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Aerobic Exercise and its Effect on Students' Readiness to Learn

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Aerobic Fitness and its Impact on Students' Readiness to Learn

An Action Research Project by

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Abstract

The purpose of this research was to test if aerobic exercise done before academic work would improve student learning readiness which includes increased alertness, longer periods of concentration and a resilience in doing work. The six-week study incorporated twenty-minutes of aerobic exercise every morning and involved 26 students between the ages of 9 and 12 years in a Montessori classroom. Data collection included pre and post surveys on student energy levels, exercise logs filled out by each student daily, on-task observation sheets and levels of attention observation sheets done by myself daily for the first thirty-minutes to evaluate students' depth of focus on their first works. Results from the post survey showed that most students' felt that the exercise increased their energy levels and improved their ability to do academic work. The majority of students recorded an increase in energy after exercise on their daily exercise logs. The data showed a positive correlation between aerobic exercise and student learning readiness in children ages 9 to 12. Suggestions for future research include testing if student physical fitness impacts learning outcomes and an extended research period.

Key Words: aerobic exercise, student, cognitive functions, Montessori

Students in most school settings spend a large part of their time sitting. As educators we are required to meet the academic needs of our students, but what many educators don't realize is that physical activity enhances learning outcomes. It is natural in a Montessori classroom to see students working and moving freely. In this aspect, Montessori classrooms provide physical activity for their students, however, I still found that in my Montessori classroom the movement didn't require much exertion. I thought adding aerobic exercise to my students' day would better benefit their overall physical fitness. I also wondered if aerobic exercise would help get students ready to learn by increasing their mental arousal and ability to focus. According to Ratey (2008), when students move it makes the brain function at its best. Much of recent research shows that exercise benefits the body and, more importantly, the brain in ways that are more diverse than previously understood; thus students need exercise to produce optimal learning experiences.

As children learn, synapses in the brain are connecting and rewiring. Current research shows that exercise helps with making and rewiring these connections as well as providing constant oxygen and glucose to the brain which provides nourishment for brain activity (Ratey, 2008). In fact, current research shows that exercise also enhances neurotransmitter activity that effects the communication and learning hormones in the brain. The ability for students to learn increases with exercise. To serve every aspect of the child, exercise is an essential component to the learning equation. Therefore, an important piece to education needs to be providing more physical activity to students and to increase opportunities for movement experiences during a school day.

In a Montessori environment, students move during work more than in a traditional setting. This critical difference does provide a level of necessary movement for optimal brain and body connection. However, based on my research, I do feel more emphasis needs to be on

aerobic activity. Aerobic activity increases the students' heart rates to an optimal level for increased health outcomes and mental arousal. Therefore, educational time spent on aerobic activity should enhance student-learning outcomes. These opportunities give students the capabilities needed to access higher reasoning and to maintain focus for longer periods of time.

To support students, educators need to rethink how physical activity plays a role in education. Observational methods in a Montessori environment will assist in providing data to support these claims. Strategies to implement more movement for students include adding exercise before morning work, continuing movement activities during work and allowing for further opportunities for independent exercise for students as needed.

Previous research has shown that exercise done consistently over time does improve brain function and learning outcomes, but there is less research about the direct impact of exercise on students' learning readiness before they start academic work. I would like to see how aerobic exercise directly improves student learning for my classroom and if there is improvement share my findings with my school community.

The research was conducted in a mixed-age classroom of twenty-seven students between the age of nine and twelve in a Montessori charter school in the western United States. I wanted to see if exercise before work would help students have the energy and mental arousal to choose work more efficiently and to stay focused on work for longer periods of time.

Review of Literature

Introduction

Individuals who are physically active are more focused, more prepared to learn, less distracted and in a better mood (Ratey & Hagerman, 2008). Leaders in neuroscience and physical education are revisiting the possibility of physical activity having a significant impact

on learning (Benham & Ciotto, 2014). It is widely known that exercise benefits the body but current research has shown that physical activity improves cognitive functions (Atkinson, 2004; Benham & Ciotto, 2014; Blaydes, 2009; Ratey & Hagerman, 2008; Stevens-Smith, 2016 & Tomporowski, 2008). Cognitive functions include any mental process underlying learning such as alertness, concentration, attention, mood, motivation, predicting, sequencing, ordering, focus, memory and planning (Atkinson, 2004; Benham & Ciotto, 2014; Ratey & Hagerman, 2008 &; Stevens-Smith, 2016).

In schools educators focus on intellectual functions, cognitive abilities and academic achievement as a premise for student learning (Tomporowski, 2008). A trend in school systems, however, has reduced physical activity for students to give more time to academic subjects. This works against what researchers know about the benefits to learning from physical activity (Howie, Schatz & Pate, 2015). Increased physical education time has been reported to not impede academic performance and research also shows that it could possibly improve academic performance (Liam et al., 2010). These findings could have implications for educator policy.

Exercise and Learning

Exercise improves brain functions. "Exercise benefits the brain even before it benefits the body" (Blaydes, 2009). The brain is made up of one hundred billion neurons. The communication between these neurons as well as the creation of new neural pathways are impacted by exercise (Ratey & Hagerman, 2008). Exercise also balances the neurotransmitters, serotonin, dopamine and norepinephrine that help regulate mood and behavior. Serotonin keeps brain activity in balance and norepinephrine excites signals that impact attention, perception, motivation and arousal (Ratey & Hagerman, 2008; Blaydes, 2009). Another benefit to the brain from exercise is that it triggers the production of brain-derived neurotrophic factor (BDNF); this

protein helps take care of the circuitry of the brain. With increased BDNF, a greater amount of neurons are able to exchange and retain information at a greater rate (Hall, 2007; Hannaford, 2005; Medina, 2014; Moreau, 2015; Ratey & Hagerman, 2008). The greatest discovery with BDNF and its increase due to exercise is that it sparks the hippocampus which is the center of learning in the brain. These findings were discovered by a Carl Cotman, director of the Institute for Brain Aging and Dementia at the University of California, Irvine. (Ratey & Hagerman, 2008). This current research gives new evidence of physical activity's influence on cognitive functions.

Exercise enhances learning by increased blood flow. Exercise provides oxygen and glucose to the brain (Jensen 2005; Hall, 2007; Blaydes 2009). The brain requires a large amount of energy. The brain uses 20% of the body's glucose (Medina, 2014). Consistent exercise builds new blood vessels into all parts of the body. It supplies a greater volume of blood to the hippocampus, the area referred to earlier that is at the center of learning. This allows for the brain's greater access to the energy it needs to execute cognitive tasks (Medina, 2014). With exercise improving neural pathways and increased blood flow, the evidence supports physical activity as an aid to learning.

Exercise improves student achievement. Students who are physically fit also have higher test scores (Atkinson, 2004; Catching, 2011; Ratey & Hagerman, 2008; Stevens-Smith, 2016). The California Department of Education in 2001 correlated scores from state-mandated physical fitness tests with standard achievement tests for over a million students. Physically fit students scored twice as high as unfit students (Ratey & Hagerman, 2008). Along with this study, Ratey and Hagernan refer to a panel of researchers in 2004 that did an extensive review of over 850 studies on physical fitness and school-age children. Most studies concluded that 30-45

minutes of moderate-vigorous exercise, three to five days a week was effective in impacting cognition. This panel's recommendation was that students should be participating in one-hour or more of moderate-vigorous exercise a day. They supported the premise that exercise does influence memory, behavior and concentration (Catching, 2011; Ratey & Hagerman, 2008; Schmidt, 2016).

Another case study done by John Ratey in Naperville, Illinois, supported the correlation between physical fitness and improved student achievement (Ratey & Hagerman, 2008). The Naperville District 203 has become a model for its focus on physical fitness to improve learning. This district was chosen to participate in the Trends in International Mathematics and Science Study (TIMSS). This test is designed to compare achievement scores from different countries. These tests are what mark the United States as below international standards in math and language. Only 7% of United States students score in the top tier of the test. Students from the Naperville District 203 scored first on science just ahead of Singapore and scored sixth in math. The two factors that this district has are its unique physical education program and its test scores. Thus, a strong correlation between physical fitness and academic achievement exists. This correlation is too strong to dismiss (Ratey & Hagerman, 2008).

Acute bouts of exercise and learning. Long-term exercise impacts the brain differently than acute exercise (one-time session). Research on acute bouts of exercise are limited and require further study specifically in children (Howie et al., 2015). Studies from Howie et al. (2015) were the first to examine acute bouts of exercise in a school setting on students 9-12 years of age through exercise breaks. They found that exercise impacted cognition best when the duration was longer than ten minutes and best at twenty minutes. It also needed to raise the heart rate above 60% maximum volume for the duration of the activity (Howie et al., 2015).

A review by Tomporowski that analyzed multiple studies done on acute bouts of exercise (2008) reported that proponents of exercise concluded that acute bouts of exercise helped one think more clearly and increased mental arousal. They also found that response speed is affected by exercise. The most compelling distinction discovered was that acute bouts of exercise didn't directly improve cognitive function but "acute exercise exerts a selective influence on the manner in which an individual prepares for the onset of stimulus" (Tomporowski, 2008, p. 10). Acute bouts of exercise facilitate and prepare the conditions of the brain for optimal uptake of information and processing. Individuals can perform cognitive tasks more quickly and efficiently. Executive function tasks of planning, initiating and monitoring actions are best facilitated when the brain has access to resources. Acute bouts of exercise increase the brain's ability to access those cognitive resources required for maximum attention. Research shows that acute bouts of exercise indirectly facilitate learning by preparing the brain for optimal uptake of information (Tomporowski, 2008). This indicates that those functions that assist in learning such as attention and focus are enhanced by acute bouts of exercise.

Limitations of research. The research is limited in relation to exercise's impact on cognition in the classroom. Most studies have been observational and few have been done on children (Liam et al., 2010). Classroom studies have lacked adequate control conditions. Some of the studies also lacked ecological validity. A study was done to further the research of exercise and attention in the classroom. Its aim was to investigate whether increased physical exercise during the school day influenced cognitive performance in the classroom (Liam et al., 2010). A randomized, crossover-design trial of two weeks with 1224 children aged 8-11 years was conducted. The results of the study concluded that exercise did benefit cognitive

performance. The limitation of the study is the benefit depends on the context of the testing and participants' characteristics (Liam et al., 2010).

Conclusion

Studies have consistently reported the benefits of physical activity on cognition. Exercise improves brain functions through increased blood flow, uptake of proteins and the overall health of the infrastructure of the brain. Research has also shown there is a strong correlation between student achievement and physically fit individuals. More research needs to be done on exercise and learning in the classroom on children. With my research project, I will further the research on this topic by implementing exercise in the classroom and collecting data on student attention to work and work quality.

Methodology

The implementation of exercise for my action research project took place over six weeks in the months of September and October of 2017. It began after the first few weeks of school after the students had settled into their daily routines. Implementing the exercise was a change to the routine of the first part of the day which had previously only contained a mild walk.

I explained the changes to the class and gave them a clear understanding of the expectations of participating in the research project. Students took home the parental permission form to ensure the students could be a part of the project. None of the parents refused to have their students be in the research. The new schedule during the research would include twenty-minutes of aerobic exercise followed by independent work time where I would be observing for thirty-minutes each day first thing in the morning with an observation chart (Appendix A). In my Montessori classroom, students work independently with a self-guided work chart during an

academic cycle of three-hours. This way students can do independent work without the dependency on a teacher. This strategy allowed me to observe students without interruption.

During the first week of the study before beginning the intervention, I reviewed the data sheets with the students. They practiced filling out the data sheet they would be using every day after exercise: the daily exercise log (Appendix B). This data sheet required students to determine their energy levels before and after exercise on a scale from 1-5. For this data sheet, they also needed to record the type of exercise and the predetermined duration of twenty-minutes for the exercise.

Furthermore, students took the pre-survey (Appendix C) the first week of the study to determine their perceptions of their work experience in the morning and the amount of energy they felt. This sheet asked close-ended questions on a scale about whether they felt low energy in the morning before work cycle or high energy. A post-survey (Appendix D) was done at the completion of the study to see if students felt that exercise in the morning improved their mental alertness upon entering the three-hours of academic work as opposed to without it based on the pre-survey before the intervention.

I also showed the students the fourth data sheet, the attention chart (Appendix E) and told them that it would be used by me to review their work samples that I would collect at the first part of every day. I also included my observations of their attention on work on the data sheet when work samples were not obtainable. I defined for the students the differences between various types of attention which ranged from passive attention to deep attention based on the rubric (Appendix F).

Once I began the intervention, I would begin each morning explaining the necessary movements to be successful at the workout. My strategy to choose exercise was a combination

of high-intensity interval workouts and sport games that I knew would increase student heart rates to the needed level of 60% maximum heart rate for twenty-minutes determined in my research (Ratey & Hagerman, 2008). I also chose work outs that didn't require a lot of explanation or skill in an effort to not make the work out about skill acquisition instead of aerobic activity for the desired purpose of my research. These work outs included both aerobic activity such as jumping jacks, sprints, jump rope and endurance runs as well as core-building exercises such as burpees, lunges, squats, pushups and sit ups. The sport games would include soccer, mile-run challenges, capture the flag and dodge ball. Before the work out I would go to a randomly selected set of students and get heart rates with a heart rate monitor. I would check the same students after the work out and record their heart rates to ensure that the activity brought the students' heart rates up to the desired rate. I also made sure that each work out lasted for at least twenty-minutes as prescribed in my action research plan.

I would remind the students daily before and after their workouts to fill out the exercise log. Before the work out they wrote down their pre-energy levels and after the work out the students would fill out their post-energy levels. I would go and check each student to ensure the data was collected. During my observations following the students' exercise I would use the observation sheet (Appendix A) to document students who were in one of the following categories: not on task, have a task but not doing it, and doing a task. I would check the students every three-minutes for thirty-minutes. Simultaneously, I would document what work each student chose on my attention data sheet (Appendix E) and determine through observation and later with work samples the depth of student attention on work. Daily I would compile my observations and work samples. Weekly, I would collect the exercise logs. The data collection process lasted for an hour each morning, a half-hour for exercise and a half-hour for observation.

The data collection process was successful except for a few setbacks such as assemblies, special visitors and inclement weather. These were minor and didn't have a large impact on the study.

Analysis of Data

The data gathered during this action research project consisted of information retrieved from observation of students, student-logs and work samples. Before beginning my action research I wanted to determine my students' energy levels in the morning prior to academic work. To do this, I administered the pre-intervention survey. At the end of the intervention I administered the post-intervention survey to see how the students perceived the difference in energy levels with the addition of exercise prior to academic work.

Energy Levels	Pre-Survey	Post-Survey
Low	12%	0%
Low-Average	27%	14%
Average	31%	18%
Above Average	19%	49%
High	0%	18%

Figure 1. Students' energy levels based on surveys given before and after the intervention.

The data shows that with exercise students that responded with average-energy increased their level of energy to above-average or higher. There were no entries from students in the post-survey indicating students with low energy. This shows that on average students' perceived that their energy levels did increased with exercise.

Along with the pre and post surveys, I started tracking student learning-behaviors daily. Because I was looking for students' readiness to learn after aerobic exercise, my next data collection tool was an on-task chart (Appendix A) that looked for behaviors such as the ability to concentrate and maintain focus on academic work. I observed student-work at the first half-hour of every work cycle following the aerobic activity. The data collected from the on-task chart is seen in the graph below.

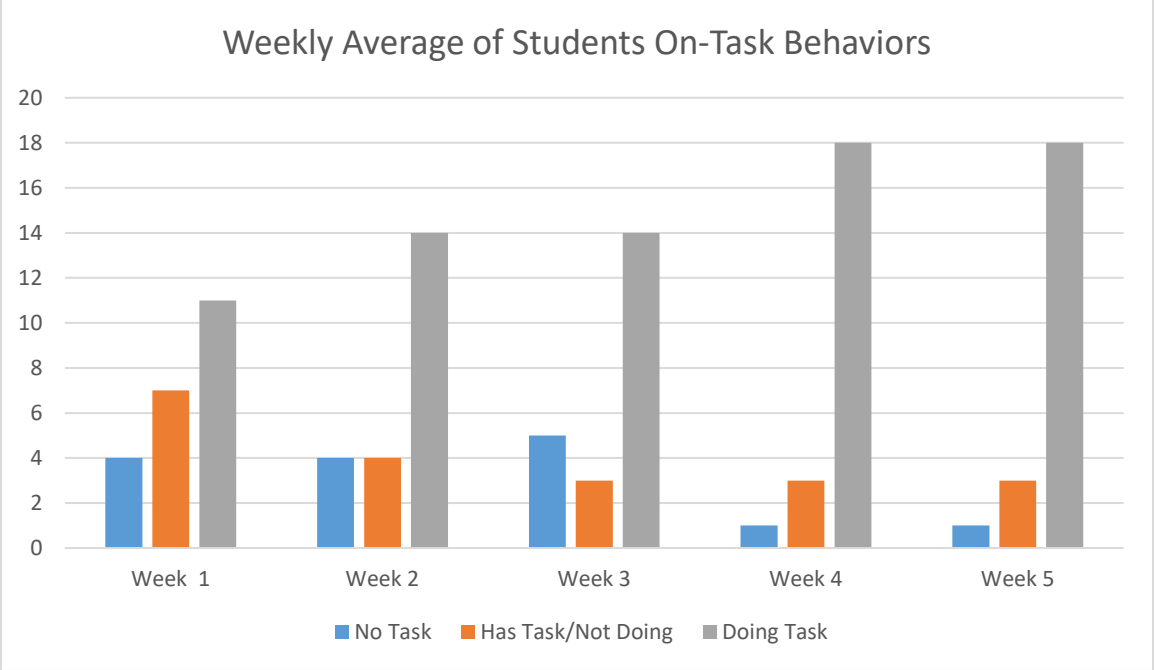

Figure 2. The graph shows students on-task behavior on average over five weeks based on the following scale: no task, has task but not doing it and doing task.

This data shows that there was a progressive increase in student on-task behavior. The results show that students tended to be on-task with much greater frequency than being off task. Students took a while initially to find a work but within the first ten-minutes of the observation most students were involved in a task. I also noticed that some students would tend to pick a light work at first and in the same range of ten-minute would move on to a more complicated

task and remain with it for the duration of the thirty-minute observation. An observation I noticed for further research was that I found students who were more physical fit tended to have a stronger ability to concentrate and for longer periods; this was the tendency but maybe not the rule. Again that would be for a question for further research. I also noticed that as the weeks of the implementation progressed the amount of students on task increased.

The final data I collected was a Work Sample/Attention Chart (Appendix E). I wanted to see how deeply students paid attention to their work. Deep attention includes student work that shows full ownership of the learning activity as well as displaying high levels of energy, also that they did quality work. Students who exhibit lower levels of attention would be easily distracted, not show commitment to the work and do the work in a rote manner. There were varying levels of attention on a gradient of six levels. The results below show how many students fell into each category on the chosen observation days. The data below has been figured to make up for the difference in student population.

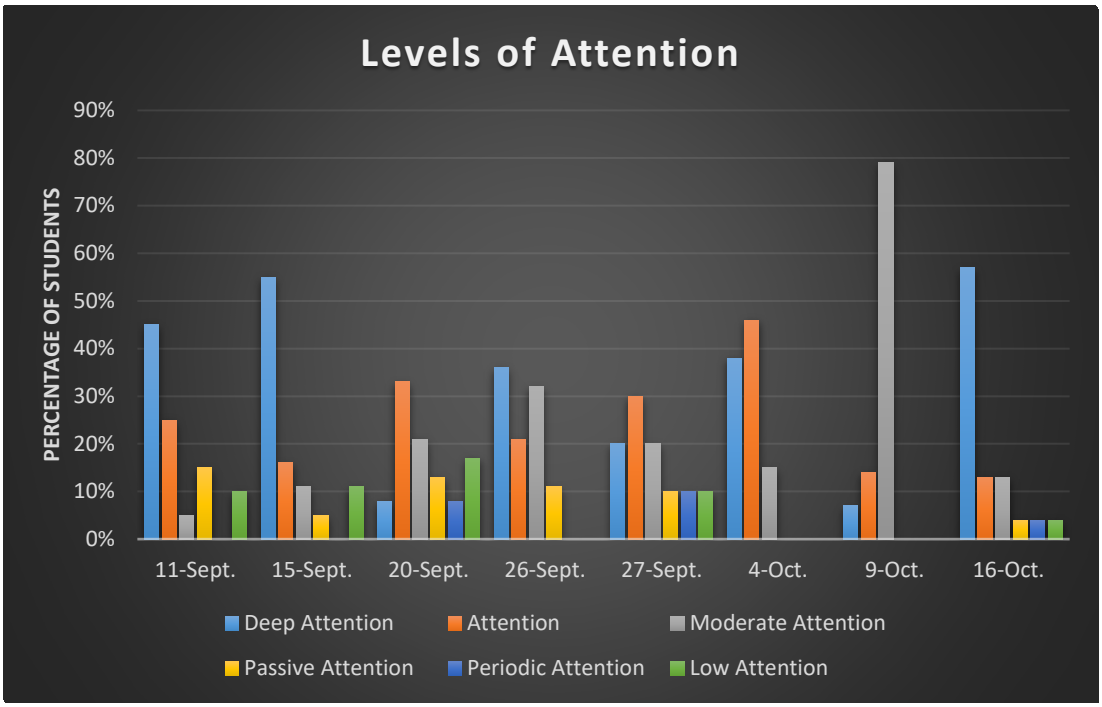

Figure 4. Levels of Attention. The graph above shows students' levels of attention on various days observed.

Looking at the data on attention another way, one can see that on any of the days observed most students had levels of attention in the moderate to deep levels as opposed to the passive to low attention levels. This indicates to me that having exercise before academic work didn't impede students' ability to give attention to work and the data shows that it could possibly have had a positive influence in increasing levels of attention in academic work.

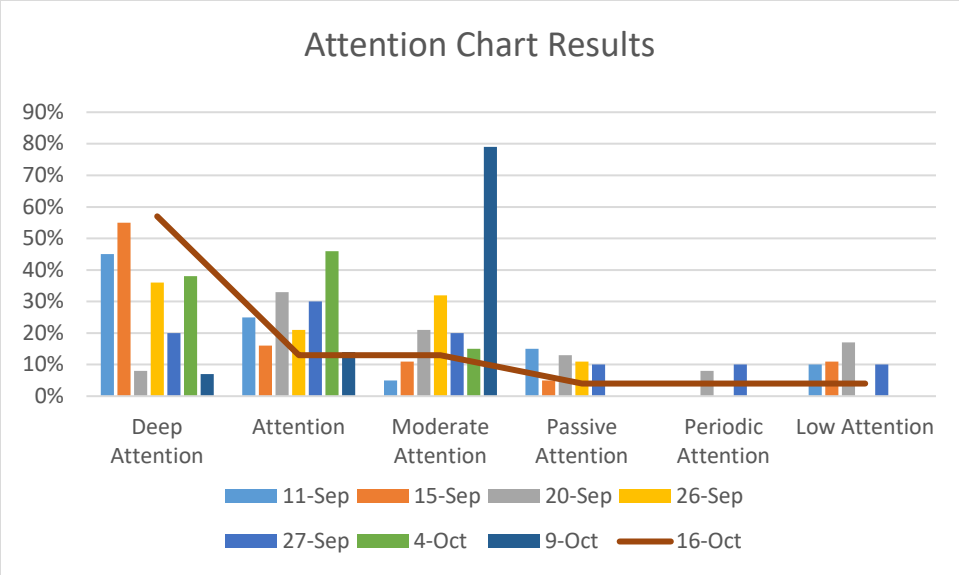

Figure 5. This chart shows level of attention on any given day.

In further review of other data collection sources such as the anecdotal notes, a few correlations became evident. First of all, it was noted that on days that students didn't receive exercise, off-task behaviors escalated. The diminishing effect was a lack of focus and an irritability and hyperactivity by the end of work cycle. Discipline behaviors increased and an overabundance of talking ensued. Furthermore, the number of emotional outbursts and disputes between students seemed to be higher on days that we didn't exercise. Whether or not there is a correlation is yet to be determined. Finally, the days the students exercised, students seemed to have peace and contentment that on the non-exercise days they did not tend to have. Many other factors may have come into play as well such as lack of sleep and food in the mornings. It is difficult to determine if exercise had a direct effect on learning outcomes but with the data I'm confident to say it didn't have a detrimental effect on learning outcomes.

Action Plan

The purpose of this research was to see if providing students with aerobic exercise before academic work would improve students' cognitive functions, namely concentration, mental

arousal, information processing and resilience in work. To be fully-equipped with a knowledge base before implementing the project, I researched the literature on the subject and evaluated my own practice. When I felt I had considered a significant amount of information on exercise and its impact on learning, I began my implementation of my intervention by providing my students exercise in the morning before academic work. Afterwards, I analyzed my results.

Through the analysis of my data, I saw aerobic activity before morning academic work had a positive effect on learning outcomes in general. The findings show that although students had various levels of ability to concentrate and these fundamental limitations did not seem to be altered by aerobic activity, exercise did help the students within their personal levels of ability.

The results of my research leave me confident I can continue to provide exercise before academic work. I found students were happier on days we exercised and the whole class functioned better. I personally felt more awake and engaged after our class had been moving and interacting together. The students also confirmed a positive effect of exercise on their ability to learn and their overall sense of wellbeing.

Based on the data showing continued improvement from the students with on-task behavior and a deeper level of attention to work, if given more time, I believe the intervention would continue to prove exercise helps learning. Also, from the literature, it was clear that not only do learning benefits come from daily exercise but the benefits are even more profound with increased physical fitness of the student. The students in this study came to the study with various levels of physical fitness. I believe given more time maintaining the exercise regime, students would show more academic improvements as their physical fitness increased. Knowing, however, that more research will need to be done by myself to verify its impact on

student learning, I will base my future actions on the assurance that exercise has a general positive impact on student learning.

I am confident in providing aerobic activity before academic work to my students. Since positive results were documented in this intervention, a possible addition would be providing aerobic exercise at other times of the day or as part of academic lessons. A second addition could be to see if aerobic activity reduces discipline problems in the classroom thus indirectly improving student learning by reducing misconduct that impedes student progress.

In drawing conclusions from this research, further study and observation is needed to fully link aerobic activity to learning outcomes. To continue the study, I would include other classrooms to provide baselines and I would include state test scores as well as other test data. Another possible approach is to also evaluate individual student improvement from year to year.

As one can see, this research has many potential directions it could go. Overall, it is clear to me through the study of the literature and by my own observations that aerobic activity has a positive impact on student learning. Before this action research project, I wondered if using academic time for exercise was beneficial. Now I have seen the impact exercise has on classroom alertness and productivity. I hope that those who view this research will see the value of aerobic activity and be confident that it has a positive effect on learning.

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Appendix A

Student Attention Chart

Date:

Total Students in Attendance:

3 minute intervals for thirty minutes once work cycle begins	Students not pursuing a learning task.	Students have a learning task but have not engaged in it.	Students engaged in a learning task.	Students still engaged in the first learning task of the day.
3 minutes				
6 minutes				
9 minutes				
12 minutes				
15 minutes				
18 minutes				
21 minutes				
24 minutes				
27 minutes				
30 minutes				

Appendix B

Daily Physical Activity Reflection Log

Energy Level Rubric

1 No energy	2 A little energy	3 Average energy	4 More than average energy	5 Extreme amounts of energy

Date					
Pre- H.R.					
Pre-energy level					
Activity					
Duration					
Post H.R.					
Post-energy level					

Appendix C

Pre-intervention Reflection Survey

Name:

When you first arrive at school, how does your body usually feel?

Really Tired Somewhat Tired Awake Actively Awake Bursting with Energy

When morning work time begins, how do you feel?

Really Tired Somewhat Tired Awake Actively Awake Bursting with Energy

How does your mind feel starting your first work of the day?

Hard to think Somewhat hard to think normal Thinking is clear Thinking is quick and easy

Appendix D

Post-intervention Reflection Survey

Name:

When you first arrive at school, how does your body usually feel?

Really Tired Somewhat Tired Awake Actively Awake Bursting with Energy

When morning work time begins, after morning exercise how do you feel?

Really Tired Somewhat Tired Awake Actively Awake Bursting with Energy

How does your mind feel starting your first work of the day?

Hard to think Somewhat hard to think normal Thinking is clear Thinking is quick and easy

Appendix E

Student Work Sample

Daily Record

Student Name	Deep Attention	Attention	Moderate Attention	Passive Attention	Periodic Attention	Low Attention

Appendix F

Attention Rubric

Deep Attention: Student's work shows full ownership of learning activity, displaying high levels of energy, a willingness to ask questions, pursue answers, consider alternatives, and take risks in pursuit of quality.
Attention: Student's work is beginning to show student taking ownership of learning activity. His/her involvement shows concentration and effort to understand and complete the task. His/her work shows evidence that he/she wants to improve the quality of his/her performance.
Moderate Attention: Student's work shows participation in learning activity and he/she stays on task without teacher intervention. However, his/her work has a routine or rote quality and significant thought or commitment to quality is not evident.
Passive Attention: Student's work shows evidence of being done in a rote or routine manner. Work shows evidence of student being distracted during activity.
Periodic Attention: Student's work sample shows that attention and participation in the work fluctuates. The work has signs that the student appears distractible and the tendency to stall out easily when questions emerge. Student work required frequent teacher assistance.
No Attention: Student's work shows evidence of student being blocked, unable or unwilling to participate in learning activity.