DOES ACUTE AEROBIC EXERCISE INCREASE ATTENTION IN ADULTS
WITH SELF-REPORTED ADHD SYMPTOMS INDICATED BY A CHANGE IN
EYE BLINKS AND CPT-II SCORES?

by

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ABSTRACT

Purpose: Attention-deficit/hyperactivity disorder is the world’s leading child neurobehavioral disorder (Zimmerman, 2003; Wigal, Emmerson, Gehricke & Galassetti, 2012), and it is increasingly being recognized that adults also suffer from the disorder. For years the preferred management option for the disorder has been medication, but the proposed research helps support the promotion of exercise as a management intervention for adults with ADHD.

Method: Ten adult self-reported ADHD participants (based on their responses to the Amen and ASRS screening questionnaires) (M=24.2 years, SD=3.94) consisting of 7 males and 3 females, along with 10 matched (M=24 years, SD=3.65, 3 males and 7 males) non-ADHD participants completed the Conners’ CPT-II pre and post a 20 min sub-maximal aerobic exercise on the stationary cycle ergometer.

Results: A two-way ANOVA was conducted to examine the effects of 20 minutes of exercise on the omission scores between the ADHD and control participants, as well as the commission scores. Exercise had a significant effect on the self-reported ADHD participants with a change in omissions scores (CPT-II) from pre to post exercise, $F(1,18)=11.23, p=.004$. Conclusion: The results of this study support the promotion of exercise as a management intervention for adults reporting symptoms of ADHD.
ACKNOWLEDGEMENTS

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<th>Symbol</th>
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<tbody>
<tr>
<td>AADHD</td>
<td>Adult Attention-deficit/hyperactivity disorder</td>
</tr>
<tr>
<td>ADHD</td>
<td>Attention-deficit/hyperactivity disorder</td>
</tr>
<tr>
<td>BDNF</td>
<td>Brain-Deprived Neurotropic Factor</td>
</tr>
<tr>
<td>CD</td>
<td>Conduct Disorder</td>
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<tr>
<td>CPT-II</td>
<td>Conners’ Continuous Performance Test II</td>
</tr>
<tr>
<td>DA</td>
<td>Dopamine</td>
</tr>
<tr>
<td>DSM-IV-TR</td>
<td>Diagnostic and Statistical Manual of Mental Disorders (4th Edition, Revised)</td>
</tr>
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<td>DSM-V</td>
<td>Diagnostic and Statistical Manual of Mental Disorders (5th Edition)</td>
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<td>EF</td>
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<td>HRR</td>
<td>Heart Rate Reserve</td>
</tr>
<tr>
<td>L</td>
<td>Litre</td>
</tr>
<tr>
<td>MPH</td>
<td>Methylphenidate</td>
</tr>
<tr>
<td>NIRS</td>
<td>Near Infrared Spectroscopy</td>
</tr>
<tr>
<td>NA</td>
<td>Not Applicable</td>
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<td>OCD</td>
<td>Obsessive Compulsive Disorder</td>
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<td>Oppositional Defiant Disorder</td>
</tr>
<tr>
<td>PFC</td>
<td>Prefrontal Cortex</td>
</tr>
<tr>
<td>RHR</td>
<td>Resting Heart Rate</td>
</tr>
<tr>
<td>RPE</td>
<td>Borg’s Scale of Rate of Perceived Exertion</td>
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<tr>
<td>SEBR</td>
<td>Spontaneous Eye-Blink Rate</td>
</tr>
<tr>
<td>SED</td>
<td>Sedentary</td>
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<tr>
<td>Abbreviation</td>
<td>Description</td>
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<tr>
<td>SN</td>
<td>Substantia Nigra</td>
</tr>
<tr>
<td>STU</td>
<td>St. Thomas University</td>
</tr>
<tr>
<td>TE</td>
<td>Therapeutic Eurythmy</td>
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<tr>
<td>VO2max</td>
<td>Maximum value of oxygen uptake attained in a high intensity test</td>
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<tr>
<td>VO2peak</td>
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Chapter 1: Introduction

Attention-deficit/hyperactivity disorder (ADHD), especially in adults, is becoming more of a concern in today’s society, in particular because of its negative impact on work productivity (Walker, 2014). The majority of past research in this area has focused primarily on children, with the common belief that as the child matures, the disorder fades. Recent research has found this to not be the case (APA, 2013). With the release of the fifth edition of The Diagnostic and Statistical Manual of Mental Disorders (American Psychiatric Association, 2013), the new diagnostic criteria indicate that the disorder does, indeed, include adults.

Attention-deficit/hyperactivity disorder has been around for many decades but only gained mainstream recognition in the 1990s with the release of The Diagnostic and Statistical Manual of Mental Disorders -IV-TR (APA, 2000), which categorized the disorder as Attention-deficit/hyperactivity disorder with three subcategories: primarily inattentive, primarily impulsive/hyperactive, and a combination of the two. The DSM-IV-TR (APA, 2000) indicated that the child must show signs and symptoms of the disorder by the age of seven, for a minimum of six months, causing impairment in two different settings (i.e. school, sports, home). This represents an area of concern for adults 19 and older seeking a diagnosis, as the practice of diagnosing this disorder for adults is relatively new, and many missed the opportunity to be properly evaluated and diagnosed as children.

The work world is extremely competitive, and attention to detail and the ability to complete tasks in a timely manner are necessary skills for success. To be successful in this fast-paced world, it is essential to be able to employ the majority of the executive
functions (EF) that are often inhibited with ADHD (Barkley, Edwards, Laneri, Fletcher & Metevia, 2001). Adults with ADHD struggle with time management and organization, have poor frustration control, sleep dysfunction, motivational dysfunction, and they often lack social skills, leading to instances of talking too much and/or too fast in meetings or social settings (Greydanus, Pratt, & Patel, 2007). Due to these issues associated with the disorder, it is common for those affected to have: difficulties maintaining long-term employment; a higher divorce rate; lower levels of socioeconomic status; lower education levels; more driving infractions; and difficulties sustaining healthy relationships (Kessler, Lane, Stang, & Van Brunt, 2008).

Thus, the disorder has a major impact on one’s life, impacting health, career, family, and financial stability (Pinkhardt, et al., 2009). Because ADHD is highly comorbid with numerous other disorders, other associated difficulties might also play a crucial role in terms of performance in the work field. As individuals with ADHD age into adolescence and early adulthood, substance abuse and depression become more prevalent and problematic (Zimmerman, 2003; Graydenus et al., 2007). It is evident that adults with ADHD are in need of an effective method for managing the impact of the disorder. Considering the fact that these men and women often struggle to maintain long-term employment and relationships (Zimmerman, 2003), they may not be able to financially afford the primary management option (i.e. medication), which is only effective if the individual has been properly diagnosed with ADHD, or has an employment health benefits/plan to cover treatment cost. For these people an alternative method for managing the impact of ADHD is necessary (Zimmerman, 2003).
Fortunately, medication is not the only option for ADHD management. There have been many years of anecdotal evidence suggesting that exercise is an effective management intervention for the disorder. Many researchers have focused on the impact of exercise on the executive functioning of children with ADHD with varying results. These studies range from a minimum of 20 minutes of low intensity exercise (eg. walking) that has been shown to have a small positive effect on EF (Barnard-Bark, Davis, Sulak, & Brak, 2011), to the finding that moderate to vigorous aerobic exercise was positively associated with increased EF (Gapin & Etnier, 2010). The literature also speaks to the belief that with a decrease in spontaneous eye-blink rate (SEBR), attention is increased in adults during video display terminal (VDT) use (Schloete, Kadner, Freudenthaler, 2004; Helland et al., 2007), while maximal aerobic exertion causes an increase in SEBR in male children (Tantillo, Kesick, Hynd, & Dishman, 2002). Although acute aerobic exercise appears to be beneficial for children with ADHD, there has yet to be research conducted on adults with ADHD to verify if exercise has the same alleviating effect as it does for children.

1.1 Research Hypothesis

The current study is very similar to the work done by Tantillo et al. (2002) in which children (boys and girls) with ADHD completed a maximal treadmill-walking test to determine their VO2 peak. The children were then randomly assigned to counterbalanced conditions in which they completed either a sub maximal treadmill-walking test at 65-75% of their VO2 peak, or a quiet rest. Eye blinks and motor impersistence were measured under both conditions. Tantillo et al. (2002) used an auditory stimulus to measure motor impersistence, while the current study used a visual...
stimulus test, the Conners’ Continuous Performance Test (CPT-II). Tantillo et al. (2002) found that boys with ADHD had increased eye blinks, and decreased motor impersistence after maximal exercise. Based on these findings, the following null hypotheses (H0) were formulated for the proposed study:

**Hypothesis H0.1a):** Acute maximum aerobic exercise will not increase attention in ADHD participants as indicated by comparing pre and post exercise CPT-II scores; b) There will be no difference in the pre-post CPT-II change scores between ADHD and non-ADHD participants in the acute maximum aerobic exercise condition.

**Hypothesis H0.2a):** Acute sub-maximum aerobic exercise will not increase attention in ADHD participants as indicated by comparing pre and post exercise CPT-II scores; b) There will be no difference in the pre-post CPT-II change scores between ADHD and non-ADHD participants in the acute sub-maximum aerobic exercise condition.

**Hypothesis H0.3a):** Acute maximum aerobic exercise will not have an effect on spontaneous eye blink rate (SEBR) in ADHD participants; b) There will be no significant difference in the pre-post SEBR change scores between ADHD and non-ADHD participants in the acute maximum aerobic exercise condition.

**Hypothesis H0.4a):** Acute sub-maximum exercise will not have an effect on spontaneous eye blink rate in ADHD participants; b) There will be no significant difference in the pre-post SEBR change scores between ADHD and non-ADHD participants in the acute sub-maximum aerobic exercise condition.

1.2 Delimitations of the Study

The following restrictions applied to the study:
(1) All participants will be healthy and will have no cardiovascular, respiratory, or musculoskeletal disorders.

(2) All participants will not have any visual impairment in either eye.

(3) All participants will maintain their normal activity level throughout the study.

(4) Participants will cover the spectrum of fitness levels from sedentary to elite athlete.

1.3 Limitations of the study

The following limitations are acknowledged:

(1) The assumption that participants will respond truthfully and accurately to all screening questions.

(2) That participants will perform maximum volitional effort when asked to do so.

1.4 Purpose of the study

The overall purpose of this study was to: (1) determine if acute aerobic exercise of an intensity and duration thought to elevate brain dopamine levels, can improve attention and motor persistence in adult attention-deficit/hyperactivity disorder; and (2) to determine if focus is affected by acute exercise, which was evaluated using the ISCAN ETL-570 by measuring eye blinks.

1.5 Significance

This work may help promote the beneficial effects of aerobic exercise on psychological disorders in adults, primarily increasing attention in adults with or without ADHD, and encouraging physical exercise in the workplace and/or school setting on a
daily basis. It will also aid in connecting the research on how physical exercise improves EF in children with ADHD to the adult population.
Chapter 2: Review of the Literature

2.1 History of Attention-deficit/hyperactivity disorder

Attention-deficit/hyperactivity disorder (ADHD) is the world’s leading childhood neurobehavioral disorder (Zimmerman, 2003; Wigal, Emmerson, Gehricke, & Galassetti, 2013). The disorder is described as leading to significant behaviour problems with regard to attention, hyperactivity, or acting impulsively, that are not appropriate for a person’s age (APA, 2013; APA, 2000). According to the DSM-IV-TR (APA, 2000), ADHD symptoms must be evident by age seven and be present for more than six months, and must be causing impairment in two separate settings (i.e. school, sports, home) for a diagnosis to be made. The more recent DSM-5 (APA, 2013) indicates that symptoms must be present before the age of 12, and do not have to cause impairment. Attention-deficit/hyperactivity disorder is a highly researched disorder in children; however, the cause of the disorder is still relatively unknown. The disorder is believed to currently affect about 4-12% (Zimmerman, 2003; Zametkin & Liotta., 1998; Kim et al., 2011; Kamp, Sperlich & Holmberg, 2014; Chang, Liu, Yu & Lee, 2012; Tantillo et al., 2002; Graydanus et al. 2007) of children when diagnosed via the DSM-IV-TR criteria, equaling more than 2.5 million school-aged children in the US (Pontifex, Saliba, Raine, Picchietti & Hillman, 2013; Chang et al. 2012) and is diagnosed approximately three times more in boys than in girls (Zimmerman, 2003). About 60-80% of people diagnosed in childhood continue to have symptoms into adulthood (Kim et al., 2011) and between 2-5% of adults are believed to have the condition (Zametkin & Liotta., 1998, Graydenus et al., 2007). The diagnosis of ADHD may appear to be a relatively new diagnosis, corresponding in the mid-1990s with the release of the fourth edition of The Diagnostic and Statistical
Manual of Mental Health Disorders (APA, 1994); however, documentation of the disorder dates back as far as 1775 (Barkley & Peters, 2012). It was originally believed that German physician Heinrich Hoffman identified the first case of ADHD, in 1865, based on the poems he would write about his patients, which included a poem about *Fidgety Phillip*, a hyperactive child. However, Melchior Adam Weikard has more recently received this credit with the English translation of a chapter in his medical textbook, in which he describes a patient with the symptoms of ADHD in 1775 (Barkley & Peters, 2012).

The description of ADHD has changed over the ensuing century from when Hoffman wrote *Fidgety Phillip* and described his young patient’s traits, all of which now fall within the current criteria for ADHD. Understanding of the disorder has evolved, beginning with the diagnosis of Von Economo’s Disease (children with attention dysfunction and conduct-disorder-like behaviour) from 1916-1927. During this time, it was believed that the pathophysiology was encephalitis with subsequent brain damage. Other terms that evolved included hyperkinetic syndrome and hyperactive reaction of childhood, and eventually these became two separate disorders: Attention Deficit Disorder and Attention Deficit-Hyperactivity Disorder (Greydanus et al. 2007). The disorder is now termed Attention-deficit/hyperactivity disorder (ADHD) with three sub-categories (APA, 2013; APA, 2000): primarily inattentive; primarily hyperactive-impulsive; and a combination of the two.

Historically, ADHD was thought to be a childhood disorder; however more recent research has indicated the progression of ADHD into adolescence and adulthood. Zimmerman (2003) indicated that over 70% of hyperactive children continue to meet the
criteria for ADHD in adolescence, and 65% of the original population continue to meet the criteria in adulthood. Adults with ADHD (Zimmerman, 2003; Graydenus et al., 2007) exhibit some common characteristics, including:

- an inability to relax
- the tendency to be easily distracted, including the inability to concentrate on tasks and difficulty completing work/assignments
- an inability to control their temper
- disorganization
- poor time management
- impulsive behaviours, including speaking at inappropriate times
- interpersonal disturbances, including difficulty maintaining relationships
- academic and occupational disturbances, including difficulty maintaining employment.

2.2 Signs and Symptoms

Inattention, hyperactivity (restlessness in adults), disruptive behaviour, and impulsivity are common in people with ADHD. Academic difficulties are frequent, as are problems with relationships. The symptoms can sometimes be difficult to define, as it is hard to draw a line at where normal levels of inattention, hyperactivity, and impulsivity end and significant levels requiring intervention begin. According to the DSM-IV-TR, signs and symptoms are to be observed in two separate settings (e.g., school, home, sport, work), must persist for a minimum of six months, and are evident to a degree greater than other children of that age (APA, 1994). The DSM-IV-TR, however, defines it as a childhood disorder and does not take into consideration adults with the disorder and their
symptoms and impairments. The *DSM-5*, the latest edition of psychiatry’s mental disorder manual, provides reference to adults being included in the disorder. According to the *DSM-5* (APA, 2013), the symptoms must be present by the age of 12 and be present in two or more settings, but they do not have to cause impairment. The symptoms of each subcategory remain the same with the inclusion of developmentally appropriate examples for both adolescents and adults. This latest edition notes that individuals over the age of 17 only need to exhibit 5 symptoms, while individuals younger than 17 need to exhibit 6 of the 9 symptoms. The *DSM-5* (APA, 2013) is more inclusive of a variety of profiles for the diagnosis, as the disorder is now diagnosed with the severity modifiers Mild, Moderate, or Severe. Mild severity includes cases where there are few, if any, symptoms beyond the amount required to make the diagnosis, with only minor impairment in functioning. Severe includes cases with many symptoms in excess of the required number, where symptoms are especially severe, or there is impairment resulting from the symptoms. Under the *DSM-IV-TR* criteria, only the Severe category would have been diagnosed.

As previously mentioned, there are three subtypes of ADHD: primarily inattentive, primarily impulsive/hyperactive, and a combination of the two. An individual with inattention has to have a minimum of 6 of the following symptoms (APA, 1994; APA, 2013):

- Be easily distracted, miss details, forget things, and frequently switch from one activity to another.
- Have difficulty maintaining focus on one task.
- Become bored with a task after only a few minutes, unless doing something enjoyable.

- Have difficulties focusing attention on organizing and completing a task or learning something new.

- Have trouble completing or turning in homework assignments, often losing things (e.g., pencils, toys, assignments) needed to complete tasks or activities.

- Not seem to listen when spoken to.

- Daydream, become easily confused, and move slowly.

- Have difficulty processing information as quickly and accurately as others.

- Struggle to follow instructions.

An individual with hyperactivity may have some or all of the following symptoms (APA, 1994; APA, 2013):

- Fidget and squirm in their seats.

- Talk non-stop.

- Dash around, touching or playing with anything and everything in sight.

- Have trouble sitting still during dinner, at school, while doing homework, and during story time.

- Be constantly in motion.

- Have difficulty doing quiet tasks or activities.

An individual with impulsivity may have some or all of the following symptoms (APA, 1994; APA, 2013):

- Be very impatient.
- Blurt out inappropriate comments, show their emotions without restraint, and act without regard for consequences.
- Have difficulty waiting for things they want or waiting their turn in games
- Often interrupt conversations or others’ activities.

People with ADHD often have difficulties with social skills, such as social interactions and forming and maintaining relationships. People with ADHD have attention deficits, which cause subsequent difficulty with processing verbal and nonverbal language and can negatively affect social interaction. They may also drift during conversations and miss social cues (Elia, Ambrosini, & Rapoport, 1999).

2.3 Diagnosis

As with many other psychological disorders, a qualified professional makes a formal diagnosis based on a set number of criteria. In the United States these criteria are defined by the American Psychiatric Association’s *Diagnostic and Statistical Manual of Mental Disorders* (DSM).

The diagnosis of childhood ADHD often begins with an interview of the parents, as a child lacks insight regarding their own actions and behaviours (Zimmerman, 2003). When it comes to assessment instruments, no single test is considered sufficient. There are several instruments/tests that are commonly used for the diagnosis of the disorder and some of these include:

- Child Behavioral Check List (CBCL) (Achenbach, 2001)
- Conners Parent and Teach Rating Scale (CRS) (Conners, 2000)
- Adult ADHD Rating Scale (ASRS) (Adler, Kessler, & Spencer, 2006)
- The Amen Clinic (Amen, 2003)
There are a number of additional tests and measures that the individual being diagnosed can complete that provide a more in-depth, and often objective, understanding of the criteria related to ADHD such as reaction time and the ability to inhibit. These include:

- The Stroop Color Test (Stroop, 1935): This test measures reaction time by displaying the name of a colour (e.g. “red”, “yellow”, “blue”) printed in a different colour (e.g. the word “green” is printed in blue ink instead of green ink). Naming the colour of the word has a slower reaction time and prone to more errors when the name and colour do not match.

- Conner’s Continuous Performance Test II (Conners, 2000): A computerized continuous performance test in which single letters are shown on a display screen at three different rates: one every second; one every two second; or one every four seconds, for a total of 12 minutes. The participant presses the space button on a keyboard to every signal but must inhibit the response when the target signal appears. The test scores the total number of omissions (missed targets), total commissions (false hits), and hit rate (reaction times).

- Eriksen Flanker Task (Eriksen & Eriksen, 1974): response inhibition tests in which the target is flanked by a non-target stimuli which either corresponds to the same directional response as the target (congruent), is opposite to the target (incongruent), or is neither (neutral).

Despite the number of available tests, there continues to be limited consensus regarding the combination of methods and tests that best identify children who meet the criteria for ADHD diagnosis.
2.4 Associated Disorders

In children with ADHD, other disorders also occur about 50% of the time (Zametkin & Liotta, 1998). It is crucial for ADHD to be properly diagnosed, as well as the comorbid disorder(s), for the diagnosed individual to reach their maximum potential. Some of the associated disorders, such as depression, have an enormous impact on society. Broadhead, Blazer, George and Kit Tse (1990) found individuals with depression were associated with 51% more disability days away from the workplace. Most places of employment pay their employees for disability days, allowing the individual to be absent but resulting in a loss in productivity for the employer. Some of the commonly associated disorders include:

- **Learning disabilities** (Zimmerman, 2003), which have been found to occur in 20-30% of children with ADHD. Learning disabilities can include developmental speech and language disorders and academic skills disorders. Attention-deficit/hyperactivity disorder, however, is not considered a learning disability, though it can still significantly impact academic performance.

- **Tourette syndrome** (Zimmerman, 2003; Graydenus et al., 2007) has been found to occur more commonly in the ADHD population.

- **Oppositional defiant disorder (ODD) & Conduct disorder (CD)** (Zimmerman, 2003; Graydenus et al., 2007) occur comorbidly with ADHD in about 50% and 20% of cases respectively. These disorders are characterized by antisocial behaviours such as stubbornness, aggression, frequent temper tantrums, deceitfulness, lying, and stealing. About half of those people with hyperactivity and ODD or CD develop *antisocial personality disorder* in adulthood.
- **Mood disorders** (Zimmerman, 2003; Graydenus et al., 2007) (especially *bipolar disorder* and *major depressive disorder*) can be common. Boys diagnosed with the combined ADHD subtype are more likely to have a mood disorder. Adults with ADHD sometimes also have bipolar disorder, which requires careful assessment to accurately diagnose and then treat both conditions.

- **Anxiety disorders** (Graydenus et al., 2007) have been found to occur more commonly in the ADHD population.

- **Obsessive-compulsive disorder (OCD)** (Graydenus et al., 2007) can co-occur with ADHD and often shares many of its characteristics.

- Adolescents and adults with ADHD are at increased risk of developing a *substance use disorder* (Zimmerman, 2003; Graydenus et al., 2007). This is most commonly found with regard to alcohol and cannabis. The reason for this may be due to an altered reward pathway in the brains of individuals with ADHD. This particular co-morbidity makes the evaluation and treatment of ADHD more difficult, with serious substance misuse problems usually treated first, due to the greater risks associated with them.

- **Restless legs syndrome** (Cortese, Konofal, & Lecendreux, 2008; Walters et al. 2000) has been found to be more common in those with ADHD and is often due to iron deficiency anemia. However, restless legs can simply be a part of ADHD and requires careful assessment to differentiate between the two disorders.

- **Sleep disorder** (Graydenus et al. 2007; Cortese, Konofal, & Lecendreux, 2008) and ADHD commonly co-exist. Sleep disorders can also occur as a side effect of the medication used to treat ADHD. In children with ADHD, insomnia is the most
common sleep disorder with behavioural therapy the preferred treatment. Problems with sleep initiation are common among individuals with ADHD but they will often be deep sleepers once asleep and have significant difficulty waking up in the morning. Melatonin is sometimes used with children who have sleep onset insomnia.

2.5 Causes

Attention-deficit/hyperactivity disorder is a psychological disorder for which the exact cause is still unknown (Majorek, Tuchelmann, & Heusser, 2004; Zimmerman, 2003; Wigal et al., 2013; Graydanus et al. 2007; Panzer & Viljoen, 2005). Some research supports the theory that it results from a combination of factors related to nature and nurture (Majorek, Tuchelmann, & Heusser, 2004) resulting in the inability to self-regulate, stemming from a biological issue as well as environmental disturbances.

2.5.1 Genetics

It is believed that children who lack the ability to self-regulate have difficulties concentrating, which then leads to restlessness and negative interactions when other children are trying to focus on the assigned task, commonly leading to negative reactions from the environment and, in particular, peers. The negative reinforcement could be perceived as social rejection, decreasing the child with ADHD self-esteem (Majorek, Tuchelmann & Heusser, 2004). Twin studies indicate that the disorder is often inherited from one’s parents with genetics determining about 75% of cases. Research using twins suggests that there is a major genetic and familial pattern in ADHD (Zimmerman, 2003).
Genetics have also been implicated in ADHD with the findings that siblings of affected children and children of affected adults are at increased risk of the disorder. There is a greater concordance between identical than fraternal twins (Feldman, 2001). One study describes a four year follow-up study on boys with ADHD at mid-adolescence and found that 85% continued to have the disorder (Biederman et al., 1996) after four years. They also found that the prevalence of the disorder was much higher among relatives with ADHD compared to their matched subjects. Parents were 20 times more likely to have ADHD than the compared controls, with siblings being 17 times more likely. Biederman et al. (1996) also found that relatives of individuals with ADHD came from lower social classes, with the relatives being at higher risk for ADHD, conduct disorder, major depression, and anxiety disorders. Certain disorders, such as depression and anxiety disorders were more prevalent in the adult samples.

2.5.2 Environment

Environmental factors, such as an inappropriate learning environment, school curriculum that does not match the child’s abilities, family dysfunction, poor parenting, child neglect, and parental psychopathology, may also play a contributing role (Zimmerman, 2003). There are several environmental factors related to birth and development that should also be taken into consideration such as pregnancy complications, including low birth weight, and other factors that may affect brain development such as trauma, disease, fetal exposure to alcohol and tobacco, early exposure to high levels of lead, and diminished activity in certain brain regions (Zimmerman, 2003). Exposure to tobacco smoke during pregnancy can cause problems with central nervous system development and can increase the risk of ADHD. Many
children exposed to tobacco, however, do not develop ADHD or only have mild symptoms that do not reach the threshold for a diagnosis.

2.6. Brain Structure

The pathophysiology of ADHD is becoming better understood with a number of competing explanations posited. Kim et al. (2011) indicated that the dysfunction occurs in the midbrain substantia nigra (SN), believed to be the part of the brain most responsible for the behavioural symptoms of ADHD. Panzer and Viljoen (2005) found emotional regulation is dependent on the right orbitofrontal dominance of both limbic circuits, in which dopamine innervates the deeper layers, something unique in the adult cortex. This theory suggests that children with ADHD remain in the early practicing period developmental phase longer than their peers.

Wigal et al. (2013) state that the prefrontal cortex (PFC) is a region of central importance to attention and inhibitory control for working memory. The dysregulation of dopamine in the PFC has been shown to play an important role in the pathophysiology of ADHD. It is believed that the PFC and dopaminergic systems interact as a regulated network that is associated with cognitive and behaviour control (Wigal et al., 2013; Zimmerman, 2003). Wigal et al. (2013) found that dopamine levels in the PFC increase during performance of working memory tasks, and obstructing dopamine in the PFC creates working memory deficits. Because individuals with ADHD frequently exhibit working memory deficits, findings from this study suggest that dysregulation in the dopamine levels within the PFC may explain some of the cognitive deficits associated with ADHD.
2.7 Neurotransmitters

As previously mentioned, ADHD is a neurobehavioral disorder with abnormalities in neurotransmitters, primarily the dopaminergic system (Graydanus et al. 2007; Panzer & Viljoen, 2005). The dopaminergic system is associated with motor control, motivation, and rewards, which are connected to the PFC. It is believed that the dopaminergic system and PFC interact as a regulated system associated with cognitive and behavioural control. Attentional impairments may be due to a hypodopaminergic state in the PFC, and the hyperdopaminergic state may be responsible for motor hyperactivity (Zimmerman, 2003; Kim et al., 2011).

2.8 Executive Function

Another outlook on ADHD suggests that the symptoms associated with the disorder arise from difficulty with executive functioning. Executive functions refer to a number of mental processes that are required to regulate, control, and manage daily tasks. Some of these impairments include problems with organizational skills and time keeping, excessive procrastination, concentration problems, slow processing speed, difficulty regulating emotions, and problems using working memory and short-term memory. People with ADHD usually have functioning long-term memory skills. Due to the rates of brain maturation and the increasing demands for executive control, as a person gets older, ADHD impairments may not fully manifest themselves until adolescence or even early adulthood (Zimmerman, 2003; Kim et al., 2011; Graydanus et al., 2007; Panzer & Viljoen, 2005; Wigal et al., 2013).

Barkley et al. (2001) examined the differences in executive function in adolescents with ADHD and ODD. The Conners’ Continuous Performance Test (CPT)
was used in their study to assess persistence of accurate responses and impulsiveness. The results indicated that the ADHD group had significantly higher CPT Inattention scores than the control group. Previous studies of EF in children with ADHD frequently found them to be less attentive and more impulsive, as indicated by CPT performance, however they did not indicate poorer inhibition functioning on the CPT scores. It is noted that stimulants do improve many measures of cognitive function, and in this study the participants were asked to refrain from taking any medication, but the researchers could not guarantee that the participants obeyed. It is significant to note that more than half of the ADHD group was on stimulant medication for management of their ADHD at entry into the study.

2.9 Management

Majorek, Tuchelmann, and Heusser (2004) believe that there are more than 20 different methods for managing ADHD, indicating the complexity of the disorder. Although medication tends to be the leading management option, it has been found that the benefits of medication are greater when combined with a non-medical therapy method (i.e. counselling, lifestyle changes) as well, especially for children with co-morbid disorders (Richters, et al., 1995; Zimmerman, 2003; Elia, Ambrosini, & Rapoport, 1999; Owens et al., 2003). Management must also be individualized as each individual with ADHD struggles with differences in severity, as well as different co-morbid disorders (Zimmerman, 2003).
2.9.1 Psychosocial

It is believed that the impact of symptoms can be greatly reduced by a supportive home; however, it has been shown that children with ADHD are more likely to have a parent also with ADHD, meaning that the ideal environment may not be likely and the environment created may ultimately cause the condition to persist for both the child and parent (Majorek, Tuchelmann & Heusser, 2004). Some of the leading psychosocial therapy options include occupational therapy, play therapy, sensory integration, diet, therapeutic eurythmy (TE), and firm positive reinforcement (Zimmerman, 2003; Majorek, Tuchelmann & Heusser, 2004; Graydanus et al. 2007). The goal is for the child to gain self-esteem as well as improve relationships.

Therapeutic Euryhmy (TE) is a technique for ADHD management, reported in the literature by Majorek, Tuchelmann, and Heusser (2004), where children are taught to imitate patterns of movement that involve cognitive, emotional, and volitional elements, and the child is expected to perform these movements several times a day until they are performed in a concentrated, precise and joyful manner. It is designed to aid the ADHD patient in concentrating and becoming aware of feelings in a controlled manner. Their study consisted of 5 children participating in thirty-minute TE training sessions, ranging from 7 to 25 sessions per child. Post-intervention, the mothers of the children reported that their children had matured and developed greater self-esteem. The psychological tests administered indicated improvement in attention, concentration, tempo of work, coordination and social behaviour. One limitation of this study, however, is the failure to note that the improvements may have stemmed from another source of management such as exercise, relationships at home, and/or diet.
Behavioural management is another popular intervention and with this strategy the goal is to provide positive reinforcement to reduce problematic behaviour (Zimmerman, 2003). Behavioural strategies are more effective when the teacher and parents follow the same guidelines, which then evolve with the child’s improved behaviour. Following are some examples of strategies aimed at managing unwanted behaviour in children with ADHD (Zimmerman, 2003):

- Give the child immediate feedback and consequences.
- Give the child frequent feedback.
- Use more powerful consequences.
- Plan ahead for problem situations.
- Strive for consistency.

Other interventions mentioned in the literature include meditation, support groups, parent/teacher training, biofeedback, and other forms of social skills training (Graydanus et al., 2007).

2.9.2 Medication

Stimulant medication is used to treat approximately 85% of children diagnosed with ADHD (Wigal et al., 2013) and stimulants show improvement rates on the behavioural symptoms of ADHD, cognitive and academic performance, interactions with family and peers, and aggression, as high as 80-90% (Zimmerman, 2003; Wigal et al., 2013). The most commonly used stimulants are methylphenidate (Ritalin), an amphetamine mixture (Adderall), and dextroamphetamine (Dexedrine). The efficacy of these medications lies in their ability to enhance dopamine availability, resulting in enhancement to the individual’s attention (Zimmerman, 2003). Methylphenidate acts as a
dopamine agonist by blocking the re-uptake of dopamine in the synaptic cleft. This allows the dopamine to remain in the synaptic cleft longer, allowing more time for post-synaptic binding (Tantillo et al., 2002; Graydenus et al., 2007; Kim et al., 2011). The medication has been shown to have positive effects on aggression and cognitive and academic performance as a result of increased vigilance, productivity and classroom compliance, and on the quality of peer and family interactions among diagnosed children, often with a reduction in hyperactivity, restlessness, and impulsivity. Stimulant medication has also been shown to improve behaviour and social adjustment in 50-95% of children with ADHD (Zimmerman, 2003; Graydenus et al., 2007).

Walters et al. (2000) examined the effects of dopaminergic therapy by administering various dosages of either levodopa (L-dopa) or the dopamine agonist pergolide, to children with restless leg syndrome (RLS). It is believed that RLS could possibly be a contributing factor to ADHD, as RLS patients tend to have significant sleep disruptions that could lead to developing ADHD. Seven RLS children participated in mono dopaminergic therapy, and results indicated that they all significantly improved on the Conner’s Parent Rating Scale, the Inattention/Overactivity Score, Oppositional-Defiant Behavior Score, and the visual memory scores on the Wide Range Assessment of Memory and Learning. After the dopaminergic monotherapy, three of the seven children no longer met the criteria for ADHD based on the DSM-IV (Walters et al., 2000).

2.9.3 Exercise

Years of anecdotal reports from parents and teachers suggest that exercise can alleviate the symptoms of ADHD in children. The majority of the research has been performed on children and small animals, with varying results. One of the major
confounding factors in measuring the success of exercise is the difficulty inherent in
deriving an exact measurement of activity, as well as the need for using noninvasive
measures. Dubbert (1992) reviewed the health benefits of exercise on numerous health
issues such as osteoporosis, psychological effects, cancer, and diabetes, and found that
regular exercise is, in fact, a primary, or adjunctive therapy for mood, anxiety, depression
and addictive disorders. It is difficult to measure the optimal levels of activity as many of
these patients were very ill and their activity levels varied. Although Dubbert (1992) did
not measure ADHD directly, her findings indicated that exercise would likely be
beneficial to ADHD patients given the high rate of comorbidity between ADHD and
mood disorders, anxiety, depression and addictive behaviours.

Numerous small animal studies have been performed in attempts to determine the
effects of exercise on the brain. Kim et al. (2011) support the belief that chronic exercise
improves motor performance, cognitive function, learning, and memory. They examined
the effects of physical exercise (treadmill running) on hyperactivity, spatial learning
memory, dopamine synthesis and brain-deprived neurotrophic factor (BDNF) expression
in ADHD rats. The rats were randomly assigned to a control group, ADHD group,
ADHD and methylphenidate (MPH)-treated group, ADHD and treadmill exercise group,
or ADHD and MPH-treated with treadmill exercise group (n=15). The MPH group
received 1mg/kg MPH orally for 28 days and treadmill rats were to run for 30 minutes
once a day, five days a week, for 28 days. Their spatial learning was tested using an 8-
arm maze test. Results indicated that treadmill exercise and MPH alleviated the ADHD-
induced hyperactivity and spatial learning memory impairment. These findings suggest
the possibility that exercise may be used as just as effective a therapeutic intervention for ADHD patients as MPH treatment.

Pontifex, Saliba, Raine, Picchetti and Hillman (2012) examined the effects of a single bout of moderate-intensity exercise on the inhibitory control deficits in children with ADHD. The study compared 20 children, 14 of who were male, aged 8-10, and all of who were suspected of having or were already diagnosed with ADHD. The participants completed a modified version of the Eriksen Flanker task. The participants were divided into groups in which they completed 20 minutes of either seated reading or aerobic exercise on a treadmill at an intensity of 65-75% of their maximum heart rate. Upon completion of the conditions and once the heart rate returned to within 10% of pre-experimental levels, the Flanker’s tasks were performed, followed by administration of the third edition of the Wide Range Achievement Test (WRAT3). The results indicated that both groups exhibited enhanced performance after exercise on tests of reading comprehension and arithmetic. The findings suggest that single bouts of moderate intense aerobic exercise may positively affect the inhibitory control, as well as cognitive functioning in children with ADHD.

Kamp, Sperlich, and Holmberg (2014) performed a meta-analysis on the impact and beneficial effects of different types of exercise on childhood ADHD. A variety of exercises, durations, and intensities were examined, ranging from low-moderate types such as yoga for 1 hour and walking for 30 minutes, to moderate and moderate-high types such as aerobic exercise/training for 45-90 minutes. The studies they looked at found that all types of exercise were beneficial to the studied variables (improved social behaviour, strength and motor skills, increased neuropsychological measures, and/or attenuating the
symptoms of ADHD). Exercise is generally believed to be a safe ADHD management option with no known side effects.

Chang et al. (2012) examined the effects of acute aerobic exercise on executive function in children with ADHD using the Stroop Test and the Wisconsin Card Sorting Test (WCST). Forty children were recruited for the study (3 females) with an age range of 8-13. The participants were divided into two groups: an exercise group and a control group. Measures of the children’s heart rates were collected, as well as ratings of their perceived exertion at two-minute intervals based on the original Borg scale [a numerical scale ranging from 6-20, designed to follow a healthy heart rate, multiplying by 10 (i.e Borg scale 6 = no exertion, which is equivalent to a heart rate of 60 beats per minute)]. Each participant completed all stages of the experiment. In the first stage of the study the child and parent arrived to visit the lab to complete the necessary paper work. They then entered the second stage consisting of completing the Stroop test and the WCST. The exercise group then completed moderate exercise (50-70% Heart Rate Reserve (HRR)) for 30 minutes (5 minute warm up, 20 minutes of exercise, 5 minute cool down). The control group watched a 30-minute video based on running/exercise. Within a minute of completing the third stage, each participant was asked to complete the Stroop test and the WCST again. The results indicated that acute moderate intense exercise improved performance in the Stroop Color-Word condition, as well as improvements in the WSCT. No improvements were found in the controlled group.

A meta-analysis was conducted (Verburgh, Konigs, Scherder, & Oosterlaan, 2013) on 19 studies to assess the effects of acute physical exercise on executive function in children, adolescents, and young adults (age 18 to 35). They found that exercise had
positive and significant overall effects on executive functions, with no significant
difference found between groups. Acute physical exercise had significant effects on the
domains of inhibition/interference control (Verburgh et al. 2013).

Tantillo et al. (2002) found that boys with ADHD had an increased spontaneous
eye-blink rate (SEBR) (motor reflexes sensitive to dopaminergic agonists) and decreased
motor impersistence (i.e., the inability to sustain simple motor acts such as maintaining a
conjugate gaze) after maximal exercise. Thus, similar to stimulant medication, the
physiological effects of exercise seem to increase levels of dopamine, the catecholamine
believed to influence information processing in the brain, with potential impacts on
cognitive functioning and mood. From these studies we can see that exercise can be
viewed as a management intervention for children with ADHD. Also findings from
several studies evaluating the effects of exercise on adults with ADHD (Verburg et al.,
2013) and exercise on other disorders associated with ADHD (Dubbert, 1993; Kim et al.,
2011) supports exercise as a management intervention for adults with ADHD.

2.10 Spontaneous eye-blinks

The physiology of blinking is not well known (Hallett, 2002). The spontaneous
eye-blink rate provides a non-invasive peripheral measure of central dopamine activity
(Barbato et al., 2000; Colzato, van den Wildenberg, van Wouwe, Pannebakker &
Hommel, 2009; Chermahini & Hommel, 2010; Taylor et al., 1999; Chen, Lam, Chen &
Nguyen, 1996; Karson, 1987). Many factors, such as eye irritation, level of arousal,
readily available dopamine, and cognitive variables influence blink rate (Karson, 1987).
As previously stated, dopamine availability results in enhancement of the individual’s
capacity to maintain attention (Zimmerman, 2003). Barbato et al. (2000) examined the
spontaneous eye blink rates throughout the day of healthy individuals. Higher levels of activation or arousal were associated with elevated blink rate. Blinks occurred more frequently when subjects performed tests involving higher levels of attention (i.e., speaking, memorizing, and mental arithmetic). Barbato et al. (2000) excluded participants with a cold, flu, or headache as those factors could influence visual sensitivity.

Colzato et al. (2009) examined dopamine and inhibitory action control. They stated that functional magnetic resonance imaging (fMRI) studies have demonstrated the involvement of the prefrontal cortex in response inhibition when subjects were completing an inhibition test, similar to the CPT II. The stop-signal task provides a direct behavioural assessment of the ability to stop a planned or ongoing motor response in a voluntary motion. Other studies have found that schizophrenia patients (elevated blink rates) who suffer from dopamine imbalances inhibit responses more slowly than controlled subjects. In this study, the measure of dopamine function was the SEBR. Healthy adults (n=27) (20 females, 7 males) participated in the study. For this study, data was also never collected after 5 p.m. as prior research indicated that SEBR is supposed to be most stable during the daytime but increases in the evening (after 8:30 p.m.) (Barbato et al., 2000). Their findings suggest that in healthy people, the SEBR reliably predicts the efficiency in inhibiting action tendencies in a stop-signal task. Taken together, the results help support the theory that dopamine plays a crucial role in inhibitory control in everyone.

Chen et al. (1996) studied the blink rates in people with schizophrenia. Blink rates of inpatients with schizophrenia (n=40) were assessed in the relaxed condition in which they listened to slow string music, as well as an attentive condition where they counted
irregular paced out pure tones, and were compared to controlled participants (n=33). Relaxed, inpatients had significantly higher blink rates than controls. No differences were found between the groups in the attentive condition, suggesting an increase in the resting level of dopaminergic activation in patients. Blink rate is modestly affected by the dosage of neuroleptic medication. A reduction in blink rate upon initiation of neuroleptics has been previously reported. Conditions in which there is reduced dopamine availability, such as ADHD and Parkinson’s disease, have reduced eye blink rates. Daydreaming, a common symptom of inattentiveness in ADHD, has been found to decrease blink rate (Holland & Tarlow, 1975). Excessive eye blinking may help indicate the onset of disorders associated with ADHD such as Tourette syndrome.

Freudenthaler, Neuf, Kadner and Schlote (2003) examined the spontaneous eye blink rate (SEBR) of healthy individuals (n=51). Eye blinks were measured for 10 minutes under three separate conditions: during conversation, during video display terminal (VDT) use without corneal anaesthesia, and during VDT use with corneal anaesthesia. The results found that the SEBR significantly decreased during VDT use compared to conversation and corneal anaesthesia further significantly reduced SEBR. Helland et al. (2008) also examined the effects of SEBR during light conversation and VDT use. They found results similar to those found by Freudenthaler et al. (2003) as they found a reduction in eye blinks during VDT use compared to light conversation (VDU work, mean = 9.7 blinks per minute’ “easy conversation,” mean = 21.4 blinks per minute). Schlote et al. (2004) examined the effects of SEBR on dry eye participants during VDT use and they found comparable results to the previously mentioned studies. In comparison with SEBR during conversation, the SEBR significantly decreased during
initial VDT use and remained significantly decreased during the re-measurement after 30 minutes.

Tantillo et al. (2002) evaluated the effects of exercise on children (n=18) with ADHD, ranging in age from 8-12. They measured the children’s SEBR and motor impersistence. The children were evaluated on three separate days, beginning with a maximum oxygen uptake test on a treadmill. Upon completion, the children were randomly assigned to counter balanced conditions of either sitting quietly while watching an episode of “Winnie the Pooh” or treadmill walking. Results showed that boys with ADHD had increased SEBR and decreased motor impersistence after maximal exercise. There was only an improvement found in boys with motor impersistence after maximal exercise. Tantillo et al. (2002) measured reaction time and eye blinks while the children were responding to an auditory stimulus; the current study will be examining SEBR and reaction time on a visual test. Based on the results of the previous studies, we hypothesize that spontaneous eye blinks will decrease, post-acute sub maximum exercise in adults with ADHD, due to an increase in dopamine in the pre frontal cortex, allowing the individual to increase attention during their second CPT-II evaluation.
Chapter 3: Materials and Methods

The following protocols were designed based on previous research in order to determine whether acute aerobic exercise can be used by young adults with ADHD to help alleviate ADHD symptoms. Pilot studies were performed to test this methodology, resulting in modifications that were made to reduce errors. The results of each pilot study are outlined in Appendix A. The study was approved by the UNB Research Ethics Board (case # 2013-096).

3.1 Subjects

Twenty-seven university students (19-30 years) were recruited; however, only 20 completed the full data collection. Ten adult self-reported ADHD participants (based on their response to the Amen and ASRS screening questionnaires) (M=24.2 years, SD=3.94) consisting of 7 males and 3 females, along with 10 matched (M=24 years, SD=3.65, 3 males and 7 males) non-ADHD. Seven participants withdrew from the study (4 prior to data collection, 3 post VO2 max test).

3.2 Recruitment

Participants were drawn from the UNB and STU campus community via word-of-mouth and advertisements on the UNB campus. Posters included information about where interested individuals can contact the researchers to obtain an Informed Consent Form. In addition, contact was made with the Director of the UNB Student Accessibility Centre who was asked to independently send an email of the advertisement to an equal number of ADHD and non-ADHD individuals from their most recent client lists. The
researcher was not informed of the participant’s test group, as the initial data was collected by a research assistant, with the intent to maintain a double blinded study.

3.3 Questionnaires

The participants were required to complete the Informed Consent Form (see Appendix B) prior to continuing the evaluation. The participants were also required to complete a Participant Background Questionnaire, Par-Q & You, Adult ADHD Self-Report Scales (ASRS) Screener, and the Amen Clinic ADD Type Questionnaire with the same research assistant each time. The complete forms of each questionnaire are included in Appendix B. Ethics approval was obtained from the UNB Research Ethics Board, following the approval of the proposed study by the Faculty of Kinesiology Ethics Committee. The participants were assured that their information would remain confidential. This was accomplished by assigning each participant a numerical code as opposed to their name on all written or electronic documents. The documents were locked in a secure office to which only the researchers had access.

3.4 Experimental Design

Both ADHD and control participants attended three experimental sessions referred to as the following: (1) familiarization of the equipment and exercise; (2) maximum oxygen uptake test (VO2 max); and (3) acute sub maximum exercise (70%-80% of their perceived exertion from the Borg Scale and heart rate). The three sessions were completed within a 7-day period to avoid a practice/training effect. For each exercise condition, the participant cycled at 70 rpm to keep consistency within, as well as across participants. Spontaneous eye blink, assessed by ISCAN ETL-570, and motor
control, commission, omission, and reaction time, assessed by the Conners’ Continuous Performance Test II (CPT-II), were recorded before and after each of the two exercise conditions.

3.4.1 Conners’ Continuous Performance Test (CPT II)

The Conners’ Continuous Performance Test (CPT-II) is a computerized 15-minute visual performance task in which the participant must respond repeatedly to non-targeted figures (capital letters) and then inhibit response when the infrequent target figure appears (the letter X). Omissions represent the number of targets that the participant fails to respond to (not hitting the space bar when a letter that is not an X is presented). Commission refers to the number of times a participant responds to the non-target stimulus (letter X) as it appears on the screen (Soreni, Crosbie, Ickowicz, & Schachar, 2009). In accordance with the manual instructions, the examiner sat behind the divider following the completion of the practice trial. The administration instructions for the CPT-II encourage the examiner to leave the room; however, the examiner in this study had to remain present to ensure the ISCAN-ETL 570 recorded accurately.

3.4.2 ISCAN-ETL 570

The ISCAN model ETL-570 (Figure 1) is a head mounted video-based eye tracking system with eye and scene cameras located on a visor. It requires tight mounting to the head to avoid shifts in calibration accuracy. It measures direction of gaze and blink rate for one eye (left) with an infrared video-based system. The source data is pupil only.
Only full blinks are counted, however, when the pupil is obscured for other reasons (such as scratching around the eye) it is considered a blink.

To calibrate the ISCAN ETL-570, the participant was asked to sit stationary in a comfortable position as they were prepared to complete the CPT-II, with little to no movement of the head. The calibration began with the participant gazing at the middle of the computer screen.

The researcher ensured the pupil would appear as white as possible to detect the small black dot in the middle of the pupil (Figure 2).

The researcher must click “track active” then “options”. The bottom left screen then switched to calibration controls. In the POR Calibrate tab, the researcher asked the participant to look at the middle of the computer screen. The researcher was also able to see the area to which the participant was looking, making the calibration of the contour of the computer screen important (Figure 3). The goal of the calibration was to ensure that the participant maintains focus on the computer screen throughout the CPT-II test. The ICAN, however, will continue to record blinks even if the participant’s gaze falls outside of the coordinates. The researcher moved the white targets on the bottom left screen (Figure 4) to match the focus on the centre of the screen, top right, top left, bottom right, and bottom
left corners of the CPT-II computer screen. Once the ISCAN was calibrated, the participant began the CPT-II. When the participant was ready, the researcher clicked “blink set” then “record”, as the participant began the CPT-II.

Figure 3. ISCAN ETL-570 Calibration controls.

Figure 4. Top right screen indicates where the participant is looking.

3.4.3 Metabolic Cart

The metabolic cart is a computerized system that was used to measure the volume oxygen consumption (VO2) and volume carbon dioxide production (VCO2), providing the Resting Energy Expenditure (VCO2/VO2). Calibration is performed once the
analyzer warm-up period of 30 minutes is complete, if the metabolic cart has changed location, or every eight hours of continuous use. The flow sensors and gas analyzers are calibrated based on the manufacturer recommendations with precision compressed gas. Normally they contain 16% of oxygen and 3% of carbon dioxide. The volume of air inspired is measured using a mechanical flow meter (3L calibration syringe series 5530), which is used to push air through the system imitating the breathing pattern of an adult. Oxygen and carbon dioxide concentrations were measured using an electronic gas analyzer. The participant sat stationary for two minutes with a secure fitted mask while the metabolic cart collected the baseline data by reading their oxygen consumption, carbon dioxide production, and current heart rate. Collecting a baseline is necessary to ensure proper calibration and performance of the metabolic measurement system, as well as to ensure the mask fits properly without any leakage.

Gas Calibration: To calibrate, click on the TrueOne Exer icon from the desktop, then click the gas calibration button from their main screen. A screen will appear in which the current temperature, barometric pressure, and humidity will have to be entered. The program will instruct you to turn on the gas tank. Turn the handle 90 degrees, then press “ok” to continue. The computer will take 30 seconds to sample room and calibration air. A memo will appear instructing to turn gas off. Turn gas off. Once the sampled air is measured a box will appear comparing the sample air to the standard gas (both O2 and CO2). Click “save”. Gas calibration is complete.

Flowmeter Calibration: Flowmeter calibration should immediately follow gas calibration. Ensure the moisture filter is connected to a liquid trap, then connect the tube with the two-way breathing valve, which connects to the 3L calibration syringe. Click
“flowmeter calibration” on the main screen. It will prompt you to enter the temperature, barometric pressure, as well as the humidity, but all values should already be saved from the gas calibration. Click “sample baseline”. Begin with the syringe plunger all the way in. The system will prompt for one detection stroke, and four flush strokes. The first five calibration strokes are essentially practice strokes. Make sure the syringe is being pulled and pushed all the way in/out. The following five strokes require the syringe to be pulled and pushed all the way in/out or else calibration will fail. There is a dotted yellow line above the solid yellow line, in which each stroke should be above the dotted line, reading at approximately 150L/min. The system will automatically create another dotted line, where you want the stroke to read just above that line. Once the strokes are complete, you want to look at the high and low for average flow, and if there is a greater than a 5% difference, you need to re-do the flowmeter calibration. It is also essential to have the average flow as close to 3.00L as possible. This concludes calibrating the metabolic cart for an exercise test.

3.5 Familiarization Protocol

After completing the questionnaires, the research assistant contacted the primary research team with contact information for the participant, allowing the researcher and participant to arrange the remaining testing sessions. The testing sessions began with the familiarization session at which the participant was introduced to all the equipment. At this session, the required personal physical information was measured (height, weight, mask size, seat height).

The participant was then introduced to the equipment that would be used in the subsequent testing sessions. They had the opportunity to wear the equipment, if
interested, such as the heart rate monitor, as well as the ISCAN ETL-570, to become more comfortable with what to expect during subsequent sessions. The researcher verbally explained the CPT-II and, as part of the CPT-II protocol, the participant had the opportunity to complete a trial of the test prior to each actual test administration during the experimental sessions. Participants were strongly encouraged to partake in a short warm-up on the stationary cycle ergometer to replicate the upcoming protocols and to determine which mask was the best fit to avoid any leakage, the correct seat height, and for the participant to become more comfortable with performing aerobic exercise with the mask on and while attached to the metabolic cart. The researcher answered any questions the participant had at this point. If the participant was willing to continue, arrangements for the following testing sessions were made, at that point in time. It was required that the scheduled testing sessions be completed within a week, on separate days.

3.6 Maximum oxygen uptake test (VO2 max) Protocol

Prior to the participant arriving for each test sessions, the CPT-II administration was set-up, as well as the flow and gas calibration for the metabolic cart. Once the participant arrived, they were asked to put on the heart rate monitor and to take a seat on the stationary chair in front of the computer used to complete the CPT-II as shown in Figure 5.
The researcher assisted with the set-up of the ISCAN ETL-570. Once the ISCAN ETL-570 was calibrated, the participant was able to begin the CPT-II. The eye blinks and movements were only recorded for the duration of the CPT-II. Upon completion of the CPT-II, the researcher assisted the participant in switching to the stationary cycle ergometer.

For the VO2 max test, the participants began with a rest period of 120 seconds to complete the calibration of the metabolic cart. Each warm-up had a duration of 10 seconds followed by graded interval increments. The males were selected to complete one of two tests, depending on their level of fitness (only those identified as level 4 were considered “fit”), as were the females, as outlined in Table 1. Borg’s scale of rate of perceived exertion (RPE) was used to obtain ratings of perceived exertion (ranging from 6, or “no exertion”, to 20, “maximum exertion”) during the final 15 seconds of each level of exercise (Borg, 1970). Participants communicated RPE to the researcher using hand signals with their right hand.

Figure 5. Position of participant prepared to complete the CPT-II.
Table 1. Graded VO2 Tests.

<table>
<thead>
<tr>
<th>Level</th>
<th>Time (s)</th>
<th>Female Fit (Watts)</th>
<th>Female Sed. (Watts)</th>
<th>Male Fit (Watts)</th>
<th>Male Sed. (Watts)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rest</td>
<td>120</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Warm-Up</td>
<td>120</td>
<td>60</td>
<td>45</td>
<td>90</td>
<td>60</td>
</tr>
<tr>
<td>Level 1</td>
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<td>90</td>
<td>60</td>
<td>120</td>
<td>90</td>
</tr>
<tr>
<td>Level 2</td>
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<td>130</td>
<td>90</td>
<td>180</td>
<td>150</td>
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<tr>
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<td>120</td>
<td>150</td>
<td>105</td>
<td>210</td>
<td>180</td>
</tr>
<tr>
<td>Level 5</td>
<td>20</td>
<td>165</td>
<td>120</td>
<td>225</td>
<td>195</td>
</tr>
<tr>
<td>Level 6</td>
<td>20</td>
<td>180</td>
<td>135</td>
<td>240</td>
<td>210</td>
</tr>
<tr>
<td>Level 7</td>
<td>20</td>
<td>195</td>
<td>150</td>
<td>255</td>
<td>225</td>
</tr>
</tbody>
</table>

Once the participant reached their maximum level, they performed a cool-down (reducing the watts to the warm-up level) to reduce their heart rate to 10% of their resting heart rate (RHR).

3.7 Sub-maximal oxygen uptake test (20 min) Protocol

The sub-maximal oxygen uptake test is based on the results of the RPE, maximum level achieved, and heart rate from their VO2 max test results. The participants began with a 120 second rest period, followed by a five-minute warm-up. The participant was expected to complete 20 minutes of cycling at ~70-80% of their VO2 peak heat rate and RPE results. It was decided that acute sub maximum exercise duration would be 20 minutes, based on previous studies on children (Pontifex et al., 2013; Kamp, Sperlich, &
Holmberg, 2014; Chang et al. 2012; Tantillo et al., 2002) and as a duration that could be completed within an hour lunch break at work. Once the 20 minutes had been completed, a cool-down period was encouraged to assist in reducing the heart rate back to 10% of their RHR. The participant was required to give their RPE every 5 minutes to ensure the participant was meeting the desired level of exercise.

3.8 Statistical Analysis

Parametric statistical tests were performed on collected data. A paired t-test was used to compare the pre and post CPT-II scores, as well as the pre and post SEBR scores for the ADHD participants. When comparing each dependent variable (CPT-II scores and SEBR scores), a mixed model ANOVA was applied to each, as this compares between groups (ADHD vs. non) and one repeated factor (time). Tantillo et al. (2002) evaluated the effect of exercise on 18 children, while Pontifex, Saliba, Raine, Picchietti and Hillman (2012) evacuated the effects of exercise on 20 children. Using G*Power Data Analysis, as well as the number of participants from previous studies, it was determined that a sample size of 20 participants was necessary to achieve a medium effect size (r=.3), along with a significance value at 0.05, and to obtain an 80% probability of detecting that effect.
Chapter 4: Results

Of the 20 participants that completed both data collection sessions, 10 self-reported as identifying symptoms of ADHD on both the Adult ADHD Self-Report Scales (ASRS) Screener, and the Amen Clinic ADD Type Questionnaire. Eight of the other 10 participants reported as non-ADHD on both questionnaires, with only two participants reporting as having ADHD symptoms on one of the questionnaires but not the other. The results of the questionnaires were the determining factor for a control or a self-reported ADHD participant. The self-reported ADHD participants had an average activity level of 2.6 on a 4 point scale, with three considering themselves a smokers, while the non ADHD participants had an average activity level of 3, with only two reporting as smokers. Of the seven participants that withdrew, five of those participants were recruited through the Student Accessibility Centre at UNB. The other two participants moved and were unable to complete the data collection.

4.1 Acute Maximum Aerobic Exercise and CPT-II Scores

It was hypothesized that acute maximum aerobic exercise would not increase attention in ADHD participants, as indicated by comparing pre and post exercise CPT-II scores. The CPT-II scores were broken down to examine the number of commission errors and omission errors. The errors are presented as scaled data ranging from markedly atypical, mildly atypical, average, good, and very good on a five-point scale [markedly atypical (1) - very good (5)]. A paired t-test was conducted in which we failed to reject the null hypothesis as there was a non-significant difference in the omission errors pre exercise (M=1.00, SD=1.76) and post exercise (M=0.20, SD=0.42) conditions; t(9)= 1.31, p= 0.22 ; and the commission errors pre (M=11.0, SD=5.19) and post (M=10.7,
SD=6.29) exercise conditions; t(9)= 0.39, p= 0.71. Mean omissions and commissions scores are shown in Figure 6 and Figure 7, respectively.

It was also hypothesized that there would be no difference in the pre-post CPT-II change scores between ADHD and the control participants in CPT-II scores. A repeated measures ANOVA was conducted to compare the effects of exercise on ADHD versus control subjects on CPT-II scores. We failed to reject the null hypothesis as there was not a significant effect, the raw omission errors, F(1,18)= 0.63, p= 0.81.; as well as commission errors, F(1,18)= 1.79, p= 0.19.

4.2 Acute Sub-maximum aerobic exercise and CPT-II scores

It was hypothesized that acute sub-maximum aerobic exercise would not increase attention in ADHD participants as indicated by comparing pre and post exercise CPT-II scores. A paired t-test was conducted in which we failed to reject the null hypothesis as there was a non-significant difference in the omission errors pre exercise (M= 0.80, SD= 1.48) and post exercise (M=1.10, SD=1.10) conditions;
t(9) = -0.58, p = 0.59.; and the commission errors pre (M=9.00, SD=6.06) and post (M=8.90, SD=4.89) exercise conditions; t(9) = 0.80, p=0.94.

It was hypothesized that acute sub-maximum aerobic exercise would not increase attention in self-reported ADHD adult participants by comparing pre and post exercise CPT-II scores to the control group. A repeated-measures ANOVA was conducted that examined the effects of 20 minutes of exercise on the ADHD participants versus the control on the CPT-II scores. A two-way ANOVA was conducted to examine the effects of 20 minutes of exercise on the omission scores between the ADHD and control participants. A significant interaction was found between the ADHD and control groups on the omission scores from pre to post exercise $F(1, 18) = 11.23, p = .004$. A repeated measures ANOVA was conducted to examine the effects of 20 minutes of exercise on the commission scores of ADHD versus control participants. A significant interaction was not found $F(1, 18) = 0.06, p=0.81$. We rejected the null hypothesis, as there was a significant decrease in omission

Figure 8. Self-reported ADHD and control participants’ omission error scores pre and post sub maximum exercise condition.
errors from pre-post after 20 minutes of sub-maximum exercise. Omissions and commissions scores are shown in Figure 9 and Figure 10, respectively.

4.3 Acute Maximum Aerobic Exercise and Spontaneous Eye Blink Rate

It was hypothesized that acute maximum aerobic exercise would not have an effect on spontaneous eye blink rate (SEBR) in ADHD participants. A paired t-test was conducted in which we failed to reject the null hypothesis as there was a non-significant difference in the overall SEBR score pre (M=359.90, SD=346.89) and post exercise (M=236.60, SD=161.99) conditions; t(9)= 1.08, p= 0.31.

It was also hypothesized that there would be no significant difference in the pre-post SEBR change scores between ADHD and non-ADHD participants in the acute maximum aerobic exercise condition. A repeated measures ANOVA was conducted that examined the effects of acute maximum exercise on the ADHD participants versus the control on SEBR, F(1,18)= 0.42, p= 0.53, in which we failed to reject the null hypothesis.

4.4 Acute Sub-maximum Exercise and Spontaneous Eye Blink Rate

It was hypothesized that acute sub-maximum exercise would not have an effect on spontaneous eye blink rate in ADHD participants. A paired t-test was conducted in which we failed to reject the null hypothesis as there was a non-significant difference in the
overall SEBR score pre exercise (M=360.20, SD=294.89) and post exercise (M=369.80, SD=368.95) conditions; t(9)= -0.081, p= 0.94.

It was also hypothesized that there would be no significant difference in the pre-post SEBR change scores between ADHD and non-ADHD participants in the acute sub-maximum aerobic exercise condition. A repeated measures ANOVA was conducted that examined the effects of 20 minutes of exercise on the ADHD participants versus the control on SEBR, F (1,18) = 1.91, p= 0.18, in which we failed to reject the null hypothesis.

4.5 Summary of Results

In summary, the results indicate that exercise does have a positive effect on attention, as evidenced by an improvement in omission and commission scores in both ADHD and control groups, reaching significance in the omission scores for ADHD participants’ post-acute sub maximum aerobic exercise. Spontaneous eye blinks did not reach significance from pre to post exercise in self-reported ADHD participants in either exercise condition.
Chapter 5: Discussion

The results of the present study support the years of anecdotal evidence, as well as the results of past studies, suggesting that exercise could be a management intervention for individuals with ADHD. As previously mentioned, the majority of the research has examined the effects of mild, moderate and intense aerobic exercise on children (Kamp, Sperlich, & Holmberg, 2014; Pontifex et al., 2013; Tantillo et al., 2002), however this study extends the support to include the theory that exercise could be an effective management tool for adults with ADHD.

5.1 Acute Maximum Aerobic Exercise and CPT-II Scores

Self-reported ADHD adults’ CPT-II scores were compared to the control group from pre to post-acute maximum aerobic exercise. When examining the omission (poor omission scores are a sign of distractibility) scores, Figure 7 illustrates an improvement post maximum aerobic exercise, although the results did not reach significance, with the self-reported ADHD group. Figure 7 also illustrates that the control group’s scores actually decrease marginally. The results indicating higher omission errors post exercise for the controls, indicates that they were more distracted post exercise, which may be why the mean of the CPT-II scores did not improve for this group post maximum aerobic exercise. Exercise is believed to be an effective tool for increasing dopamine in the prefrontal cortex, which leads to an increase in attention. Considering the inverted U theory, in which too much exercise, or too much dopamine, can cause an opposing effect (McMorris & Graydon, 2000), may explain why the control group’s omission scores did not improve with maximum exercise and, in fact, there was a decrease in performance in omission scores.
Figure 6 illustrates the changes in commission scores from pre to post-acute maximum aerobic exercise for both the self-reported ADHD and the controls. As indicated, there was no change for the controls from pre to post exercise, however the ADHD participants slightly improved their commission scores post exercise, although the results did not reach significance. Commission scores are viewed as inattentive or impulsive depending on the reaction times of the individuals. Therefore, the results indicate that the ADHD group reduced their impulsivity and/or inattentiveness post-acute maximum aerobic exercise.

5.2 Acute Sub-maximum aerobic exercise and CPT-II scores

Figure 8 illustrates the omission scores from pre to post exercise conditions for both the ADHD and control groups. The control group slightly decreased their omission scores, indicating they were more distracted post exercise. This could have been due to numerous factors such as perspiration, humidity, and/or comfort. The majority of participants in this group were female so having their hair fall in their face may have been a distraction as well. The results for the ADHD group indicate a significant effect from pre to post exercise on omission scores, implying that these participants were less distracted post 20 minutes of sub-maximum exercise, supporting the findings from studies on exercise and children with ADHD (Kamp, Sperlich & Holmberg, 2014; Pontifex et al., 2013; Tantillo et al., 2002). It should also be noted that the current study did not have any clinically diagnosed ADHD individuals, which may be a factor as to why acute sub maximum exercise only had a significant effect on omission scores, and not commission scores as well. The results from the present study could be used to help promote the beneficial effects of 20 minutes of exercise, and implementing physical
activity in the workplace to help attentional lagging. The results also support the
continuation of research on adults with ADHD, who may or may not be diagnosed, but
may be struggling to manage their symptoms.

Figure 9 illustrates the commission error scores of the ADHD group, as well as
the controls from pre to post sub maximum exercise. As indicated, exercise did not affect
the commission errors for the ADHD group, however the controls slightly improved,
although not significantly, post exercise. Although exercise may not have affected the
commission errors for the ADHD group, it is important to note that the scores remained
the same, and that exercise did not have an impeding effect.

The present study focused on adults with self-reported ADHD symptoms, based
on two screening assessments. The majority of published research on the effects of
exercise and ADHD focuses on children, as the disorder only became adult inclusive in
2013. Due to changes in the DSM-5, limited research is available on adults clinically
diagnosed with ADHD under the new diagnostic criteria. Past studies examined clinically
diagnosed children with ADHD, while the present study did not assess any clinically
referred participants. The participants in the present study only completed the Amen and
ASRS questionnaires as the decisional basis for being categorized into the ADHD or
control group. As a result, there inclusion in one group or the other is based on their
perceived symptoms of ADHD, rather than a true diagnoses. Previous research also
examined comorbid disorders that may have been associated with their participants and
could have altered results. This information might have been more accessible had the
information come from clinically referred participants. The participants from the present
study were not clinically referred nor did they complete a questionnaire in regards to possible comorbid disorders.

5.3 Delimitations and Limitations

To address the delimitations of the study noted in Chapter 1: Introduction, it was found that all appear to be true, namely: 1) all participants did not have visual impairments in either eye; 2) maintained normal activity levels throughout the study (as all participants completed their testing within one week); 3) participants covered the spectrum from sedentary to elite athlete; and 4) all participants reported to be healthy with no cardiovascular, respiratory, or musculoskeletal disorder. However, the majority of the participants did admit to finding it difficult to breathe and/or to perform to their full capability due to the mask. For future studies the aerobic exercise should imitate regular aerobic exercise (without a mask) that could be performed in a non-laboratory setting so that the participant might be better able to transfer the benefits of exercise to everyday life. The present study was a double blinded study in which the research assistant gathered the personal information from the participants, while the primary researcher collected the data during the subsequent two sessions. Since the participants were categorized based on their own self-perceived ADHD symptoms (based on the Amen and ASRS), it is unknown whether the participants were using stimulant medication during testing or not.

There were several limitations to this study that should be addressed in future research. As previously mentioned in Chapter 1: Introduction, there were a few limitations prior to collecting the data, namely: 1) the assumption that all participants would respond truthfully and accurately to all screening questions; and 2) all participants
would perform maximum valiance effort when asked to do so. However, the study would benefit from a larger sample size employing ADHD diagnoses derived from clinical controls, and obtaining a more detailed background from the participants to ensure a comorbid disorder is not affecting the results of the CPT-II. The participants were university students, which also may have created less variance between and within groups. As previously mentioned, adults with ADHD struggle with executive functions (Greydanus, Pratt, & Patel, 2007) making it common to have difficulties maintaining long-term employment, a higher divorce rate, lower levels of socioeconomic status, lower levels of educational attainment, more driving infractions, and difficulties sustaining healthy relationships (Kessler, Lane, Stang, & Van Brunt, 2008). A clinically referred group may not have been as educated, active, and also may not have been as driven to overcome the deficits associated with the disorder to obtain a university degree, causing a greater variance between and within groups. It should also be noted that the majority of the participants (5/7) that withdrew from the study were recruited through the Student Accessibility Centre, suprting the theory that adults with ADHD are not as motivated or driven to complete tasks. Those participants had an increased chance of being diagnosed with ADHD. If they had completed the study, there may have been more variance within groups; however, they would have been placed in either the self-reported ADHD group, or control, strictly based on their responses to the questionnaires, and not isolated into the ADHD group just because they had an actual diagnosis. Also, if the participants in the control group were derived from a general population there may have been more variance in the overall scores. The evaluation lab was quite loud some days with basketball being played above, kids camps outside, and students coming in and out, all of which could
cause distractions to the participants. A more controlled setting, as well as a more controlled test group, could have produced different results. Since the study was a double blind study, the researcher did not ask the participant to identify if medication, of any sort, was administered prior to testing (e.g., anti-depressants, Ritalin, Adderall, oral contraceptives, caffeine, etc.). The administration of certain medications or caffeine could have affected the heart rate, leading to the participant believing they had a higher perceived exertion than they actually did. However, the higher heart rate, and higher RPE should have still correlated with one another.

There are also limitations with regard to interpretation of the SEBR results. The data was collected in the summer, with high humidity levels. This could have affected the comfort level, and produced more perspiration. The eye blink data had a large degree of variance, which may have been due to the perspiration post exercise, causing a distraction or an increase in eye blinks. The high humidity levels could have also caused an increase in the blink rate. Several studies that examined SEBR data, collected their data for SEBR during a 10 minute conversation with the participant in order to obtain a baseline level (Freudenthaler et al. 2003; Helland et al. 2008; Schlote et al. 2004). Baseline SEBR data was not collected in the present study, resulting in an inability to determine whether SEBR increased or decreased during completion of the CPT-II. Barbato et al. (2000) excluded participants with a cold, flu, or headache, as those factors could influence visual sensitivity. Barbato et al. (2000) also never collected data after 5 p.m. as prior research has indicated that SEBR is supposed to be most stable during the daytime but increases in the evening (after 8:30 p.m.). The present study had several participants who were only available after 5 p.m., which could also have been a factor as to why the variance was so
high within as well as between groups. For future work, it is essential to collect baseline data for eye blinks to determine if there is a change during VDU work such as completing the CPT-II (pre and post exercise) compared to the baseline blinks. It is also helpful to compare the baseline blinks from the maximum exercise protocol and the sub maximum exercise protocol to determine the day-to-day variance.

It is important to note that we do not yet have a clear understanding regarding the half-life of a single bout of exercise, given the limited research in this area. The participants began the second CPT-II within five minutes of completing their exercise session. To increase the validity that exercise does have an effect on CPT-II scores, the CPT-II could have been re-administered a half hour-hour post exercise to see if the results differ from five minutes post exercise.

5.4 Conclusion

In conclusion, acute sub maximum exercise does appear to have a positive effect on attention, based on the significant decrease in omission errors found in this study. Though maximum exertion exercise did not produce significant results across the board, there was still a trend indicating that self-reported ADHD adults improved their CPT-II scores post exercise (maximum and sub maximum). Extensive research is still necessary in this field to assist in developing a greater understanding of ADHD, especially in adults. Future work should use clinically referred adult ADHD participants to be able to categorize participants into sub categories of mild, moderate, or severe, as well as categorize participants into the three subcategories of ADHD, and knowledge of their comorbid disorder(s). By obtaining a more detailed background of the disorder for each
participant, a more detailed report can be produced in regards to the effectiveness of acute aerobic exercise on their specific disorder.
Bibliography


Kamp, C. F., Sperlich, B., & Holmberg, H-C. (2014). Exercise reduces the symptoms of attention-deficit/hyperactivity disorder and improves social behaviour, motor skills,


Appendix A

Pilot Data:

1. Eye movement counted as blinks:
   
   (1) 10 Slow eye blinks performed – 10 eye blinks recorded
   
   (2) 15 eye blinks at different rates – 15 eye blinks recorded
   
   (3) Gazed down at the keyboard (5x), no full blinks – 0 eye blinks recorded
   
   (4) Squint, no full blinks – 0 eye blinks recorded
   
   (5) 1 blink, 1 eye rub – 2 blinks recorded
   
   (6) 1 eye rub – 1 blink recorded
   
   (7) Gaze above the computer screen (5x) – 0 blinks recorded

2. Spontaneous Eye Blinks recorded pre and post exercise:

**Table 2.** Spontaneous eye blinks recorded pre and post sub maximal aerobic exercise while completing the CPT-II (non-ADHD).

<table>
<thead>
<tr>
<th>Pre Exercise</th>
<th>Post exercise</th>
</tr>
</thead>
<tbody>
<tr>
<td>35</td>
<td>27</td>
</tr>
<tr>
<td>49</td>
<td>28</td>
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<td>52</td>
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</tr>
<tr>
<td>62</td>
<td>33</td>
</tr>
<tr>
<td>107</td>
<td>32</td>
</tr>
</tbody>
</table>
A paired t-test was conducted to compare the change in eye blinks before and after submaximal aerobic exercise conditions. There was not a significant difference in the eye blinks for pre (M=61.00, SD=27.47) and post exercise (M=45.20, SD=34.08) conditions, t (4) = 0.76, p=0.489.

3. CPT-II scores pre and post exercise

Table 3. CPT-II score recorded pre and post sub maximal aerobic exercise (non-ADHD).

<table>
<thead>
<tr>
<th>Pre Exercise</th>
<th>Post Exercise</th>
</tr>
</thead>
<tbody>
<tr>
<td>85.29</td>
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<td>95.17</td>
</tr>
<tr>
<td>94.49</td>
<td>99.9</td>
</tr>
</tbody>
</table>

A paired t-test was conducted to compare the change in CPT-II scores before and after submaximal aerobic exercise conditions. There was not a significant difference in CPT-II scores for pre (M=95.94, SD= 5.70) and post exercise (M=99.11, SD= 1.93) conditions, t (5) =1.175, p= 0.293.
Appendix B

DOES ACUTE AEROBIC EXERCISE ATTENUATE ATTENTION IN YOUNG ADULTS BY A CHANGE IN EYE MOVEMENT AND BLINKS?

Researchers: Kate Ehrhardt, Graduate Student., Faculty of Kinesiology
University of New Brunswick &
Jeff Landine, Ph.D., Faculty of Education

PARTICIPANT INFORMATION & CONSENT FORM

PURPOSE
The purpose of this study is to take the first steps in determining if a moderately intense acute aerobic exercise can be used by young adults to help alleviate the symptoms of Adult Attention Deficit Disorder (AADD). To accomplish this we seek individuals without and with AADD to volunteer to participate in the study. We will also be examining if focus is affected by acute exercise that will be evaluated using the ISCAN ETL-570 by measuring the eye movements and blinks.

BACKGROUND
There is a strong psycho-neurological basis to support the hypothesis that moderately intense aerobic exercise training may be used to reduce the attention deficit problems encountered by individuals with AADD by increasing the levels of the catecholamine neurotransmitters dopamine and norepinephrine in the brain, an effect similar to that which arises from taking prescription medication such as Ritalin™. Previous research has shown that individuals with ADHD have lower dopamine and norepinephrine levels than those without ADHD and aerobic exercise has been well documented as being a powerful stimulus of catecholamine production when done at a moderately high intensity for a moderate (≈45 minute) duration. There has been very limited research into the effects of aerobic exercise on ADHD in humans and that research has been done with children looking at single aerobic exercise bouts or participating in general physical education programs. Better designed and controlled experimental studies are needed to determine if aerobic exercise training really is effective or not.

WHAT YOU WILL BE ASKED TO DO
You will be asked to come to the Exercise Physiology Research Lab (downstairs in the Lady Beaverbrook Gym) to participate in this research project. The total time commitment for this project is listed is the details below:
All participants– 1 hour familiarization + 2 testing sessions of ≈90 minutes
Familiarization Session  We will go over all of the protocols and any questions, clarifications, and concerns that you may have will be answered. You will then be asked to answer three short questionnaires, one on background information and the other two on AADD tendencies. All questionnaires are used only to gather background and baseline data for group characteristics and individual pre- and post-exercise comparisons; they will not be used for any diagnostic purposes. Basic fitness data (height, weight, skinfold and/or girths, resting blood pressure, and resting heart rate) will also be collected. You will then have the opportunity to try out the exercise bike that will be used for testing and the equipment that will be used to collect the data. This session should take approximately 45 to 60 minutes.

Exercise Testing Sessions  This session will consist of a computer based attention test called the Connor’s Continuous Performance Test (CCPT; which is again only used for baseline data for group characteristics and individual pre- and post-exercise comparisons, and is not being used for any diagnostic purpose) followed by an exercise test. The exercise test will be a maximal effort; after five minutes of warm-up the intensity will gradually increase until you voluntarily stop. You will be encouraged to exercise as long as possible to reach your best performance. There will be several measures taken during the exercise test: heart rate (HR) will be recorded with a chest strap, two sensors will be placed on your forehead for near infrared spectroscopy (NIRS) to measure cerebral blood flow, and a SenseWear armband (SWA) will be worn to measure activity responses. You will also breathe into a mouthpiece so that your expired air can be analyzed to measure your aerobic endurance capacity (VO2peak). Upon completion of the exercise test you will perform the CCPT again. Each of the three testing session should take approximately 75-90 minutes.

NICET 45 Minute Test  This session will also consist of the CCPT (pre- and post-exercise comparisons) followed by a progressive cycle ergometer based exercise. The initial training load and duration will be set based upon your initial exercise test session results. The intent is for the training sessions to achieve the target of 45 minutes at 70-75% of your VO2peak. For some individuals this intensity and/or duration of exercise may take a week or two of progressive training to achieve. The workload will be adjusted accordingly to maintain the 70-75% intensity level. The training session will also include a standardized warm-up and cool-down based upon heart rate and workload responses, each of which will be about 5 minutes in duration.

The sessions will be conducted by the researchers who will be responsible for monitoring the workloads to ensure that the intensity of your effort stays within the target zone throughout the session and data collection. It is not uncommon over 45 minutes for various equipment, environmental (e.g. room temperature), and/or physiological (e.g. hydration level) factors causing the intensity to drift above or below the target zone. During the NICET 45 Minute Test session you will wear the SWA and HR strap as described above, and you will also be asked to indicate your
level of exertion by pointing to a numerical scale at regular intervals. You will be wearing the facemask during training.

It is very important for you to understand that for the duration of the study, regardless of which group you belong to, that you DO NOT MAKE ANY CHANGES to your normal physical activity, exercise, sleep, medication, and dietary practices other than those requested in the study. To do so would preclude our ability to properly and accurately attribute the results from the test sessions (be they positive, no difference, or negative). Should you not be able to commit to this obligation, it would be best if you chose not to volunteer to participate in the study at the present time. Thank you for your consideration.

POTENTIAL RISKS AND DISCOMFORTS
To our knowledge and understanding, and based upon our experiences, the procedures and exercise involved in this study should not pose any undue risk to you. The sensations of pain and discomfort which you will experience during the exercise testing and NICET session are normal and should be similar to that of a moderate to intense exercise or training session. Should you feel any troublesome or unfamiliar sensations, you should inform the researcher or research assistant immediately. The research assistants have been trained to conduct safe and effective testing sessions.

POTENTIAL BENEFITS TO YOU AND SOCIETY
Participation in this study will provide you with the opportunity to learn about research currently being conducted concerning attention deficit disorders and exercise training. Completion of the familiarization and exercise testing protocol will provide you with information concerning your fitness level.

Information arising from this study will further the understanding of alternate, less invasive, and potentially less costly approaches to deal with attention deficit disorders; which currently are estimated to cost Canadian society millions of dollars in lost productivity and medical costs in addition to the non-monetary psycho-social costs at an individual and societal level.

CONFIDENTIALITY OF INFORMATION
Any personal information that is obtained from you in connection with this study will be held in confidence. A code number in place of your name will be used for questionnaire and data analysis and storage purposes. Computer-based data will be retained in a password-protected format with back-up of the computer files being retained on the UNB computer system in a manner that UNB Information Technology Services has indicated as being secure. Any presentation or publication of the results of this study for educational, scholarly, or research purposes will present data in an anonymous and/or grouped manner such that you could not be personally identified.
PARTICIPATION AND WITHDRAWAL
You understand that your participation in the study is voluntary and that you are free to withdraw your consent and discontinue participation at any time, without any obligation or consequence to you.

QUESTIONS & CONTACTS
Should you have any questions regarding this project at any time during your involvement please do not hesitate to ask the research assistants or contact one of the researchers:

Kate Ehrhardt, Graduate student
Email: h9w2q@unb.ca
Phone: (506) 333-2363

Jeff Landine, Ph.D.
Email: jlandine@unb.ca
Phone: (506) 453-4839

Should you wish to speak with someone not associated with the project please contact:

Steven Turner, Chair UNB Research Ethics Board
Email: ethics@unb.ca
Phone (506) 453-5189

This project has been reviewed by the Research Ethics Board of the University of New Brunswick and is on file as REB 2013-096.
PARTICIPANT BACKGROUND QUESTIONNAIRE

The purpose of this questionnaire is to allow us to gather background information to aid in the interpretation of data. Thus, it is important that you answer the following questions as honestly and thoroughly as possible. If you have any concerns, questions, or feel uncomfortable with any of the questions, please discuss those with us.

Assigned Numerical Code: _____________ Age: _____ M ___ F__

1. Do you feel that you often, or consistently, have difficulty with any of the following? If you wish, write any clarification or comment you may have under the question.

   Concentrating on homework for an extended period of time? YES , NO,
   Paying attention throughout in class lectures? YES , NO,
   Completing a boring or mundane task? YES , NO,
   Paying attention throughout your favourite TV show? YES , NO,
   Completing an aerobic or weight training workout? YES , NO,
   Paying attention in group discussions? YES , NO,
   Completing an interesting, but prolonged task? YES , NO,

2. How would you rate your physical activity level over the past year?

   ___ Didn’t do much other than walk to classes and walked when shopping.
   ___ Walk to classes and engaged in a few other physical activities
   ___ Engaged in several physical activities or sports on a fairly regular basis
   ___ Exercised regularly and/or did sporting activities nearly every day

3. Have you engaged in regular aerobic training in the past 2 years? YES , NO,

   If yes, how many times per week and what was your perception of the intensity?
What was the main activity or sport your training was geared towards?


4. To your knowledge, do you presently have any of the following conditions that would limit your ability to exercise? You can give more detail if you would like.

Musculoskeletal:  
- Ligament sprains: YES, NO,
- Muscle strains: YES, NO,
- Tendonitis: YES, NO,
- Bursitis: YES, NO,
- Stress fractures: YES, NO,
- Other: YES, NO,

General illness:  
- Cold: YES, NO,
- Flu: YES, NO,
- Asthma: YES, NO,
- Hypertension: YES, NO,
- Infection: YES, NO,
- Other: YES, NO,

Did you smoke?  
- Previously: YES, NO,
- Currently: YES, NO,

Do you have any other ‘medical’ conditions, or are taking any medications, which may affect your response to and/or your ability to participate in moderate to fairly intense aerobic exercise? YES, NO,
Familiarization Session

Date:______________

Assigned Numerical Code:___________ Assistant:_______________

Birth Date:_______ CPT Name:_________ Seat:_______ Mask size:_______

PAR-Q completed  YES □ NO □

Cleared to participate from Screening Form and PAR-Q  YES □ NO □

Height:______cm______inch  Weight:______kg ________lbs

Omron %body fat: ________

TANITA

Weight:___  % Fat:_____  %H2O:_____  Lean Mass (kg):_____  Bone(kg):_______

SKIN FOLDS

Triceps:_____/____  Biceps:_____/____  Subscap:_____/____  Iliac:_____/____

Calf (inside):_____/____

Resting Heart Rate_______bpm  Resting BP_______ mmHg

Familiarization with all equipment  YES □ NO □

Five minute low-intensity warm-up on cycle ergometer  YES □ NO □

Did the participant have any questions?  YES □ NO □

Were they answered satisfactorily?  YES □ NO □

Participant given Preliminary Instructions for Exercise Testing Sessions  YES □ NO □

First Exercise Testing Session Scheduled

for:_________________________________
Participant's Measurements

Height _______cm _______inch  Weight _______kg _______lbs

% Body Fat

% Omron______

TANITA
% Fat:_____ %H2O:_____ Lean Mass (kg):_____ Bone (kg):_____

% Skin folds______

% Bio-ZM_______

Total eye blinks before exercise _________

Total eye blinks post exercise _________
PAR-Q & YOU

(A Questionnaire for People Aged 15 to 69)

Regular physical activity is fun and healthy, and increasingly more people are starting to become more active every day. Being more active is very safe for most people. However, some people should check with their doctor before they start becoming much more physically active.

If you are planning to become much more physically active than you are now, start by answering the seven questions in the box below. If you are between the ages of 15 and 69, the PAR-Q will tell you if you should check with your doctor before you start. If you are over 69 years of age, and you are not used to being very active, check with your doctor.

Common sense is your best guide when you answer these questions. Please read the questions carefully and answer each one honestly: check YES or NO.

### YES NO

1. Has your doctor ever said that you have a heart condition and that you should only do physical activity recommended by a doctor?
2. Do you feel pain in your chest when you do physical activity?
3. In the past month, have you had chest pain when you were not doing physical activity?
4. Do you lose your balance because of dizziness or do you ever lose consciousness?
5. Do you have a bone or joint problem (for example, back, knee or hip) that could be made worse by a change in your physical activity?
6. Is your doctor currently prescribing drugs (for example, water pills) for your blood pressure or heart condition?
7. Do you know of any other reason why you should not do physical activity?

### YES to one or more questions
Talk with your doctor by phone or in person BEFORE you start becoming much more physically active or BEFORE you have a fitness appraisal. Tell your doctor about the PAR-Q and which questions you answered YES.
- You may be able to do any activity you want — as long as you start slowly and build up gradually. Or, you may need to restrict your activities to those which are safe for you. Talk with your doctor about the kinds of activities you would like to participate in and follow his/her advice.
- Find out which community programs are safe and helpful for you.

### NO to all questions
If you answered NO honestly to all PAR-Q questions, you can be reasonably sure that you can:
- start becoming much more physically active — begin slowly and build up gradually. This is the safest and easiest way to go.
- take part in a fitness appraisal — this is an excellent way to determine your basic fitness so that you can plan the best way for you to be active. It is also highly recommended that you have your blood pressure evaluated. If your reading is over 144/94, talk with your doctor before you start becoming much more physically active.

**DELAY BECOMING MUCH MORE ACTIVE:**
- If you are not feeling well because of a temporary illness such as a cold or a fever — wait until you feel better; or
- If you are or may be pregnant — talk to your doctor before you start becoming more active.

**PLEASE NOTE:** If your health changes so that you then answer YES to any of the above questions, tell your fitness or health professional. Ask whether you should change your physical activity plan.

Informed Use of the PAR-Q: The Canadian Society for Exercise Physiology, Health Canada, and their agents assume no liability for persons who undertake physical activity and will not be held liable for any errors or for any consequences, legal or otherwise, of the use of this questionnaire to help determine if the person is physically able to undertake physical activity.

No changes permitted. You are encouraged to photocopy the PAR-Q but only if you use the entire form.

NOTE: If the PAR-Q is being given to a person before he or she participates in a physical activity program or a fitness appraisal, this section may be used for legal or administrative purposes.

“I have read, understood and completed this questionnaire. Any questions I had were answered to my full satisfaction.”

NAME: ____________________________
SIGNATURE: _______________________
DATE: ________________

SIGNATURE OF PARENT,
or GUARDIAN (for participants under the age of majority)
WITNESS: _______________________

Note: This physical activity clearance is valid for a maximum of 12 months from the date it is completed and becomes invalid if your condition changes so that you would answer YES to any of the seven questions.

© Canadian Society for Exercise Physiology, www.csep.ca/forms

69
Adult ADHD Self-Report Scale (ASRS-v1.1) Symptom Checklist
Instructions

The questions on the back page are designed to stimulate dialogue between you and your patients and to help confirm if they may be suffering from the symptoms of attention-deficit/hyperactivity disorder (ADHD).

Description: The Symptom Checklist is an instrument consisting of the eighteen DSM-IV-TR criteria. Six of the eighteen questions were found to be the most predictive of symptoms consistent with ADHD. These six questions are the basis for the ASRS v1.1 Screener and are also Part A of the Symptom Checklist. Part B of the Symptom Checklist contains the remaining twelve questions.

Instructions:

Symptoms

1. Ask the patient to complete both Part A and Part B of the Symptom Checklist by marking an X in the box that most closely represents the frequency of occurrence of each of the symptoms.

2. Score Part A. If four or more marks appear in the darkly shaded boxes within Part A then the patient has symptoms highly consistent with ADHD in adults and further investigation is warranted.

3. The frequency scores on Part B provide additional cues and can serve as further probes into the patient’s symptoms. Pay particular attention to marks appearing in the dark shaded boxes. The frequency-based response is more sensitive with certain questions. No total score or diagnostic likelihood is utilized for the twelve questions. It has been found that the six questions in Part A are the most predictive of the disorder and are best for use as a screening instrument.

Impairments

1. Review the entire Symptom Checklist with your patients and evaluate the level of impairment associated with the symptom.

2. Consider work/school, social and family settings.

3. Symptom frequency is often associated with symptom severity, therefore the Symptom Checklist may also aid in the assessment of impairments. If your patients have frequent symptoms, you may want to ask them to describe how these problems have affected the ability to work, take care of things at home, or get along with other people such as their spouse/significant other.

History

1. Assess the presence of these symptoms or similar symptoms in childhood. Adults who have ADHD need not have been formally diagnosed in childhood. In evaluating a patient’s history, look for evidence of early-appearing and long-standing problems with attention or self-control. Some significant symptoms should have been present in childhood, but full symptomology is not necessary.
## Adult ADHD Self-Report Scale (ASRS-v1.1) Symptom Checklist

<table>
<thead>
<tr>
<th>Patient Name</th>
<th>Today’s Date</th>
</tr>
</thead>
</table>

Please answer the questions below, rating yourself on each of the criteria shown using the scale on the right side of the page. As you answer each question, place an X in the box that best describes how you have felt and conducted yourself over the past 6 months. Please give this completed checklist to your healthcare professional to discuss during today’s appointment.

### Part A

1. How often do you have trouble wrapping up the final details of a project, once the challenging parts have been done? 
2. How often do you have difficulty getting things in order when you have to do a task that requires organization? 
3. How often do you have problems remembering appointments or obligations? 
4. When you have a task that requires a lot of thought, how often do you avoid or delay getting started? 
5. How often do you fidget or squirm with your hands or feet when you have to sit down for a long time? 
6. How often do you feel overly active and compelled to do things, like you were driven by a motor? 
7. How often do you make careless mistakes when you have to work on a boring or difficult project? 
8. How often do you have difficulty keeping your attention when you are doing boring or repetitive work? 
9. How often do you have difficulty concentrating on what people say to you, even when they are speaking to you directly? 
10. How often do you misplace or have difficulty finding things at home or at work? 
11. How often are you distracted by activity or noise around you? 
12. How often do you leave your seat in meetings or other situations in which you are expected to remain seated? 
13. How often do you feel restless or fidgety? 
14. How often do you have difficulty unwinding and relaxing when you have time to yourself? 
15. How often do you find yourself talking too much when you are in social situations? 
16. When you’re in a conversation, how often do you find yourself finishing the sentences of the people you are talking to, before they can finish them themselves? 
17. How often do you have difficulty waiting your turn in situations when turn taking is required? 
18. How often do you interrupt others when they are busy? 

### Part B
The Value of Screening for Adults With ADHD

Research suggests that the symptoms of ADHD can persist into adulthood, having a significant impact on the relationships, careers, and even the personal safety of your patients who may suffer from it. Because this disorder is often misunderstood, many people who have it do not receive appropriate treatment and, as a result, may never reach their full potential. Part of the problem is that it can be difficult to diagnose, particularly in adults.

The Adult ADHD Self-Report Scale (ASRS-v1.1) Symptom Checklist was developed in conjunction with the World Health Organization (WHO), and the Workgroup on Adult ADHD that included the following team of psychiatrists and researchers:

- **Lenard Adler, MD**
  Associate Professor of Psychiatry and Neurology
  New York University Medical School

- **Ronald C. Kessler, PhD**
  Professor, Department of Health Care Policy
  Harvard Medical School

- **Thomas Spencer, MD**
  Associate Professor of Psychiatry
  Harvard Medical School

As a healthcare professional, you can use the ASRS v1.1 as a tool to help screen for ADHD in adult patients. Insights gained through this screening may suggest the need for a more in-depth clinician interview. The questions in the ASRS v1.1 are consistent with DSM-IV criteria and address the manifestations of ADHD symptoms in adults. Content of the questionnaire also reflects the importance that DSM-IV places on symptoms, impairments, and history for a correct diagnosis.

The checklist takes about 5 minutes to complete and can provide information that is critical to supplement the diagnostic process.

References:
The Amen Clinic ADD Type Questionnaire

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Client: ____________________________
Rater: ____________________________
Date: __/__/____

Please rate yourself (or the person you are evaluating) on each of the symptoms listed below using the following scale.

0  Never
1  Rarely
2  Occasionally
3  Frequently
4  Very Frequently
N/A Not Applicable

<table>
<thead>
<tr>
<th></th>
<th>N/A</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>is easily distracted</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>2.</td>
<td>has difficulty sustaining attention span for most tasks in play, school, or work</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>3.</td>
<td>has trouble listening when others are talking</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>4.</td>
<td>has difficulty following through (procrastination) on tasks or instructions</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>5.</td>
<td>has difficulty keeping an organized area (room, desk, backpack, filing cabinet, locker, etc.)</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>6.</td>
<td>has trouble with time; for example, is frequently late or hurried, tasks take longer than expected, projects or homework are “last-minute” or turned in late</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>7.</td>
<td>has a tendency to lose things</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>8.</td>
<td>makes careless mistakes, poor attention to detail</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>9.</td>
<td>is forgetful</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>10.</td>
<td>daydreams excessively</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>11.</td>
<td>complains of being bored</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>12.</td>
<td>appears apathetic or unmotivated</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>13.</td>
<td>is tired, sluggish, or slow-moving</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>14.</td>
<td>is spacey or seems preoccupied</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>15.</td>
<td>is restless or hyperactive</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>16.</td>
<td>has trouble sitting still</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>17.</td>
<td>is fidgety, in constant motion (hands, feet, body)</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>18.</td>
<td>is noisy, has a hard time being quiet</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>19.</td>
<td>acts as if “driven by a motor”</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>No.</td>
<td>Behavior</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
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<tr>
<td>20</td>
<td>talks excessively</td>
<td></td>
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<td>o</td>
</tr>
<tr>
<td>21</td>
<td>is impulsive (doesn’t think through comments or actions before they are said or done)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>o</td>
</tr>
<tr>
<td>22</td>
<td>has difficulty waiting his or her turn</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>o</td>
</tr>
<tr>
<td>23</td>
<td>interrupts or intrudes on others (e.g., butts into conversations or games)</td>
<td></td>
<td></td>
<td></td>
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<td>o</td>
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<tr>
<td>24</td>
<td>worries excessively or senselessly</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>o</td>
</tr>
<tr>
<td>25</td>
<td>is superorganized</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>o</td>
</tr>
<tr>
<td>26</td>
<td>is oppositional, argumentative</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>o</td>
</tr>
<tr>
<td>27</td>
<td>has a strong tendency to get locked into negative thoughts; has the same thought over and over</td>
<td></td>
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<td></td>
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<td>o</td>
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<tr>
<td>28</td>
<td>has a tendency toward compulsive behavior</td>
<td></td>
<td></td>
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<td>o</td>
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<tr>
<td>29</td>
<td>has an intense dislike of change</td>
<td></td>
<td></td>
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<td>o</td>
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<tr>
<td>30</td>
<td>has a tendency to hold grudges</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>o</td>
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<tr>
<td>31</td>
<td>has trouble shifting attention from subject to subject</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>o</td>
</tr>
<tr>
<td>32</td>
<td>has difficulties seeing options in situations</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>o</td>
</tr>
<tr>
<td>33</td>
<td>has a tendency to hold on to own opinion and not listen to others</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>o</td>
</tr>
<tr>
<td>34</td>
<td>has a tendency to get locked into a course of action, whether or not it is good for the person</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>o</td>
</tr>
<tr>
<td>35</td>
<td>needs to have things done a certain way or becomes very upset</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>o</td>
</tr>
<tr>
<td>36</td>
<td>often complains that he or she worries too much</td>
<td></td>
<td></td>
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<td></td>
<td>o</td>
</tr>
<tr>
<td>37</td>
<td>has periods of quick temper or rages with little provocation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>o</td>
</tr>
<tr>
<td>38</td>
<td>misinterprets comments as negative when they are not</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>o</td>
</tr>
<tr>
<td>39</td>
<td>irritability tends to build, then explodes, then recedes; is often tired after a rage</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>o</td>
</tr>
<tr>
<td>40</td>
<td>has periods of spaciness or confusion</td>
<td></td>
<td></td>
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<td></td>
<td>o</td>
</tr>
<tr>
<td>41</td>
<td>has periods of panic and/or fear for no specific reason</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>o</td>
</tr>
<tr>
<td>42</td>
<td>perceives visual changes, such as seeing shadows or objects changing shape</td>
<td></td>
<td></td>
<td></td>
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<td>o</td>
</tr>
<tr>
<td>43</td>
<td>has periods of deja vu (feelings of being somewhere before even though he or she has never been there)</td>
<td></td>
<td></td>
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<td>o</td>
</tr>
<tr>
<td>44</td>
<td>is sensitive or mildly paranoid</td>
<td></td>
<td></td>
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<td>o</td>
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<tr>
<td>Item</td>
<td>Description</td>
<td>Score Options</td>
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<td></td>
</tr>
<tr>
<td>45</td>
<td>has headaches or abdominal pain of uncertain origin</td>
<td>N/A 0 1 2 3 4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>46</td>
<td>has a history of a head injury or a family history of violence or explosiveness</td>
<td>N/A 0 1 2 3 4</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>47</td>
<td>has dark thoughts, may involve suicidal or homicidal thoughts</td>
<td>N/A 0 1 2 3 4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>48</td>
<td>has periods of forgetfulness or memory problems</td>
<td>N/A 0 1 2 3 4</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>49</td>
<td>has a short fuse or periods of extreme irritability</td>
<td>N/A 0 1 2 3 4</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>50</td>
<td>is moody</td>
<td>N/A 0 1 2 3 4</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>51</td>
<td>is negative</td>
<td>N/A 0 1 2 3 4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>52</td>
<td>has low energy</td>
<td>N/A 0 1 2 3 4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>53</td>
<td>is frequently irritable</td>
<td>N/A 0 1 2 3 4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>54</td>
<td>has a tendency to be socially isolated</td>
<td>N/A 0 1 2 3 4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>55</td>
<td>has frequent feelings of helplessness, hopelessness, or excessive guilt</td>
<td>N/A 0 1 2 3 4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>56</td>
<td>has lowered interest in things that are usually considered fun</td>
<td>N/A 0 1 2 3 4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>57</td>
<td>undergoes sleep changes (too much or too little)</td>
<td>N/A 0 1 2 3 4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>58</td>
<td>has chronic low self-esteem</td>
<td>N/A 0 1 2 3 4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>59</td>
<td>is angry or aggressive</td>
<td>N/A 0 1 2 3 4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>60</td>
<td>is sensitive to noise, light, clothes or touch</td>
<td>N/A 0 1 2 3 4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>61</td>
<td>undergoes frequent or cyclic mood changes (highs and lows)</td>
<td>N/A 0 1 2 3 4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>62</td>
<td>is inflexible, rigid in thinking</td>
<td>N/A 0 1 2 3 4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>63</td>
<td>demands to have his or her way, when told “no” multiple times</td>
<td>N/A 0 1 2 3 4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>64</td>
<td>has periods of mean, nasty, or insensitive behavior</td>
<td>N/A 0 1 2 3 4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>65</td>
<td>has periods of increased talkativeness</td>
<td>N/A 0 1 2 3 4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>66</td>
<td>has periods of increased impulsivity</td>
<td>N/A 0 1 2 3 4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>67</td>
<td>displays unpredictable behavior</td>
<td>N/A 0 1 2 3 4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>68</td>
<td>way of thinking is grandiose or “larger-than-life”</td>
<td>N/A 0 1 2 3 4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>69</td>
<td>talks fast</td>
<td>N/A 0 1 2 3 4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>70</td>
<td>feels that thoughts go fast</td>
<td>N/A 0 1 2 3 4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>71</td>
<td>appears anxious or fearful</td>
<td>N/A 0 1 2 3 4</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

The Amen Clinic ADD Type Questionnaire

Please rate yourself (or the person you are evaluating) on each of the symptoms listed below using the following scale. If possible, also have someone else rate you or the other person (such as a spouse or parent). This is done to obtain a more complete picture of the situation.

0= Never
1=Rarely
2=Occasionally
3=Frequently
4=Very Frequently
NA=Not Applicable

SELF OTHER

___ ___ 1. is easily distracted

___ ___ 2. has difficulty sustaining attention span for most tasks in play, school or work

___ ___ 3. has trouble listening when others are talking

___ ___ 4. has difficulty following through (procrastination) on tasks or instructions

___ ___ 5. has difficulty keeping an organized area (room, desk, book bag, filing cabinet, locker etc)

___ ___ 6. has trouble with time, for example, is frequently late or hurried, tasks take longer than expected, projects or homework are “last minute” or turned in late

___ ___ 7. has a tendency to lose things

___ ___ 8. makes careless mistakes, poor attention to detail

___ ___ 9. is forgetful

___ ___ 10. daydreams excessively

___ ___ 11. complains of being bored

___ ___ 12. appears apathetic or unmotivated

___ ___ 13. is tired, sluggish, or slow-moving

___ ___ 14. is spacey or seems preoccupied
<table>
<thead>
<tr>
<th>Self</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>15.</td>
<td>is restless or hyperactive</td>
</tr>
<tr>
<td>16.</td>
<td>has trouble sitting still</td>
</tr>
<tr>
<td>17.</td>
<td>is fidgety, in constant motion (hands, feet, body)</td>
</tr>
<tr>
<td>18.</td>
<td>is noisy, has a hard time being quiet</td>
</tr>
<tr>
<td>19.</td>
<td>acts as if “driven by a motor”</td>
</tr>
<tr>
<td>20.</td>
<td>talks excessively</td>
</tr>
<tr>
<td>21.</td>
<td>is impulsive (doesn’t think through comments or actions before they are said or done)</td>
</tr>
<tr>
<td>22.</td>
<td>has difficulty waiting his or her turn</td>
</tr>
<tr>
<td>23.</td>
<td>interrupts or intrudes on others (e.g., butts into conversations or games)</td>
</tr>
<tr>
<td>24.</td>
<td>worries excessively or senselessly</td>
</tr>
<tr>
<td>25.</td>
<td>is superorganized</td>
</tr>
<tr>
<td>26.</td>
<td>is oppositional, argumentative</td>
</tr>
<tr>
<td>27.</td>
<td>has a strong tendency to get locked into negative thoughts; has the same thought over and over</td>
</tr>
<tr>
<td>28.</td>
<td>has a tendency toward compulsive behavior</td>
</tr>
<tr>
<td>29.</td>
<td>has an intense dislike of change</td>
</tr>
<tr>
<td>30.</td>
<td>has tendency to hold grudges</td>
</tr>
<tr>
<td>31.</td>
<td>has trouble shifting attention from subject to subject</td>
</tr>
<tr>
<td>32.</td>
<td>has difficulty seeing options in situations</td>
</tr>
<tr>
<td>33.</td>
<td>has a tendency to hold on to own opinion and not listen to others</td>
</tr>
<tr>
<td>34.</td>
<td>has a tendency to get locked into a course of action, whether or not it is good for the person</td>
</tr>
<tr>
<td>35.</td>
<td>needs to have things done a certain way or becomes very upset</td>
</tr>
<tr>
<td>36.</td>
<td>others complain that he or she worries too much</td>
</tr>
<tr>
<td>37.</td>
<td>has periods of quick temper, of rages with little provocation</td>
</tr>
<tr>
<td>38.</td>
<td>misinterprets comments as negative when they are not</td>
</tr>
<tr>
<td>39.</td>
<td>irritability tends to build, then explodes, then recedes; is often tired after a rage</td>
</tr>
</tbody>
</table>
40. has periods of spaceiness or confusion

Self Other

41. has periods of panic and/or fear for no specific reason

42. perceives visual changes, such as seeing shadows or objects changing shape

43. has frequent periods of déjà vu (feelings of being somewhere before even though he/she has never been there

44. is sensitive or mildly paranoid

45. has headaches or abdominal pain of uncertain origin

46. has a history of head injury or a family history of violence or explosiveness

47. has dark thoughts, may involve suicidal or homicidal thoughts

48. has periods of forgetfulness or memory problems

49. has a short fuse or periods of extreme irriability

50. is moody

51. is negative

52. has low energy

53. is frequently irritable

54. has a tendency to be socially isolated

55. has frequent feelings of hopelessness, helplessness, or excessive guilt

56. has lowered interest in things that are usually considered fun

57. Undergoes sleep changes (too much or too little)

58. has chronic low self esteem

59. is angry or aggressive

60. Is sensitive to noise, light, clothes, or touch

61. Undergoes frequent or cyclic mood changes (highs and lows)
66. has periods of increased impulsivity
67. displays unpredictable behavior

Self Other
68. way of thinking is grandiose or “larger than life”
69. talks fast
70. feels that thoughts go too fast
71. appears anxious or fearful

For each group listed below, add up the number of answers that were scored as three or four and place them in the space provided. A cutoff score is provided with each type. Some people score positively in more than one group; some score positively in three or four groups. Use the scores to help guide choices in learning strategies.

Type 1: Classic ADD (Questions 1-23)
Meets the criteria for both the inattentiveness questions and the hyperactivity-impulsivity questions.

Inattentiveness questions 1-14: Six or more of a score of three or four is needed to determine probable type; more than four is suspicious for this type of ADD.

Hyperactivity-impulsivity questions 15-23: Six or more of a score of three or four is needed to determine probable type; more than four is suspicious.

Inattentiveness score of three or four:____
Hyperactivity-impulsivity score of three or four:____

Type 2: Inattentive ADD (Questions 1-14)
Six or more of a score of three is needed to determine probable type; more than four is suspicious but does not score six or more on the hyperactivity-impulsivity questions (15-23).

Inattentive ADD score of three or four:____

Type 3: Overfocus ADD (Questions 24-36)
Meets the criteria for inattentiveness (six or more on questions 1-14), and also scores six or more on overfocus questions.

Overfocus ADD score of three or four:____
Type 4: Temporal lobe ADD (Questions 37-49)

Meets the criteria for inattentiveness (six or more on questions 1-14), and also scores six or more on the temporal lobe questions.

Temporal Lobe ADD score of three or four: _____

Type 5: Limbic ADD (Questions 50-58)

Meets the criteria for inattentiveness (six or more on questions 1-14), and also scores five or more on limbic questions.

Limbic ADD score of three or four: _____

Type 6: “Ring of Fire” ADD (Questions 59-71)

Meets the criteria for inattentiveness (six or more on questions 1-14), and also scores five or more on Ring of Fire questions.

“Ring of Fire” ADD score of three or four: _____
CURRICULUM VITAE

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New Brunswick Health Research Foundation 2015