56). The Eriksen Flanker Task is a common way to test for inhibitory control and according to these tests, children with higher cardiovascular fitness did better with the task.

Haapala's review concludes that evidence suggests that children with higher levels of cardiovascular fitness have more efficient brain activation and even improved academic progress compared to those who are less fit. Another physiological improvement found in this review between the cardiovascularly fit and those unfit are larger subcortical brain structures.

Adults Cognitive Development

Cognitive development is the construction of thought processes, including remembering, problem solving, and decision-making, from childhood through adolescence to adulthood (Encyclopedia of Children's Health, 2020). With that definition it can be argued that adulthood is the finish line for cognitive development. There is not as much research on cognitive development in adults. However, it was found that aerobic exercise before learning or after learning, even in adults, had a positive effect on memory consolidation. The release of exercise induced neurochemicals mostly has to do with how much intensity you are exercising with (Statton et at., 2015).

Statton's research took 24 healthy young adults and performed motor tasks either before or after 30 minutes of exercise. The purpose of this study was to find the relationship between a single bout of exercise and motor skill learning. The results suggest that the moderate aerobic exercise might be able to prime the nervous system for learning of new skills.

Impact of Duration on Cognitive Development

It is well known that physical activity and exercise has a positive impact on cognitive development (Statton, 2015). This section will review the literature on what kinds of exercise and how long you must exercise to trigger best cognitive function or development. Physical activity has been associated with different effects on brain structure. Not all of these effects are completely understood at this time. One effect includes improved capacity for cortical plasticity,

which is the brain's ability to make new neural connections. This could potentially be a reason for why physical activity can be associated with memory (Smith, 2014).

Types of Physical Activity

Acute Physical Activity

Acute exercise is defined here as a single bout of exercise. Can a single bout of exercise influence cognitive function or development? Research has shown that a single bout of exercise can immediately improve learning and memory. Aerobic exercise is considered a “priming” effect that may be responsible for promoting neuroplasticity (Statton, 2015).

Smith’s research attempted to find a link between acute exercise at different levels of intensity and short-interval intracortical inhibition (SICI). She was able to test this by having different levels of intensity being tested. All exercise tested in this study was acute and was tested before, immediately afterward and then 15 minutes after exercise. It was found that 80% of active motor threshold had the most reduction in SICI which in turn helps with reaction time. A single bout of exercise may be responsible for creating an optimal environment for enhanced neuroplasticity (Smith, 2014).

In a series of studies, Ando examined acute exercise and its effect on cognitive function in a variety of different conditions. First he examined at rest and during exercise the cognitive function of his participants under moderate or severe hypoxia, which is when parts of the body lack oxygen. It was found that acute moderate intensity exercise improved cognitive function under these conditions. He also discussed cerebral blood flow and its impact on cognitive function. It was determined that cerebral blood flow may not be directly linked to cognitive function but he suggests more studies are necessary to make a better conclusion (Ando et, al. 2018).

In a recent study from, Bhattacharyya (2017), tested the Queen's College Step Test which is a test that has been useful for testing cognitive performance. The participants consisted of 10 young adult males. Simple reaction time was used to test speed of processing, and stroop task for attention. They measured the participant's times before and after 30 minutes of exercise and then again 30 minutes after exercise. The results of this study showed a significant decrease in the amount of reaction time after exercise by nearly 40%. The results from the stroop test proved a 20% reduction in time after exercise compared to before. Another interesting correlation that Bhattacharyya found was that the most improvement they found in the test was immediately after exercise. The study results show that of many, a single bout of aerobic exercise can help to improve cognitive function.

Chronic Physical Activity

Chronic exercise is defined as repeated bouts exercise over the course of time. Moderate intensity defined as 70%-80% of maximum heart rate has been known to improve memory. There is plenty of research that supports the idea that over time physical activity and regular exercise can help support cognitive growth (Bhattacharyya, 2017). Khan and Hilman's research from 2014 found that children that were considered more-fit compared with those that were unfit had improved retention especially when the task became more challenging. This may suggest that chronic physical activity has something to do with enhanced learning. In order for a child to be considered fit it can be assumed that they have some sort of physical activity in their lives.

In a recent study, from 2016, Masoudi, Seghatoleslami, and Saghebjoo took 45 female children at the age of 8 and separated into a control group and experimental groups. Both groups were equal and consisted of girls that had learning disorders. The purpose of the study was to see if aerobic exercise over time can have any effect on cognitive development in children with

learning disorders. The experimental group was given 8 weeks of aerobic exercise. The results of the study showed the experimental group had “significant influence” on cognitive performance when compared to the control group. This study shows the influence and potential that chronic physical activity may have on cognitive development.

Summary

No matter the amount or when or how often someone exercises the research shows that cognitive development and function are improved when adding exercise or physical activity. Whenever compared to inactive or unfit children or adults, the more active and fit seem to improve when tested on cognitive function. Even a single bout of exercise has been proven to improve cognitive function.

Chapter 4 - Results

The purpose of this synthesis project is to review the literature on how physical activity can impact cognitive development and how these results align with the purported research questions which guided this synthesis project. In addition, recommendations for future research as it relates to physical activity and its impact on cognitive development are presented. The results of this review of literature revealed the following that physical activity, specifically aerobic exercise, has a positive correlation with cognitive development and function.

Discussion

Interpretations

As part of this literature review, two research questions were posed. The first research question was to what extent does physical activity impact cognitive development? The results found in this critical mass of literature has provided ample evidence that there is a positive correlation between. The second research question was how often do you need to exercise in order to improve cognitive function? The results in this synthesis project has not only explained how often but also what kinds of physical activity work best. Even a single bout of aerobic exercise can have a positive effect on cognitive function.

As it has been stated numerous times throughout this synthesis project and perhaps stated best by the research done by Khan and Hillman in 2014, “physical activity is suggested to indirectly improve cognition and brain health by attenuating the risk for disease” (Khan & Hillman, 2014, p. 138). This of course does not mean that physical activity is a cure all to all

brain ailments but instead could prove useful in the prevention of such ailments that may occur in the brain.

Preventing disease and especially preventing disease within the brain is perhaps one of the most important health issues of our time. Research gathered in this synthesis project has not only proven that having a high standard of physical health contributes positively to mental health over time but also has shown evidence that physical activity can also play an essential part in producing positive results immediately.

Implications

Most research agrees that physical activity has a positive correlation with cognitive development and brain function. How this occurs and to what extent physical activity impacts cognitive development is still up for debate. Some research states that blood flow to the brain during aerobic exercise is what causes the positive correlation. Khan and Hillman's research in 2014 cited aerobic exercise and how it increased blood flow to the hippocampus and how it could improve memory in those who were considered higher-fit children. This is an example of how chronic exercise may positively correlate with cognitive development.

Other research shows that even a single bout of exercise can have a positive impact on cognitive function. Simple reaction time is one brain function that improves immediately after exercise. According to Bhattacharyya this effect can last up to 30 minutes after exercise. Other research explains that after a single bout of exercise can in turn improve the environment needed for enhanced neuroplasticity (Smith, 2014).

These findings confirm that physical activity, chronic or acute, can play a major role in cognitive development. These results also point out a potentially major flaw in educating our students and children. Students spend essentially an entire work week at school (30-40 hours). During this "work week" the amount of physical activity is very low compared to how much time they spend at their desks or on computers. New York State mandates that students grade K-6 get 120 minutes of physical education a week (nysed.gov). When broken down this is only 24 minutes a day out of the 7-8 hours they spend at school. Administrators should perhaps be looking for a way to increase physical activity time during the school day to improve cognitive development.

Future Research

In reviewing the data based on cognitive development and physical activity, the following limitations were noted regarding the studies under review. Further research is needed to confirm the extent in which a single bout of exercise can improve cognitive development and brain function. It is very unclear exactly how much exercise is needed to achieve the optimal cognitive results. Future studies should compare chronic and acute exercise and the benefits that go along with each in terms of cognitive development and brain function.

Based on these limitations and other insights related to the literature the following recommendations for future research should be considered:

1. Future research on the extent of physical activity and its impact on cognitive development and brain function
2. Research on what types or how often physical activity is needed to achieve optimal cognitive results.

3. Future research should compare those who are physical activity with those who are more sedentary in terms of cognitive function.

Summary

Overall Summary

The purpose of this literature review was to determine how physical activity can impact cognitive development. Delimiting variables were used to do an exhaustive data-based search which yielded 10 articles. These articles were then systematically used to determine how physical activity can impact cognitive development.

Research revealed that physical activity, both acute and chronic, have a positive impact on cognitive development and cognitive function. Memory and reaction time are two things that are positively associated with physical activity. Future research should examine exactly how much exercise is needed in order to gain the optimal cognitive results and should then be applied within our school systems.

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Wright, P. M., Zittel, L. L., & Gipson, T., (2019). Assessing relationships between physical development and other indicators of school readiness among preschool students. *Journal of Teaching in Physical Education,* 2019, 38, 388-392 https://doi.org/10.1123/jtpe.2018-0172

Appendix A
Article Grid

Author	Title	Source	Purpose	Methods & Procedures	Analysis	Findings	Discussion/ Recommendations Research Notes – Commonalities/Differences
Ando, S., Komiyama, T., & Higaki, Y.	The Effects of Acute Exercise on Cognitive Function	*Adv. Exerc. Sports Physiol., Vol.24,*	The purpose of this study was to find a correlation between acute exercise and cognitive function	The authors assessed cognitive function at rest and then again after acute exercise.	Go/No-Go cognitive task	The data suggests that cognitive function improved after exercise.	It is recommended that further research is needed to determine the mechanisms underlying cognitive development induced by acute exercise.
Bhattacharyya, D., Sen, S., Chatterjee, S., Chatterjee, T., & Pal, M.	Effect of Queen's College Step Test on Cognitive Performance Among Young Adults	*Biology of Exercise, Vol 13.1*	The purpose of this study was to test cognitive performance after a brief exercise. The brief exercise is called Queen's College Step test.	Simple Reaction Time (SRT) test and Stroop Test before after the Queen's College Step test. The SRT and stroop tests came 30 minutes after exercise.	ANOVA Pearson's Correlation Co-efficient	The data showed improvement in SRT 30 minutes after exercise.	The results show that even just 3 minutes of exercise can have an impact on cognitive performance. More research is recommended in the form of short duration exercise and cognitive performance.
Haapala, E. A.	Cardiorespiratory Fitness and Motor Skills in Relation to Cognition	*Journal of Human Kinetics volume 36.* 55-58.	The purpose of this review is to examine the relationship between	Haapala reviewed literature that compared children that	Literature Review	This review suggests that children	Cardiorespiratory fitness has shown evidence to better improve brain health and function.

	and Academic Performance in Children: A review.		cardiorespiratory fitness and academic performance.	were considered fit and those who were not fit in terms of cardiorespiratory fitness.		who have better cardiorespiratory fitness have a larger subcortical brain structure, superior inhibitory control, better working memory and more positive academic achievement	
Hillman, C. H., Buck, S. M., Themanson, J. R., Pontifex, M. B., & Castelli, D. M	Aerobic Fitness and Cognitive Development: Event-Related Brain Potential and Task Performance Indices of Executive Control in	*Developmental Psychology Vol. 45, No. 1, 114–129*	The purpose of this study is to compare preadolescent children that are considered fit with those who are not in a cognitive	48 preadolescent children were separated into two groups (fit and un-fit). The Eriksen flanker task was used to examine	FITNESSGRAM was used to determine groups. MANOVA	This study found that the higher-fit children performed better on the flanker test and with quicker	The flanker test is one way to test executive function. The higher-fit children scored better on this test. Reaction time and greater accuracy was revealed in those who were considered higher-fit.

	Preadolescent Children		performance task.	interference control.		responses and less error.	
Hillman, C. H., Erickson, K. I. & Kramer, A. F.	Be Smart, Exercise your Heart: Exercise Effects on Brain and Cognition	*Science and Society, Vol 9.* 58-65	The purpose of this article is to examine positive effects of aerobic activity on cognitive function.	A meta-analysis on older adults and analyzed the fitness training effect on this group compared to the control group who did not partake in the fitness training. The training lasted for 10 weeks and in each of the four categories tested (executive, spatial, controlled, and speed) the experimental group showed gains while the control group did not	Meta-Anyalysis	This article determined that the group that who did the training had scored better in the four categories measured (executive, spatial, controlled, and speed). Executive functions scored where up to 0.6 times as high as compared to those who did	There is evidence to show that physical activity is beneficial to cognitive performance. Furthermore there is evidence to shows physical activity can promote brain function in those who are lessoning in health.

						not do the training.	
Khan, N. A., & Hillman, C. H.	The Relation of Childhood Physical Activity and Aerobic Fitness to Brain Function and Cognition: A Review.	*Pediatric Exercise Science, 2014, 26, 138-14*	The purpose of this review is to examine research in relation to childhood physical activity and brain function.	Literature Review	Literature Review	Physical activity may be a potential weapon to help aid with age-related brain tissue loss and can be associated with better cognitive function in children.	This review has provided evidence that being physically active over a child's life all the way into adulthood may aid many brain ailments later in lif as well as improve current function.
Masoudi M, Seghatoleslami A, Saghebjoo M.	The Effect of 8 Weeks of Aerobic Training on Cognitive Performance in Children with Learning Disorders	Journal of Fundamentals of Mental Health 2016 May-Jun; 18(3): 161-8.	The purpose of this study is to investigate the impact aerobic training has on cognitive performance in girls with learning disorders.	45 8 year old girls with learning disorders were selected. The experimental group received an 8-week aerobic training therapy while the control group did not.	SPSS	Cognitive performance had a "significant influence" for the experimental group compared to the control group.	Aerobic training can be used as a way to help children with learning disorders. The author also cited that this is non-invasive and non-pharmacological method for improving cognitive performance within this population.

				Statistical analysis using descriptive analysis was used.			
Smith, A. E., Goldsworthy, M. R., Garside, Tessa., Wood, F. M., & Ridding, M. C.	The Influence of a Single Bout of Aerobic Exercise on Short-Interval Intracortical Excitability	*Exp. Brain Res doi:10.1007/s00221-014-3879-z*	The purpose of this study is to explore the effects of a single bout of exercise may have on cortical excitability and inhibition.	There were two levels of intensity that were tested in this study (low-moderate, moderate to high). All exercise tested in this study was acute and was tested before, immediately afterward and then 15 minutes after exercise.	rANOVA Four way rANOVA	The results of this study found that there was a reduction in SICI (which is important for reaction time). The results also found no changes in corticospinal excitability.	This study provides further evidence supporting a reduction in reaction time immediately after exercise.
Statton M.A., Encarnacion M., Celnik P, Bastian A.J.	A Single Bout of Moderate Aerobic Exercise Improves Motor Skill Acquisition	*Plos One.*	The purpose of this study is to determine of a single bout of aerobic exercise	This study took 46 healthy adults and performed a Sequential Visual Isometric Pinch	ANOVA Greenhouse-Geisser	The results show that all groups showed significant	The authors suggest that there may be some important information discovered here that could be used in rehabilitation. It

			can have on motor learning.	Task (SVIPT. The control group was asked to walk a slow pace for 35 minutes. Two experimental groups were formed. The Aerobic group ran for 30 minutes and immediately took the test while the Aerobic + Rest group waited an hour before taking the test.		improvement in skill measure but the groups that did more scored better on the SVIPT.	remains undetermined which neurochemical responses are the result of aerobic activity and more research is needed.
Wright, P. M., Zittel, L. L., & Gipson, T.,	Assessing Relationships Between Physical Development and Other Indicators of School Readiness Among Preschool Students	*Journal of Teaching in Physical Education,* 2019, 38, 388-392	The purpose of this study is to examine the relationship between physical development and other criteria used to determine school readiness.	172 preschool students were used in this study aged 3-5 years. Teachers ranked the students on physical, cognitive, language, social–emotional, and literacy.	Two-Tailed Pearson Correlation TS-GOLD	This study shows there is a positive correlation between a preschool child's physical development and other	The authors suggest that physical development is an important part of predicting future success in school.

						categories that determine school readiness.	