FOOD FOR THOUGHT
THE RELATIONSHIP BETWEEN NUTRITION AND ACADEMIC PERFORMANCE

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Abstract

Food for Thought
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The media is constantly providing new information on brain food or ways to increase our metabolisms. This nutrition craze has even influenced schools to look at the nutritional value of the foods being served to students and educators are working on ways to improve the options offered. We are all aware of the importance of nutrition, but I wanted to look at the short-term effects of diet quality upon the academic performance of pre-adolescents.

In this quantitative study, conducted at a suburban Seattle school, surveys were handed out to three afternoon mathematics classes on test days. The surveys involved information on what type of lunch and what specific foods the student had eaten during lunch. The type of lunch was then analyzed to see if any relationship exists between the quality of lunch and that student's test score. A healthy eating index was used to provide a numerical value for each student's diet at lunch. I was then able to use this numerical value to look at the correlation between the quality of student lunches and their academic performance in afternoon classes.

The results of this study showed that students who brought lunch from home did slightly better compared to those who ate school provided lunches even though school provided lunches had a higher value on the healthy eating index scale. Both students who brought lunches from home and those that ate school provided lunches did significantly better academically compared to students who did not eat at all. No correlation was found between the quality of lunches eaten and academic performance when looked at as

a class. However, when this relationship was looked at for each student over several testing days a correlation was found for the majority of the students. These results show that the quality of student lunches impact their academic performance in the afternoon.

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Introduction

Walking into a middle school during lunch hour, the chatter of hundreds of students who are racing through the cafeteria is striking. Each student is eating as quickly as possible, so he or she can rush off to their free time. If you take a closer look at what the students are cramming into their bodies, you will notice food high in sugar and saturated fats and not nearly enough fruits, vegetables or whole grains. As lunch hour comes to an end and the students return to their classrooms, they have a difficult time concentrating on tasks given to them, causing their academic performance to suffer.

Researchers have found that when students do not get adequate nutrition their grades and academic performance decline (Florence, Asbridge and Veugelers, 2008). Their studies have found that breakfast significantly improves children's scholastic and social development (Stokes, 2008).

Although a considerable amount of research has been done on how breakfast affects students' functions in class, there is a lack of information concerning student lunch habits and performances. Are students getting all the nutrients necessary during lunch to be fully involved for their learning? Is there a noticeable academic difference between students who bring their own lunch compared to students who take advantage of school provided lunches? Addressing these questions will help us understand how important the food we consume is in regards to education and learning.

As our nation is beginning to focus on the crucial role nutrition plays in our health and development, schools have started to improve the food options given to the students. However, there is still room for improvement inside the schools where many students eat

two meals a day; breakfast and lunch. Currently, many researchers are concentrating on how certain micronutrients affect our brain functioning. There are new articles being published continually on "brain foods" that everyone should be eating to have optimal brain performance and development, but are schools adjusting to these new findings? In the following literature review, I will outline the research focused on micronutrients that enhance brain functioning, describe the quality of student diets, and determine how inadequate nutrition can impact student learning and academic performance.

Literature Review

The three major themes that organize the following literature review are: the impact of micronutrients on cognitive functioning (specifically iron, zinc, omega-3 fatty acids, artificial flavoring and coloring, water and vitamin B), the quality of adolescent's diets in general and in a school environment in addition to the regulations school lunch programs are instructed to follow, and lastly, the relationship between diet quality and academic performance. These major themes give a broad overview of how nutrition can impact cognitive functioning and student learning.

Micronutrients

Quality nutritional intake of school aged children is essential for growth and optimal functioning which are both immediate and long term (Tomlinson, Wilkinson H. and Wilkinson P., 2009). The human brain uses twenty to thirty percent of our total body energy, but is only two percent of our total body weight (Stokes, 2008). This demonstrates how significant nutrition is for the brain to function; specifically during adolescence, as the brain is developing more adult ways of reasoning, such as abstract thinking, deductive reasoning, and problem solving skills (Benton, 2008). Studies have

shown that undernourished students tend to have decreased school attendance, attention, and academic performances (Florence et al., 2008). Where undernourishment is typically defined as inadequate amounts of food, not all the food groups are eaten regularly, or the daily recommendation of micronutrients are not met. Micronutrients play a vital role in the overall diets of children; inadequate levels of just one micronutrient can make a big impact on their cognitive function.

Iron

Iron is essential for proper brain function, when insufficient levels of iron are present hypomyelination, the delayed transmission of impulses occurs (Malone, 2005). The transmission of impulses are critical as children are developing because these impulses assist with developing strategies, testing hypotheses when problem solving, and focusing attention (Malone, 2005). Therefore, iron deficiency may cause students to have lower performances at school, a decline in cognitive function, and lower IQ scores, especially in females (Malone, 2005; Tomlinson et al., 2009). Three percent of school aged children in the United States have an iron deficiency, but among adolescent girls, iron deficiency is as high as nine percent (Taras, 2005). Of these children with iron deficiency there may be an association with poor academic performances in math (Taras, 2005). Murray-Kolb and Beard found women with adequate levels of iron had improved cognitive performance than those with iron deficiency or anemia, concluding that adequate levels of iron are necessary for cognitive performance (Stokes, 2008).

Zinc

Zinc is necessary for cognitive development during periods of rapid brain growth and in adolescences (Tomlinson et al., 2009). A zinc deficiency has been linked to a

negative affect on attention span, neuropsychological behavior, impaired memory and learning capacity (Tomlinson et al., 2009). Contrary to Tomlinson et al. findings, Howard Taras (2005) reports a zinc supplementation alone is not likely to change cognitive abilities or school performances even in students with a zinc deficiency.

Omega- 3 Fatty Acids

Omega-3 fatty acids form new outer membranes around the cells of the brain to protect the neurons involved in learning and memory (Nunn, 2010). When a diet contains too many processed foods which are high in saturated fats and low in micronutrients there are low levels of fatty acids, such as eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) (Tomlinson et al., 2009). Children, who were hyperactive, but not necessarily diagnosed with ADHD, tend to have similar symptoms to children with a fatty acid deficiency (Tomlinson et al., 2009).

A control group and a group receiving fatty acid supplements were examined to see the effects of fatty acids in the diet (Tomlinson et al., 2009). The group receiving the supplements showed significant improvements in lowering hyperactivity and in reading and spelling performances compared to the control group (Tomlinson et al., 2009). However, Stevens et al. also gave fatty acid supplements to children with behavior similar to ADHD but did not find clear results of any improvement (Tomlinson et al., 2009).

Although there may be a weak correlation between fatty acid supplements and improved behavior, these studies are significant because five to ten percent of school aged children are diagnosed with ADHD (Tomlinson et al., 2009). ADHD increases the

risk of disruptive behavior and therefore interferes with the student's learning, as well as that of others in the classroom.

Other Micronutrients

Fatty acids are not the only factors possibly having an impact on an ADHD student. Artificial flavoring and colorings promote hyperactivity in children (Tomlinson et al., 2009). B.F. Feingold claimed that thirty to fifty percent of children with hyperactivity benefited from a diet free of any artificial flavoring or coloring (Tomlinson et al., 2009). In conjunction, Pelsser et al. showed behavior improvements in seventy percent of the children after eliminating food additives (Tomlinson et al., 2009). With the results of these two studies we can conclude some food additives may decrease hyperactivity and improve behavior in children with ADHD symptoms.

Water, another micronutrient that is often overlooked, plays a key role in the functioning of our brains. Eighty percent of the brain is water, and when the brain becomes dehydrated we start to see restlessness, irritability, and difficulty concentrating resulting in a decline in cognitive performance (Stokes, 2008). In addition, there may be an association between low intakes of folate, a B vitamin also known as folic acid, and poor cognitive function (Stokes, 2008). B vitamins are necessary for enhancing memory (Nunn, 2010).

Quality of Youths' Diets

General

Poor dietary habits in young children may impair their growth and development. In a 2002 study on the quality of children's diets, Lino, Basiotis, Gerrior, and Carlson found that most children need to improve their eating habits. Lino et al. (2002) used the

Healthy Eating Index (HEI) to evaluate children, ages two to nine. The study measured their intake of food including the five major food groups, total fat, saturated fat, cholesterol, and sodium consumption (Lino et al., 2002). The maximum score on the HEI is 100; a score over 80 implies a "good" diet; a score between 51 and 80 is a diet that "needs improvement"; and a score below 51 is a "poor" diet. 81 percent of young children had diets that were classified as needed improvement or poor and only 19 percent had good diets (Lino et al., 2002, pg. 53).

Although most of these children had diets that needed improvement, the children were still able to meet the recommended dietary allowance (RDA) of essential nutrients (Lino et al., 2002). In the five major food groups, 18 percent met the meat RDA, 22 percent of children met the vegetable RDA, 33 percent met the fruit RDA, 36 percent met the grains RDA, and 46 percent met the milk RDA (Lino et al., 2002). In overall diets, boys had a slightly higher percentage of healthy diets compared to girls; 20 percent to 18 percent (Lino et al., 2002). Boys tended to meet the five major food group recommendations while the girls met the essential nutrients (Lino et al., 2002). Focus needs to be put on improving the quality of children's diets to ensure adequate growth and development (Lino et al., 2002).

In conjunction, Rangan, Randall, Hector, Gill and Webb (2008) evaluated Australian children's diets by measuring the types and quantities of energy-dense, nutrient-poor 'extra' foods consumed. Energy-dense, nutrient-poor foods are defined as foods with few micronutrients and substantial amounts of fat and/or sugar, and are high in energy (Rangan et al., 2008). 'Extra' foods are defined as foods that do not fit into the five main food groups and contain more than fifteen percent fat and more than twenty

percent sugar (Rangan et al., 2008). For children aged four to eighteen the estimated amount of 'extra' foods that are allowed to be eaten per day is between five and twenty percent (Rangan et al., 2008).

Rangan et al. (2008) conducted interviews with participants to identify foods eaten the previous day. Nearly all the participants, 99.8 percent, consumed at least one 'extra' food (Rangan et al., 2008). Of the food items eaten by the participants, over a third were classified as 'extra' foods (Rangan et al., 2008). The most common 'extra' food type consumed was margarine followed by sugar-sweetened soft drinks, cordials, and sugar (Rangan et al., 2008). Each of those items was consumed by over one-third of the participants (Rangan et al., 2008). The amount of 'extra' foods eaten increased significantly with age; 381 grams for 2 to 3 year olds compared to 1178 grams for 16 to 18 year olds (Rangan et al., 2008). Males consumed more 'extra' foods than females in every category (Rangan et al., 2008). Total nutrient intake from both core and 'extra' foods combined met the 70 percent recommendation for all micronutrients for each age and sex subgroup, with the exception that adolescent girls did not meet the zinc and calcium recommendation (Rangan et al., 2008).

According to Susan Malone (2005), 28 percent of children over the age of two get the recommended two servings of fruit, three percent eat the recommended vegetable servings per day, and seven percent eat the recommended six daily servings of grains. There has been an 11 percent increase since 1977 in meals eaten away from home, which tend to be lower in nutritional value and are adversely affecting overall diet quality (Malone, 2005).

School Environment

School is generally where children spend most of their day. Therefore it is especially important to have quality food and beverage consumption inside schools. But most public schools allow children to have access to competitive foods, which are foods and beverages sold outside of the reimbursable federal school meal program (Thompson, Yaroch, Moser, Rutten and Agrus-Collins, 2010). These competitive foods tend to be energy dense and nutrient poor. 21.1 percent of elementary, 62.4 percent of middle, and 85.8 percent of high schools have at least one vending machine and 16.7 percent of elementary, 33.0 percent of middle, and 50.1 percent of high schools have a school store or snack bar (Thompson et al., 2010).

Thompson et al. (2010) evaluated the relationship of school vending machine purchasing behavior with school policy and individual level dietary characteristics with a nationwide survey for students aged 9 to 18 in 2005. The majority of the participants, 58.7 percent, reported having restricted access to school vending machines such as only after school (Thompson et al., 2010). Less than a quarter of the participants with restricted access made purchases from the vending machine most days of the week, and close to half never purchased items (Thompson et al., 2010). However, when students had unrestricted access, most students purchased items at least once per week (Thompson et al., 2010). The students who are purchasing from the vending machines are also purchasing pizza or fried food from the school cafeteria at least once per week (Thompson et al., 2010). Of the adolescents who purchased items from the vending machines three or more times per week, 74 percent were consuming soda regularly (Thompson et al., 2010). In addition, age was associated with increased purchasing from

vending machines on one or more days per week as older students purchased considerably more items than younger students (Thompson et al., 2010).

More schools across the country are starting to improve the nutritional quality of lunch options students receive. Lazor, Chapman and Levine (2010) evaluated student's willingness to accept soy products as healthy lunch alternatives. Soy products provide nutritious options for school meals and meet healthier US guidelines because they are lower in calories, fat, and saturated fat, and provide essential nutrients (Lazor et al., 2010). Four soy entrees were tested in Maryland public schools. They were soy based nuggets, a 'hybrid' patty with half ground beef and half soy, soy based chicken-less slices on a Cesar salad, and macaroni and cheese with soy pasta (Lazor et al., 2010). On average, the soy based entrees had 18 percent less calories, 45 percent less fat, less than half the saturated fat, one fifth the cholesterol, same amount of protein, twice the iron, six times as much fiber, but 20 percent more sodium than traditional entrees served (Lazor et al., 2010).

Students tended not to consume as much of the hybrid' patty and soy based chicken-less slices on a salad, although the difference in weight was less than half an ounce when compared to traditional entrees (Lazor et al., 2010). However, the pasta and nuggets were consumed in higher amounts (Lazor et al., 2010). Lazor et al. (2010) also found a high approval of soy based products in chili, spaghetti sauce, and stuffed ravioli in Illinois schools. In addition, soymilk was accepted when offered as an alternative to dairy milk in elementary schools (Lazor et al., 2010). Lazor et al. (2010) concluded that students are willing to accept soy based lunches and try alternatives they consider more healthful.

School regulations

The National School Lunch Program started in 1946 "as a measure of national security, to safeguard the health and well-being of the nation's children" (David, 2010, p.88). According to the US Department of Agriculture (USDA), school meals should include less than 30 percent of total energy from fat, less than ten percent of total energy from saturated fat, and 14 grams of fiber per 1000 calories (Lazor et al., 2010). At breakfast, one fourth and at lunch time, one third, of the RDAs for energy, protein, vitamin A, vitamin C, calcium, and iron should be the goal for schools (Lazor et al., 2010). Evaluations show that meeting these requirements has been challenging for schools; less than one third of public schools serve lunches that meet the recommendations (Lazor et al., 2010). However, the percentage of schools serving lunches that meet the USDA standards for saturated fat has increased from 15 percent in 1999 to 34 percent in 2005 in elementary schools, and 13 percent to 26 percent in secondary schools (Lazor et al., 2010). Still, school meals are too high in saturated fat and too low in fruits, vegetables, and whole grains (David, 2010).

Although, school lunches may not always meet the nutritional standards, they tend to be more nutritious than those brought from home or purchases from private vendors as schools serve milk instead of sugared drinks (David, 2010). School vending machines decrease the nutritional value students receive at school, so for students to have better eating habits schools need to reduce the number of such machines or eliminate them altogether (David, 2010). Not only are vending machines contributing to the low nutrition students receive at school, but a la carte purchasing allows easy access to foods

high in fat. Fruit and vegetable items are only 4.5 percent of the total a la carte items available (Malone, 2005).

The ability of schools to offer breakfast and lunch while meeting the nutritional standards has been restricted by high food costs, decreasing school budgets, and reduced federal reimbursement and funding (David, 2010). In 2006, more then $1.6 billion was spent to market foods and beverages to children and adolescents in the United States (Thompson et al., 2010). Of these funds, $186 million was used for marketing to schools, where the majority was spent promoting carbonated beverages (Thompson et al., 2010).

Diet Quality and Academic Performance

There are varying results on how students' diets affect their performance at school. Kleinman, Hall, Green, Korzec-Ramirez, Patton, Pagano, and Murphy (2002) found children who experienced frequent hunger were more likely to have lower grades in math and more days absent from school. About one-third of inner city public school children had low caloric intake and/or low intake of selected micronutrients (Kleinman et al., 2002) These children had significantly worse grades than children with more adequate dietary intakes (Kleinman et al., 2002).

Six years later, Florence et al. (2008) examined the association between overall diet quality and academic performance, while highlighting which specific aspects of the diet are most important to student performance. Fifth grade students were given a questionnaire which researchers used to evaluate their diet on a 0 to 100 range, 100 being the maximum (Florence et al., 2008). Then the students were instructed to complete a variety of readings and answer written questions based on the reading (Florence et al.,

2008). Good academic performance was defined as passing both assessments while poor academic achievement was failing one or both of the assessments (Florence et al., 2008).

Diet qualities of the children ranged from 26.0 to 86.0, the average being 62.4 (Florence et al., 2008). Students reporting increased diet qualities, higher fruit and vegetable intake, and lower fat and caloric intake, were significantly less likely to fail the assessment (Florence et al., 2008). The dietary components that most influenced the academic performance of the students were variety and adequacy rather than moderation and balance (Florence et al., 2008). These findings suggest improved learning as a benefit of a healthy diet in children.

Breakfast

Before the school breakfast program was implemented, one in three students were at "nutritional risk" (David, 2010). Now about 85 percent of the schools that participate in the National School Lunch Program are also offering breakfast to students (David, 2010). This meal is usually served before school starts and as a result many students are not allowed to participate in the program because of bus schedules (David, 2010). Consuming meals throughout the day has been reported to improve brain function because this allows the brain a constant supply of energy. Children who regularly eat breakfast perform better than those who do not eat breakfast (Stokes, 2008). In addition, Taras (2005) found a positive impact of breakfast on cognitive skills in the short term, but the long-term effects of breakfast on a student's performance is still unknown.

Kleinman et al. (2002) conducted a voluntary study to evaluate any associations between the nutritional quality of breakfast and improvements in academic and behavioral functioning. In this study, a low-energy diet was considered a diet with total

caloric intake less than 50 percent of the RDA (Kleinman et al., 2002). Overall GPA, math, reading, social studies, and science grades were evaluated before and after the implementation of a breakfast program (Kleinman et al., 2002). Prior to the introduction of the breakfast program, the mean GPA of students with a low nutritional intake was 2.1, as compared to 2.8 for children with adequate diets (Kleinman et al., 2002). The same pattern was observed in each of the four subject areas, with one half to one full letter grade difference between nutritionally at-risk children and those not at risk (Kleinman et al., 2002). After the execution of the breakfast program, math grades were found to be statistically significant in relation to improved nutritional intake (Kleinman et al., 2002).

David Benton (2008) found skipping breakfast obstructs cognition and learning, specifically in children who are nutritionally at risk. 9 to 11 year olds who ate breakfast saw improved cognitive performance for one hour after eating, as compared to those who fasted (Benton, 2008). Furthermore, 12 year olds that consumed breakfast cereals saw a slow decline in attention and memory for an hour and a half, as compared to those fasting (Benton, 2008). However, when children ate oatmeal, there was even more improvement in memory and attention because the low glycemic meal slowed the release of glucose into the blood (Benton, 2008). A low glycemic breakfast was associated with better memory, attention, and more time spent on tasks (Benton, 2008).

Summary

As discussed in this literature review, micronutrients assist in the development and functioning of the human brain. Iron had the biggest impact on cognitive function in schoolchildren, especially females. The lack of micronutrients in children today may be a result of their poor dietary habits. Schools have begun to change the diet choices for

students, but have not reached the standards set by USDA. There are no clear statistical correlations between diet quality and academic performance, but overall, a healthier child tends to have a better performance in school.

Research Question

In light of this research involving student responses to the quality of their dietary intake, I am left wondering what correlation there is between the quality of student lunches and their academic performance in afternoon classes. The primary research question at the heart of this study is: What types of academic differences are evident between students who bring their own lunch to school and those eating the lunches provided by the school? A secondary question is: How does the nutritional value of school provided lunches compare to that of lunches brought from student homes?

Methodology

Method and Rationale

In response to the primary research question, which drives this project, I employed a quantitative research methodology. A quantitative study involves measureable research techniques used to gather data. Such a methodology was appropriate for this study because the research was looking at the correlation between the quality of student lunches and the students' academic performances. The quality of student lunches was analyzed using a healthy eating index to provide a numerical value for the foods students were eating. This research also looked at the relationship between student test grades and whether they ate school provided lunches or lunches brought from home.

Sample

The data sample consisted of three afternoon sixth grade mathematic classes at the Renton School District in a Seattle suburb. All three classrooms contained male and female students in grade level mathematics, and all had the same teacher.

However, two of the three classrooms consisted of remedial sixth grade mathematic students. The majority of these students were at a third or fourth grade level mathematically, but were learning sixth grade math. Therefore, the data gathered may have impacted the results of this study due to the fact that most of the students in those classrooms struggle with math.

In spite of this, the Renton School District provided a good sample for this study, since it allowed me to collect data from a diverse group of students based on gender, ethnic background, and socioeconomic status.

Instrumentation

In order to properly answer the research questions, I tracked the source of student lunches. Some were eating lunch provided by the school, some bringing lunches from home, and some did not eat.

I also analyzed the specific foods students were eating at lunchtime and measured the quality of their diet using a healthy eating index. Afterwards, I recorded the test scores students received the day those foods were consumed. Looking at this information allowed me to see any relationship between quality of pre-adolescent diets and their performances at school in the short term.

The data was collected on student lunch behavior by handing out a survey to the students after they had taken their traditional math assessment. The surveys were handed out on three different days, April 6th, May 6th, and June 2nd. The first time the surveys

were distributed I was not able to be in the classroom so, the teacher in that classroom distributed the surveys. I was present when the other two surveys were given. Being present in the classroom allowed me to ask clarifying questions to students on the foods they consumed. Below is an example of the survey I distributed each time.

Name: _____ Date:_____ Grade:_____ Period:_____

1. What type of lunch did you eat today (circle one):

School Provided Brought From Home Did Not Eat

2. What foods were packed in your lunch or did you select from the school provided options? (Please be specific; eg. Ham sandwich with one slice of cheese, lettuce, and mayo on wheat or a large apple)

3. What foods did you eat during lunch? Please be specific. What and how much of each food item was consumed? (eg. Ate 3/4 of the ham sandwich or ate the whole apple)

I provided each student with a letter and numerical value in the data in order to provide protection and anonymity for each participant. Then I recorded the source of their lunch, test grade and the quality of the students' food consumption using a healthy

eating index to provide a numerical value. Using these three pieces of information I was able to look at two different relationships. One was the grade the student received on the test versus the source of the lunch. The other was the quality of the lunch versus the test grade.

Analysis and Validity

To determine if a relationship exists between student performance and the lunch source, I began by looking at the type of lunch eaten by the student compared to the test scores received. Afterwards, I took closer look at the food choices made by the students, using a healthy eating index. This index provided a numerical value of overall diet quality to each meal eaten by the students and is based on different aspects of a healthful diet. The healthy eating index provided information to examine any correlation between the quality of student lunches and the students' school performances in the afternoon.

The healthy eating index (HEI) was developed by the United States Department of Agriculture (USDA) to evaluate how well Americans are eating. The USDA's index evaluates the food consumed using ten different categories, each with a score out of 10 providing each participant with a score out of 100.

I used the index as a guide when developing a healthy eating index appropriate for this study. However, I had to make a small adjustment in the HEI by eliminating the variety category since the USDA suggested using three days' worth of data to get an accurate analysis and I was only evaluating one meal. Therefore, in this study each participant has a score out of 90; a score less than 45.9 is considered poor, a score greater than 45.9 but less than 72 needs improvement, and a score greater than 72 is good.

The nine categories used were, grains, vegetables, fruits, milk, meat, fat, saturated fat, cholesterol, and sodium. For the five food groups, the serving amount was adjusted to be appropriate for pre-teens according to the USDA. Also, since I was evaluating only one meal, the servings per day were divided by three to maintain proper parameters.

Appendix A shows the specific guidelines I followed for both males and females in each of the nine categories. To receive a score of 10 in each food groups the student must have eaten the necessary servings needed for the day. Any amount below that was calculated proportionately.

Index scores for fat and saturated fat were examined in proportion to the total calories consumed by that individual. Fat intakes of less than 30 percent were given a score of 10, whereas fat intake greater than 45 percent was given a zero and any amount in between was assigned proportionately. A score of 10 was given to saturated fat intakes less than 10 percent. A zero was assigned when saturated fat reached a level of 15 percent or more. Any score between 10 percent and 15 percent was calculated proportionately.

The scores of cholesterol and sodium were each based on milligrams consumed. To follow accurate guidelines, the daily limits were divided by three. A score of 10 was given for cholesterol amount less than 100 milligrams and a score of zero was assigned when more than 150 milligrams was consumed. Cholesterol amounts anywhere in between were calculated proportionately. A maximum score for sodium was assigned at intake levels of 800 milligram or less. Zero points were given when more than 1600 milligrams were consumed. Any number in between was calculated proportionately.

Using this method to analyze the data allowed me to look at the impact nutrition makes on school performances. In addition, the surveys were distributed several times in each classroom to provide more accurate information. The data collected is also from several different classrooms, which enhances the accountability of my findings because they were obtained from several sources. Once the results were calculated, I was able to compare my findings with other research that has been done on nutrition and student performances to help triangulate the conclusions.

Influence of the Researcher

I have always had an interest in nutrition, and believe having a balanced diet promotes proper brain function for everyone, especially children. My bias may play a part when evaluating the foods students are eating. Although I was following a healthy eating index, I had to use my best judgment at times when students were not specific on what and how much of a certain food was consumed. I guarded against my bias by asking clarifying questions to students when I was unsure of something they have written on their survey. Also, if I was unsure of how much of a certain food was eaten, I used the same standard for each student when there was no measurement given from the student of how much was consumed. In addition, I repeated the experiment across three classrooms, which should help eliminate any bias that could come from being in the same classroom as some students.

Data

I have taken the surveys distributed to the students and created a table of their information; Tables 1 through 7. The first column is the letter and numerical value assigned to each participant, in order to provide protection and anonymity. The

following column shows what type of lunch the student had; school provided, brought from home or did not eat (DNE). The third column is that particular student's healthy eating index (HEI) score, which was calculated from the student's response of what he or she ate for lunch. The healthy eating index score is out of 90 points. The final column shows the number of points correct the student received on their test that particular day. The number in the parenthesis at the top of each table shows the number of possible points on the test.

Student	Source	HEI	Test Scores (12)
A1-1	School	38.5	5.5
A1-2	School	42.9998	8.4
A1-3	School	59.8787	5.6
A1-4	DNE	40	2.5
A1-5	School	55.2126	1
A1-6	School	81.2818	6
A1-7	School	63.8716	4.5
A1-8	School	80	5.6
A1-9	School	58.4289	6
A1-10	School	79.3098	7
A1-11	School	49.1625	10.4
A1-12	Home	50	9.1
A1-13	School	48.1427	5.9
A1-14	School	65.8377	4.5
A1-15	School	71.5299	3.9
A1-17	Home	39.8829	8.9
A1-18	DNE	40	4
A1-20	School	59.879	6.2
A1-21	Home	68.2099	5.1

A1-22	School	68.8955	6.5
A1-23	School	62.8375	9.3
A1-25	School	76.0877	5.9
A1-26	School	52.4834	7.9

Table 1. Class A on the first test day, April 6th.

Student	Source	HEI	Test Score (12)
B1-1	School	62.9627	2.4
B1-2	School	75.9988	5.2
B1-3	School	70	4.5
B1-4	DNE	40	6
B1-6	School	55	6.9
B1-7	School	50	9.9
B1-8	Home	58.4014	7
B1-9	Home	65.45	10.9
B1-10	DNE	40	4.5
B1-11	Home	40.9745	8.2
B1-12	School	45.9999	7.3
B1-13	School	58.1525	4.6
B1-14	School	45	4.9
B1-15	Home	43.7	4.6
B1-16	School	74.877	3.2
B1-17	School	58.5868	7.6
B1-18	School	47.5499	9.6
B1-19	School	70.6023	10.3
B1-20	School	81.8748	8.6
B1-21	School	68.8399	5
B1-22	School	51.6827	4.6
B1-23	Home	43.3749	7.6
B1-24	Home	74.4014	3.4
B1-26	Home	47.7993	3.9

B1-27	Home	61.2	4.3
B1-28	School	70	5.1

Table 2. Class B on the first test day, April 6th.

Student	Source	HEI	Test Score (8)
A2-1	School	54.7728	4.5
A2-2	DNE	40	4.5
A2-3	School	56.733	5
A2-4	School	56.733	6
A2-5	School	66.1838	1
A2-6	School	66.51	7
A2-7	School	54.9747	2
A2-9	School	52.7173	7
A2-10	School	64.5138	7.5
A2-11	Home	77.9998	8
A2-12	Home	60	3.5
A2-13	School	49	4.5
A2-14	DNE	40	5.5
A2-15	School	67.7613	2.5
A2-16	School	35.0001	4.5
A2-17	Home	51.4975	8
A2-18	DNE	40	4
A2-19	School	53.7025	7
A2-20	School	51.075	1.5
A2-21	Home	61.7998	5
A2-22	School	40.469	5
A2-23	School	68.8329	7.5
A2-25	School	68.9007	3.5
A2-26	School	75.164	6

Table 3. Class A on the second test day, May 6th.

Student	Source	HEI	Test Score (8)
B2-1	School	50.4923	7
B2-2	School	63.0358	4
B2-3	DNE	40	2
B2-4	DNE	40	5
B2-5	School	57.742	6
B2-6	School	56.2054	8
B2-7	DNE	40	7.5
B2-8	Home	30	6
B2-9	School	72.2354	7.5
B2-10	Home	40	5.5
B2-11	DNE	32.9714	7
B2-12	School	55.7706	7.5
B2-13	School	68.4733	5.5
B2-15	Home	44.9659	4
B2-16	School	57.0975	4
B2-17	School	57.9762	7.5
B2-18	School	58.2506	5.5
B2-19	School	54.4736	8
B2-20	School	56.733	5.5
B2-21	School	71.5145	2.5
B2-22	School	63.586	4.5
B2-23	DNE	40	6
B2-24	Home	50	3.5
B2-26	Home	44.5675	3.5
B2-27	Home	64.2647	6
B2-28	School	69.7299	4.5

Table 4. Class B on the second test day, May 6th.

Student	Source	HEI	Test Score (8)
C2-1	School	65.3809	7

C2-2	DNE	40	3
C2-3	Home	54.5913	6
C2-4	School	55.6828	5.5
C2-5	Home	40.2442	5
C2-6	DNE	40	4.5
C2-7	School	63.5037	7
C2-8	DNE	40	7
C2-9	School	66.8373	7
C2-10	DNE	40	1.5
C2-12	Home	45.8748	6
C2-13	Home	67.8873	5.5
C2-14	School	47.6112	7
C2-15	School	40.9999	5
C2-16	Home	49.8874	8
C2-17	School	66.7015	5
C2-18	School	57.7757	6.5
C2-19	School	44.75	6
C2-20	School	52.5758	5.5
C2-21	Home	44.1912	8
C2-23	School	78.8708	8
C2-24	School	69.8129	7

Table 5. Class C on the second test day, May 6th.

Student	Source	HEI	Test Score (6)
A3-1	School	54.2473	5
A3-2	School	70.899	6
A3-3	School	65.9999	5
A3-4	Home	60	2
A3-6	School	77.715	5
A3-7	DNE	40	5
A3-9	School	43.85	6
A3-10	School	70.5334	6

A3-11	Home	65.101	6
A3-12	Home	62.4125	5
A3-13	School	53.6774	5
A3-14	School	53.4977	5
A3-16	School	62.4616	4
A3-17	Home	34.711	6
A3-18	DNE	40	4
A3-19	School	61.9477	6
A3-20	School	67.0096	4
A3-21	Home	58.3348	5
A3-22	School	71.5812	4
A3-23	School	66.0002	6
A3-26	School	46.8648	3

Table 6. Class A on the third test day, June 2nd.

Student	Source	HEI Scores	Test Score (6)
B3-1	School	56.657	3
B3-4	DNE	40	4
B3-5	School	68.7498	6
B3-6	School	55.248	4
B3-7	DNE	40	6
B3-8	Home	29.4125	4
B3-9	Home	65	6
B3-10	DNE	40	4
B3-11	Home	50.1393	5
B3-12	School	73.4739	3
B3-13	Home	51.2757	2
B3-15	Home	55	5
B3-16	School	71.3309	2
B3-17	DNE	40	3
B3-18	Home	49	5
B3-19	School	74.525	5

B3-20	School	58.7498	6
B3-21	School	72.8646	1
B3-22	School	50	4
B3-23	DNE	40	5
B3-24	Home	71.7376	5
B3-25	School	67.4996	3
B3-26	Home	48.5121	2
B3-28	School	45	5

Table 7. Class B on the third test day, June 2nd.

There is only one day of data for Class C because every Friday at the middle school where my research was done is a late start, which affects the schedule. As a result of this, Class C has lunch prior to math class where as Monday through Thursday they have lunch after. The second testing day, May 6th, was a Friday and therefore Class C was able to participate in this study. The first and third testing days were Thursdays, thus, Class C came to math prior to lunch and was not able to contribute to the data on those days.

Table 8 shows the average test score percentages for students who did not eat, brought their lunch from home, or ate a school provided lunch. The bottom of Table 8 shows the average percentage for all the tests and classes combined. Table 9 displays the healthy eating index score for the students who brought lunches from home and the students who ate school provided lunches for each testing day along with an overall average. The students that did not eat were not included in this chart because every student who did not eat received a score of 40.

CLASS	DNE (%)	HOME	SCHOOL
Class A - 4.6	27.08	64.17	50.97
Class B - 4.6	43.75	51.98	51.93
Class A - 5.6	58.33	76.56	60.29
Class B - 5.6	68.75	59.38	72.92
Class C - 5.6	50.00	80.21	78.98
Class A - 6.2	75.00	80.00	83.33
Class B - 6.2	73.33	70.83	63.63
TOTAL	56.61	69.02	66.01

Table 8. Average test scores for each source of lunch.

CLASS	HOME	SCHOOL
Class A - 4.6	54.05	61.91
Class B - 4.6	54.41	61.70
Class A - 5.6	62.82	57.83
Class B - 5.6	45.63	60.89
Class C - 5.6	50.45	59.21
Class A - 6.2	56.11	61.88
Class B - 6.2	52.51	63.10
TOTAL	53.71	60.93

Table 9. HEI scores for each source of lunch.

Table 10 shows the correlation found between the students' healthy eating index scores and their test scores evaluated as a class on each testing day. A graph for each class can be found in Appendix B, which shows the data points of each student. In addition to assessing the healthy eating index scores and test score as a class, I looked at

each student individually to see what correlation exists between their eating habits and their test scores over the course of this study. Table 11 shows each student's correlation when evaluated individually in Class A. Table 12 shows the results of Class B. Some students were not included in the data because I did not have three sets of figures for the student, which was needed to provide accurate information.

CLASS	CORRELATION BETWEEN HEI AND TEST SCORES
Class A - 4.6	0.00967
Class B - 4.6	0.00832
Class A - 5.6	0.02708
Class B - 5.6	0.00174
Class C - 5.6	0.20946
Class A - 6.2	0.00345
Class B - 6.2	0.01703

Table 10. Correlation found for each class.

STUDENT	CORRELATION BETWEEN HEI AND TEST SCORES
A-1	0.4823
A-2	0.95057
A-3	0.50007
A-4	0.31226
A-6	0.57296
A-7	0.6973
A-9	0.84449
A-10	0.72147
A-11	0.80066
A-12	0.02537
A-13	0.99716

A-14	0.41963
A-17	0.0468
A-20	0.97706
A-21	0.96713
A-22	0.01253
A-23	0.52114
A-26	0.78039
MEAN	0.590516111

Table 11. Correlation found for each student in Class A.

STUDENT	CORRELATION BETWEEN HEI AND TEST SCORES
B1	0.99503
B6	0.99989
B7	0.87583
B8	0.73449
B9	0.06732
B11	0.02833
B12	0.1554
B13	0.92485
B15	0.97765
B16	0.99166
B17	0.51115
B18	0.88555
B19	0.99788
B20	0.12859
B21	0.92165
B22	0.00143
B23	0.82798
B24	0.02197
B26	0.94493
B28	0.89613
MEAN	0.6443855

Table 12. Correlation found for each student in Class B.

Analysis

Home Lunches vs. School Lunches

In order to evaluate the relationship that may exist between students who bring their lunches from home and students who eat school provided lunches, the average test score each student received was found using Tables 1 through 7. These results were then recorded with the source of lunch for each testing day and the overall mean was found. On average, students who brought their lunches from home did three percent better on each test than students who are school provided lunches, which can be seen on Table 8. Students who choose not to eat lunch tended to do thirteen percent worse compared to the students who brought lunch from home.

The next step was to determine if the quality of lunch was influencing academic performance. The results were a little surprising. Students who choose to eat school provided lunches had a higher healthy eating index score by about 7 points. The average healthy eating index score of students who brought lunches from home was 53.71 where as school provided lunches yielded a score of 60.93. Both scores are significantly better than the students who did not consume lunch; each of those students received a score of 40. This information on can found on Table 9.

However, several errors may have occurred in calculating the healthy eating index scores. Students who brought lunches from home were more difficult to calculate scores for than those who ate at school. This was because I had access to the nutritional information of school provided lunches, which included the amount served to each

student and the servings for each group, allowing for more accurate scores for those students. For the students who brought lunch from home I used the USDA's website to obtain the general nutritional value of each food item, but the serving size for each item may not be as accurate. Even though the surveys asked students to be specific, not every sixth grader was. These few errors may have contributed to slightly inaccurate results in this study.

However, the results of my study would agree with the results found in the literature review. Previous studies found that schools were in the process of changing the food options offered to students, but were not quite up to the standards set by the USDA. Consistent with that research, I found my subject school is providing students with healthier lunches compared to the students who are bringing lunches from home. Still, although the school is offering better options to students. The average student is still below the requirements of "good" on the healthy eating index scale. There is room for improvements.

The results above show that students who eat lunches from home have a tendency to perform better on their afternoon exams, but they are not necessarily eating healthier compared to the students who are eating school provided lunches. On the other hand, all students who eat lunch at all whether from home or from the school, eat healthier and perform better academically than those who do not eat at all. So, the question still at hand is does the nutritional value of a student's lunch affect his or her academic performance?

Class Analysis

I began to look at the relationship between the quality of students' lunches and their academic performance as a class to see if there was an overall correlation. This also allows me to see the significance of other factors that contribute to a student's performance. Table 10 shows what correlations were found for each class. These correlations were obtained by graphing each students healthy eating index score against their test score for every individual in the class. The graphs of each class can be found in Appendix B. There were no correlations found for class A or class B. However, the one-day class C participated in the study a very weak correlation (.20946) between their healthy eating index scores and their test scores was present.

As a result of that class only being able to participate once in this study I am not sure if it is a coincidence. Class C had a range of mathematical abilities among the students, whereas in classes A and B the majority of the students were remedial and struggled mathematically. Without more research being done, it is hard to say if the correlation found is showing nutrition plays a small role in a student's performance.

Research in the literature review suggests that students who eat breakfast regularly performed better academically compared to those who did not eat. Following these results, I expected the quality of lunch should impact the academic performances of students in the afternoon. However, when the regression was run as a class no significant results were found. One contributing factor may have been that each student has a different mathematical ability.

Individual Analysis

After considering each student's ability in mathematics may be affecting the results when examined as a class, I decided to look at each student individually for a

correlation. The class results may have been affected because each student develops at a different rate. Eating better may help that particular student perform significantly better, but not out perform a student who finds math easy. For that reason, the relationship between the quality of their lunches and test scores were evaluated over the course of this study. Tables 11 and 12 look at the correlation for each student.

The majority of the students had a strong correlation between how well they ate on a particular day and their performance on their math exam. For example, student A-13 has a correlation of .99716, A-20 had .97706, B-1 showed a correlation of .99503, and B-16 had .99166. All of these students and many others showed that the better they ate the better they performed on their exam. This demonstrates that the mathematical ability or another factor may have hindered the results when looked at as a class.

Even after taking the average correlation of each student within the class, the mean was found to be statistically significant. Class A had an average correlation of .59 and class B .64. Only classes A and B were analyzed because I had to have at least three data points per student to get accurate results.

These findings suggest a correlation may exist between the diet quality of a student's lunch and how well he or she performs academically. One reason for this is the varied learning levels of each student. It is hard to examine a class for a relationship between the healthiness of a lunch and test performance because each student is at a different place and will perform differently. Every student has different challenges in math that may be prohibiting them from doing well, but with the enhanced nutrition they are able to improve their performance.

The results of the students individually match up with the research in the literature review. Many studies suggested that students need micronutrients and a balanced diet in order to have proper brain function. These coincide with other studies involving the relationship between breakfast and academic performance. Such studies showed a correlation between eating breakfast and performing better academically. Both of those results were found in this study. The correlation that was found between each student's healthy eating index scores and the student's test scores demonstrates that the more balanced the student's diet is, the better his or her brain can function and focus on the test the student is taking. The average correlation for each individual found in this study is similar to the correlation found in studies performed on breakfast and academic performance. Therefore, I can conclude that a healthy lunch is equally as important as consuming a well balanced breakfast in order for our students to increase their academic performance in the afternoon.

Implications/Recommendations

This quantitative study suggests that students who eat something for lunch do better academically than those who choose to skip lunch. Students who bring their lunch from home have a tendency to do slightly better than those who eat a school provided lunch even though the food is slightly less nutritious. No correlation was found to exist when the relationship between the healthiness of lunch and academic performance was examined as a class. There was, however a correlation present when examined as individuals. These results suggest we should be providing our students with healthy choices and encouraging them all to eat during their lunchtime. Improving the food

choices of pre-adolescents may increase their performances at school, but it is not necessary for students to bring lunches from home to increase their academic scores.

The results of this study leave me wondering, what results would occur if a few student's lunch habits were followed throughout the year. This type of study would allow research to be done in other academic subjects such as language arts or social studies. Also, being able to follow a few students closely would allow for more conversations with the students on what they were eating, how they felt when taking the test, do they find they are able to be easily successful in this subject, etc. Another follow up to this study could involve taking a closer look at the results of the classes directly after lunch compared to those a few hours later. Do the effects of lunch decrease throughout the afternoon? Taking a qualitative spin on the results produced thus far would provide more in depth insight into how the nutritional value of a student's lunch might affect the student's academic performance in the afternoon.

Conclusion

This study produced results that were consistent with prior findings. Schools are providing healthier lunch options, but these lunches on average are not quite in the "good" range on the USDA healthy eating index scale. As discussed in the literature review, there may be a weak correlation between the quality of a students' diet and their academic performances. When students are deficient in some micronutrients, their brains are not fully functioning, but breakfast can significantly improve student performance by providing a more regular supply of energy to the brain. Similar to the result breakfast can play on a child's academic performance, I can conclude that providing students with a healthy lunch will help increase their academic performance in the afternoon.

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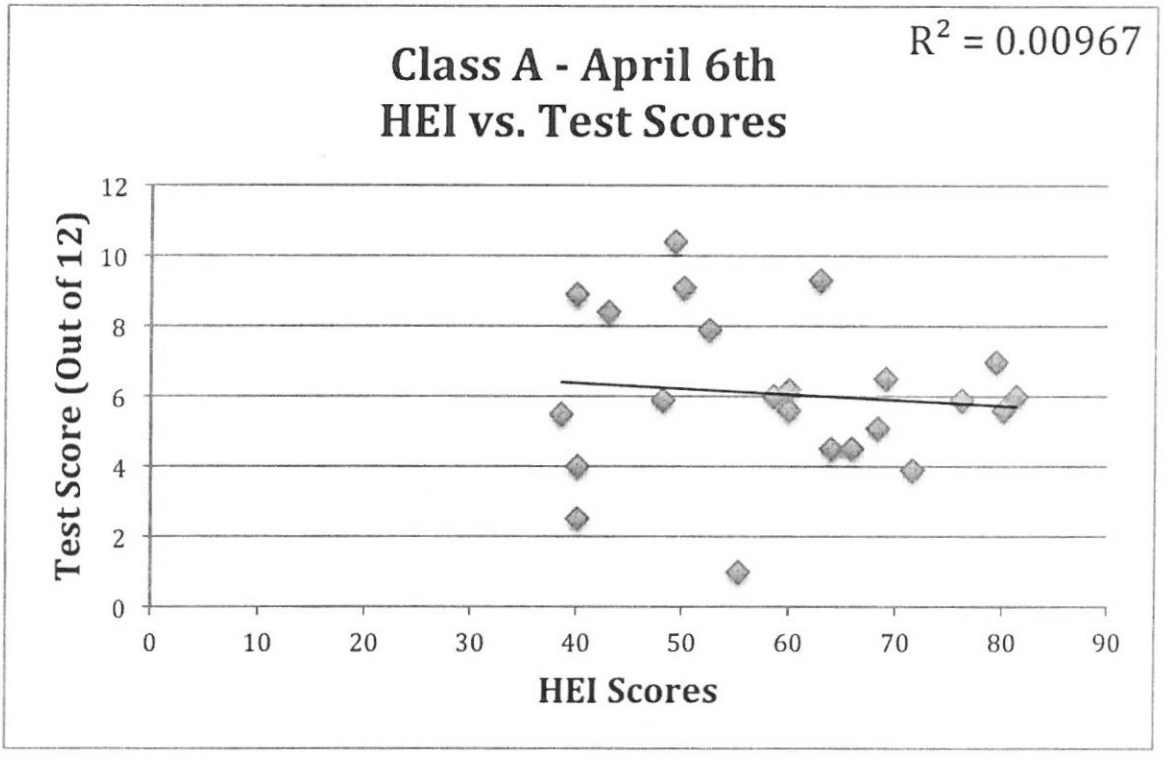
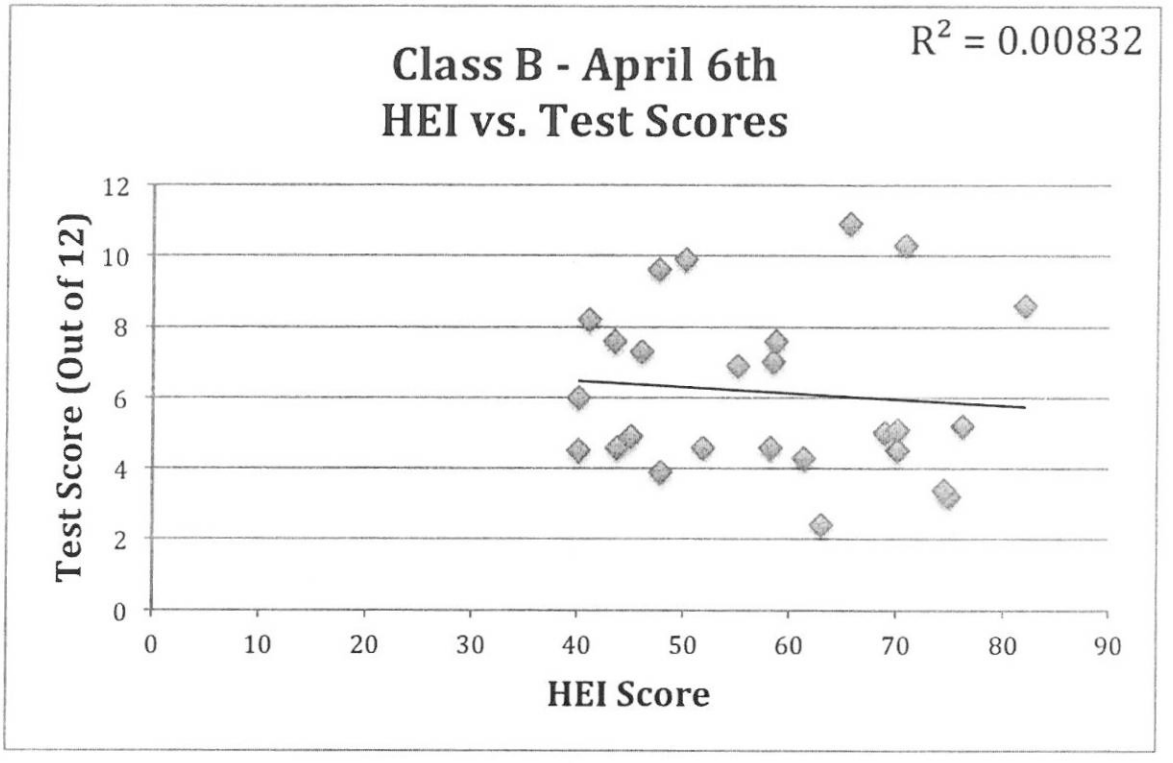
Appendix A

COMPONENT	MALES	FEMALES
GRAINS	2.00	1.67
VEGETABLES	0.83	0.67
FRUIT	0.50	0.50
MILK	1.00	1.00
MEAT	1.67	1.67
FAT	30% - 45%	30% - 45%
SATURATED FAT	10% - 15%	10% - 15%
CHOLESTROL	100 mg - 150 mg	100 mg - 150 mg
SODIUM	800 mg - 1600 mg	800 mg - 1600 mg

Appendix B




Class B - April 6th
HEI vs. Test Scores
$R^2 = 0.00832$
Test Score (Out of 12)
HEI Score
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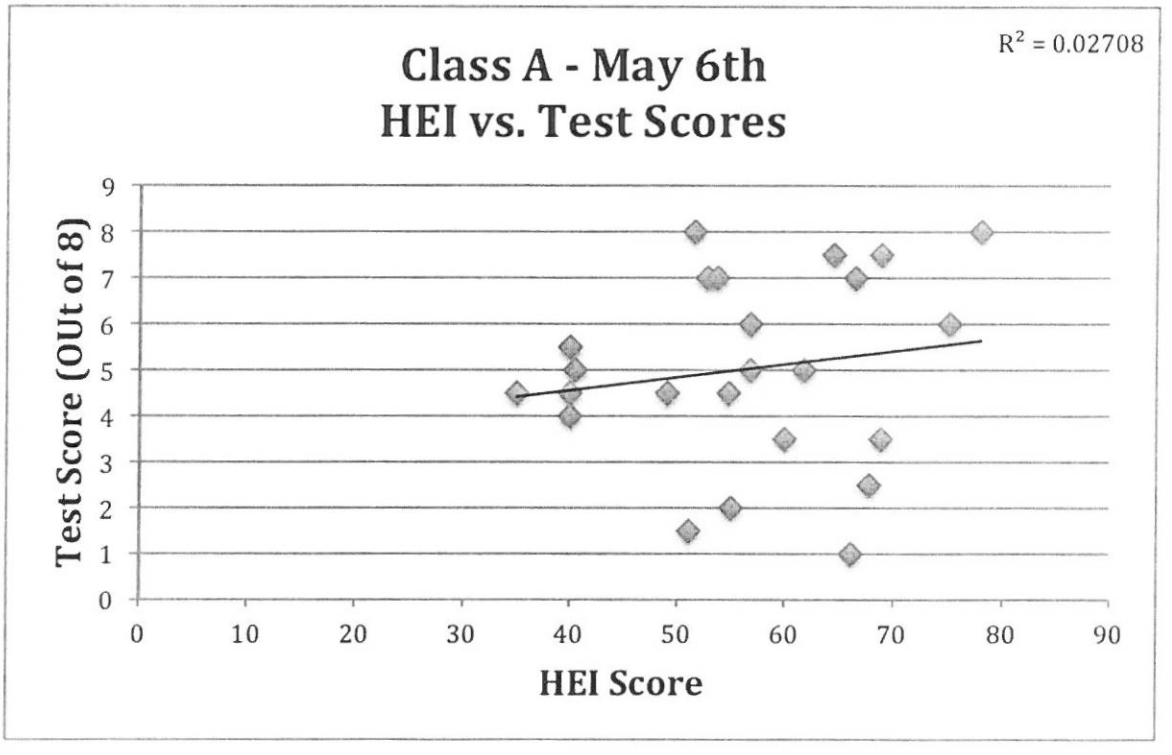
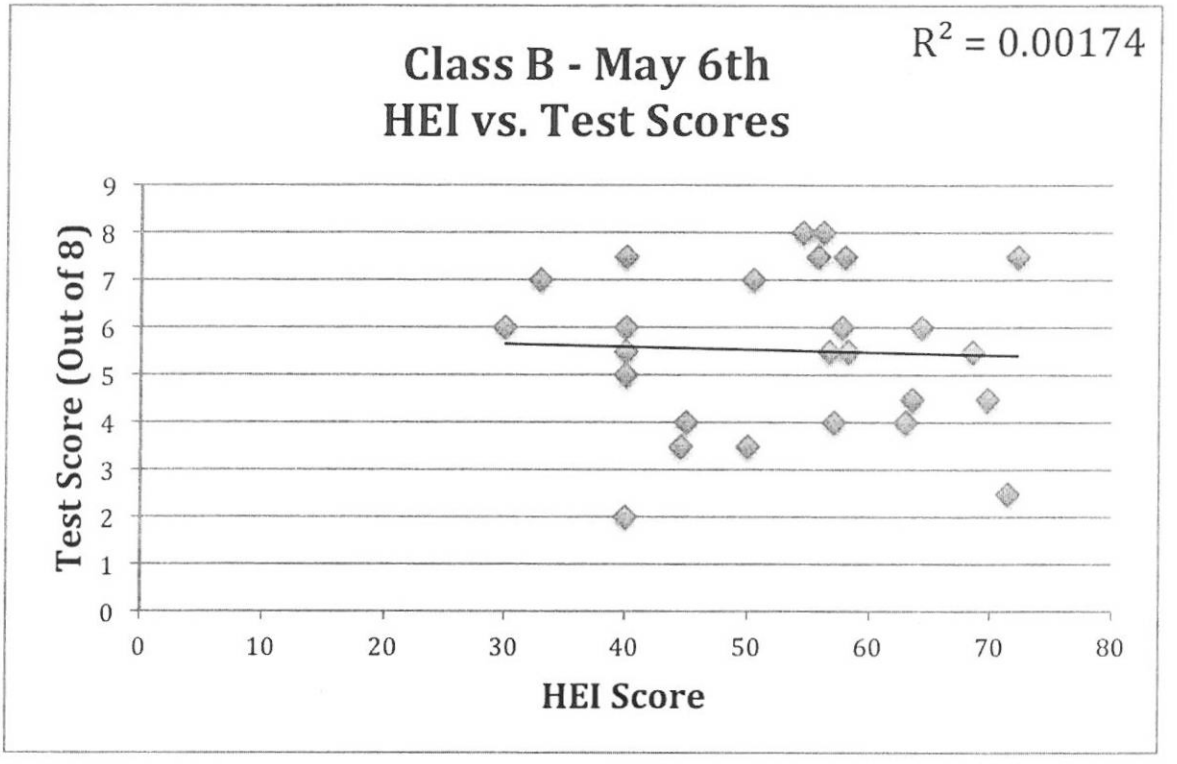
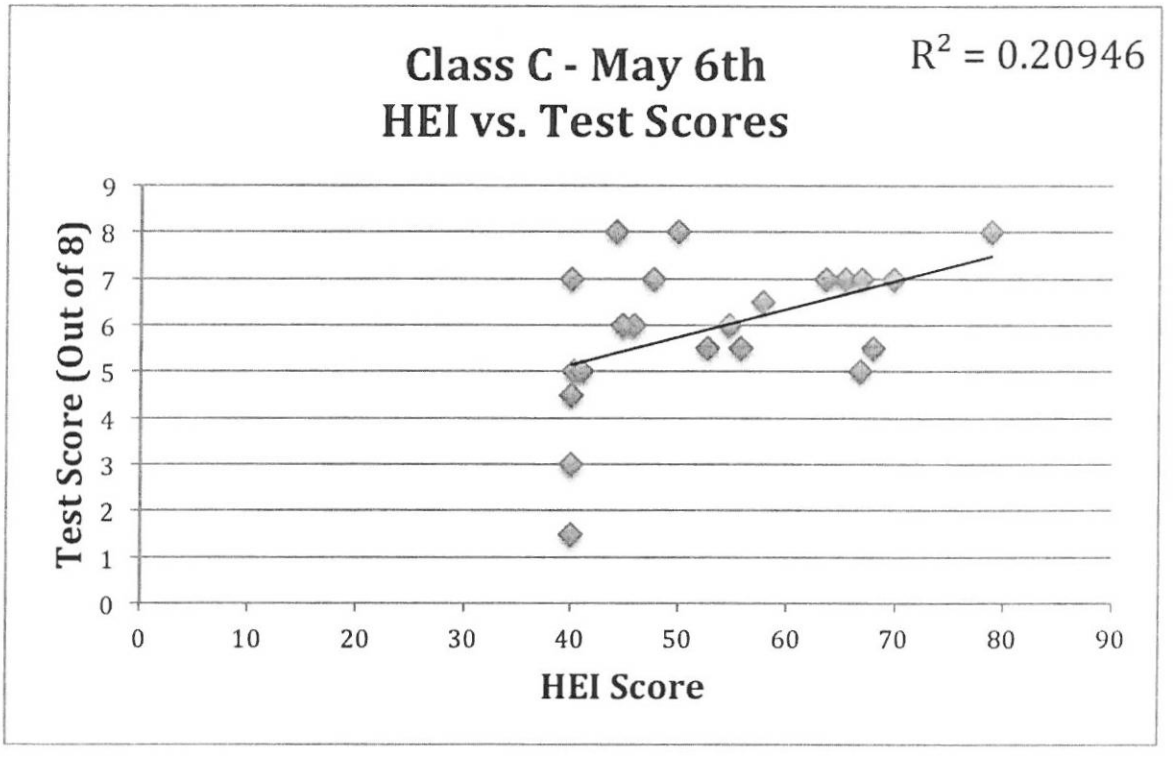
2
4
6
8
10
12
0
10
20
30
40
50
60
70
80
90


Class A - May 6th
HEI vs. Test Scores
$R^2 = 0.02708$
Test Score (OUt of 8)
HEI Score
0
1
2
3
4
5
6
7
8
9
0
10
20
30
40
50
60
70
80
90


Class B - May 6th
HEI vs. Test Scores
$R^2 = 0.00174$
Test Score (Out of 8)
HEI Score
0
1
2
3
4
5
6
7
8
9
0
10
20
30
40
50
60
70
80


Class C - May 6th
HEI vs. Test Scores
$R^2 = 0.20946$
Test Score (Out of 8)
HEI Score
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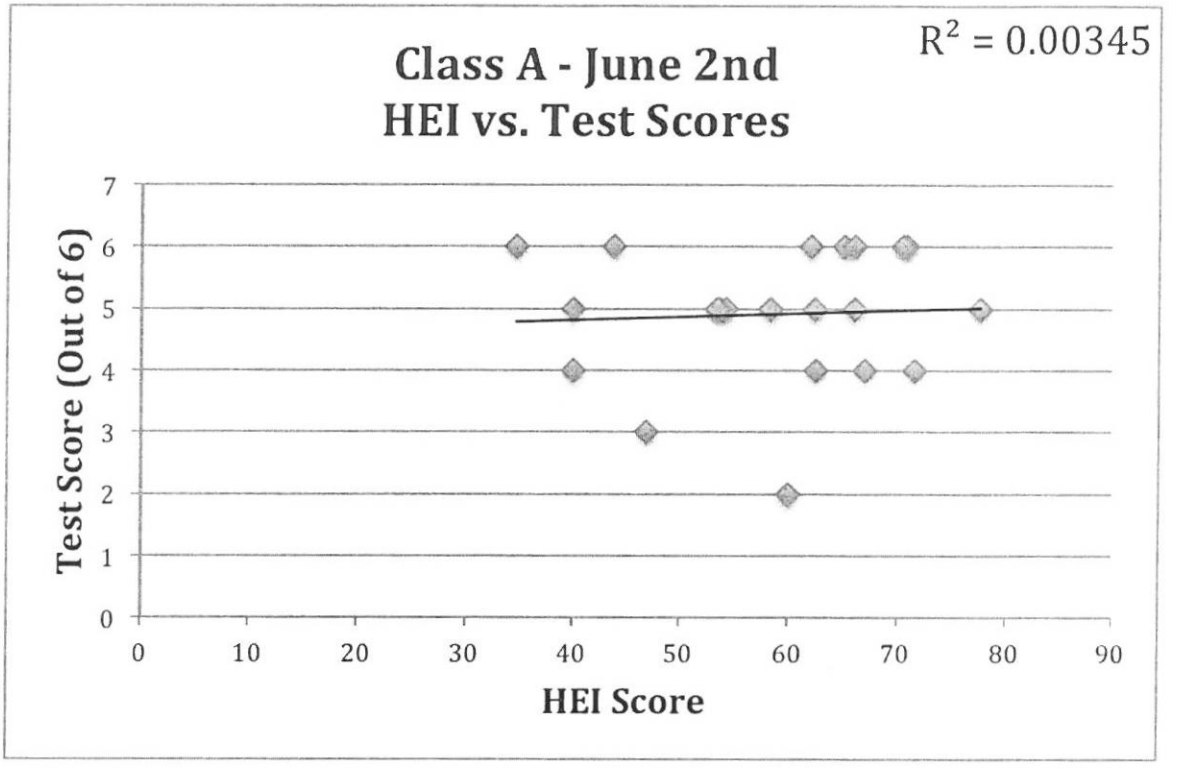
4
5
6
7
8
9
0
10
20
30
40
50
60
70
80
90


Class A - June 2nd
HEI vs. Test Scores
$R^2 = 0.00345$
Test Score (Out of 6)
HEI Score
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3
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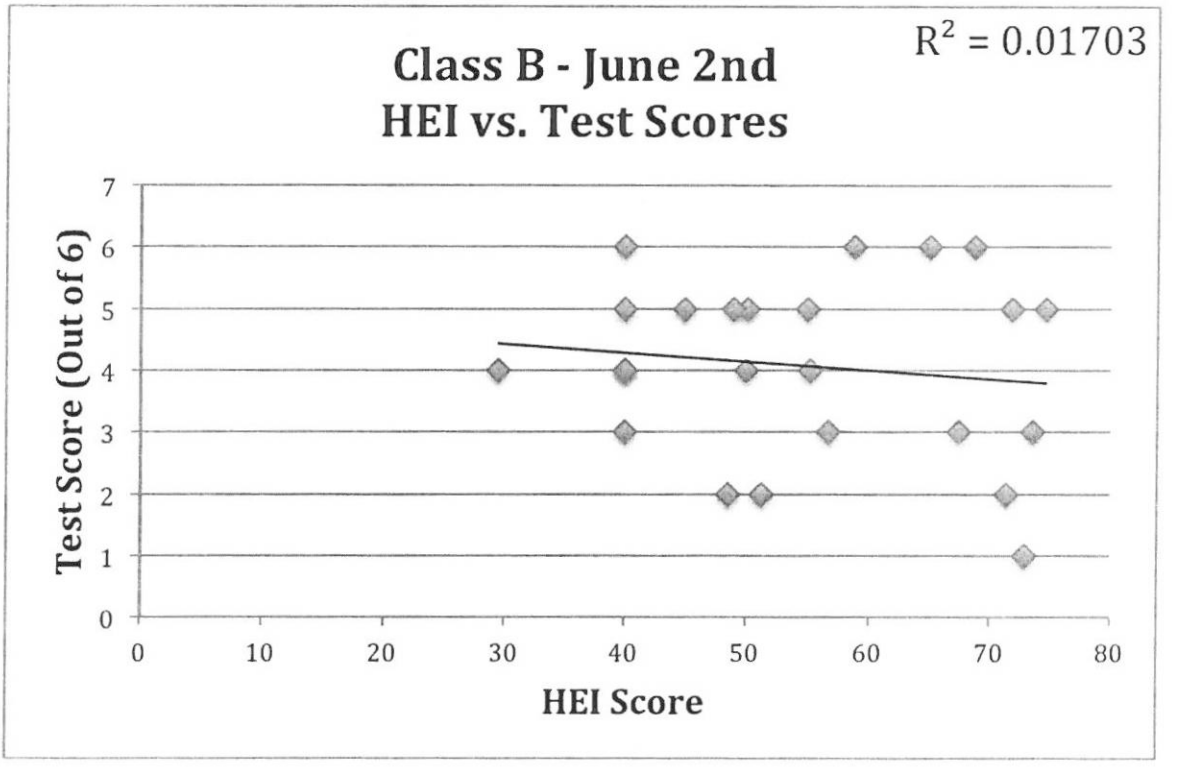
6
7
0
10
20
30
40
50
60
70
80
90


Class B - June 2nd
HEI vs. Test Scores
$R^2 = 0.01703$
Test Score (Out of 6)
HEI Score
0
1
2
3
4
5
6
7
0
10
20
30
40
50
60
70
80