FINAL REPORT: February 2015

Enhancing Educational Achievement: Reducing Effects of ADHD and Learning Differences with Exercise

The Health and Optimism Provided with Exercise (HOPE) Study: A unique experimental design at Shelton School of Dallas, Texas

Shelton School
August 1, 2012 to December 2014

HOPE Feasibility Final Report: February 2015

This is the final report for **The Health and Optimism Provided with Exercise (HOPE) Study.** This was a unique experimental design conducted at the Shelton School. The objective of the study was to enhance educational achievement by reducing effects of ADHD and Learning Differences with exercise. The study was successful in implementing a monitored exercise program with spinning bikes and telemetric EKG monitoring in a health class at the Shelton School that was enthusiastically accepted and endorsed by the students. The program was conducted over a two year period with four different cohorts completing the study.

The following letter captures the essence of the most hoped for outcome for a study of this sort. It is from a student who was so excited about his improvement while taking the exercise health class that he wanted to report to the administration his accomplishments.

(See Exhibit 1, next page.)

Exhibit 1.

Zak Fisher made these comments about his participation in the exercise Study during the second semester of the study January to May 2014.

Before being in the Shelton Health Class and participating in the exercise study, I felt:

- Overloaded
- Anxious
- Sick more and missed more days of school
- Needed medications
- Insomnia
- Stress
- Almost failed Biology
- Lack of incentive

During the study I felt:

- Less stress
- Did not need medications
- Slept better
- Finished homework faster
- Eating and drinking better (less soft drinks)
- Aware of everything around me yet focused and in control.

Other Comments from Zak:
I am grateful that this experience has taught me how to control my ADHD.
Medications helped but I feel better off medications.
I really liked the class.
Once the class started I could ride for hours.
I like to stand to make it more physical.
This year I am going to ride before school and midday for the exercise.
The exercise increased my focus for 4 – 5 hours.
Font size and spacing help me with my reading challenges.

Zachary Fisher
Zak Fisher

11/05/14
Date

SUBJECT PARTICIPATION: There was continued excellent participation in the study over the two year period from January 2013 to December 2014 with good gender representation for the study.

Table 1: Demographics: Gender of Participants Cohorts 1 - 4

		Frequency	Percent	Cumulative Percent
Valid	Female	71	36.2	36.2
	Male	125	63.8	100.0
	Total	196	100.0	

DESIGN: The unique experimental design of the study at the Shelton School incorporates both within group (before and after measures for each subject) and between group comparisons. Between group comparisons include wait-list controls compared to the exercise experimental group (gender and those with and without ADHD within each of exercise/waitlist groups). The study was essentially repeated a total of four times over four different semesters for two years assuring good representation of students and demonstrating replicability and sustainability. The aerobic exercise intervention consisted of the "spinning" exercise bikes in the semester-long health class conducted by Coach McBride. Participants were taught how to achieve and maintain an average heart rate (HR) >70% Max or approximately 10Kcal/kg energy expenditure for a minimum of 20 minutes at the beginning of each class. After the completion of the exercise, the teacher presented the lesson and the students could take notes on their computers which were mounted on the bikes and participate in discussion and continue "spinning" if they wanted to which many did. The waitlist control group was made up of participants in other classes the same semester who were similar in age and gender representation but had not yet taken the health class. Following a one semester waiting period many were been crossed over to exercise condition in the second semester (hence, it was possible for all subjects to receive an exercise intervention).

SUBJECT recruitment. The study participants were from the 9-12th grades at Shelton School with ages ranging from 13 to 18. Both genders reported enjoying the class and the addition of the exercise as part of the class which was important for a study such as this. We had good recruitment for the duration of the study (Table 2).

Table 2. Subject Recruitment

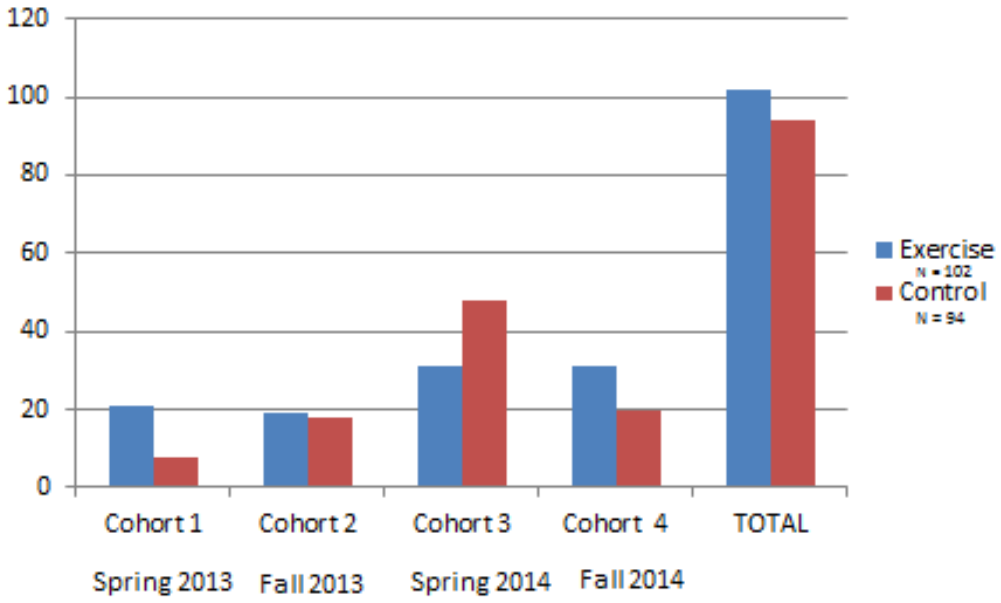


Table 3 summarizes the mean ages for gender by the two groups, and also indicates 95% confidence intervals for age. There were no age differences between either the groups or genders so age does not explain any of the differences found.

Table 3 Demographics. Ages for Gender by Group

Group	Gender	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Exercise	F	15.672	.186	15.305	16.038
	M	15.673	.124	15.429	15.917
Waitlist Control	F	15.752	.162	15.431	16.072
	M	15.592	.128	15.339	15.845

DATA ANALYSES. All results were entered into a set of permanent databases begun in the summer of 2013. These data bases merge data from different sources (computer derived and scored files for the Quotient, data from the TriFit equipment, the Gray Oral Reading test, and the various academic scores coming from different teachers and classes and satisfaction surveys. The design and large amount of data allowed us to do important data analyses utilizing various analyses of variance (including covariate analyses where confounding variables were controlled for), and multiple regressions which will allow us to take into account the obvious

variables of group assignment, age/grade, and gender. We included measures of effect size, eta^2, where values of .01, .06, and .14 represent small, medium, and large effect size which have become increasingly more important than just reporting significant differences (p- values such as the classical p < .05). One of the unique features of this study is the inclusion of participants and measures that result in the first study of a large specialized school where students have a variety of learning differences (insufficient number of subjects at other schools and in earlier studies to look at such factors) and various childhood disorders (such as ADHD) with many on various types of psychotropic medications. As a consequence we reported earlier that we can include the diagnosis of ADHD as a factor in our analyses since approximately half of the participant's records indicate a history of the disorder. Table 4 shows the mean ages by exercise group, gender and ADHD diagnosis and that there were no differences in ages among them.

Table 4. Descriptive Statistics Group by ADHD Diagnosis

Dependent Variable: Age.1

Group	Gender	Diagnosis	Mean	Std. Error	95% Confidence Interval	
					Lower Bound	Upper Bound
Exercise	F	ADHD	15.924	.308	15.315	16.533
		No ADHD	15.419	.207	15.011	15.828
	M	ADHD	15.415	.172	15.076	15.754
		No ADHD	15.931	.178	15.579	16.282
Waitlist Control	F	ADHD	15.986	.267	15.459	16.514
		No ADHD	15.517	.185	15.152	15.882
	M	ADHD	15.380	.193	14.999	15.761
		No ADHD	15.804	.169	15.471	16.138

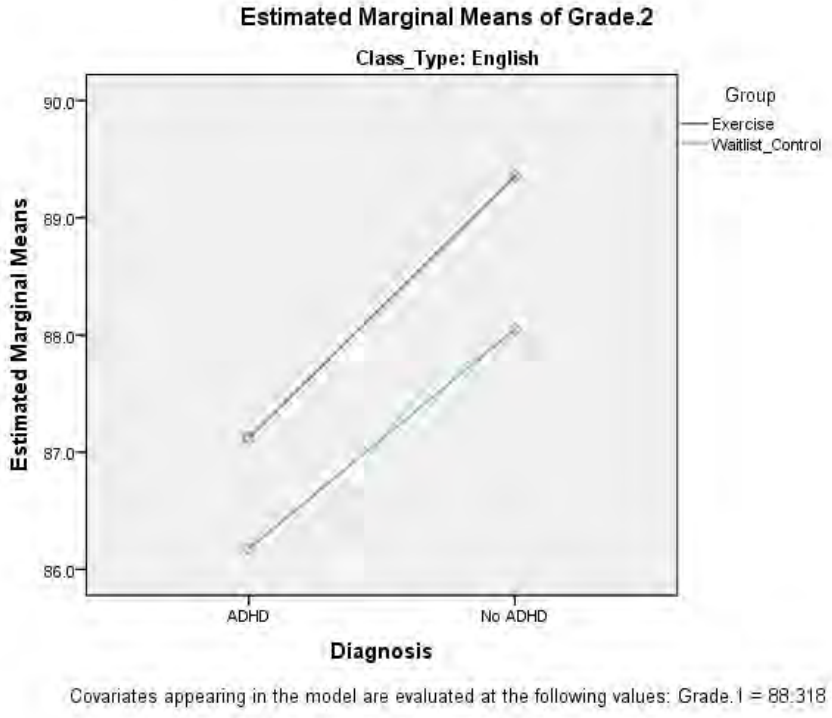
Academic Grades

Average grades at baseline vs. exit for Exercise group based on Percent average of courses before and after Exercise.

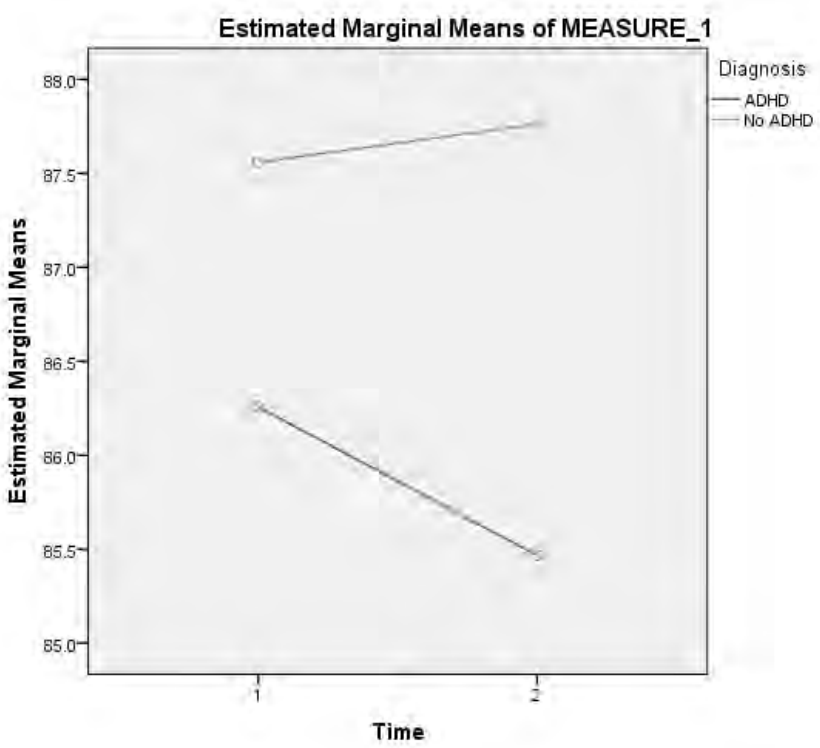
Each student had from 5-8 subjects that they were enrolled in any given semester. The difficulty of the classes varied from semester to semester depending on what they were enrolled in and resulted in a lot of variability and non-equivalency for the grades as an outcome measure. Instead of using overall grade average, we analyzed the specific classes of math and English representing more difficult subjects, courses that many of the participants would be enrolled in both semesters. The semester before exercise intervention served as the subjects own control, with the effects of exercise based on the course grade the following semester. So for each subject, we had grades for the semester before exercise intervention and for the same type of course (English vs. Math) after exercise intervention that we used as our primary outcome measure.

We used two different statistical analytic approaches. In the first we used an analysis that controlled for the baseline grade scores for Math and English (the class the semester before the exercise intervention). For English (but not Math) those without ADHD had overall average grades better than those with ADHD which is to be expected [$F(1,105) = 5.4$, $p = .02$).

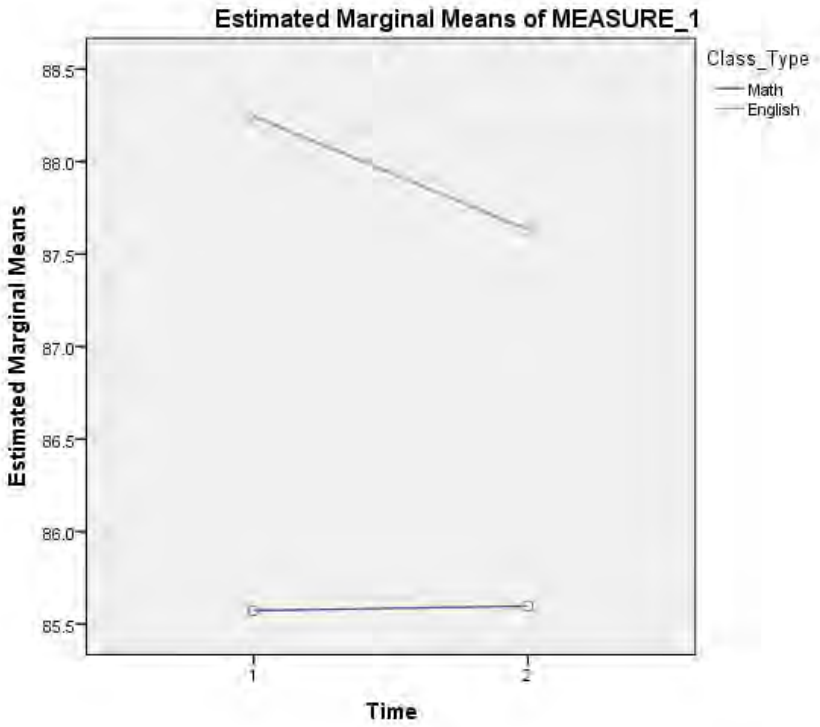
The figure below shows that those in the exercise class were doing better overall than those in the waitlist condition, but this was not a significant finding (p = .2) (more subjects would have been required for it to be significant).



In a second analysis we included the class type as well as the exercise condition and diagnosis in a repeated measure analysis of variance that compares the before and after scores. There were no major findings to support the effects of exercise but we did find that, as above, those without ADHD were performing better than those with ADHD at both baseline and after exercise intervention.



We also found that overall the various participants were performing better in their English class than in the Math classes [$F(1,220) = 8.8$, $p = .003$] but the effects of exercise were not significant ($p = .11$).



In sum, we did not find any effect of this short term exercise intervention on Math and English grades.

TriFit Exercise Class Data:

Cohorts 1-4 exercise subjects.

Table 5 indicates 6 key measures of fitness that were obtained prior to the exercise class and then again at the end of the class using the objective TriFit measuring equipment. These measures were important indices of the impact of exercise and support the physiological benefits that are being derived from the exercise.

TriFit Data: All Exercise results:

Table 5. Paired Samples Statistics (red are significant findings)

		Mean	N	Std. Deviation	t-test	p-values
Pair 1	**Bgn_BMI**	**22.365**	83	4.2328	-1.97	.05
	End_BMI	**22.588**	83	4.0606		
Pair 2	Bgn_Body_Water	81.253	83	17.7735	-.55	.581
	End_Body_Water	81.446	83	18.0590		
Pair 3	Bgn_Body_Mass	111.012	83	24.3764	-.47	.639
	End_Body_Mass	111.241	83	24.5975		
Pair 4	Bgn_Height	66.229	83	3.6033	-1.42	.159
	End_Height	66.410	83	3.6561		
Pair 5	**Bgn_Impedance**	**20.193**	83	9.7761	-4.28	.00005
	End_Impedance	**21.253**	83	10.0351		
Pair 6	**Bgn_Weight**	**140.518**	83	32.9817	-3.92	.00018
	End_Weight	**142.518**	83	32.3289		

Throughout the study significant findings related to changes in the Body Mass Index and body weight as well as the body impedance measures were found. All indicate improvement in overall conditioning and good health for the participants as a result of exercise. For example, bioelectrical impedance analysis is a commonly used method for estimating body composition, and in particular body fat and suggests improved muscle tone. Recent studies note that exercise (without diet intervention) typically results in increased weight as body adipose tissue (fat) is converted to muscle mass which is heavier. This is a good effect, but to lose weight, one will also need to address nutrition in a manner that reduces overall calorie and sugar consumption.

Progress Testing:

Reading Accuracy, Reading Rates, Reading Comprehension based on the Gray Oral Reading Test (GORT) for those that received the exercise intervention.

Multiple analytic approaches were used to thoroughly mine the results of the Gray Oral Reading Test (GORT) for the measures of reading comprehension, reading rate, and reading accuracy. There were no significant differences between the exercise group and the waitlist controls. Based on the fairly large sample size one would tend to conclude that this measure is not sensitive to the short term impact of exercise on these measures. There is also a possible explanation that changing to a newer version of the test midway through the study may have "masked" any differences that might have been found as the newer version scores were found to be different from the prior version scores.

Quotient® Testing of Attention and Body Motion:

Measures of Accuracy and Movement

***Quotient® ADHD System*.** The Quotient® is a computerized continuous performance test assessing a participant's ability to pay attention and focus on a designed "boring" test and ability to sit still. The Pearson Corporation supplied the equipment and scoring for the test at no charge. They are very interested in this work and our findings. The Quotient® provides precise, reliable, and reproducible information on symptom severity under controlled conditions that replicate a classroom environment. Participants wear a headband with an attached motion reflector, which faces an infrared motion analysis tracking system (located just above the computer monitor). They have similar reflectors attached to the shin of each leg. Movement greater than 0.04 mm resolution is detected by the tracking system from the motion reflector, and movement data is collected nearly 50 times per second throughout the 15-minute task[24]. Participants are asked to press the space bar each time they see an eight-pointed star but to inhibit their response to five-pointed stars. Each target appears on a white computer screen for 200 milliseconds in different, random spots on the screen at 2-second intervals. Variables collected include movement (number of position changes), displacement (total distance moved), temporal scaling (pattern of movement in time; lower values reflect less movement), accuracy (percentage of correct responses), omission errors (percentage of missed targets), commission errors (percentage of inaccurate responses to non-targets), latency (average amount of time to respond correctly), and variability (variation in response time to the correct target). We recently confirmed the factor loadings for ADHD using the Quotient® in a paper published in the *Journal of Attention Disorder* (Smith, et al, 2013). We have another paper recently published that demonstrates the

ability of the Quotient® to discriminate ADHD from individuals with oral language disorders (Hughes and Pickering, et al, 2013) that we also conducted at The Shelton School. The computer administered Quotient objective test device has a number of measures that reflect attention, focus and uncontrolled movement (all indices of ADHD-like behaviors and others that affect academic performance). Summarized below are 23 different measures representing both a baseline, and then post-treatment (or wait-list) intervention, or 46 total measures in all that we looked at. Our analyses focused on tests showing areas of improvement following the exercise class at the end of the semester. This extensive test battery was administered to those who participated in the exercise class.

We thank the Pearson Corporation for supplying the equipment and scoring for the test at no charge.

Analytic Approach. All 196 subjects were tested on the Quotient before and after either the Exercise intervention or if in the Waitlist control condition. Prior to conducting the final statistical analysis, we used an SPSS program that looked for any significant anomalies (outliers) in the data. The analysis indicated that data for 9 of the subjects had scores significantly out of range and hence, these individuals' scores were deleted. A second set of analyses looked specifically at the random responding measure (some would just sit there, stare off and hit the button making no serious attempt to complete the test correctly although they had been encouraged to do it correctly). Those who had greater than 10% of their responses scored as random were deleted. A similar approach was done to "minimal" responding, which indicates that the student wasn't even bothering to hit the button. Clearly these are not considered valid test scores and hence were eliminated from the data set.

Multiple analytic techniques were used that included various covariates (consort described below) and where the baseline score was used as a covariate to eliminate any effects of various groups differences that had occurred by chance. We also included major variables for group (exercise vs. waitlist), ADHD (with or w/o), and gender (M or F); all of these are techniques that achieves the minimal error variance and increases the likelihood of finding group differences if they did exist.

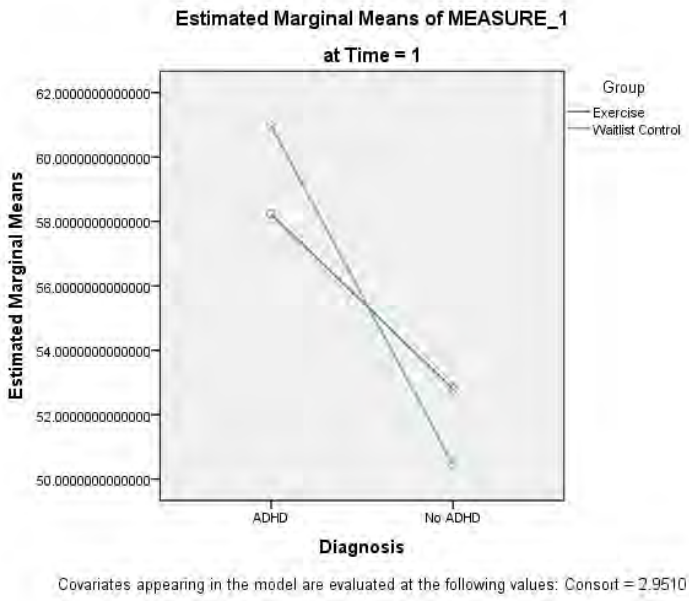
Our focus of this report however remained focused on detecting any differences due to the exercise intervention. As would be expected with the Quotient measures, there were different effects on the various measures found for whether an individual had ADHD or not, and gender differences. These are not reported as exercise or not appeared to have no influence on these finding.

Quotient Significant Findings:

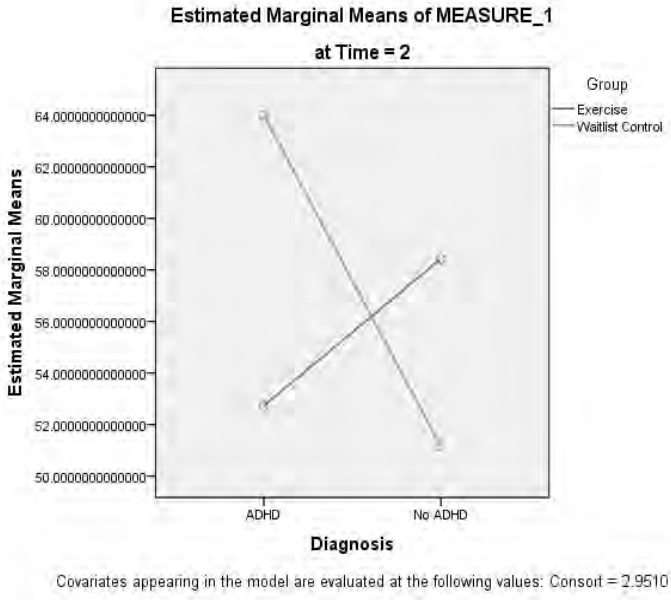
Activity Severity: – a measure of overall movements typical of ADHD.

The Exercise group for those with ADHD improved significantly (i.e., reduced their amounts of excessive physical activity) from their baseline scores whereas there were no changes for those in the Waitlist group. This finding was reflected in a significant group by diagnosis by time interaction [$F(1, 134) = 6.5$, $p = .01$, $\eta 2 = .05$]. The effect size approached a medium effect where effect size ($\eta 2$) values of .01, .06, and .14 represent small, medium, and large effects sizes respectively.

BASELINE (scores prior to exercise)



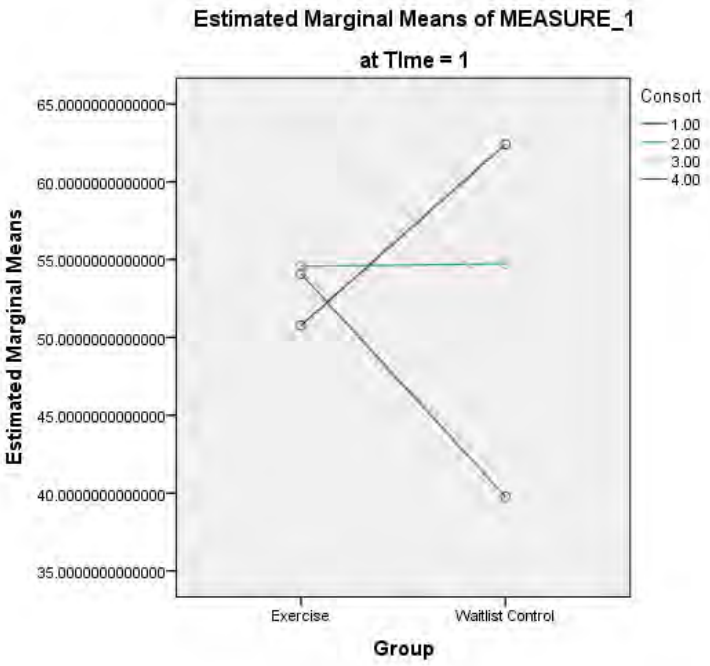
Post Exercise Intervention scores



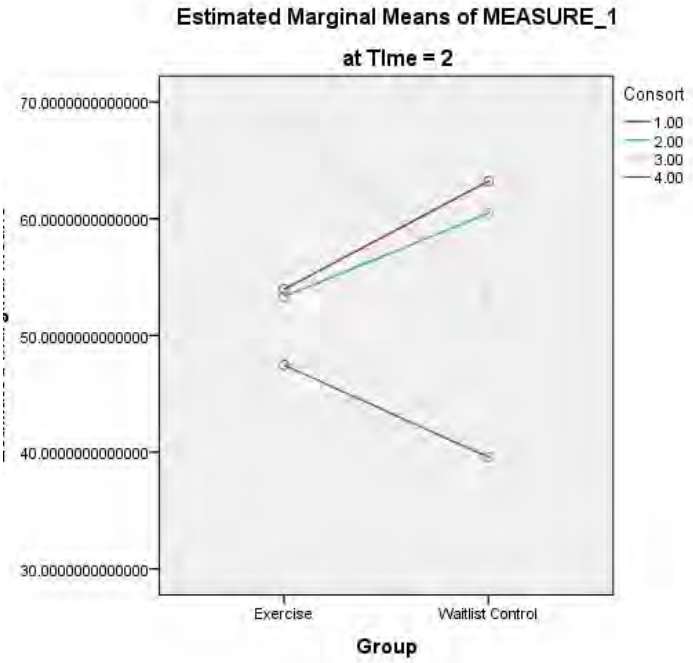
Whereas the Waitlist group scores (Green lines) of the left and right panels don't change pre and post, the Exercise scores (Blue lines) for the ADHD subjects show the decrease activity levels from baseline (left panel) in the post exercise intervention in the right panel.

The following figure summarizes the activity severity scores for each of the four consorts of subjects. The basic take away message was how many differences there were among the four different groups over time. This variability significantly reduces the likelihood of finding consistent statistical differences for the various other Quotient measures.

BASELINE (before exercise or waitlist intervention)



POST EXERCISE OR WAITLIST



There were No Significant Findings on the following measures related to exercise:

ADHD Severity: Not Significant – a combination of measures that sum on overall ADHD traits.
Temporal Scaling of Head: Not Significant - a big decrease by ADHD in the frequency of movement
Random Responding: Not Significant – the tendency to respond in a random fashion indicating a lack of focus.
Inattention Severity – Not Significant
Accuracy – Not Significant (both WC and Exer got better over time; practice effect?)
Commission Errors – Not Significant (both WC and Exer got better over time; practice effect?)
Latency – Not Significant
Variability – Not Significant

Distracted - Not Significant (both WC and Exer got better over time; practice effect?)
Minimal Responding – Not Significant
Immobility of Head – Not Significant
Spatial Complexity of Head - Not Significant
Immobility Shifts – Not Significant
Omission Errors – Not Significant
Covariability – Not Significant
Number of Shifts – Not Significant
Number of Shifts RMC – Not Significant
Attentive – Not Significant
Impulsive – Not Significant
Head Movements – Not Significant
Displacement of Head - Not Significant
Area of the Head - Not Significant

Pictures show a subject sitting at the Quotient® device in the left panel being described the task and having the shin reflectors being attached in the right panel.

Study Satisfaction Surveys

Probably the most important finding comes from the more subjective measures of study satisfaction by the participants as opposed to the quantitative measures summarized above. We administered a follow-up satisfaction of study participation to the students, teachers and the Health Class Instructor as the participants complete the exercise portion of the study for each consort:

1. Have you observed in improvement in the student's (your) ability to focus in class?
2. Have you observed an improvement in the student's (your) memory?
3. Have you observed an improvement in the student's (your) learning?

Comments:
Items were given a score of:
1 = Not at all, 2 = Just a little, 3 = Quite a bit, 4 = Very much

See all of the summary statements from students, teachers and coaches in Appendix 1.

STUDENT FEEDBACK ABOUT THE EXERCISE INTERVENTION.

The following are the feedback that students offered about their impression of how the exercise class had helped them. Unlike the objective measures reported on above, this feedback captures the more subjective and more difficult to quantify, but very important impact of the exercise intervention on the student.

Question 6 of the survey for the student health class participants asked: If you have seen improvement in focus, memory and/or learning please comment on the improvement you have noticed.

(Responses from different students have been placed in quotations w/o correction of spelling or grammar; i.e., it is in their own words.)

"I have been able to learn much better and my memory has increased a lot including my focus."
"I had a good experience in the class but saw no improvements. I never had an issue with focus, memory or learning before. I am still getting the same high A's as I always have."
"Remembering things easier"
"I think this class helped my focus and learning."
"I have not been cycling a lot."
"My memory has gotten a lot better the last couple of weeks then it was before."
"I've gotten good grades on my exams in this class. It has helped my memorization. I focused better.
"I'm happier after the class."
"I have seen improvement in my ability to remember things. It has helped me learn better."
"I've noticed that I am able to focus more and stay on task. Within the first month I was able to learn much easier."
"I have been able to focus much more during and post riding the bike." My retention of information has increased."
"I feel that while riding I was able to focus better same as when I shake my leg I do it to help me focu and keep myself alert."
"I have some improvements, I, have, been doing a little better with stamina."
I can remember vocab words and deffinitions [sic] a little better"
"Because of this class, I have started to make quizlets for most of my quizzes or tests and I have become more active in learning and studying by taking short breaks to let the body move."
"I focus more in 6th period during notes after we bike."
"None"
"I am able to remeber things a lot more and longer. I stay more focus especially towards the end off the day."
"Its easier to focus"
"I tend to feel moe aware and more alert the next period."
"I haven't seen anything to big in my ability to focus and to memorize material."
"Remember class discusins better feel like im mere focussed."
"No difference"
"None"
"Memory, learning"
"I have noticed improvement in learning and focus."

“I am able to improve my study stratagies like memorization after my class.”
“I’ve seen improvement, because I’ve been doing better on tests and memory.”
“I’ve noticed that I am more inclined to pay attention and not goof off.”
“Yes, I’ve been able to stay focused and awake throughout each class.”
“I don’t dose off anymore in class.”
“Yes, I have noticed I am able to focus a little bit better.”
“It doesn’t help me by getting on the bike and me dripping sweat & I am pale & feel like I am going to pass out.” “Makes me fall asleep cause I ran so hard”
“I have not seen any improvement in memory or learning.”
“My ability to memorize terms and dates for class had improved dramatically.”
“It has helped me focus in class when I am biking.”
“I have been to fill out work sheets and pertain the information that is given to me.”
“I can’t tell the difference”.
“I have been understaning better in all of my classes.”
“I’m making better grades than last year.”
“Remebering things after I exercise is easier”.
“I can memorize things very easily.”
“feel more focused and all around prepared.”
“I have seen improvement in focuseing in other classes. It helps me learn better.”
“I don’t know”
“I feel I hav a better focus later in the day after health.”
“I am abel to rember small details better than I used to.”
“I have been able to focus more intensly in my falening classes. The biking has been benifitiial to my attention span as well as help physicly.”

Clearly the overall subjective experience of the majority of the students is very positive. It is very important to have an intervention that is enjoyed and viewed as beneficial and this exercise intervention was definitely view that way.

SUMMARY

Summary of Results: We have successfully completed all four cohorts of subjects this past fall. Data for 196 subjects were collected. We demonstrated that subjects will participate in a semester long intervention that required exercise on "spinning" bikes while being required to maintain a 70% max of heart rate with individual rates projected up on to a screen at the front of the class. These individuals also participated in additional tests of attention, focus, and movement at the beginning and end of the semester as well as TriFit measures of physiological fitness along with their standard measures of academic performance. Exercise participants demonstrated improvement and overwhelming reported enjoying the class. Data bases were established and finalized and analyzed for the huge volume of data collected. Experience from the first cohort of subjects led to a significant improvement in the process for obtaining consent and assuring that the necessary physicals were completed before beginning the study for all future cohorts. This was reflected in the continued excellent enrollment of subjects with each subsequent cohort. We had good gender and different grade level representation as well as a variety of learning differences, attention disorders, and medications represented which contributes to the uniqueness of this study. The study demonstrated differentiation in the academic and attention performances of those who get the exercise intervention versus those that do not.

So in sum, the students have responded well to the use of "spinning" bikes in the classroom and have been able to meet the exercise goals. Use of the TRI-FIT monitoring equipment continues to be an essential part of the study for monitoring heart rate while exercising. The equipment also helped to demonstrate an improvement in overall conditioning as reflected in the reduced body fat and water, and improvement in body impedance indicating the overall conditioning level of the individual. These physiological measures were important to the credibility of the study demonstrating that the exercise intervention was adhered to. The positive ratings for the exercise class and the enthusiasm for participating are one of those extremely important subjective findings that are very encouraging (see Appendix 1).

The use of the objective Quotient® ADHD continuous performance task indicated significant reduction in overall hyperactivity for those with ADHD who were in the exercise group. We also found a number of additional differences for gender and ADHD as we increased the power of the analyses with additional participants. We also found differences in the various cohorts which were to be expected. These differences however were not an effect of exercise.

The grades used as a metric for overall academic performance had a lot of variability. So for this set of analyses we focused in on the Math and English classes specifically. However, we were unable to demonstrate positive effects of the exercise intervention on academic performance in the more rigorous courses.

The survey of the health class instructor and student participants, as well as the various teachers of these provided important feedback. The students continued to be very positive in their response to the exercise in the classroom. One would anticipate that some just would not find it attractive (no outright negative responses were found). By contrast they report enjoying it, and importantly many noticing significant improvement in ability to focus, memory and learning ability in general which is a very important finding. The findings from the various teachers were mixed in that some saw no change in some cases, but in others significant improvement. A closer inspection of these results reflected the baseline performance of the student. If the student was already doing an excellent job in the classroom the teacher reported that there was no room for change as would be expected. But more importantly, the

intervention was designed for those who were struggling in different ways with the class work and it is those where the improvements are reported. These subjective/qualitative findings lend support for the importance of this study.

The HOPE study made a number of unique contributions to existing data: The majority of information about the effectiveness of exercise in school settings to date is non-experimental without appropriate control groups; rather the conclusions are based on variants of anecdotal reporting and correlational studies (which limits cause/effect conclusions). It is important to test the concept with experimental designs that include appropriate control groups. We conducted such a unique experimental design at the Shelton School. Shelton School, as the largest school that focuses on learning differences in the country, creates the additional unique opportunity to study exercise as a non-pharmacological intervention to enhance the overall learning skills and academic performance in a population of well-diagnosed adolescents with learning difference and various attention disorders (e.g., ADHD). This is the first, large scale experimental study of such students. It could be argued that these are students that could stand to benefit most from such an intervention if effective. It is important to test the effectiveness of exercise for this population.

Significance

The study has contributed to the strong need for non-medication alternatives for the treatment of Attention-Deficit/Hyperactivity Disorder (ADHD) and enhancing educational achievement for children and adolescents with different types of learning disabilities/differences (LD). Recent research suggests that aerobic exercise may be a potential such treatment based on the increased release of Brain Derived Neurotropic Factor (BDNF) and brain neurotransmitters that accompanies vigorous exercise. ADHD is one of the most prevalent disorders of childhood causing substantial social and academic impairment. The estimates of the prevalence of ADHD from the general population range from approximately 2-5% (Costello et al., 1996; Shaffer et al., 1996).

Studies have been conducted showing positive relationships between physical exercise and many aspects of ADHD behavior related to school performance. For example, Etnier (1997) in a review of 134 studies, found a positive association between physical education and cognitive performance. Colcombe (2003) in a review of 18 studies found aerobic exercise and strength training in combination to improve cognitive performance more than either one alone. They concluded that 30 minutes of exercise appeared to produce the best results and this was also reported by Coe (2006). In a different review of 44 studies there was a significant positive relationship between physical activity and cognitive function in children (Sibley, 2003). Different studies of the impact of physical education on academic performance are also positive (Field, 2001; Oh, 2003). The California Department of Education in a 2001 study of nearly one million students (grades 5, 7, 9) showed a positive correlation between levels of fitness and standardized test scores in math and reading. Castelli (2007), in a study of 259 3rd and 5th graders, found positive relations between aerobic fitness measures and scores in reading, math, and total academic performance. All of these studies suggest a positive effect of aerobic exercise on academic performance.

Investigators

Joyce Pickering, M.A., Hum. D, SLP/CC, CALT, QI, LDT – The CEO emerita of Shelton School and expert in children and adolescents with learning differences. She has implemented many innovative approaches to the education of students with learning differences. She and Dr. Hughes worked as research collaborators on the CAARTE project to develop non-medication interventions for children with ADHD. She will be responsible for all aspects of testing related to academic and cognitive performance.

Carroll W. Hughes, Ph.D., ABPP – Former director of research at Shelton School and Professor of Psychiatry at University of Texas Southwestern Medical Center – Dallas will serve as the research design, methods and statistical consultant for the project. He has been the Principal Investigator on National Institutes Mental Health grants and most recently completed a project successfully treating non-medicated depressed adolescents with exercise.

Steve McBride, M.S., Certified Physical Education Teacher – Has been involved in the field of physical education for 25 years and currently is a coach of strength and conditioning, football, track, and cross county. In addition, Coach McBride teaches several Health courses to Shelton high school students

Stephanie Weatherford, Research administration and senior study coordinator. She has extensive experience in recruiting, consenting, and Quotient testing of students and played a key role in coordinating all of the various steps of the research study. The study team recognizes the significant contribution she made to the study and that the success of the study was in part to her attention and follow through to all the details required for a successful study.

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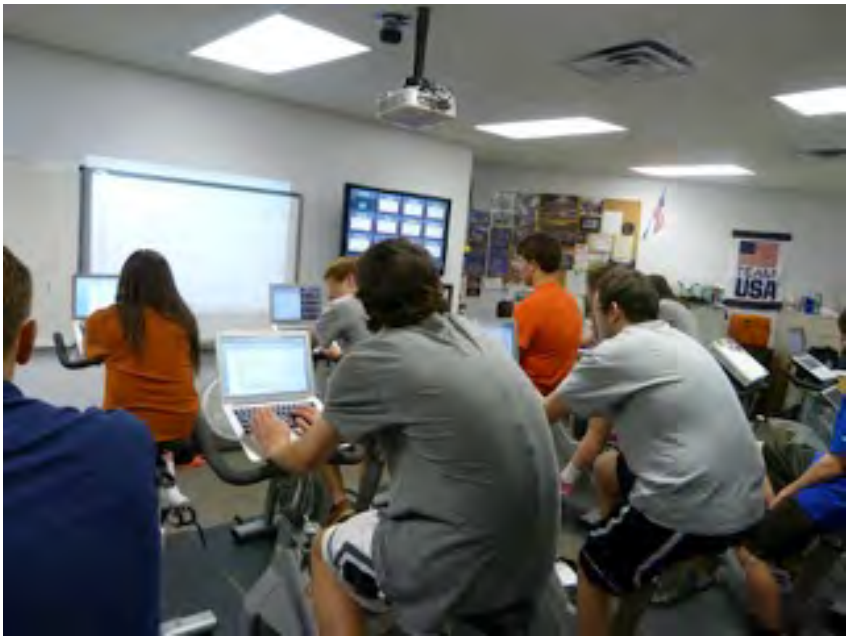
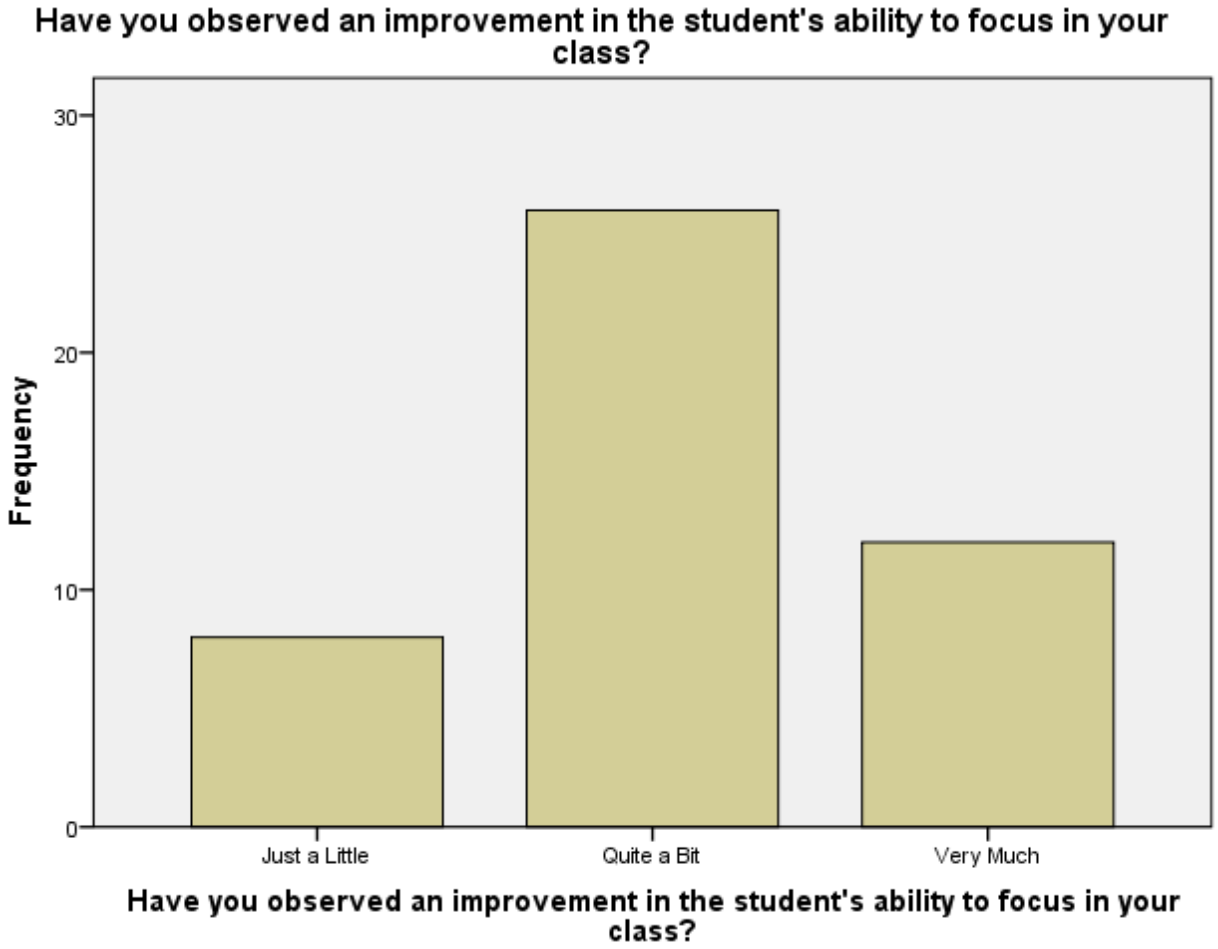
Health Class Exercise Room – Participants in Action



Appendix 1 --- Student, Coach, and Teacher responses to study.

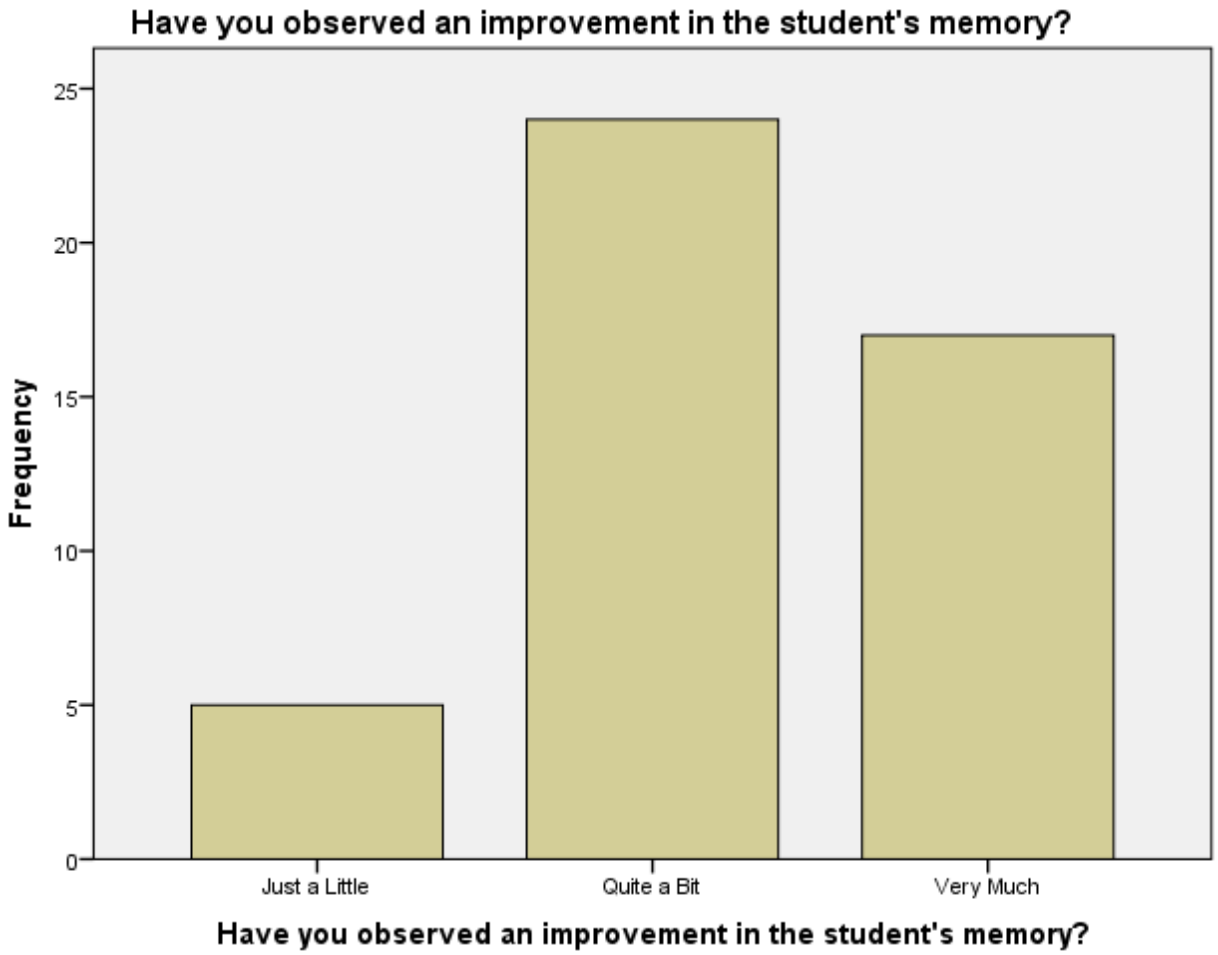
Health Class Instructor:

For the three items the instructor indicated that there were no students for which he didn't see some improvement. In looking at the following three graphs one will note a significantly large percentage that were rated in all three domains of focus, memory and learning to be quite a bit or very much improved.

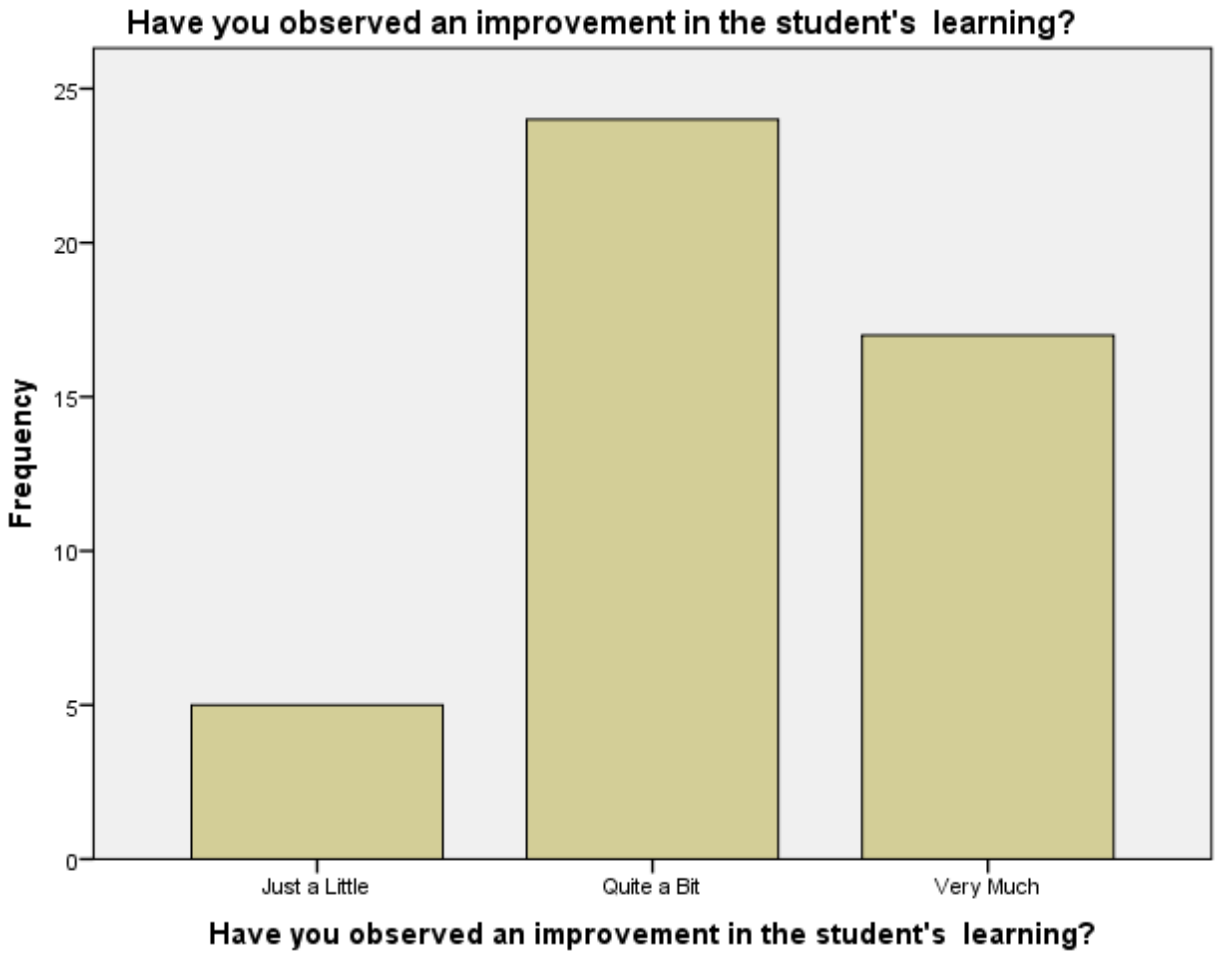


Have you observed an improvement in the student's ability to focus in your class?

		Frequency	Valid Percent	Cumulative Percent
Valid	Just a Little	8	17.4	17.4
	Quite a Bit	26	56.5	73.9
	Very Much	12	26.1	100.0
	Total	46	100.0	

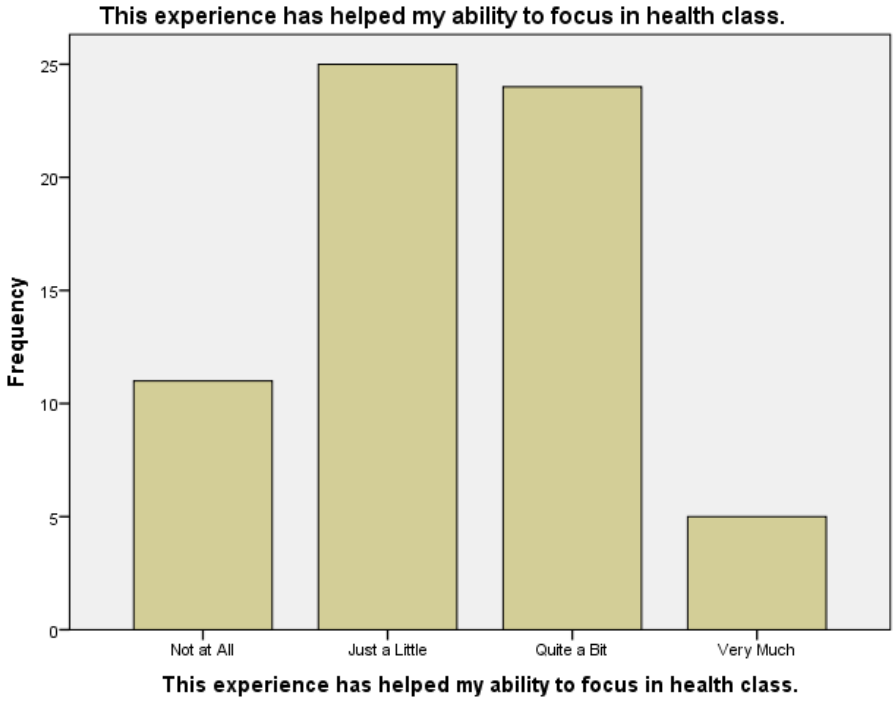


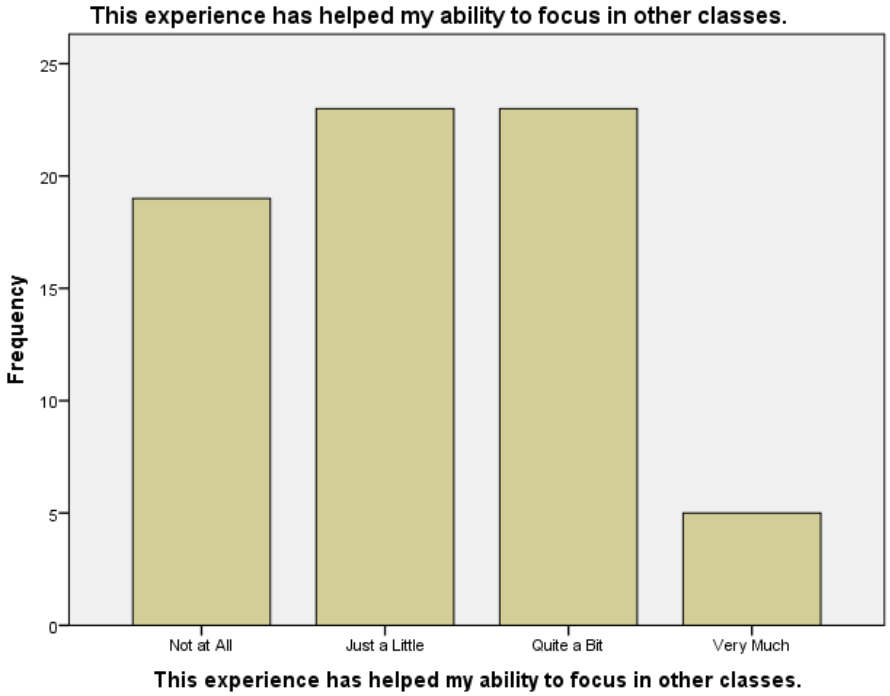
Have you observed an improvement in the student's memory?		Frequency	Valid Percent	Cumulative Percent
Valid	Just a Little	5	10.9	10.9
	Quite a Bit	24	52.2	63.0
	Very Much	17	37.0	100.0
	Total	46	100.0	

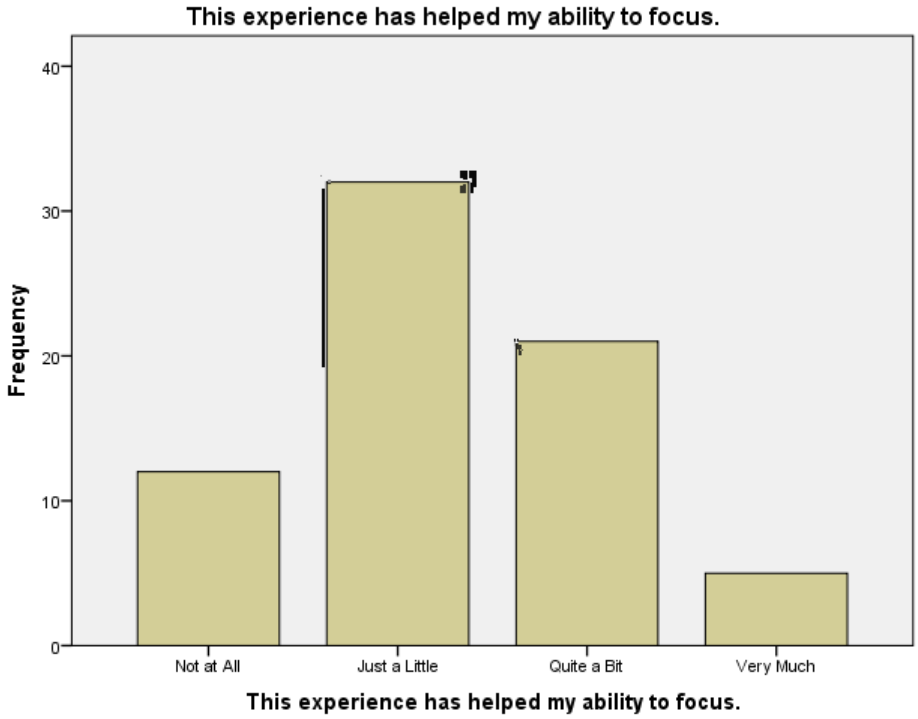


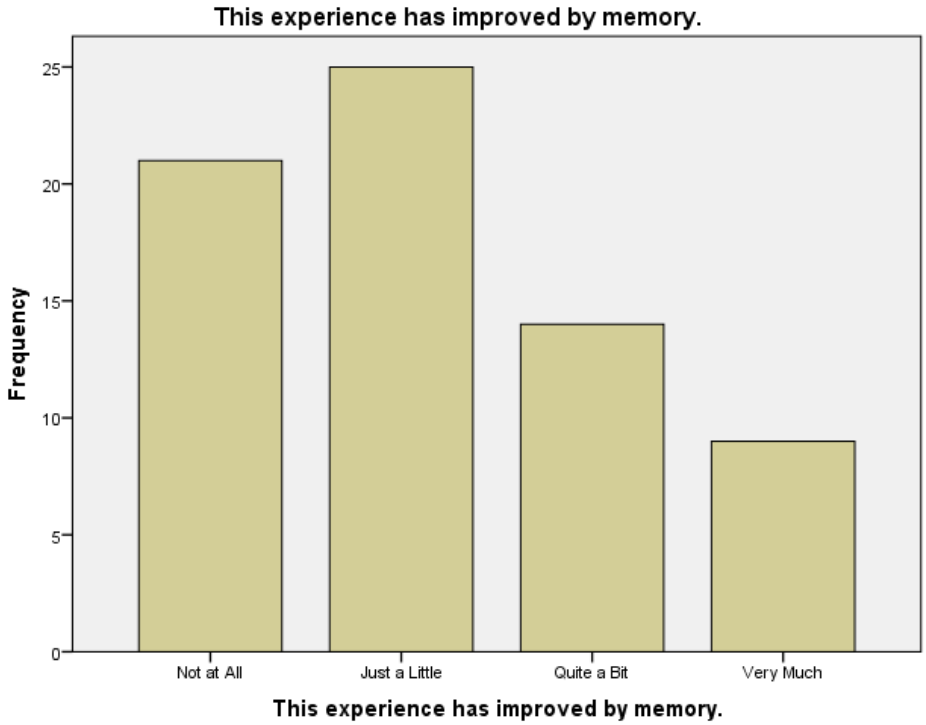
Have you observed an improvement in the student's learning?		Frequency	Valid Percent	Cumulative Percent
Valid	Just a Little	5	10.9	10.9
	Quite a Bit	24	52.2	63.0
	Very Much	17	37.0	100.0
	Total	46	100.0	

Student responses who participated in the exercise class:






This experience has helped my ability to focus.
Frequency
40
30
20
10
0
Not at All
Just a Little
Quite a Bit
Very Much
This experience has helped my ability to focus.


This experience has improved by memory.
Frequency
25
20
15
10
5
0
Not at All
Just a Little
Quite a Bit
Very Much
This experience has improved by memory.

Overall, the students note the most improvement in their ability to focus; less so for improvements in memory and ability to learn. However, the overall trend is for the student to report improvement in all areas.

Question 6 for student Health class participants. If you have seen improvement in focus, memory and/or learning please comment on the improvement you have noticed.

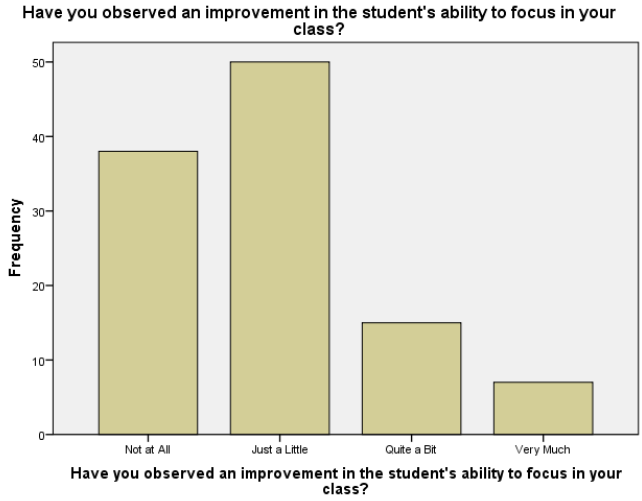
This quite positive report of improvement with exercise information was reported in the text above and not repeated her; please refer back to it.

Teacher responses about students who participated in the exercise class:

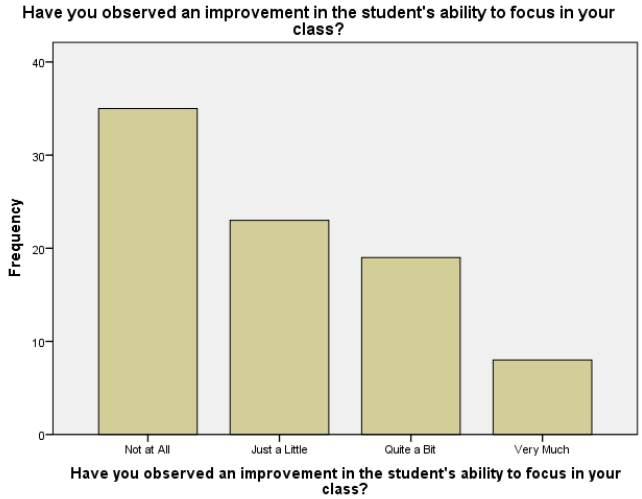
The teacher responses are divided into two response groups based on whether the student went to the exercise class BEFORE theirs, or AFTER. The question was whether the effect was found carried over day to day, or was more directly related to how recently they had exercise; and did exercise right before a class to better than exercise after a class? Interestingly, there were significant differences in the teacher reports between having exercised before versus after a class for all measures.

The data reflect variability in the student's academic abilities related to memory, focus, and learning that are present at the baseline measures of the study. I.e., some teachers will note that the student is already performing at a high level, hence not much room for improvement and no change seen. However, for those students where classroom behavior and performance is not at a high level, one can see where the teacher perceives that it really has benefited the student. It is the latter students that are the focus of this research. If we had selected for only those students, the results would reflect an even stronger impact of the exercise intervention. However, we designed the study to include all as the exercise is all beneficial in non-academic ways as reported for the TriFit data on overall conditioning.

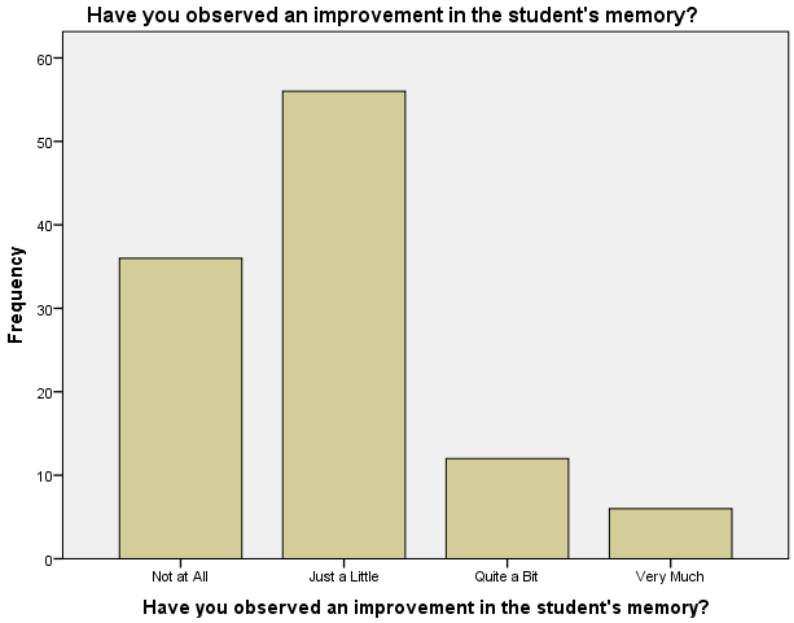
Exercise BEFORE class: ABILITY TO FOCUS [χ^2 (df = 9) 20.2, p = .017]



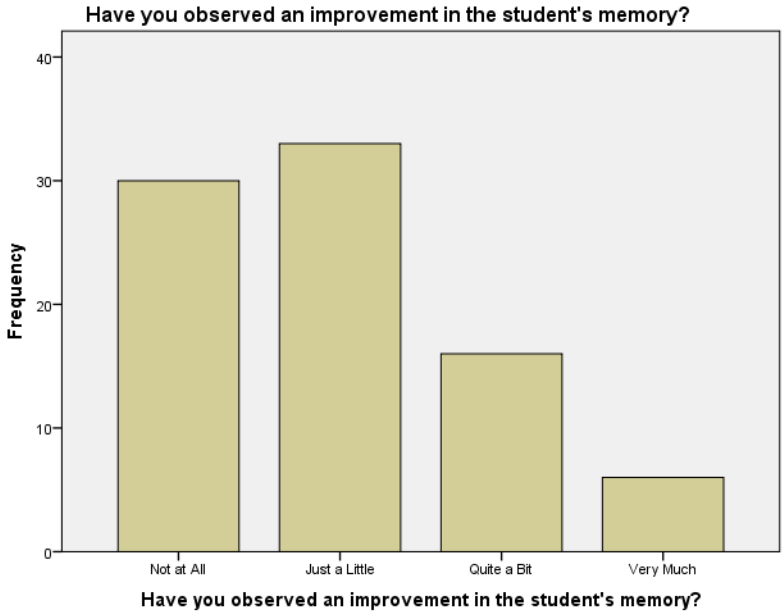
Exercise AFTER class:



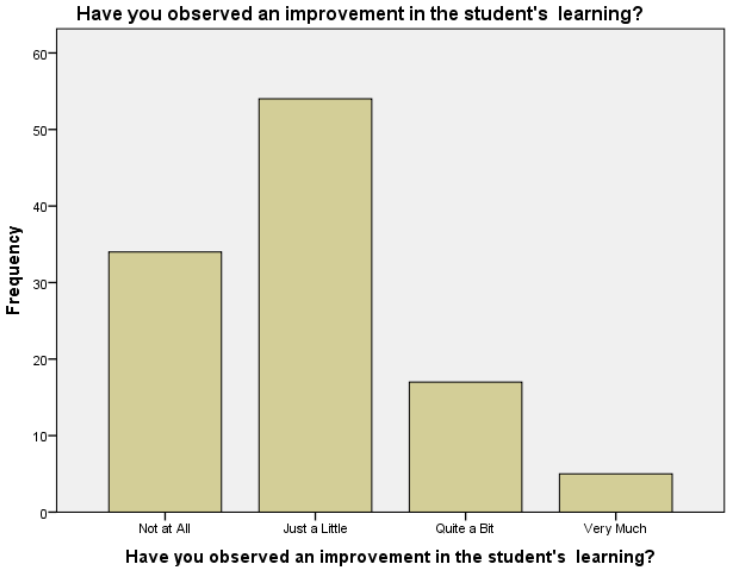
Exercise BEFORE class: IMPROVEMENT IN MEMORY [χ^2 (df = 9) 18.8, p = .027]

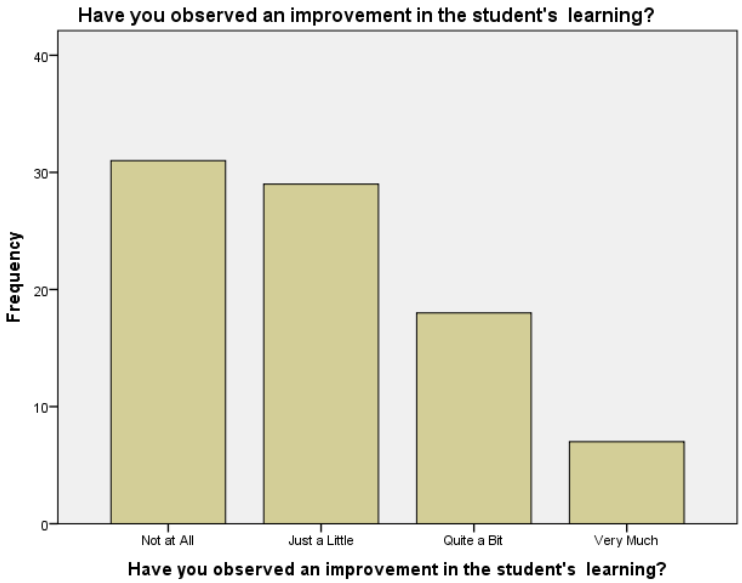


Exercise AFTER class: IMPROVEMENT IN MEMORY



Exercise BEFORE class: IMPROVEMENT IN STUDENT'S ABILITY TO LEARN [χ^2 (df = 9) 21.8, p = .01]





The following reflect the written feedback that teachers reported that go along with the data presented above. We have colored coded to compare comments reflecting exercise before class (**GREEN**) or that the exercise is after the class being evaluated by the teacher (**RED**).

Class occurs AFTER exercise:

He seems a little more focused and serious about his work. BIOLOGY Student 1

Class occurs BEFORE exercise:

In regards to the learning piece, with Football it's a little difficult to gauge because we don't "test". But I can definitely say his focus, attention and willingness to learn and retain has dramatically improved.PE **Student 2**

Class occurs AFTER exercise:

He has been much more alert and has participated more as the semester has gone on. Hard to know what to attribute that to, as students often improve in their willingness to try/take risks and therefore learn as the year goes on. But, the alertness and focus are notable. ART Student 2

Class occurs BEFORE exercise:

He is showing improvement in being able to focus and grasp the material. ALGEBRA I MODIFIED
He is a great student who always gives his best effort. I didn't notice a difference in focusing because he is always focused in class. ENGLISH Student 3

Class occurs AFTER exercise:

He is working very hard and wants to please. I am proud of him! BIOLOGY Student 3

Class occurs BEFORE exercise:

He is always attentive, with an excellent memory and strong focus. ART Student 4

Class occurs AFTER exercise:

He has always had good focus though. BIOLOGY
He seems to be a bit more focused and quick to respond to questions. READING COMPREHENSION
He can be a good student (A-B) but he has gotten involved with theatre so his work quality fluctuates. Generally he is reserved in class, seems attentive and responds appropriately to oral questions in class. WORLD HISTORY Student 4

Class occurs BEFORE exercise:

He has always had great memory. It is hard to answer the questions. He has been on different meds during the semester. ETHICS Student 5

Class occurs BEFORE exercise:

I have him in 8th period for cheer; so it is not a typical classroom setting. While part of what I have noticed may be maturity; he has been attentive and very "settled" during cheer practice. PE Student 6

Class occurs BEFORE exercise:

It is difficult to tell with him. He is so disorganized and so smart. He thinks it has helped! ALGEBRA
I have noticed that even though he does not seem to be focused in class, when I ask him a question, he is right on target with the answer. His memory and learning has always been strong. ENGLISH Student 7

Class occurs AFTER exercise:

He is "beyond brilliant" and is more focused than in August. WRITING LABS Student 7

Class occurs BEFORE exercise:

He has seemed more settled and "sharing" in his classroom contributions. FILM Student 8

Class occurs AFTER exercise:

He is very bright and works very hard – off on tangents is only complaint. BIIOLOGY
He has maintained his interest in learning, but it has not changed. He makes low grades due to not completing work. ALGEBRA Student 8

Class occurs BEFORE exercise:

I have her in 8th grade cheer. As the semester progressed, she seemed to gain focus. PE Student 9

Class occurs AFTER exercise:

She is doing much better on quizzes and tests. BIOLOGY Student 9

Class occurs AFTER exercise:

He is working very hard and I am proud of him! BIOLOGY Student 10

Class occurs BEFORE exercise:

Didn't need to improve. Already a dream student! ANATOMY Student 11

Class occurs AFTER exercise:

He is a strong student – attentive in class, responds appropriately and produces quality work. I have observed no significant change. US HISTORY Student 11

Class occurs BEFORE exercise:

I have experienced her being willing to communicate her particular study-help needs in world history. The exercise may be helping her confidence and willingness to seek assistance. In class she appears attentive, but struggles with the reading. WE read aloud in class (I do it) and there are study guide questions on the smart board that the class answers as we read. She seems to be a good typist and appears to keep up with class. HISTORY
I think that she has improved in both the memory and recall parts of learning. It's hard to tell how much of it is becoming more comfortable and overcoming shyness though. My answers to her improvement are on a spectrum between "a little" and "a lot". Thanks! ENGLISH Student 12

Class occurs AFTER exercise:

She is working very hard and I am proud of her. BIOLOGY Student 12

Class occurs BEFORE exercise:

He does very well in all 3 categories – right from the start. I have not seen change. ALGEBRA Student 13

Class occurs AFTER exercise:

Doesn't need to improve – wonderful student already! BIOLOGY
He does not have trouble in any of these areas in my class; therefore, I have really not seen an improvement. ENGLISH Student 13

Class occurs BEFORE exercise:

He was pretty "droopy" at the beginning of the school year, announcing that he was not good at art and didn't like it. He's improved his skill and the attitude improved with it. That a pretty normal turn around that I work for every year. However, he seems to have more energy and stamina now. He's more awake. I don't think I have to do with that. ART Student 14

Class occurs AFTER exercise:

She has always been an outstanding – to not improvement would be 9.6 to 10. SPEECH
She concentrates very well so no improvement was needed. Algebra is getting harder, so her grades have slipped a tiny bit. ALGEBRA Student 15
She is strong in all of the areas. ENGLISH

Class occurs BEFORE exercise:

He says that he is able to focus more in class – I agree and this is so important for him! ALGEBRA Student 16

Class occurs AFTER exercise:

I have seen improvement in all areas for him. ENGLISH Student 16

Class occurs BEFORE exercise:

I see her in a drill team/practice setting. I have noticed a positive difference starting in mid-November. She is more focused, organized and has a better attitude. PE

She arrives to 7th period typically exhausted, lethargic with a very inconsistent level of focus. THEATRE Student 17

Class occurs AFTER exercise:

She has been able to focus on Algebra. ALGEBRA

She is doing well when she studies and focuses in class. She is working hard and I'm proud of her! BIOLOGY Student 17

Class occurs AFTER exercise:

She has made great improvements in all areas. ENGLISH Student 18

Class occurs BEFORE exercise:

Still not able to stay focused for any length of time. ALGEBRA – regular.

He has improved a little bit in biology. He has had a homework coach so I'm not sure how much is attributed to that or the exercise study. BIOLOGY Student 19

Class occurs AFTER exercise:

However, he also transferred to a different class – less distracting. His focus has improved … less fidgeting, angst and disturbing others. . FILM Student 20

Class occurs BEFORE exercise:

He is about the same – maybe more relaxed and verbal. SPEECH. Student 21.

Class occurs BEFORE exercise:

A very pleasant young lady, but very hyper. It is 8th period and all my students are exhausted. SPEECH Student 22

Class occurs AFTER exercise:

More attentive to the details . FILM Student 23

Class occurs AFTER exercise:

8th period …. End of the day. They use up their last energy bar to focus. SPEECH Student 24

Class occurs AFTER exercise:

He has also moved from the back now to the front. . ENGLISH Student 25

Class occurs AFTER exercise:

She seems less anxious than she did at the start of the term. Could be due to just getting more comfortable with high school. Western GEOGRAPHY Student 26

Class occurs AFTER exercise:

This particular student has always been an over-achiever. He's always made straight A's and has been well-behaved. The only change I've seen from last year is that he's a bit more mature. . SOCIOLOGY Student 27

Class occurs AFTER exercise:

I've only know her since the start of this school year, but she seems less anxious. However, that could be the result of just being more comfortable w/ me and with high school in general. . WESTERN GEOGRAPHY Student 28

Class occurs AFTER exercise:

Doesn't need more – he's so smart already. . ANATOMY Student 29

Class occurs AFTER exercise:

I have seen quite an improvement in him. I had him in English as a freshman and have him again in English this year.. . ENGLISH Student 30

Class occurs BEFORE exercise:

I have noticed an improvement in him since the beginning of the year. ENGLISH. Student 31.

Class occurs BEFORE exercise:

I have not noticed a big difference – she has always been a great student in my class. ENGLISH. Student 32.

Class occurs BEFORE exercise:

I have noticed a difference in memory and learning but not ability of focus. ENGLISH. Student 33.

Class occurs AFTER exercise:

I noticed a difference in him this semester. . ENGLISH Student 34

Class occurs AFTER exercise:

What I have noticed about her: I used to call on her and she would ramble on and on. Now she answers question with details in a timely manner. . ENGLISH Student 35

Class occurs BEFORE exercise:

I have noticed an improvement in the area of vocabulary. ENGLISH. Student 36.

Class occurs AFTER exercise:

I think his stress level is much improved . ENGLISH Student 37

Class occurs AFTER exercise:

His ability to focus has improved. . ENGLISH Student 38

Class occurs BEFORE exercise:

He still has difficulty focusing. ENGLISH. Student 39.

Class occurs AFTER exercise:

I have not noticed a difference = he has always been able to focus, memorize, and learn . ENGLISH Student 40

Class occurs BEFORE exercise:

He still has trouble focusing in English. ENGLISH. Student 41.

Class occurs AFTER exercise:

She has always had an ability to focus, memorize and learn. ENGLISH Student 42

Class occurs BEFORE exercise:

I have noticed some differences. ENGLISH. Student 43.

Class occurs AFTER exercise:

Yes, I have noticed some difference . ENGLISH Student 44

Class occurs BEFORE exercise:

She is very capable but when she doesn't appear to study, she does very poorly on tests. He class work, however, is quite good quality. Western HISTORY. Student 45.

Class occurs BEFORE exercise:

He is very chatty in class. He likes to engage in random conversation. His study skills are weak, so his test performance is erratic. HISTORY. Student 46.

Class occurs BEFORE exercise:

He has been a good student from the beginning of the semester so I have not observed change.. Western HISTORY. Student 47.

Class occurs BEFORE exercise:

She struggles with memory and comprehension of abstract concepts. There are gaps in her general knowledge. She has done poorly on both class work and tests/quizzes. She cooperates and participate in class but it is difficult to measure her learning. US HISTORY. Student 48.

Class occurs BEFORE exercise:

He was strong from the beginning. He has improved his skills but he generally performed at a higher level than many of the students I teach. Western HISTORY Student 49.

Class occurs BEFORE exercise:

He was sick for an extended time. He has spent the last few weeks catching up in all his classes. His energy seems low, so his work effort and performance on tests seems lower than normal. He performed well fist semester, but has since regressed. US HISTORY Student 50

Class occurs AFTER exercise:

Does well, but does not focus on auditory. ALGEBRA Student 51

Class occurs BEFORE exercise:

If anything, it is getting worse. ALGEBRA. Student 52.

Class occurs AFTER exercise:

Beginning of year she was often tired or unfocused, now she seems more attentive and awake. READING COMPREHENSION Student 53

Class occurs AFTER exercise:

Honestly, I haven't seen a problem in any of these particular areas, so I can't say I've seen any improvement. He is an excellent student. The main thing I see is a lot of anxiety and great difficulty adjusting to anything unexpected. US HISTORY Student 54

Class occurs AFTER exercise:

He is distracted by outside class activities. For the past month he was always talking about getting a new motorbike. He continues to show little motivation to do as well as he could. SPANISH Student 55

Class occurs BEFORE exercise:

She wants to do well and is very social, very caring of others. She does well on certain class tasks. However, sleep and health issues have been a challenge this semester. SPANISH. Student 56.

Class occurs AFTER exercise:

She often seems to be preoccupied or off in the distance. I placed her with an assistant and she seems more focused on the work. She also has sleep and energy issues due to soccer and basketball. SPANISH Student 57

Class occurs AFTER exercise:

He was a good student to start the year and he continues to grow in skills, motivation and demonstrated interest and achievement. SPANISH Student 58

Class occurs AFTER exercise:

She CARES about learning and works diligently. SPANISH Student 59

Class occurs AFTER exercise:

He is hard to evaluate as he has done well all year. We have a small class with incredibly well-behaved, motivated, cooperative students. ENGLISH Student 60

Class occurs BEFORE exercise:

She has focused pretty well all semester. She has been willingly answering questions more and seems to understand better in the last month or so. ART. Student 61.

Class occurs BEFORE exercise:

Focus has decreased. He is needing more and more redirecting to stay on task last few weeks. However, he has had a good memory and learning all semester. Bright kid. ART. Student 62.

Class occurs AFTER exercise:

She is a super math student focusing is great, memory great. ALGEBRA Student 63

Class occurs BEFORE exercise:

She is a terrific student; memory, focus, learning are all terrific. GEOMETRY Student 64.

Class occurs AFTER exercise:

Great, difficulty with memory, focusing, learning. ALGEBRA Student 65

Class occurs AFTER exercise:

She is a super math student focusing is great, memory great. ALGEBRA Student 66

Class occurs BEFORE exercise:

She is a great math student; just great all the time. GEOMETRY Student 67.

Class occurs BEFORE exercise:

Good math student. GEOMETRY Student 68.

Class occurs BEFORE exercise:

Great difficulty with focusing, memory, learning. GEOMETRY Student 69.

Class occurs AFTER exercise:

He has always focus in English. Again, his memory has always been good. He has always been a good student. ENGLISH Student 70

Class occurs AFTER exercise:

She struggles with consistent focus in class. She really works hard and wants to achieve – her memory skill are very weak. ENGLISH Student 71

Class occurs AFTER exercise:

She is "good to go" for college! ENGLISH Student 72