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Michelle M. Lynn

*Georgia College & State University*

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## **The Effects of Exercise on the Attention Span of Adolescents with Attention Deficit Hyperactivity Disorder (ADHD)**

Michelle M. Lynn

### **Abstract**

The purpose of this study was to observe and determine the effects of strenuous physical exertion on the engaged behavior of a select and small number of subjects identified as having Attention Deficit Hyperactivity Disorder (ADHD). Participants were siblings identified as having ADHD. One was taking Ritalin, and the other was not. Both participated in early morning swim practice three days a week. Students were observed for the first hour of their academic classes on randomly selected days over a two month period. On-task behavior was timed and recorded. Results were compared for swim practice (treatment) days and non-practice (control) days. Findings indicated that swim practice positively affected the on-task behavior of the participants, particularly the student who was not taking medication.

## **The Effects of Exercise on the Attention Span of Adolescents with Attention Deficit Hyperactivity Disorder (ADHD)**

Literature in special education and psychology contains numerous studies which document various classroom-based interventions to mediate the attention span difficulties of children and adolescents with Attention Deficit Hyperactivity Disorder and Learning Disabilities. It is less inclusive, however, related to interventions that are not classroom-based and/or teacher-directed. In the area of physical activity, there are a few studies addressing the possible direct effects of specific physical activity on the attention span of children with attention span disabilities.

## **What is Attention Deficit Hyperactivity Disorder (ADHD)?**

Attention deficit hyperactivity disorder (ADHD) is a disorder characterized by impulsiveness, poor attention span and extreme restlessness (Garber, Garber, & Spizman, 1996; & Lerner, Lowenthal, & Lerner, 1995). Although this disorder has captured the attention of today's society, particularly over the last decade, research has better defined ADHD and determined that it also occurs in adults. Unfortunately, there is no specific lab test or procedure that makes the diagnosis and treatment of ADHD easy.

In 1994 the American Psychiatric Association (APA) published the Fourth Edition of the Diagnostic and Statistical Manual of Mental Disorders, better known by its acronym, the DSM-IV. Physicians and psychologists use this manual to identify all kinds of psychological problems that people may have, ranging from stress and adjustment problems to more serious disorders.

The DSM-IV (1994) divides the disorder known as Attention Deficit Hyperactivity Disorder into three subtypes: ADHD Combined Type, ADHD Predominantly Inattentive Type, and ADHD predominantly Hyperactive-Impulsive Type. These categories were developed after controversy arose over the definitions of this disorder in the DSM-III (1980) and the DSM-III-R (1987). Livingston (1997) explains that this disorder first appeared in the DSM-II in 1968 as "hyperkinetic reaction of childhood" (p. 4). The use of the term "reaction" was significant because the APA makes a distinction between a disorder and a reaction, with the term "reaction" suggesting a milder, less chronic condition. In the DSM-III, published in 1980, the disorder was first given the name Attention Deficit Disorder (ADD): A distinction was made at that time between ADD with hyperactivity (ADD/H) and ADD without hyperactivity (ADD/WO). In 1987, the DSM-III was revised (DSM-III-R), and the two categories were combined into one, ADHD. The fourth edition keeps the ADHD umbrella, but distinguishes between the two subtypes of attention deficits with hyperactivity only and with inattention only and adds a third subtype which combines the two (Livingston, 1997).

A trained professional may make the diagnosis of ADHD by using background information on the individual, along with doing clinical interviews, and information supplied by the child's teachers. The goal should be to establish, in detail, under what circumstances the presenting symptoms occur and to take a complete developmental, medical, and family history. The clinician should screen for other problems that might be the real source of difficulty, including other mental disorders such as depression or anxiety. The child should also be given a thorough medical examination to rule out neurological or sensory problems. Additional tests of intelligence and achievement can assist in identifying specific problem areas which might affect school performance (Garber et al., 1996; Lerner et al., 1995; & Livingston, 1997).

### **How many individuals in the United States have ADHD?**

Most researchers estimate that ADHD affects 3-5% of the school-aged population, or approximately two million children and adolescents (Garber et al., 1996; Lerner, et al., 1995; Montague & Warger, 1997; & Smith, Polloway, Patton, & Dowdy, 1998). Higdon (1999) cites a study by Johns Hopkins that estimates that at least one child in every U.S. classroom has ADHD. Until recently experts believed that most cases of ADHD disappeared with the onset of puberty. That belief, however, has changed as recent studies indicate ADHD does not typically disappear in adolescents and adults. In fact, studies show that approximately 50% of children with ADHD grow up to become adults with ADHD (Lerner, et al., 1995). With time, the problematic symptoms may change, or the individuals may independently develop a number of coping skills, but problems and challenges remain, often requiring new adjustments and new coping techniques (Garber, et al., 1996).

### **Is there a difference in occurrence between males and females?**

Although males are between five and nine times more likely to be referred and diagnosed with ADHD than females

(Livingston, 1997), Barkley (1995), through a meta-analysis of the existing published literature and examination of clinical and community assessments, determined that males and females appear to demonstrate the same types or qualities of difficulties with sustained attention, impulse control, and hyperactivity. Differences appeared to be more a matter of the degree of such difficulties rather than ones of kind. Females with ADHD showed less hyperactivity on rating scales and made fewer impulsive errors on continuous performance tasks (CPT's). No sex differences, however, seemed to exist in either source of samples in the domains of academic performance, fine motor skills, and general ratings of social functioning. However, Barkley did find one gender difference in the manifestation of behavior: Males with ADHD demonstrate significantly more aggressive behavior and conduct disorder symptoms than do females. This fact explains the reason boys are more likely to be referred for evaluation than females and why there is a perception that more boys than girls have this disorder.

### **How can you treat ADHD?**

Many children with ADHD are able to function efficiently when behavioral techniques are instituted, such as using positive or negative consequences or providing opportunities for direct feedback. Improvements may also be seen when appropriate adjustments are made in school programs, such as seating assignments, structured environment, and reduced assignments (Garber et al., 1996). However, many students benefit from the use of medication. The most common category of drugs used are stimulants. In a review of research, McMurray (1995) found that 75 - 80% of children with ADHD experience a positive effect when using stimulant drugs such as Ritalin, as compared to children in control groups who are given placebos. Stimulant drugs have been proven effective at increasing the ability to focus attention more efficiently and decrease impulsive behavior so that the child may be more able to reflect on the consequences of his or her actions before proceeding. Side effects have included decreased appetite and insomnia, which are common and appear in 50% or more of children. Irritability,

sometimes known as the *rebound effect*, occurs in less than 20% of children, usually as the medication is wearing off. In rare cases, psychostimulants such as Ritalin have been known to increase or bring out tic disorders (McMurray, 1995).

### **How do psychostimulants work?**

In order to understand how stimulant medications such as Ritalin work to help individuals with ADHD, one must use a neurochemical model of brain functioning. Deficits in attention occur when the brain is unable to produce enough of a family of neurotransmitters called catecholamines. Of the more than 50 identified chemical neurotransmitters, the most important in the attention system appear to be norepinephrine and dopamine. These neurotransmitters are thought to affect a wide variety of behaviors, including the regulation of attention, inhibition, and motor responses. These neurotransmitter deficiencies occur within the brain stem. The chemicals are then distributed to other areas of the brain through neurons, or nerve cells, passing from one nerve ending to another nerve ending and thereby transmitting messages. Other areas of the brain thought to be implicated in attention deficit disorders are the prefrontal lobes, responsible for selective attention; the motor strip area, responsible for fidgetiness and overactive behaviors; and the subcortical/limbic areas, thought to be responsible for poor pencil control, disinhibition, and emotional overresponsiveness. These abnormalities appear to be reversed by stimulant medication (Lerner, et al., 1995).

Extensive research on the neurological and chemical aspects of ADHD has been completed by a team of neurologists at The University of Georgia. Their research has helped explain why psychostimulants appear to be so beneficial to individuals with ADHD. The brain is made up of millions of nerve cells called neurons. Information moves through the brain as nerve impulses that are transmitted from cell to cell by neurotransmitters. An impulse travels along the cell body of a *sending* nerve cell. Between the sending nerve and the *receiving* nerve cell is a small space, called a synapse. The impulse causes the sending cell to release chemicals

- neurotransmitters - from tiny sacs located at the synapse between the sending cell and the receiving cell. The chemicals are taken up by receptors in the receiving nerve cell, causing that cell to fire and thus pass the impulse along to the next cell. After the cell fires, the chemical is deactivated and taken up again for storage in the sacs in the original sending cell. The neurotransmitters that are activated in this process help regulate attention and behavior. Problems can arise either in the production of the chemicals in the brain stem or in the distribution to other parts of the brain through the neurotransmitter system (Hynd, et al., 1991; & Jackson, personal conversation, Fall semester 1999).

According to neurochemical theory, individuals with ADHD have a breakdown somewhere in the neurotransmitter activity within the brain stem. Clinical and research studies confirm that ADHD is associated with a deficiency of norepinephrine (Goodyear & Hynd, 1992; Hynd et al. 1991; & Riccio et al. 1993) The level of norepinephrine can be measured through laboratory tests of the blood, urine, and cerebrospinal fluid. Studies show that before taking medication individuals with ADHD have a deficiency of norepinephrine in the brain stem area; after taking psychostimulant medications their norepinephrine levels are normal. When norepinephrine approaches normal levels, the behaviors associated with ADHD - inattention, impulsivity, and hyperactivity - decrease. In this way psychostimulant medication improves the child's attention, motivation, motor responses, activity level, and ability to focus.

It is believed that norepinephrine levels can also be increased through natural stimulation of the brain. This explains one confusing characteristic sometimes reported by individuals with ADHD and the people around them: their ability to focus on an activity for hours at a time. The most common example reported is the child (or adult) with ADHD who will play computer or video games for hours. It is believed that overfocusing on such an activity naturally increases production of neurotransmitters in the brain which allows the child to focus on an activity for long periods of time. Activities such as this must be stimulating to the child

in order to naturally increase production of neurotransmitters (Goodyear & Hynd, 1992; Hynd et al., 1991; Jackson, personal conversation, Fall semester 1999; & Riccio et al., 1993). Part of the increase in the diagnosis of ADHD could be due to the decrease in physical activity in American children. It has been found that exercise does increase the levels of neurotransmitters in children and adolescents with ADHD. (Putnam & Copans, 1998). Research cited by Putnam & Copans (1998) shows that the effects of light aerobic exercise were comparable to the effects of low doses of stimulant medication.

Even though we know that psychostimulants are valuable in helping individuals with ADHD, there is much controversy about whether or not we are overmedicating children in America (Gibbs, 1998; & Livingston, 1997) or that we are too quick to prescribe medication without trying other interventions first (Gibbs, 1998; Higdon, 1999; Livingston, 1997; & McMurray, 1995). According to Garber et al. (1996), "ADHD is a complex disorder. It cannot simply be cured by a pill. It is crucial for ADHD youngsters and adults, their loved ones, and those who work with them to understand what effect medication may have on the troubling characteristics of the disorder. If they elect to use medication, they must realize that it is never the sole form of treatment, and they must make the commitment to identify and work to control, cope with, or solve those problems that medication alone simply cannot solve" (p. 10).

### **Is there an alternative approach to treating ADHD?**

The purpose of this study was to explore the effects of exercise on adolescents with ADHD. However, it was very difficult to find recent research studies in educational journals which specifically address this issue. After exhausting a search of educational literature, I began to review literature in the field of exercise. The first article I happened upon was in *Runner's World* (1999). It was very enlightening, even though it was not a research study. The article was a story about Tom Scott, a psychologist who helps children with ADHD by introducing them to regular exercise. He has a



unique connection to the children he helps because he, too, has ADHD. The article relates that while in high school, Scott could not try out for the track team because he was not academically eligible. Once Scott entered college, however, he joined the track team and began practicing twice a day. He started to realize that he could retain information much better up to two hours after practice. Eventually Scott graduated with his Masters in Psychology and now has his own private practice which focuses primarily on children who have been diagnosed as having ADHD. It is his opinion that helping the children relax and release feelings through exercise also helps to calm them as it once calmed him (Higdon, 1999).

Putnam and Copans (1998) conducted an extensive review of literature regarding exercise and ADHD and found only a few studies which had been conducted in classroom or school environments. They report two classroom studies (Allen, 1980; Bass, 1985) in which the researchers compared student classroom behavior on days that students jogged with days they did not jog. Although these studies did not include students with diagnosed ADHD, they found that running not only improved attention span and impulse control in the students, but also decreased the number of classroom disruptions by 50%. The beneficial effects of running appeared to last from 2 to 4 hours. Putnam and Copans (1998) cited a similar study by Shipman (1985) which found that jogging decreased hyperactivity and impulsivity in students with ADHD. This study also found that exercise was found to be most beneficial during the first 2 to 4 hours after jogging. In addition, this study found that students who were taking stimulant medication during the time of the study required less medication when they were jogging regularly. Finally, Putnam and Copans (1998) report a dissertation by Elsom (1980) which studied the effects of exercise on four hyperactive boys. This study suggested that light aerobic exercise had effects comparable to low doses of stimulant medication. In all four subjects, exercise led to substantial improvements in attention as well as significant decreases in depression. After reviewing the research on exercise and ADHD, Putnam and Copans (1998) conclude that current research indicates that regular exercise programs lead to fewer symptoms of

ADHD and that it would seem reasonable to consider that one intervention for ADHD could be a program of regular physical exercise.

Because there were so few research studies specific to ADHD and exercise, I tried to establish a more theoretical link by turning to information presented by Eric Jensen in his book, Teaching With the Brain in Mind (1998). He discusses new discoveries being made that link the cerebellum and cognition. Until recently the cerebellum was thought to process signals only from the cerebrum and send them to the motor cortex. In other words, although it was known that the cerebellum played a tremendous part in controlling our motor functions, it has only recently been theorized that it may also play a significant role in thinking. Jensen describes how pathways have now been traced from the cerebellum back to parts of the brain involved in memory, attention, and spatial perception. In fact, the part of the brain that processes movement is the same part of the brain that processes learning. He goes on to say that there appears to be no single "movement center" in our brain but that movement and learning have constant interplay.

Jensen (1998, p.85) cited a study done by Gilbert in 1977 in Seattle, Washington, on third-grade students who studied language arts concepts through dance activities. Although the districtwide reading scores for that area showed a decrease of 2% the following year, the students involved in the dance activities boosted their reading scores by 13% in 6 months. The complete dance routine included spinning, crawling, rolling, rocking, tumbling, and pointing. In a Canadian study also cited by Jensen (1998), Hannaford (1995) studied 500 school children. Those who spent an extra hour each day in a gym class performed significantly better at exam time than those who received the standard exercise time. Although Jensen does not address exercise and ADHD specifically, he makes a strong appeal to teachers and school systems to increase movement and exercise programs because of what he feels is a clear connection between movement and learning.

In summary, limited studies appear which specifically research the effect of exercise on individuals with ADHD. However, through the brief review of research presented here, there

does seem to be an indication that exercise has a positive effect on individuals with ADHD and may lessen the need for psychostimulant medications. There is certainly an indication that more research in this field needs to be conducted. The purpose of this study was to observe and determine the effects of strenuous physical exertion on the attention span, as it related to the engaged behavior, of a select and small number of subjects identified as having ADHD.

## **Method**

### **Participants**

This study was designed to observe the effects of specific strenuous physical exercise on three students, age 17, 16, and 13, who have been diagnosed as having ADHD. These three participants came from the same family and therefore are being raised under the same parenting style.

Student One, a 16-year-old male, was taking 4 milligrams of Ritalin twice a day. The morning dose was administered by the school office each morning before his first period class. Student Two, a 17-year-old female, was not taking any medication. Observations on Student Three, a 13-year-old female, were discontinued because the classroom situation was not structured enough for the observer to accurately measure engaged behavior.

### **Setting**

The students were observed in their natural school setting in a small town high school. Student One was observed during chemistry and Student Two was observed during psychology. These classes took place during the first period of the morning.

### **Target Behavior**

The behavior targeted in this study was engaged behavior. Engaged behavior, sometimes referred to as on-task behavior, simply means the subject was actively involved in the task at hand. This involvement could have been anything from looking at the teacher or task materials during the teacher's explanation to working on the task assignment for any length of time.

## **Design and procedure**

This study was a single subject design using an alternating treatment design. The subjects in this study were involved in a 1 hour and 20 minute long morning swim practice three days a week: Monday, Wednesday, and Friday. There was no swim practice on Tuesday or Thursday; therefore, these days served as the control or alternative treatment. Data were collected based on engaged behavior during the first hour of the participants' natural school setting in an academic classroom. The students were observed on days when there was no physical activity preceding the observation period and on days in which they participated in morning swim practice for the local swim team.

Observations took place throughout the week in order to gather data for both treatment and control days. Observers were college students trained to make behavioral observations. Observers used stopwatches to time engaged behavior. Data collection took place in the natural classroom setting; neither the teacher nor the students in the class knew who was being observed. Observers were introduced to the class as college students who were conducting classroom research for one of their classes. The results of these measures were then compared to determine the effects of the treatment on the attention spans of the students. The observations were completed within two hours after treatment with a total of ten observations for Student One and nine observations for Student Two.

## **Exercise Conditions**

The participants of this research were exposed to the same exercise conditions. They reported to morning swim practice at 5:30 AM for stretching and flexibility exercises. At exactly 5:45 AM both participants began swim practice with a structured warm-up period of 1,000 yards of swimming designed to increase blood flow to the muscles, enhance flexibility, and mentally prepare for the actual training and cardiovascular phase of the practice. Each subject completed similar distances during his or her training peri-

od, which would vary from 3,500 to 4,600 yards. Each participant then engaged in an active recovery period of 600 yards swimming in order to gradually lower his or her heart rate to pretraining levels before exiting the pool.

### **Data Analysis**

The amount of engaged behavior was totaled for each subject and for each observation session. Since the observations sometimes varied in length, the data was converted into percent of engaged time per session. The averages and standard deviation were calculated for percent of engaged time for both treatment and control conditions for each subject. The engaged behavior, on treatment days and regular school days, was then analyzed. These data were also plotted on x-y graphs that created a visual representation to display the effects of the alternative treatments.

### **Limitations of the Study**

Data were gathered over an eight-week time period. Observations could not be done for a set number of consecutive days because of observers' college class schedules. Under ideal circumstances, data collection should have continued throughout the entire semester; however, due to scheduled swim meets, the participants had to go to a 5-day a week practice schedule, thus, leaving no data for control. In addition, the observers were undergraduates working on their first research assignment; therefore it is possible that some inaccuracies may have occurred during observations.

### **Results**

Tables 1 and 2 show the amount of engaged behavior for both students on treatment days (Monday, Wednesday, and Friday) and control days (Tuesday and Thursday). Observations varied in length; therefore, times for engaged behavior were converted into percents.

**Table 1.**

*Percent of engaged behavior for Student 1*

Raw Data for Student					
	Monday	Tuesday	Wednesday	Thursday	Friday
Week				65%	
Week	70%	16%	62%	49%	36%
Week	58%	58%	57%	56%	

**Table 2.**

*Percent of engaged behavior for Student 2*

Raw Data for Student					
	Monday	Tuesday	Wednesday	Thursday	Friday
Week			67%	30%	
Week			92%	36%	36%
Week				12%	67%
Week			59%		
Week		43%	90%		

Table 3 shows the mean and the standard deviation of engaged behavior for treatment and control days for both students.

**Table 3.**

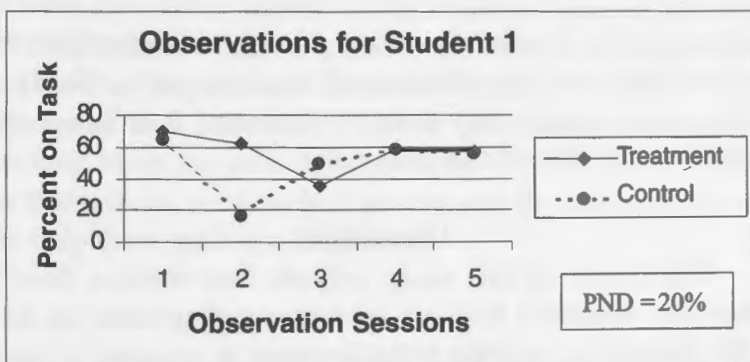
*Data summary*

		Mean	Standard Deviation
Student 1	Treatment	56.6	12.6
	Control	48.8	19.2
Student 1	Treatment	75.2	14.9
	Control	30.25	13.3

For Student Two the exercise condition resulted in more than twice as much time on-task. Student One also showed greater time on-task, but the results were not as dramatic. Student One was also more inconsistently engaged on the control days (S.D. = 19.2).

Figures 1 and 2 illustrate the difference in engaged time for both treatment and control days for Students One and Two. They also show the percent of non-overlapping data (PND), which is the percent of experimental data (treatment) that does not overlap the control data. This summary statistic is valuable for comparing the plotted data from these two studies.

**Figure 1.**



**Figure 2.**

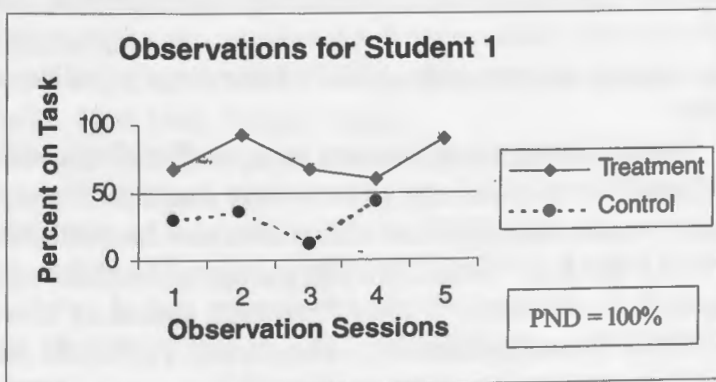


Figure 2 clearly shows that there was a big improvement in the engaged behavior for Student Two with the PND measuring 100%. Figure 1 shows a slight increase with a PND of 20% for Student One.

Another way to compare two studies is to calculate an effect size. Using the results from Table 3, an effect size was calculated for each student using the following formula:

$$E.S. = \frac{\bar{X}_T - \bar{X}_C}{\left[ \frac{SD_T + SD_C}{2} \right]}$$

The effect size for Student One was +.5, and for Student Two it was +3. The effect size is a measure of the treatment's effectiveness that takes into account day-to-day variations. It is based on the assumption of a normal distribution.

### **Discussion**

The results of this study indicate that exercise does help increase the attention span of adolescents diagnosed as having ADHD, therefore, resulting in an increase in engaged or on-task behavior within the first two hours after strenuous exercise. The increase in engaged behavior for both participants is very clear, although the results are more substantial for Student Two, the participant not taking medication. Even though this study was done on a small scale, the results suggest that exercise can play a significant part in helping students with ADHD focus their attention in the classroom.

When I enter the classroom as a teacher, I can take the results from this study and apply them to my students. For students diagnosed as having ADHD, modifications can be made on their Individual Education Plan (IEP). For example, the IEP team may recommend an extended Physical Education period or more frequent breaks throughout the day. The student's schedule may be organized so that hand-on-activities that allow movement are interspersed with activities that require focused seatwork. The information from this study also indicates that parents and teachers should encourage students with ADHD to participate in sports that involve physical activity. Unfortunately, students are often



removed from sport activities as a punishment for poor behavior (e.g., inattentiveness, impulsive remarks, etc.) or because misinformed parents or teachers feel that the student will improve his or her academic performance by studying more. The few research studies in this area, in concurrence with the results from this study, suggest that sports activities may be an answer to helping modify behavior and improve achievement.

In conclusion, the results of this study indicate that exercise may have a positive impact on the attention span of adolescents with ADHD in the classroom; however, research in this area is limited. There are implications from the limited research that strenuous exercise may have very positive benefits for students in the classroom. More research in this area may benefit not only the students themselves, but also their parents and the teachers who struggle to help them maintain their focus.

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