



***How Exercise Affects the Brain and Academic Performance of Elementary School Students***

by Ted Miracle, 2015 CTI Fellow

This curriculum unit is recommended for:  
Fourth grade science and health

**Keywords:** science, health, physical education, brain, exercise, academic achievement

**Teaching Standards:** See [Appendix 1](#) for teaching standards addressed in this unit.

**Synopsis:** Educators have long made correlations between exercise and physical health. In the past, these correlations focused on positive impacts on disease prevention, strength, cardiovascular, and general health. A growing body of research evidence indicates exercise also has a statistically significant positive impact on adolescent brain development and academic achievement. These findings are noteworthy because they can impact the educational philosophies and practices of general education and physical education teachers. For example, teachers who do not currently do so may want to consider adding more physical movement into the academic day. Schools and school systems may want to ensure students are given time during the school day for exercise and physical activity because a growing number of American students are overweight. This curriculum unit will highlight research into the connections between exercise and the brain. It includes activities for use in elementary classrooms that will teach students about how these connections between exercise and brain development are relevant to students as well as educators.

*I plan to teach this unit during the coming year to 130 students in fourth grade science and health.*

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## **How Exercise Affects the Brain and Academic Performance of Elementary School Students**

**Ted Miracle**

Historically, educational standards regarding the benefits of exercise have focused on connections between exercise and general health benefits. For example, how fitness and nutrition affects cardiovascular health and obesity is included in fourth grade North Carolina health standards and how exercise helps a person maintain a healthy body is included in North Carolina science standards. These standards do not expressly mention the importance of exercise in the ability to use the brain to process information and improve academic performance. Recent studies also indicate students who are more physically fit tend to perform better on standardized math tests. In light of these recent studies, it makes sense to teach students about how exercise can be beneficial to students in their brain development and academic progress and to provide encouragement and opportunities for students to routinely be physically active during the school day.

### **Exercise, Fitness, and Brain Development Research**

An increasing body of research has been done on the impact of exercise on brain function. This section of the curriculum unit summarizes several of those studies.

John Ratey, in his book *Spark*, details the impact of a unique approach to physical education at schools in Naperville, Illinois and results on state tests and the Trends in International Mathematics and Science Study (TIMSS). Naperville High students outscored students from more affluent districts on state tests. On the TIMSS, Naperville eighth grade students outscored the number one nation in the world on the science section and made a score that would place sixth in the world on the math section. This was accomplished with 97 percent of all eighth graders taking the TIMSS. These remarkable test scores happened at the same time Naperville instituted a revolutionary physical education program started by a junior high physical education teacher. Rather than focusing on sports, he focused on effort rather than skill. While the percent of overweight students in the U.S. hovers near 30 percent, 97 percent of Naperville's high school freshmen were at a healthy rate in 2001 and 2002.

Ratey cited a five-year study from the California Department of Education (CDE) has shown students with higher fitness scores have higher test scores. The CDE correlated scores from a fitness test called FitnessGram with scores from standardized achievement tests. The scores of approximately 279,000 ninth-grade students were reviewed in 2001 and 2002. The results showed that students who were fit scored better on academic tests than students who were unfit.

In 2004, a panel of thirteen researchers reviewed 850 studies about the effects of physical activity on school-aged children. The review covered academic performance as well as obesity, cardiovascular fitness, blood pressure, and anxiety. The panel found evidence that supported the California study and reported physical activity improves memory, concentration, and behavior (1).

The Centers for Disease Control and Prevention (CDC) completed a meta-analysis of forty-three articles that reported on fifty different research studies in order to “examine the association between school-based physical activity, including physical education, and academic performance, including indicators of cognitive skills and attitudes, academic behaviors, and academic achievement.” The 43 articles selected for analysis met CDC criteria and were selected from a pool of 406 articles. Academic performance indicators were grouped into the categories of academic achievement (such as test scores and grades), academic behavior (such as attendance and on-task behavior), and cognitive skills and attitudes (such as attention and memory).

The results of the CDC review found only 1.5% of the associations between physical activity and academic performance were negative while 50.5% were positive and 48% were not significant. Eleven of 14 studies of school-based physical education found one or more positive associations with academic performance while three found no significant associations. All eight studies of recess during the school day found at least one positive association with cognitive skills, attitudes, and academic behavior. Eight of nine studies of classroom physical activity sessions of 5-20 minutes breaks or introducing physical activity into learning activities found positive associations with cognitive skills, academic behavior, and academic achievement with no studies showing negative associations. All 19 studies of extracurricular physical activities showed at least one positive association with academic performance.

The CDC concluded “there is substantial evidence that physical activity can help improve academic achievement, including test and standardized test scores.” The CDC said the articles suggest increasing time for physical education activities may help and will not have an adverse effect on academic achievement (2).

Dr. Kim Cooke is the director of health and physical education in Charlotte-Mecklenburg Schools. She completed a doctoral dissertation in 2015 to determine correlations between academic achievement and exercise in Charlotte-Mecklenburg Schools (CMS). Cooke analyzed body mass indexes, FitnessGram scores, academic growth scores, achievement test scores, and moderate to vigorous physical activity levels of students in grades 3-8. The findings were that body mass indexes and achievement test scores showed a statistically significant difference in math scores with students having higher fitness levels doing better on the tests.

Cooke found that in grades 3-8 in Charlotte-Mecklenburg Schools, 17% of students were overweight and 19% were obese according to body mass index tests. These results are not uncommon in the United States. According to the Centers for Disease Control, about 17% of all children ages 2-19 are obese. Obesity rates differ among races with 22.4% of Hispanic children, 20.2% of black children, and 14.1% of non-Hispanic white children being obese as of 2011-12 (3).

Several studies show the impact of physical activity on brain development and cognition in addition to aerobic fitness and strength. Chaddock-Heyman et al. studied the aerobic fitness as measured by  $VO_2$ max levels and cortical thickness of 9- and 10-year old children. Their findings suggest students who are more aerobically fit perform better on math achievement tests and thickness of the cortical gray matter in anterior and superior frontal brain areas. The study scanned the brains of 45 children every two years between the ages of 5 to 11. The authors say that the loss of gray matter in part of sculpting the brain into a fully functioning adult nervous system.

A total of 48 9- and 10-year old students were included in the study. A total of 24 higher fit participants (14 boys, 10 girls) and 24 lower fit participants (8 boys, 16 girls) were included in the study. The fitness level of each student was determined by measuring oxygen uptake ( $VO_2$ max). Students ran on a treadmill at a constant speed with increases in grade of 2.5% every two minutes until students were exhausted.

Students in the study took the Kaufman Brief intelligence Test (K-BIT) to obtain an intelligence quotient (IQ) score. Academic achievement was measured with a paper and pencil test that included reading, spelling, and arithmetic. The study found association between aerobic fitness, cortical thickness, and arithmetic achievement (4).

A study completed in Georgia from 2003 to 2006 examined whether exercise completed by overweight children ages 7 to 11 improved their ability to complete a novel task and whether or not students increased academic achievement in reading and math. Data from about 170 students from five cohorts was analyzed. Students received no exercise, low dose exercise, or high dose exercise. High dose and low dose exercise sessions were both 20 minutes in length. The high dose group completed two sessions while the low dose group completed one session. The program lasted 13 weeks. Students in the high dose group had significantly higher math achievement and executive function, but not in reading. The low dose group and no exercise groups had no significant changes in any categories. These findings suggest students need to receive moderate to vigorous exercise in order to improve academic achievement (5).

Brain-derived neurotrophic factor (BDNF) is a protein that builds and maintains cell circuitry. BDNF provides the infrastructure for cells. In the 1990s, scientists discovered BDNF exists in the hippocampus area of the brain and replenishes neurons. Ratey (2008) compares it to fertilizer for the brain. Scientists found BDNF sprinkled on

neurons sprouts new cell branches. Studies with rats show those who exercise produce more BDNF in the brain than rats who do not exercise. BDNF helps neuron function and growth. Exercise elevates BDNF in the brain. Ratey cites a 2007 German study that showed people learn vocabulary words 20% faster after exercising as compared to not exercising and the learning rate correlates with BDNF levels. The conclusion is exercise has a positive impact on learning at least in part because it increases BDNF in the brain (1).

A study done in Illinois supports the idea that policies that reduce physical activity in schools to improve academic performance may have the opposite effect. The study included 221 students ages 7-9 who received an afterschool physical activity program and 221 students ages 7-9 who did not get to participate in the physical activity program. Students were selected randomly after being screened and divided into like pairs based on age, gender, race, socioeconomic status and fitness level as measured by a VO2max test. The random selection was done by coin flip.

Students in the study group participated in an exercise program called Fitness Improves Thinking in Kids (FITKids). These students received a two-hour physical activity intervention in which students participated in at least 70 minutes of moderate-to-vigorous exercise with rest breaks between activities. Students spent about 30-40 minutes at exercise stations and 45-55 minutes in organized games. The level of aerobic fitness change for the study group was significant while it was not significant for the control group. The study group saw a 6% increase in fitness while the control group saw a 1% increase in fitness.

The effects on cognitive brain function and behavior on tasks requiring attention, inhibition, and cognitive flexibility were measured for both groups. The cognitive ability test used a color-shape switching task in which participants pressed a right or left button as quickly and accurately as possible to match the direction the middle fish was facing. The fish had different shapes such as squares and circles and colors such as blue and green. The attention inhibition test involved students identifying arrays of fish the matched or did not match. The changes in the electrical activity levels of the brain were measured in both groups. The students in the study group had a greater increase in the inhibition test score and the cognitive test score. Their brains also showed more brain activity than the students in the control group (6).

This study is significant for my curriculum unit in part because the ages of the students are close to the ages of the fourth graders I teach. The study is of note for educators because of the debate about how much time should be spent on physical activity during the school day. The results of this study suggest it would be unwise to eliminate or reduce opportunities for physical activity during the school day because physical activity appears to enhance cognitive function, brain activity, and distractibility

Some research studies indicate exercise improves mental focus, memory and cognitive flexibility. Physical activity activates the brain. Hamblin cites the findings of the Hillman study discussed in the previous paragraph that show exercise helps students with cognition, brain health, and executive function. Executive function includes resisting distraction, focus, memory, and switching between tasks. Hamblin cites another study from Alan Smith at Michigan State University that suggests physical activity has a positive impact on children with attention-deficit hyperactivity disorder (ADHD). The study was done in 2008. It found a 12-week exercise program improved math and reading test scores, especially for those diagnosed with ADHD. Hamblin cites a third study from the *Journal of Attention Disorders* from 2008 that indicates just 26 minutes of physical activity a day for eight weeks is effective in alleviating ADHD symptoms. Hamblin concludes it may make sense for schools to provide exercise opportunities for students since it shows promise as an effective intervention for ADHD (7).

An article in the *British Journal of Sports Medicine* from January 2015 that physical activity should include both aerobic and strength training. The lead author, Dr. Gregory Myer from Cincinnati Children's Hospital Medical Center, and his colleagues recommend aerobic activities and those that increase strength such as resistance training, agility exercises, and core strength. One recommendation is that second graders perform body weight exercises with punch balloons with a focus on muscle strength, power, and movement. The study says regular exercise benefits behavior, emotional development, and intellectual development. (8)

Several schools in Charleston, South Carolina have developed innovative classroom programs to allow movement in classrooms. Students do not have traditional desks and do not sit in rows. Classrooms are filled with exercise bikes, stair-climbing machines, elliptical machines, mini-basketball hoops, balance boards, treadmills, punching bags, and specially outfitted kinesthetic desks that are manufactured by a company called KidsFit. Schools have included yoga instruction and "advanced p.e." classes with specially equipped learning labs. The coordinator of health, wellness, and physical education in the Charleston County School District, David Spurlock, is the key leader of the movement to include physical activity in classrooms. Spurlock believes academic tests in schools that are allowing increased student physical activity will show increases. This is based on studies that show exercise can play a major role in improving learning. Spurlock has started over a dozen of the kinesthetic "brain rooms" in the Charleston district at a variety of schools.

Stacey Shoecraft is a fifth grade teacher at Charles Pinckney Elementary. She is considered to be one of the best teachers at implementing the kinesthetic classroom. Students complete work while using kinesthetic desks, pedal bikes, climbers, desks where students can stand if they choose, balance boards, and swivels. Her classroom was the first in the United States to have only kinesthetic desks. Shoecraft says her students are more focused and have better long- and short-term memory than in the past. Parents

were skeptical at first, but after three years, she now has a waiting list of parents and students who want to be in her class.

Maese's article quotes the American College of Sports Medicine as finding only about 25% of children ages 6-15 are active for 60 or more minutes a day. This is happening as many schools in the country have been deemphasizing physical education since No Child Left Behind was passed into law in 2001, according to John Ratey. (9)

Shoecraft says her students use the kinesthetic desks on a regular basis, but that she does keep some traditional chairs for those students who want them ([www.wonderteacher.com](http://www.wonderteacher.com), 2014). Shoecraft says the use of exercise machines in her classroom does not create classroom management issues. She says the movement helps her students and that parents are thrilled with her classroom. (10)

Spurlock is motivated to implement his "brain rooms" by several factors. Nearly half of the students in Title I schools in Charleston County School District are obese. Charleston students had 50 minutes a week of physical education. Spurlock admits it has been hard to convince teachers and others that increasing physical activity was a good idea. Research studies on the connections between exercise and learning have bolstered Spurlock's case for "brain rooms." A study from the American College of Sports Medicine has found that fourth- and fifth-grade students who have ten minutes of vigorous exercise before a math test score higher than those who do not do anything. Twenty minutes of moderate exercise for children increases cognition 5-10 percent. (10) According to John Ratey (1), exercise increases blood flow, which increases oxygen levels in the brain. The brain releases higher levels of the neurotransmitters dopamine and epinephrine that improve thinking and emotions. Exercise also increases a protein called BDNF that encourages growth and function of neurons.

Each school principal has the discretion to manage his or her budget and decides whether or not to implement Spurlock's "brain rooms" that incorporate movement in the classroom. A major challenge for Spurlock is when a school that has implemented his ideas changes leadership. Even so, the Washington Post article says 12 schools have "brain rooms" and identifies six schools in the article. Spurlock believes state academic tests will show his ideas for including physical activity in classrooms will improve test scores. (10)

John Medina, in the book *Brain Rules*, lists what he calls different brain rules. Brain rule #2 is "Exercise boosts brain power." Point six in this section of his book points out that the number of studies regarding whether or not exercise helps students learn is low in number, but indicates more physically fit children pay better attention in class, cause less disruption, feel better about themselves, are less anxious, identify visual stimuli more quickly, and can give more cognitive resources to a task for a longer time

than students who are less physically fit. Medina states the things in the previous list are ingredients for academic performance.

Medina goes on to say that our brains are designed to walk 12 miles a day. He says exercise increases blood flow to body tissues. Blood flow takes oxygen and removes wastes from the body. This includes the brain. The reason this is important for learning is increased blood flow to the hippocampus region of the brain, which is deeply involved with memory, allows those brain cells more interaction with receiving oxygen and eliminating wastes for those who are more physically fit. Medina also mentions Ratey's research regarding the role of BDNF in keeping neurons healthy and able to connect with each other.

Exercise also improves memory by alleviating unhealthy stress. Medina devotes an entire chapter of his book to the need to reduce stress. Our bodies are designed to handle stress and stress can boost learning in the right situation by getting us to focus our attention to tasks, especially in times of danger. In the human experience, short bursts of stress are needed for survival. The problem in our modern world is stress lasts hours, days, and months. Our systems are not designed for that amount of stress. Long-term stress can compromise the immune system and lead to illness, memory and problem solving issues, and poor mood. Stress hormones like cortisol can disconnect neural networks in the hippocampus. The neural networks in the hippocampus store memory. Prolonged stress can lead to depression. Students can feel these stresses in school just like adults in the workplace. Exercising every day helps the brain alleviate the stress, which can improve learning and boost the brain's production of BDNF. Medina calls BDNF a "peacekeeper" in the hippocampus region of the brain because it helps prevent stress hormones from damaging the brain.

Medina advocates schools provide recess (perhaps twice a day) and have exercise equipment such as treadmills and bikes in classrooms. He believes cutting off recess is cutting off the opportunity for the very activity that can enhance cognitive performance. Medina thinks it might be wise to increase the amount of physical activity schools have during the school day. Medina states that he does not believe it would be difficult to integrate exercise into the school schedule. He cites his own experience from putting a treadmill in his office. He learned to take exercise breaks rather than coffee breaks and quickly learned to type on his laptop while walking 1.8 miles per hour on his treadmill.

Although the main emphasis of this curriculum unit focuses on how exercise positively impacts the brain function of children, it should be noted exercise benefits people for a lifetime. Medina discusses the positive impact of exercise on brain function for adults as they age. Medina cites the anecdotal case of fitness guru Jack LaLanne, who was a lifelong leader in the fitness world and had an extremely sharp mental acumen until his death at age 96. Medina states there is a relationship between exercise and mental alertness. Exercise can stave off the effects of dementia and depression. Many research



studies and articles focus on the effects of exercise on adults, including older adults. It is well known that exercise regulates appetite, reduces disease risk for things like cancer, diabetes, and cardiovascular disease, assists with weight control, reduces the effects of stress, and makes muscles and bones stronger. The lifelong benefits of exercise, including its impact on how the brain functions and learns, are important things to teach children. (11)

### **Implications for School Leaders**

Given that researchers have found statistically significant correlations between fitness, brain development, and academic achievement, it is incumbent upon educators to provide lessons about the importance of physical fitness on general health and weight control, but also to provide opportunities for students to exercise on a regular basis at school. The CDC recommends providing recess on a regular basis, increasing the amount of time students spend in physical education classes, increasing the quality of physical education lessons, provide or continue school-based sports programs, and incorporating movement activities and physical activity breaks into classrooms. (12)

Charlotte-Mecklenburg Schools (CMS) has provided its teachers with a large number of resources to support providing physical activity in classrooms. This includes classroom teachers as well as physical education teachers. Many of these resources are housed on a website maintained by the Health and Physical Education department. The website address is [www.cmshe.com](http://www.cmshe.com). Resources include videos about childhood obesity and research from John Ratey, state health and physical education essential standards, and web resources for classroom teachers to provide 5-20 minute physical activities in classrooms. Examples of web resources include fitness videos, indoor recess ideas, and Brain Break activities. (13)

Physical education teachers need to ensure their activities are of high quality and result in moderate to vigorous activity levels. Classroom teachers need to encourage students to utilize their recess time to be active. Brain breaks and physical breaks during the school day will help energize students, activate their brains, and help them learn. Districts and states need to recognize that current research shows exercise is not just important for preventing disease and promoting general health and wellness, but that it helps students be more successful in academic achievement. Therefore, physical education, recess, and brief physical activities are important components of the curriculum and should not be reduced or eliminated.

### **My Next Steps**

My awareness of the importance of exercise in brain development has been increased as a result of this seminar and my research as a CTI fellow. I plan to take several action steps

as a result. The products of these action steps are the cornerstones of this curriculum unit.

A primary goal is to teach students how exercise and good physical conditioning benefits them in their school achievement and brain development as well as to prevent disease. Activities to support these goals include the following:

- Allow students to explore the main parts of the brain by examining a model and three-dimensional models of neurons printed with a 3D printer. Students will also match parts of the brain with their functions.
- Review the basic functions of the brain and nervous system using videos from Discovery Education and the book *The Brain: All about Our Nervous System and More!* by Seymour Simon.
- Complete and interactive read aloud using the book *The Brain: All about Our Nervous System and More!* by Seymour Simon in which students discuss the function of parts of the brain and write about them in their science journals.
- Develop reading passages that teach my students about the benefits of exercise on brain function.
- Students will take a survey designed to assess their attitudes towards exercise and what they perceive to be exercise activities.
- Students will keep an exercise log for two weeks to gauge their level of physical activity in regards to amount of time spent exercising and types of exercise activities.
- Encourage students to participate in two five-minute exercise breaks called Brain Breaks during the school day, be active during the daily thirty-minute recess time, and actively exercise at least a total of 60 minutes per day.
- Analyze the body mass index scores of fourth graders at my school as measured by the Fitness Gram scores in physical education class to their Measure of Academic Progress (MAPS) math and reading scores in the fall, winter and spring to see if results are similar to other research studies that have been done to compare body mass index with test scores.

I believe the best way to start this unit will be to allow students to explore the main parts of the brain, including the hippocampus. Exploring through hands-on models will expand student understanding that will help students make connections when reading and answering questions about the brain. Relatively inexpensive models of the brain are readily available from a variety of sources, including Amazon. I want to obtain six models so small groups of students can use the models. Students will match brain functions to parts of the brain. I will provide students with statements that match brain parts, ask them to predict where the labels belong, and provide an answer sheet so students can change answers as needed. I will collaborate with Joel Bonasera from the Discovery Place Education Studio to print at least six 3D models of neurons. I am a Discovery Place STEM Fellow, but any teacher can work with Discovery Place

Education Studio by taking a class there. Discovery Place Education Studio offers classes for 3D printing that include a 3D printer for those teachers who are interested in obtaining one for classroom or school use.

I will review the basic components of the nervous system with students. Students study the nervous system and other body systems in third grade. I want to build on this background knowledge to review the components of the central nervous system, the brain and spinal cord, and the nerves that run throughout the body in the peripheral nervous system. All Charlotte-Mecklenburg Schools teachers have access to the Discovery Education website. I plan to use a video called *Real World Science: Brain and Nervous Systems* from the website as the basis of a lesson about the basic functions of the brain and nervous system. I will lead a discussion and provide students with a fact sheet based on the video. The fact sheet will be glued into student science journals for future reference. (14)

I will use a children's book titled *The Brain: All about Our Nervous System and More!* by Seymour Simon to teach students about main parts of the brain and their functions. Seymour Simon is considered to be one of the best author's of children's science books. I will use a balanced literacy technique called interactive read aloud. In an interactive read aloud, I will read the book to the students while stopping to ask questions. Students will be asked to turn and talk to partners as prompted by the teacher. Students will take notes about the book in their science journals. Students will be instructed to write about parts of the brain named in the book and describe the functions of those parts of the brain.

One activity will be to teach students a song about the parts of the brain. I will write the song to the tune of a popular children's song. The song will include motions. The song will engage kinesthetic learning. The second activity for teaching students about the main parts of the brain and their functions will be to assign students to label parts of a model of the brain with stickers that match the name of the part of the brain and main functions of that part of the brain. I will create an anchor chart poster of the main parts of the brain and their functions that will be placed on the wall and will serve as a reference material and anchor chart to help students learn and recall the main parts of the brain, their functions, and how parts of the brain benefit from exercise. (15)

A reading passage I have developed for his unit is titled *Want to Improve Your Test Scores? Exercise!* This reading passage is two pages in length. The reading passage will be screened for text complexity in order to ensure it is developmentally appropriate for fourth grade students. Topics discussed in this reading passage include information from the Centers for Disease Control regarding body mass index, a summary of research studies done by the state of California and Dr. Kim Cooke from Charlotte-Mecklenburg Schools that compared body mass index and students math and reading standardized test scores, results from the study of student fitness levels in Naperville, Illinois, the role of

brain-derived neurotrophic factor (BDNF) on student learning, and exercise recommendations for students.

A second reading passage for this unit consists of short descriptions of the benefits of exercise to the brain. It is titled *How Can Exercise Help You Learn? Let Us Count the Ways!* These sections will be numbered. Each section will consist of a one sentence title written in italics with supporting information for each reason.

Part of the curriculum unit will consist of students analyzing their own attitudes and opinions regarding their own physical fitness levels and exercise levels. I will use a questionnaire I will develop in consultation with Dr. Kim Cooke. Results from these surveys will be shared with students as a group. No individual student information will be shared with the class as a whole or with individual students. I will compare student answers to their fitness levels and MAPs scores to see if their exercise attitudes correlate to the findings on the comparison between BMI and MAPs scores. I theorize there will be a significant correlation between student self-reported exercise attitudes, body mass index, and test scores.

Students will be assigned to keep an exercise log for a two-week time period. The log is found on the website [www.cmshe.com](http://www.cmshe.com). Dr. Kim Cooke developed and maintains the website. It is one of the features of the Wellnet portal found at the site. CMS physical education teachers regularly use Wellnet to post fitness test scores. The log is one of several health logs available for all CMS teachers to use. Students will receive an informal health and science grade of 100 for keeping the log.

A true “action” step I will take is to implement what my school calls “Brain Breaks” on a regular basis. Brain Breaks are five-minute physical activities students complete with a video resource from websites like [www.brain-breaks.com](http://www.brain-breaks.com) or [www.gonoodle.com](http://www.gonoodle.com). The Brain Breaks are encouraged by Charlotte-Mecklenburg Schools (CMS). Links to the websites used for Brain Breaks are on the Charlotte-Mecklenburg Schools health and physical education website. The administration and health and wellness committee at my school support the use of Brain Breaks. There are currently two five-minute Brain Breaks built into the daily schedule. This initiative is completed by all students in the school as part of the school’s efforts to be recognized as a bronze level healthy school. I will explain to students Brain Breaks are designed to help their brains grow, develop, and increase learning.

One initiative I will implement is to complete a study of student physical fitness levels in my classroom as measured by body mass index levels from FitnessGram tests and Measures of Academic Progress (MAPS) scores at my school. Dr. Kim Cooke, head of the CMS Health and Physical Education department, has used FitnessGram data to examine student data within the district on these topics. All data examined will be done confidentially and will be used only for information within my school. I am working

closely with my physical education teacher to determine whether or not Endhaven fourth grader fitness and MAPS achievement results mirror those of other studies. A comparison of this kind can be done at any CMS elementary or middle school because all students take the FitnessGram test in physical education class to determine body mass index and take MAPS tests. I may also choose to correlate student fitness levels as gauged by body mass index on FitnessGram tests with end-of-grade test scores from 2015-16.

In summary, a main goal of this curriculum unit is to provide myself and other teachers in the future with information and materials that can be used to teach students the importance of exercise in brain development and academic achievement. Doing so will better equip students to be successful lifelong learners, understand how positive fitness choices can help them in many ways, and to make wise choices regarding their own fitness levels. The curriculum unit endeavors to provide educators with scholarly research on the topic of the brain and exercise. The implications of sharing this information with education colleagues are it will improve the understanding of educators regarding the brain and exercise and provide learning activities that teachers can use in their classrooms to help students explain connections between exercise and the brain.

## **Appendix 1: Implementing Teaching Standards**

North Carolina Health Essential Standard 4.MEH.1: Apply positive stress management strategies

<http://www.dpi.state.nc.us/docs/acre/standards/new-standards/healthful-living/3-5.pdf>

North Carolina Science Essential Standard 4.L.2.2: Understand the benefits of nutrition and exercise in maintaining a healthy body

<http://www.dpi.state.nc.us/docs/acre/standards/new-standards/healthful-living/3-5.pdf>

## Appendix 2

### Want to Improve Your Test Scores? Exercise!

Everybody knows exercise is good for your body. It helps you maintain a healthy body weight, makes your muscles stronger, and keeps your heart and lungs healthy. But did you know that exercise helps your brain learn? Did you know that students who are in better physical condition tend to do better on tests? This reading passage will tell you about research studies that show students who have a healthy fitness level tend to do better on tests. This seems to be especially true for math tests.

One way to find out your fitness level is to know your body mass index, or BMI. BMI is a measure of your body fat based on age, height and weight for children. A body mass index of 30 or more means you are obese. A body mass index of 25-29.9 means you are overweight. A BMI of 18.5-24.9 is considered normal. A BMI of less than 18.5 is considered underweight. You can find your body mass index by using a body mass index calculator for children. The calculator is on the website for the Centers for Disease Control. You can find your body mass index at <http://nccd.cdc.gov/dnpabmi/Calculator.aspx>.

The state of California looked at student state test scores in math and reading and student body mass index, or BMI, for every student in grades K-8 in 2012. The findings were that the group of students who had a healthy BMI scored a lot higher on state reading and math tests than the group of students whose BMI was in the overweight or obese range.

Dr. Kim Cooke is the director of health and physical education in Charlotte-Mecklenburg Schools. Students in Charlotte-Mecklenburg Schools take a fitness test called Fitness Gram in elementary and middle school. Dr. Cooke compared the MAPS reading and math test scores and body mass index for every student in Charlotte-Mecklenburg Schools in grades 1-8 in 2014. Students took the MAPS reading and math tests three times during the year. Dr. Cooke looked at the growth of students from the fall to spring tests. She compared the MAPS test growth with student Fitness Gram data. Dr. Cooke found that students with a healthy body mass index scored a lot higher than students with an unhealthy body mass index of 30 or more on MAPS math tests and some higher on MAPS reading tests.

The Naperville, Illinois school system started a new exercise program in p.e. classes in 1992. A teacher named Phil Lawler noticed a lot of students spent a lot of time standing around waiting for their turn in games during p.e. classes. He started a p.e. program that

focused on students trying to improve their own records in things like running a mile rather than team sports. In 1999, only 3% of students at Naperville's eighth grade were overweight compared to an average of 30% in the United States. Eighth graders from Naperville Middle School finished first in the world in science and sixth in the world in math on a test made test scores on a test called the TIMSS. TIMSS stands for Trends in Mathematics and Science Study. Students from 38 countries took the test. In 2003, Naperville Central High School scheduled a Zero Hour PE class before school started. Students received their p.e. grades based on individual growth on Fitness Gram tests. After half a school year, Naperville students took a reading comprehension test. Those who did Zero Hour PE increased their reading comprehension test scores by 17% while those who took regular p.e. classes increased 10.7%. Naperville Central High School who took Zero Hour PE did much better than students who took regular p.e. classes on algebra tests every year from 2006-2009 and on literacy tests every year from 2005-2009.

Research studies like the ones described have helped scientists believe active exercise helps your brain grow and learn. Scientists have learned there is a chemical called BDNF that your brain makes when you exercise. BDNF helps the parts of your brain that control learning grow and work better. Some scientists call BDNF Miracle-Gro for the brain. Miracle-Gro is a product that helps plants grow faster and larger. And how do you get BDNF for your brain? Exercise!

So, what should you do to help your brain learn? Studying is important and necessary, but exercise helps, too! The Centers for Disease Control recommends students actively exercise at least 60 minutes a day. That sounds like a lot, but it is not too hard to do. Do you play at recess time? That is 30 minutes a day right there. Do you participate in the two brain breaks in your class? There is another 10 minutes. Do you play an individual sport like gymnastics, karate, swimming, dance, cheerleading, or tennis? Do you play baseball, basketball, or football on a team or in the neighborhood? Do you run and play outside in the evenings and on weekends? Do you play on the McAlpine Greenway or in the park? Do you go hiking, running, and walking? Do you jump rope or do push ups? If you think about it, you might already be actively exercising 60 or more minutes every day! If not, you can find ways to do it.

If you have a healthy body mass index and you already actively exercise 60 or more minutes a day, keep up the good work! If you think you should exercise more, pick activities you enjoy and start moving. You might see your MAPS scores and end-of-grade tests scores improve!



## Appendix 3

### How Can Exercise Help Your Brain? Let Us Count the Ways!

Did you know that exercise helps your brain learn? It really does!

Your body needs 60 or more minutes of exercise each day. Your exercise needs to be moderate to vigorous to give your brain and body the most benefit. What do moderate and vigorous mean? Let's pretend you and a friend are running together. With moderate exercise, you are running pretty hard, but you can still talk to each other while you are running. With vigorous exercise, you are running really hard, you are breathing hard, and you won't be able to talk to each other while you are running. You cannot do vigorous exercise nearly as long as you can do moderate exercise.

Now let's read about how exercise helps your brain learn!

#### *1. Exercise Increases the Amount of Oxygen that Goes to Your Brain*

All parts of your body need oxygen to survive. That is why you breathe! Your brain needs oxygen, too. Your brain works better when you can get more oxygen to it. This includes the part of the brain that controls memory and learning. That part is called the hippocampus.

Exercise boosts the amount of oxygen that goes to your brain. The better your physical conditioning, the better your body gets oxygen to your whole brain, including your hippocampus. Your hippocampus is the part of your brain that controls memory and learning. You want to give it plenty of oxygen!

#### *2. Exercise Increases Nerve Connections in Your Brain*

Your brain has millions of connections in it. These connections are called neurons. They carry signals from your brain to all parts of your body. Exercise causes your brain to grow more connections. This helps your brain with memory and learning.

Scientists have discovered why exercise helps your brain grow connections. Exercise increases a protein called BDNF. BDNF has been called Miracle-Gro for the brain. Miracle-Gro is a fertilizer that helps plants grow. BDNF was given the nickname Miracle-Gro for the brain because it causes your brain to grow more nerve connections.

### *3. Exercise Relieves Stress*

Your body and brain need to experience stress to survive. What if you were being chased by a Tyrannasaurus Rex? Ahhhhhhh!! Run!! Your body and brain would be under stress and that stress would help you survive.

The problem with stress is if you experience it a lot it can harm you. You cannot learn as well if you are stressed out. Exercise is a great way for your body to relieve stress. This will help your brain help you learn.

What should you do know that you know how much exercise helps your brain learn?  
Let's go play! It will help you learn, too.

## Appendix 4

### My Exercise Survey

Student \_\_\_\_\_ Date \_\_\_\_\_

What do you do to exercise? Write an answer in the blank. Your answer should include how often you do the exercise and how much you usually do the exercise. If you never do the exercise, write never. Use notebook paper and attach answers if you need more room.

Play outside \_\_\_\_\_

Pushups \_\_\_\_\_

Jump rope \_\_\_\_\_

Dance \_\_\_\_\_

Running \_\_\_\_\_

Swim \_\_\_\_\_

Gymnastics \_\_\_\_\_

Karate \_\_\_\_\_

Hiking \_\_\_\_\_

Cheerleading \_\_\_\_\_

Basketball \_\_\_\_\_

Baseball/Softball \_\_\_\_\_

Football \_\_\_\_\_

Soccer \_\_\_\_\_

Is there something you do for exercise that is not in the list? Add it here.

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How much do you usually exercise on a normal day for you?

- I do not exercise at all
- I only exercise in p.e. class and recess at school
- I exercise less than 15 minutes a day
- I exercise between 15 and 30 minutes a day
- I exercise between 30 and 45 minutes a day
- I exercise between 45 and 60 minutes a day
- I exercise more than 60 minutes a day

How much do you like to exercise? Give a rating from 1-5. A 1 means you do not like any kind of exercise at all. A 3 means you like exercise some. A 5 means you love exercise and exercise as much as you can. You can look at the list of things that count as exercise to help you with your answer.

My How Much I Like Exercise Rating is \_\_\_\_\_

Is there an exercise you really hate? If you say no, explain why. If you say yes, name the exercise and explain why you hate it.

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Is there an exercise you really love? If you say no, explain why. If you say yes, name the exercise and explain why you love it.

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## List of Materials for Classroom Use

3D neuron models. Joel Bonasera from Discovery Place Education Studio will help me get at least six of these models printed. Discovery Place Education Studio offers courses in 3D printing. 3D printers are now available for about \$400 for those who want to own and use their own printer.

Brain Model from Learning Resources. This brain model costs \$14.89 from [www.amazon.com](http://www.amazon.com). It is designed for children ages 8 and older. It contains the cerebellum, frontal, parietal, temporal and occipital lobes, corpus callosum, brain stem, hippocampus, ventricles, insula, corpus striatum, internal capsule, and lentiform nucleus.

FitnessGram test results. FitnessGram testing is conducted by CMS physical education teachers. CMS classroom teachers who want to compare FitnessGram results with standardized testing results such as Measures for Academic Progress math and reading tests will need to contact Dr. Kim Cooke at [www.kimm.cook@cms.k12.nc.us](mailto:www.kimm.cook@cms.k12.nc.us).

[www.brain-breaks.com](http://www.brain-breaks.com). This website offers a number of exercise videos teachers can use in class to give students exercise breaks during the instructional day. This site is free to use but does require registration.

[www.cmsshpe.com](http://www.cmsshpe.com). This website contains access to Welnet. This website contains several fitness logs teachers can use in class. They include exercise and nutrition logs. The website also contains links to Brain Breaks and Go Noodle, two of the sites students will use for exercise breaks during the instructional day. It includes contact information for the CMS director of health and physical education, Dr. Kim Cooke.

[www.gonoodle.com](http://www.gonoodle.com). The website offers a variety of videos for indoor recess, exercise breaks during the instructional day, and other videos. It is free to use but requires registration.

## Reading List for Students

*How Can Exercise Help Your Brain? Let Us Count the Ways.* This is one of the student reading articles written as part of the curriculum unit.

Seymour, Simon. *The Brain: All about Our Nervous System and More!* New York: HarperCollins, 2006. This book is available from [www.amazon.com](http://www.amazon.com) for \$6.97 in paperback. It will be used as an interactive read aloud text and for students to read in small groups and individually.

*Want to Improve Your Test Scores? Exercise!* This is one of the student reading articles written as part of the curriculum unit

## Annotated Bibliography

(1) Ratey, John. *Spark: The Revolutionary New Science of Exercise and the Brain*. New York: Little, Brown and Company, 2008.

Ratey is considered a leader in the research about how exercise impacts the brain's ability to learn new information. One of his key points in this book is that exercise triggers the brain to manufacture a protein called BDNF that increases neuron growth in the hippocampus. The hippocampus is the region of the brain that controls learning and memory. This neuron growth increases capacity for learning. Ratey cites school districts that have seen outstanding test results in conjunction with the implementation of physical education programs that improved student fitness levels.

(2) Centers for Disease Control and Prevention. *The Association between School Based Physical Activity, including Physical Education, and Academic Performance*. Atlanta, GA: U.S. Department of Health and Human Services, 2010.

This CDC article is a meta-analysis of 43 articles that met CDC criteria for inclusion in the meta-analysis. The CDC found positive correlations between physical activity and academic performance.

(3) Cooke, Kim. *An Evaluation of Student Fitness and Academic Scores in a Large Urban School District*. Dissertation: August 2015.

This dissertation analyzed student reading and math test scores for students in grades 3-8 in Charlotte-Mecklenburg Schools with student fitness levels. The findings showed students with a higher fitness level tended to score higher on reading tests and statistically significantly higher on math tests.

(4) Chaddock-Heyman, Laura, Kirk Erickson, Caitlin Kienzler, Matthew King, Matthew Pontiflex, Lauren Raine, Charles Hillman, and Arthur Kramer. *The Role of Aerobic Fitness in Cortical Thickness and Mathematics Achievement in Preadolescent Children*. PLoS One 10(9), <http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0134115>.

This article highlights a research study on 9- and 10-year old students. The fitness level of students was gauged by giving students a test called VO<sub>2</sub>max to determine how well they processed oxygen. Students were then given the Kaufman Brief Intelligence Test (K-BIT). The study found that students with higher fitness levels had higher scores on the test.

(5) Davis, C.L., P.D. Tomporowski, J.E. Austin, B.P. Miller, N.E. Yanasak, J.D. Allison & J.A. Naglieri. *Exercise Improves Executive Function and Achievement and Alters Brain Activation in Overweight Children: A Randomized, Controlled Trial*. Health Psychology, 30(1), 91-98.

This research study examined five cohorts of overweight students ages 7-11 in Georgia. One group received high dose exercise, one group low dose exercise, and one group no

exercise. The high dose exercise groups scored significantly higher on math tests than the other two groups.

(6) Hillman, Charles H., Matthew B. Pontifex, Darla M. Castelli, Naiman A. Khan, Lauren B. Raine, Mark S. Scudder, Eric S. Drollette, Robert D. Moore, Chien-Ting Wu, Keita Kamijo. *Effects of the FITKids Randomized Controlled Trial on Executive Control and Brain Function*. *Pediatrics*, 134(4), October 2014.

This article is about a research study done in Illinois with students between the ages of 5 and 7. The study showed that students who participated in an exercise program were more focused, had improved memory, and completed tasks better than students who did not get to participate in the exercise program.

(7) Hamblin, James. *Exercise is ADHD Medication*. *The Atlantic*, September 2014, <http://www.theatlantic.com/health/archive/2014/09/exercise-seems-to-be-beneficial-to-children/380844/>

This article discussed three research articles about connections between exercise, attention-deficit hyperactivity disorder, and academic progress. It concludes that exercise is effective in alleviating ADHD symptoms and helps academic performance.

(8) Doyle, Kathryn. *Kids' Exercise Guidelines Need More Focus on Brain Development*. [www.reuters.com](http://www.reuters.com), 4 February 2015.

This article is about second graders who received strength and aerobic training. The article found regular exercise benefits behavior, emotional development, and intellectual development.

(9) Maese, Rick. *A Game of Healing: Youth Movement*. *The Washington Post*, 20 October 2015. <http://www.washingtonpost.com/sf/sports/wp/2015/10/20/educational-movement/>

This article from *The Washington Post* is about efforts in the Charleston, South Carolina schools to incorporate movement into the classroom. It highlights the efforts of the district physical education director in bringing kinesthetic classrooms to the district and discusses how these classrooms can benefit students.

(10) [www.wonderteacher.com](http://www.wonderteacher.com). *The Kinesthetic Classroom Featuring Stacey Shoecraft*.

This is an article that highlights the accomplishments of Stacey Shoecraft. Shoecraft is a fifth grade teacher in Charleston, South Carolina. Her classroom is completely outfitted with kinesthetic desks and stations that allow students to move as they complete academic tasks.

(11) Medina, John. *Brain Rules*. Seattle, WA: Pear Press, 2014.

This book contains numbered “rules” about the brain. Exercise and learning are two topics discussed in the book. Several other topics, such as sleep and aging, are also discussed in depth.

(12) Centers for Disease Control and Prevention. *Prevalence of Childhood Obesity in the United States, 2011-12*. Atlanta, GA: U.S. Department of Health and Human Services, 2015. [www.cdc.gov](http://www.cdc.gov).

This article recommends schools provide regular recess and physical education classes as well as physical breaks and opportunities for student movement in class.

(13) Charlotte-Mecklenburg Schools Health and Physical Education. [www.cmsshpe.com](http://www.cmsshpe.com).

This website contains a wealth of information and resources for teachers. Dr. Kim Cooke developed and maintains the website. It is not an official Charlotte-Mecklenburg Schools site. Physical education teachers routinely use it for entering assessment data from fitness tests. Classroom teachers who wish to use in-depth features such as exercise, nutrition, and other fitness logs or access fitness test scores for statistical analysis may do so by contacting Dr. Cooke at [kimm.cooke@cms.k12.nc.us](mailto:kimm.cooke@cms.k12.nc.us).

(14) Mazzarella Educational Media. *Real World Science: Brain and Nervous Systems* from Discovery Education. Full Video, 2007. <http://discoveryeducation.com>.

This video is located on Discovery Education. Discovery Education is currently available to all CMS teachers. It is a video that names and describes the three main parts of the nervous system as the brain, spinal cord, and nerves. One purpose of the video is to help students access prior knowledge from third grade because the human body and its systems are part of the third grade science essential standards.

(15) Simon, Seymour. *The Brain: All about Our Nervous System and More!* New York: HarperCollins, 2006.

Seymour Simon is renowned as a leading author of children's science trade books. This 32-page book is an extremely rich text with detailed photographs and vocabulary. It will provide an excellent anchor text for teaching students about parts of the brain and their functions.