

Exploring the Relationship between Physical Activity and the Symptoms of Attention-Deficit  
Hyperactivity Disorder in Children

by

Nicole Eleanor Irene Smith  
B. Sc., University of Victoria, 2003

A Thesis Submitted in Partial Fulfillment of the  
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### ABSTRACT

Attention-Deficit Hyperactivity Disorder (ADHD) is described by the broadly defined symptoms, attention-deficit, hyperactivity and impulsivity. Characterized as the most common diagnosed developmental disorder in childhood, pharmacological interventions have been the most studied and used forms of treatment. Given that the alleviating effects of medication are not universal, researchers have considered other adjuvant therapies. Physical activity is one intervention that has received limited attention, but has been suggested. The purpose of this study was to extend the limited research by the following: (1) provide evidence for the prevalence of physical activity in ADHD children, as well as determine the prevalence of physical activity therapeutic practices, (2) explore the relationship between physical activity and ADHD symptoms, and determine which specific ADHD symptom(s) physical activity may affect most, and (3) identify any moderators of the physical activity and ADHD symptom relationship. Participants included 101 parents, mostly from Canada, who currently have a child with diagnosed ADHD and were recruited through collaboration with the Learning Disabilities Association – South Vancouver Island Chapter by mail and through ADHD online internet parent forums. Participants were asked to complete a questionnaire pertaining to their child's medical history, behavioral symptoms, physical activity behaviors and practices, and parent socio-demographics. Results indicate that 76% of the sample did not meet Canadian national recommended physical activity guidelines, and 52% of the sample does not use physical activity as a therapy. Significant bivariate correlations between Connors' subscale of hyperactivity and total strenuous physical activity ( $r = .23$ ;  $p < .05$ ), as well as therapeutic physical activity ( $r = -.21$ ;  $p < .05$ ) were found. Moderated multiple regressions demonstrated that high parental opinion about the utility of PA showed a positive relationship between meeting physical activity guidelines and hyperactivity ( $\Delta F_{(1, 88)} = 5.25$ ,  $p < .05$ ;  $\Delta R^2 = .06$ ), parents who do not use physical activity

as a form of therapy showed a negative relationship between meeting physical activity guidelines and oppositional behavior ( $\Delta F_{(1, 90)} = 4.21, p < .05; \Delta R^2 = .04$ ), and females with ADHD showed a negative relationship between meeting physical activity guidelines and cognitive problems/inattention behavior ( $\Delta F_{(1, 92)} = 9.58, p < .05; \Delta R^2 = .09$ ). It was concluded that a large percentage of children with ADHD do not meet national recommended guidelines for physical activity, and parents who do not use physical activity as a therapy have children who display worse symptoms of ADHD oppositional behavior. Additionally, the relationship between physical activity and the symptoms of ADHD may be significantly moderated by specific variables. Future research should include further investigation into the three moderating variables identified. Further evaluation with inactive populations of ADHD children focusing on national recommended doses of physical activity, and separating the symptoms of ADHD, as well as gender is recommended.

Supervisor: Dr. Ryan E. Rhodes, (School of Exercise Science, Health and Physical Education)

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A special thanks to my family and Jorn, for their unconditional love, support, and encouragement; And, for teaching me that the pursuit of my dreams is worth fighting for.

## DEDICATION

I would like to dedicate this thesis to my family and Jorn, with love.

"Make it Happen. Greatness is not in where we stand, but in what direction we are moving. We must sail sometimes with the wind and sometimes against it. But sail we must and not drift. Nor lie at anchor"

- Oliver Wendell Holmes

## CHAPTER ONE: INTRODUCTION AND LITERATURE REVIEW

### *Introduction*

Attention-Deficit Hyperactivity Disorder (ADHD) is a developmental disorder characterized by the broadly defined symptoms, attention-deficit, hyperactivity and impulsivity (Barkley, 2004). The overwhelming prevalence of ADHD in children has become a problem society can not afford to ignore. Characterized as the most common diagnosed disorder of childhood (Conner & Steingard, 2004; Clarke et al., 2003), children with ADHD have a high rate of disciplinary problems in school, experience social and academic difficulties, and encompass 30 - 40% of the referrals to child guidance clinics (Barkley, 1998). Additionally, children with ADHD are at a high risk for adverse personal and social outcomes, health problems and increased health care costs, as well as health care utilization (St. Sauver et al., 2004). Due to the problems associated with the disorder, finding the most effective solutions for treating the symptoms experienced by those affected with ADHD has become a great concern.

Since Bradley first accidentally discovered the successful use of stimulants in children with behavior problems in 1937, a vast amount of research has been conducted with stimulants, far more than for any other known treatment for a childhood psychiatric disorder (Barkley, 2004). Throughout the years, the extreme increase in prescribing stimulants leave little doubt that they are the most commonly used treatment for the management of ADHD symptoms (Koziol et al., 1993; Anastopoulos & Shelton, 2001; Barkley, 2004; Tantillo et. al., 2002; Clarke et. al., 2003; Kimko et al., 1999; Spencer et al., 1997; Miller et al., 2001). Numerous scientific studies have noted dramatic increases in the rate of prescriptions of methylphenidate for children in the past few decades, most specifically in the US, but in Canada and the UK as well (Parr et. al, 2003; Miller et al., 2001). Literature reports a 3.1-fold increase in the prescription rates of methylphenidate for ADHD youth between the years of 1990 to 1995 (Kratochvil et al, 2004; Safer et al., 1996). Approximately 2.8% (1.5 million) of US youths aged five to

eighteen were receiving methylphenidate in mid-1995 (Safer et al., 1996). In Canada, methylphenidate prescriptions for children aged zero to five rose dramatically from 4,000 in 1993 to 12,000 in 1997 (Kratochvil et al., 2004). The beneficial acute effects of stimulants on cognitive and behavioral measures are among the best documented in the field of treatments for childhood mental health disorders (Pelham & et al., 2000; Koziol et al., 1993; Anastopoulos & Shelton, 2001, Barkley, 2004).

Despite, however, the widely validated effects of stimulants on the symptoms of ADHD children; they do have limitations in their clinical efficacy. Stimulants have been unable to produce either short or long-term changes in academic achievement or improvements in long-term prognosis (MTA Cooperative Group, 1999a; Weiss & Hectman, 1993; Daly et al., 2007). Additionally, the alleviating effects of stimulant medication are not universal, as only 70 - 80% of children with ADHD respond positively to a stimulant regimen, with a few showing sufficient improvement for their behavior to fall entirely within the normal range (Etscheidt & Ayllon, 1987; Koziol et al., 1993, Pelham et al., 2000). There are large individual differences in the size and topography of drug response, with stimulant medication benefiting some domains of functioning but not others (Pelham & Smith, 2000; Barkley, 2004; Koziol et al., 1993). Furthermore, the beneficial effects of stimulant medication are acute, as its effects stop as soon as the medication wears off, depending on its preparation (Pelham et. al., 2000). Finally, noncompliance with dosing presents many problems, particularly in the school environment. Despite the fact that stimulants would need to be used for years with most ADHD individuals, many parents give their children medication for only a few months (Sherman & Hertzog, 1991; Pelham et. al., 2000). Despite these criticisms, however, currently pharmacological treatments are the most effective treatment where ADHD is concerned (MTA Cooperative Group, 1999a). It is unlikely that stimulant medication will be completely replaced by more effective alternative therapies, however due to the presence of non-responders, as well as domains of impairment unaffected by stimulant medication, adjuvant interventions for managing the symptoms for ADHD warrant investigation.

Beyond pharmacological approaches, a variety of treatments for children with ADHD have been tested over the past century. Therapies such as dietary interventions, EEG biofeedback, sensory integrative therapy, cognitive interventions, and behavioral skills training are all therapies that have poor empirical support (Barkley, 2004; Koziol, et al., 1993; Wolraich, 1997). An intervention, such as physical activity, is one that has received limited attention, but has been suggested (Barkley, 2004; Tantillo et. al, 2002).

The following review of literature has been divided into four main sections. The first section will describe past research examining the controversial treatments involved with ADHD. The second section will focus on proposed mechanisms in how exercise affects ADHD symptoms. Literature regarding exercise and disruptive behavior will then be described and lastly, current literature on exercise and ADHD will be examined.

### ***Controversial treatments involved with ADHD***

#### ***Dietary Interventions***

Due to the present limitations of stimulant medications, many researchers have explored alternative solutions for treating the symptoms of ADHD. A previously suggested and controversial method of therapy for treating ADHD has focused on diet. The specific focus on diet adversely affecting behavior was introduced in the 1970's by Langeth and Dowd (Wolraich, 1997). They implicated sugar as a nutrient that adversely affected behavior, based on results from a large study which found hyperactive children to have similar patterns to adults who had functional reactive hypoglycemia. Similar results were found later in aggressive criminal offenders (Wolraich, 1997). Further supporting the literature against sugar for hyperactive children, two correlational studies found that hyperactive children who consumed more sugar displayed more hyperactive and aggressive behaviors (Wolraich, 1997).

The Feingold Kaiser-Permanente (K-P) diet, introduced in 1975 by allergist Dr. Ben Feingold, advocated the elimination of all foods containing artificial colorings or additives for children with an incidence of learning disabilities and hyperkinesis (Feingold, 1975; Koziol et al., 1993; Wolraich, 1997; Rojas & Chan, 2005). The Feingold K-P diet was originally developed for the treatment of adults with aspirin-sensitivity and behavioral symptoms which improved when put on a diet free from artificial and natural salicylates, artificial food colorings, and artificial food flavorings (Feingold, 1975; Rojas & Chan, 2005). Feingold believed that aspirin-sensitivity produced the behavioral symptoms associated with hyperactivity. Feingold reported a 50% improvement in hyperactive and learning disabled children when placed on diets free of artificial colorings and additives (Feingold, 1975; Koziol et al., 1993; Wolraich, 1997).

Despite the anecdotal evidence of the K-P diet and the sugar-restrictive diet, research findings do not support either of these strategies as an effective treatment for hyperactive children (Conners et al., 1976; Harley et al., 1978; Wolraich, 1997). Very small subsets of young children have demonstrated only mild improvements while adhering to the K-P diet and many studies have methodological problems (Wolraich, 1997). In addition, compliance is quite difficult due to inconveniences surrounding meal preparation, the inconveniences to family members and the possible lack of motivation by the child to comply with the strict diet (Koziol et al., 1993). The sugar-restrictive diets have been studied the most, including a meta-analysis by Wolraich and colleagues (1995), which concluded that sugar had no effect on the behavior or cognitive performance of hyperactive children (Wolraich, 1995).

### *EEG Biofeedback*

EEG biofeedback used as a treatment for ADHD is based upon the initial observation that children with ADHD demonstrate EEG abnormalities compared to controls (Rojas & Chan, 2005; Koziol et al., 1993). Past literature has indicated that ADHD children abnormally produce more theta and fewer beta rhythms, particularly in the frontal brain regions (Rojas & Chan, 2005; Koziol et al.,

1993). EEG biofeedback seeks to normalize these rhythms, thus improving attention and memory and reducing hyperactivity (Koziol et al., 1993; Rojas & Chan, 2005). EEG biofeedback most commonly uses three EEG leads that measures the amount of desired wave rhythm frequency and provides feedback to the ADHD child using a variety of visual and audio stimuli (Rojas & Chan, 2005). Although there are many studies that promote the efficacy of EEG biofeedback training for children with ADHD, most studies are seriously flawed with methodological problems, including small sample sizes, heterogeneous subjects, lack of control over comparison groups, limited measurement of behavioral, cognitive and EEG outcomes, and a lack of long-term follow-up (Rojas & Chan, 2005; Koziol et al., 1993; Daly et al., 2007). Given the many problems associated with the EEG biofeedback literature, support for the efficacy of this treatment for children with ADHD remains limited.

### *Sensory Integrative Therapy*

Sensory integrative therapy for the treatment of children with learning disabilities and attention disorders was developed and first suggested by the occupational therapist Jean Ayres (1981). The term “sensory integration” refers to the brain’s ability to organize and make use of incoming information from the various senses (Koziol et al., 1993). Ayres suggested that the vestibular system unifies the systems of the brain and that when the vestibular system does not function properly, sensory information is interpreted inconsistently and inaccurately (Koziol et al., 1993). Sensory integrative therapies consist of exercises which encourage a child to use as many nerve-cell connections as possible. Ayres suggested that this type of training would help a child learn how to organize his or her brain, thus, enabling enhanced learning of a broad variety of skills involving academics and behavior (Koziol et al., 1993). Although sensory integrative therapy is a relatively benign treatment, critics have pointed out that Ayres theories are not consistent with what is currently known about the causes of attention, impulse or learning disorders (Barkley, 2004; Koziol et al, 1993). There is no data to suggest that the vestibular system is primarily involved in regulating attention or modifying learning (Koziol et al., 1993). In

addition, studies involving sensory integrative therapy include questionable methodology and statistical analyses. The results of two well-controlled studies failed to find support for the effectiveness of its treatment (Densem et al., 1989; Humphries et al., 1992). Presently, there is no evidence that supports sensory integrative training as an effective treatment for children with impulse or attention problems (Barkley, 2004; Koziol et al., 1993).

### *Cognitive Interventions*

Over 100 years ago, the psychologist William James was the first to report that self-directed speech could be used to help individuals pay attention and control their behavior (Koziol et al., 1993). The various methods included within cognitive interventions involve self-recording, self-evaluation, self-reinforcement, self-instruction and attribution training. These specific interventions have been investigated with populations with learning problems, behavioral difficulties, brain injuries, and attention disorder. These techniques have been researched as interventions for a variety of behaviors, including on-task performance, compliance, self-esteem and social skills. All of these strategies are based on the premise that they can help children alter their behavior by teaching them to think differently and thereby gain self-control and the ability to modulate their behavior more effectively (Koziol et al., 1993). Although cognitive therapy was believed to show some promise for children with ADHD, an overview of this particular treatment by Barkley (2004) has found that there is limited evidence to support its efficacy. The biggest cognitive therapy study to date which involved training of parents, teachers, and children found no significant treatment-specific effects on any of a variety of dependent measures, with the exception of class observations of off-task/disruptive behavior, which was found to lose its treatment effect after a 6-week follow-up (Bloomquist et al., 1991). Additionally, meta-analyses of the ADHD literature on cognitive therapy have typically found effect sizes to be only a third of a standard deviation, and in many other studies, even less (Baer & Nietzel, 1991; Dush et al., 1989). Barkley (2004) concluded that although studies based on cognitive therapy may produce statistically

significant treatment effects, their clinical importance is modest and is mainly found with relatively poor measures. Thus, effective treatment with cognitive therapies is presently not supported.

### *Behavioral Skills Therapy*

Since the 1970's, a large number of studies have shown that behavioral skills intervention, including clinical behavior therapy and contingency management techniques, may be effective alternatives to pharmacological treatment (Pelham et al., 1998; Pelham & Waschbusch, 1999; Daly et al., 2007). Specifically, literature has concluded that parent training results in improvements for children and their families in several areas, including problem behavior, negative child and parent interactions, as well as stress (Daly et al., 2007). Academic interventions, where instruction and materials are modified, also have preliminary support (Daly et al., 2007). Despite these results, caution should be taken as the ability to generalize the results is limited since improvements in children have largely been based on individualized or familial factors (Daly et al., 2007). In addition, behavioral treatments have limitations that are similar to those of psychostimulant medications. Behavioral treatments alone usually do not normalize children, and the magnitude of effects is not as large as acute medication effects in key domains of functioning (Pelham et al., 1993; Daly et al., 2007). Additionally, the short-term effects of behavioral interventions are often limited to the period when the programs are actually being given, with only a few studies having shown maintenance of treatment gains after the therapy is faded (MTA Cooperative Group, 1999a). Finally, there are children who fail to show improvement following an intervention with behavioral modification (Pelham et al., 2000). In many cases, such failure may be attributable to treatment noncompliance on the part of parents and teachers. In comparison to pharmacological treatments, the fact that behavioral modification is more time consuming, difficult and expensive for parents, regular classroom teachers and agencies to deliver, the effort necessary to conduct effective behavioral interventions may not be expended (Pelham et al., 2000; Daly et al, 2007).

### *Combined Treatments*

The limitations of pharmacological and alternative interventions for treating the symptoms of ADHD alone, have led researchers to study the effects of combining treatments. The largest study to investigate the effects of combined treatments is the National Institute of Mental Health Multimodal Treatment Study (MTA Cooperative Group, 1999a). This fourteen-month, randomized clinical trial compared well-established treatments for children with attention-deficit hyperactivity disorder. A total of 597 children with ADHD-Combined type, aged 7 to 9.9 years, were randomly assigned to one of four treatments: (1) medication management alone, (2) behavioral modification alone, (3) a combination of medication and behavioral intervention, and (4) a control condition of routine community care without an intervention. Results indicated that the combination treatment and medication management alone did not differ significantly on direct comparisons, but in several instances such as parent-rated oppositional/aggressive symptoms, internalizing symptoms, teacher-rated social skills, parent-child relations, and reading achievement, the combination treatment proved superior to behavioral modification alone and community care, whereas medication management alone did not (MTA Cooperative Group, 1999a). Although the combination treatment showed significant advantages over community care in every domain, whereas medication management alone did not, it did not prove significantly superior to medication management alone for individual, specific outcome measures. The combination treatment did, however, show modest significant advantages over medication management alone on global or composite outcome indices that summed small but consistent advantages across domains (MTA Cooperative Group, 1999a). The combination treatment also provided modestly greater benefits than medication management alone for non-ADHD symptoms and positive functioning. In addition, this study provided evidence that the combination treatment allowed for lower doses of stimulant medication and greater levels of parent satisfaction (MTA Cooperative Group, 1999a; Daly et al., 2007). This additive effect was more pronounced for dually comorbid children such as those children

with both internalizing and disruptive behavior disorders (MTA Cooperative Group, 1999a). In support of combined interventions, a review investigating the effectiveness of combined interventions versus single interventions conducted by the McMaster University Evidence-Based Practice Centre Group (1999) found that combined interventions were modestly superior to non-pharmacologic intervention alone.

Although the use of stimulant medication does have its limitations, it has, to date, proven to be the best solution for managing ADHD symptoms. Since pharmacological interventions are ineffective at improving all domains of impairment in ADHD, the strategy of combining medication with other treatments that may improve the domains that medication has the inability to affect, seems logical. Results from the MTA study suggest that combination treatments may be more beneficial for many ADHD children and have led researchers to investigate other possible safe, effective and adjuvant solutions for managing the symptoms of ADHD.

One specific intervention that has received limited attention is physical activity. Few studies have focused on the effects of physical activity in children or teens with ADHD. However, preliminary evidence indicates that this particular intervention may be effective in decreasing ADHD symptoms. Further study of this specific intervention has been suggested (Barkley, 2004; Tantillo, 2002).

### ***Mechanisms of Exercise in ADHD***

Although ADHD is one of the most common disorders of childhood, exactly how the disorder is caused is still unclear (Anastopoulos & Shelton, 2001). For the most part, biological explanations have dominated the literature, though psychological and psychosocial explanations have been suggested as well. The most common and believed cause of ADHD is attributed to neurological dysfunction (Anastopoulos & Shelton, 2001). Magnetic resonance imaging (MRI), and positron emission tomography (PET) have allowed researchers to examine the neurological physiology of ADHD

individuals. Giedd and his colleagues (2001) conducted a review on the anatomy and physiology of the brains of individuals affected with ADHD. Results from this study found that anatomical imaging consistently points to developmental abnormalities of the frontal lobes, basal ganglia, corpus callosum, striatum and the cerebellum. Additionally, results found a 5% decrease in the total brain size in ADHD subjects as compared to age and gender-matched controls (Giedd et al., 2001; Castellanos et. al., 1996), and a decrease in cerebral bloodflow in the prefrontal regions of the brain in ADHD subjects (Koziol et al., 1993, Giedd et al., 2001). Literature supports the suggestion that the pathophysiology of ADHD is based on a catecholamine dysfunction, including the norephrinergetic, epinephrinergetic and the dopaminergic systems; however, the most implicated catecholamine has been dopamine (Wigal et. al., 2003; Vallone et al., 2000; Konrad et al., 2003). Studies on the dysfunction of the dopaminergic system are primarily based on observations that stimulants, such as methylphenidate, are dopaminergic agonists. The dopamine hypothesis in ADHD is further supported by recent imaging studies indicating morphological and physiological differences in right-hemisphere prefrontal-striatal systems which are rich in dopaminergic innervation (Vaidya et. al., 1998). The etiology of ADHD provides the basis by which exercise may affect ADHD symptoms.

Exercise may have an affect on neurological functioning similarly to that of methylphenidate. A study by Wigal and colleagues (2003) indicated a remarkable increase in circulating dopamine levels in response to cycle ergometer and resistance exercise in a population of healthy children. A study by Hattori and colleagues (1994) examined the physiological action of striatal dopamine turnover during treadmill running in the rat. Results indicated that dopamine turnover was increased with exercise, suggesting that both the synthesis and metabolism of dopamine have a close relationship with physical exercise. Similarly, a study by MacRae and colleagues (1987) investigated the effects of six months of endurance training of young adult rats on the relationship between steady-state levels of dopamine and its metabolites in striatum, as well as the affinity and density of dopamine receptors. Results suggested

that exercise can alter the number of dopamine binding sites and the metabolism of dopamine in young adult rats. Contrasting with this evidence, Wang and colleagues (2000) evaluated the effects of exercise on striatal dopamine release in the human brain. Participants were twelve healthy, regularly exercising volunteers, consisting of five women and seven men, of a mean age of thirty-two years. Participant dopamine levels were established at baseline and the following day, five to ten minutes after completing the exercise intervention (thirty minutes of treadmill running). Results indicated that there were no significant changes in dopamine concentration. Although this study contradicts the previous three studies on rats, there are a few limitations worth noting. Failure to observe an effect may have been due to the sensitivity of the imaging used. Furthermore, the methodology of the study only examined the effect of one bout of exercise using participants who were regular exercisers to begin with. Thus, it may be possible that the dopamine striatal system is more influenced by repeated exercise and may also be more sensitive to intensities of aerobic exercise the participant may not be accustomed to.

Although empirical evidence on the mechanisms of exercise on the symptoms of ADHD has been limited and evidence still remains equivocal, a large amount of literature does suggest that the dopaminergic system is involved in the etiology of ADHD. The preliminary findings surrounding the suggested mechanism of exercise provide justification for investigating its effects on the symptoms of ADHD.

### ***Exercise and Disruptive Behavior***

Research within the exercise and ADHD area is limited; this may be due to the problems associated with diagnosing the disorder. The symptomatology of ADHD can not be defined within a single scope. Additionally, the chief manifestations of the syndrome appear to shift with development causing an absence of an identified core deficit. Evidence also indicates a high incidence of comorbidity associated with ADHD, with a rate as high as 85% for clinical samples with at least one other

disorder (Gillberg et al., 2004; Barkley, 2004, Spencer et al. 1997, Koziol et al., 1993). Thus, it is difficult to identify a single underlying organic cause of this disorder and also suggests an intricacy involved in diagnosing ADHD behavior (Barkley, 2004).

Many researchers have examined the effects of exercise on samples of children who are not diagnosed as having ADHD, but possess similar symptoms of the disorder. Although considerably more studies have been conducted with undiagnosed samples of ADHD, the research still remains limited.

In 1995, Allison, Faith and Franklin conducted a meta-analytic review of published and unpublished studies on the treatment of disruptive behavior with antecedent exercise. They reviewed forty-two articles comprising sixteen group studies and twenty-six single case studies, from various populations, and ages. The authors not only included studies on individuals who were behaviorally disordered but also included studies on the effect of exercise on individuals with physical disabilities, autism, emotional disturbances, and mental impairment.

Antecedent exercise is defined as a type of exercise distinguished from sport that involves participation but not necessarily exertion. Antecedent exercise is applied non-contingently with the intent of decreasing later disruptive behavior (Allison et al., 1995). Disruptive behavior was defined as any observable response on the part of the participant that is typically characterized by such actions as aggression, self-injury or talking out in class.

Of the sixteen group studies, Allison, Faith and Franklin (1995) found that disruptive behavior decreased with the exercise intervention in twelve studies, and increased or stayed the same in four. The weighted mean effect size expressed as Cohen's  $d$  was 0.33 with a standard error of 0.08. Moderator analysis indicated that studies using direct behavioral observation, hyperactive subjects, or non-aerobic exercise, obtained greater effects, and studies of higher quality obtained weaker effects. Despite these findings, the results should be interpreted with caution. The four studies yielding the largest effect sizes had samples explicitly described as "hyperactive". Although several other studies included subjects who

exhibited behaviors characteristic of hyperactive persons, only these four studies explicitly defined their subjects as such. It is possible that had the other studies clearly defined the behavior of their subjects, the effect size would most likely be different. Although the moderator analysis resulted in a significantly larger weighted mean effect size for non-aerobic studies ( $M = 1.42$ ) than for aerobic studies ( $M = 0.20$ ), only two studies had non-aerobic interventions. Furthermore, the two effect sizes from the non-aerobic studies were significantly different from one another, raising the possibility that these samples did not come from a single population. Lastly, studies of greater methodological quality or rigor tended to yield lower effect sizes. This raises the concern that studies with higher effect sizes may be upwardly biased by methodological artifacts.

Of the twenty-six single-case studies, twenty-two found positive effects of antecedent exercise, one produced no effect, and three produced negative effects. The weighted mean effect size, expressed as Cohen's  $d$  was 1.99 with a standard error of 0.411. Among the single-subject studies, moderator analyses were unable to detect statistically significant moderators of effect size. Consistent with the results from the group studies, non-aerobic studies yielded a greater weighted mean effect size than aerobic studies. However, similar to the group studies, this finding should be interpreted with caution as there were only three non-aerobic studies.

The information reviewed in the meta-analysis (Alison et al., 1995) suggests that antecedent exercise effectively reduces a variety of disruptive behaviors across many different populations. Antecedent exercise is socially acceptable, can be implemented with treatment integrity and has a benign side effect profile. Nevertheless, the extent to which antecedent exercise is functionally based remains unclear due to a lack of understanding regarding its mechanism(s) of action. Since the samples in the reviewed studies were not exclusively defined as having ADHD, the hypothesized dopamine mechanism mentioned previously, may not apply.

One study which similarly explored the relationship between antecedent exercise and disruptive behavior was conducted by Basile and colleagues (1995). Their study evaluated the effects of antecedent physical exercise (AE) and a mastery task on behaviorally disturbed children's self-concepts and rates of disruptive behaviors. In addition, they evaluated whether changes in self-concept mediated the relationship between exercise and reduced disruptive behavior. The participants included fifty-eight behaviorally disturbed children, aged seven to thirteen years. Fifty-three of the participants were males and five were females. All participants were randomly assigned to one of three treatment conditions: a) antecedent exercise (jog/walk through an obstacle course, non-continuously for twenty-minutes), b) "mastery" task (a successive improvement miniature-basketball shooting task) and c) no treatment control group. Procedures included a week of baseline assessment, followed by four weeks of treatment, and concluded with another week of no treatment assessment. All phases of treatment were given four days per week and observations were made each day at approximately the same time. The authors concluded that the AE treatment phase produced significantly less disruptive behavior more than the "mastery" task or no treatment, and that changes in self-concept did not mediate AE related reductions in disruptive behavior. These results weaken the support for self-concept and "mastery" as the proposed mechanisms of action for antecedent exercise on disruptive behavior. However, the results clearly suggest that antecedent exercise is effective in reducing disruptive behavior in the particular sample that was investigated.

In contrast with the previous two articles, Etscheidt and Ayllon (1987) evaluated the efficacy of contingent exercise, rather than antecedent exercise, on the reduction of hyperactive behavior and enhanced academic performance. Contingent exercise in this particular study consisted of providing the participant with an opportunity to engage in a high level of movement whenever he failed to meet academic criteria in two different classes, reading and arithmetic, separately. The study consisted of a within-subject, multiple baseline design. The participant was a thirteen year-old hyperactive boy whose

lack of academic progress was attributed to his hyperactivity and general distractibility. The contingent exercise consisted of a variety of different callisthenic exercises such as sit-ups, push-ups and jumping jacks, which lasted for a minimum duration of five minutes. Results indicated reductions in hyperactive behavior of 29% in reading and 14% in arithmetic class. Concurrently, there were positive gains in academic performance in both reading and arithmetic class. These particular findings possibly suggest that whether exercise is administered contingently or non-contingently may not be important, as either strategy produced effective results.

In comparison to all three studies previously mentioned, Tuckman and Hinkle (1986) investigated the physical and psychological effects of running on healthy children. Participants consisted of 154 fourth, fifth and sixth grade students without any disabilities or behavioral disorders. The children were randomly assigned to two different experimental running conditions and one control group. The running program consisted of three, thirty-minute sessions per week for twelve weeks. Behavior conducive or disruptive to effective classroom participation was measured by teacher responses using the Devereaux Elementary School Behavior Rating Scale (Swift, 1982), where lower numbers indicate less disruptive behavior and higher numbers the opposite. Results indicated that the running program did not affect behavioral self-control in school. Due to the fact that none of the children in the study exhibited any behavioral disorders, it is reasonable to assume that their behavior was not overly disruptive to begin with. Therefore, relative changes in the behavior scale used would be less evident as compared to a population of children affected by ADHD. Furthermore, the type, frequency, intensity and duration of exercise should be given consideration. All running took place on a 400m track, and consisted of gradual increments in distance, interval workouts and relay runs. However, it is possible that many of the children found the running to be repetitive or may have disliked the structured activity.

Since ADHD is a disorder which presents many diagnosis challenges, many studies have used non diagnosed ADHD samples. Although this strategy gives insight into how exercise affects behavior in a wide range of individuals, it does not provide precise insight into the exact population of interest. Participants in other populations may possess similar symptoms shown in ADHD, but results from the reviewed literature indicate that there are obvious differences seen in participants with various disorders. Research specifically focusing on ADHD is needed to fully understand the relationship between exercise and ADHD symptoms.

### ***Exercise and ADHD***

One study that has specifically evaluated the effects of antecedent exercise on an ADHD diagnosed child was conducted by Silverstein and Allison in 1994. The authors evaluated the comparative efficacy of antecedent exercise, methylphenidate (Ritalin), and a placebo for the reduction of hyperactive behavior. The participant was an African American three year-old boy, diagnosed with ADHD. The study involved a within subject, alternating treatments experimental design that was lasted for a total of eighty-two days. The treatments involved three treatment conditions: methylphenidate plus attention placebo, antecedent exercise plus medication placebo and attention placebo plus medication placebo. The type of antecedent exercise involved jogging at a heart rate between 65 - 80% of maximum for a non-continuous duration of twenty minutes. The results indicated that methylphenidate produced significantly less hyperactive behavior than either placebo or antecedent exercise ( $p = 0.0238$ ). Neither methylphenidate nor antecedent exercise produced notable side-effects. It is important to note although methylphenidate improved behavior relative to placebo or exercise, behavior in general, did not improve over time on any program. Furthermore, the magnitude of the difference between the methylphenidate and the placebo was modest, calling the clinical significance into question.

Although studies including children as young as seven years of age, such as the one conducted by Basile and colleagues (1995), have shown positive results with antecedent exercise, no research has shown antecedent exercise to be effective in pre-school children. Other factors which need consideration include generalizability and intensity, frequency and type of exercise. Single-case designs are difficult to generalize the results to a larger population (Thomas & Nelson, 2001). Additionally, there may be a certain intensity of exercise which is needed for a child of the participant's age. Evidence of irregularity of attendance in the preschool setting may also have interrupted the frequency of the exercise. The author's also indicated the participant disliked the repetitive nature of the exercise, since he often attempted to escape the exercise treatment. It is possible that the treatment may have agitated the participant and resulted in negative behavioral states. Furthermore, diagnosing ADHD in a child of three years of age is questionable. Specific symptoms of ADHD are difficult to identify at such a young age. Since the average age of ADHD diagnosis is approximately seven years old, it is possible that the child was misdiagnosed (Anastopoulos & Shelton, 2001).

A recent study conducted by Azrin and colleagues (2006), investigated the efficacy of contingency management of exercise to reduce inattention and hyperactive behavior in a four year old boy diagnosed with ADHD. Procedures included a baseline recording of the child's attentive sitting during a normal 17-minute classroom setting. An inattentive response was defined as the child jumping out of his seat or positioning any part of his body substantially away from the teacher to engage in a non-task-relevant behavior. The 17-minute period was divided into 1-minute intervals. During the procedure, the child was observed in a separate room by two graduate students, independently. The graduate student observers recorded whether or not an inattentive response occurred in each of the intervals. The child was seated in a chair facing the study assistant who provided the instructions and protocol for the study. Five conditions were given on a separate day and the intended reinforcer was a 1-minute opportunity to play in an outside playground containing typical gymnastic equipment. Each time

the child entered the play area, he immediately and continuously engaged in vigorous activity with no prompting. The five conditions included shaping, descriptive praise, non-contingent reinforcement, reconditioning, and baseline. The shaping condition attempted to shape the child into sitting calmly and attentively. The initial criterion response for reinforcement was set at approximately one second and increased by approximately 50% after each duration was achieved and reinforced. The successive durations were approximately 1, 2, 3, 5, 8, 12, 18, 27, 42, and 60 seconds. Descriptive praise was given continuously. At the end of the scheduled duration, the child was informed that they could go outside and play. The descriptive praise condition involved giving descriptive praise to the child with no opportunity to use the playground. When the child left his chair, he was reminded to sit and guided back to his chair, whereupon the next trial would begin. The non-contingent reinforcement condition allowed the child access to the playground equipment every 60 seconds independent of his calmness or lack thereof. No descriptive praise was given. The reconditioning condition involved providing access to the playground equipment for 60 seconds, for every 60 seconds that the child remained attentive and calm. Descriptive praise was given. Finally, the baseline condition involved no intervention and the child was seated in the chair. Whenever the child arose from his seat, he was returned to it, and the next trial would begin. Results indicated that each condition produced some level of attention and calmness however; the reconditioning condition was the most successful at producing the longest duration of attention and calmness. Researchers concluded that engaging in vigorous physical activity was reinforcing for their subject and the results possibly support the utility of using scheduled exercise as a reinforcer for ADHD children. Nonetheless, the results of this study should be considered with great caution. Again, the results are not generalizable as the study only sampled one child. Moreover, procedure took place in an unusual, non-classroom setting and no follow-up has been investigated.

Current literature which has explicitly investigated the effects of exercise on an ADHD population is extremely limited. Tantillo and colleagues in 2002 conducted the first controlled,

experimental study of the effects of exercise on behavioral and dopaminergic-like responses in children diagnosed as having ADHD. Due to the cost and impracticality of neuroimaging, the authors used spontaneous eye blinks and the acoustic startle eye blink response (ASER) as measures of dopamine response which have been validated within the research literature (Caplan et al., 1996; Goldstein & Blumenthal, 1995). An increase in spontaneous blink rate and the ASER amplitude would indicate an increase in the dopamine response. Behavioral responses, (i.e. motor impulsiveness), were assessed by a score on the motor impulsiveness battery test (MIB). The MIB required the participants to complete, for as long as possible up to one minute, specific motor tasks. Participants were given two trials per task with the mean being used for analysis. Eighteen children with ADHD who were currently taking Ritalin and twenty-five children without ADHD were recruited from the community by flyers and newspapers advertisements. The study involved the ADHD children ceasing Ritalin medication 24 hours before and during each of three daily conditions separated by 24 - 48 hours. After a maximal treadmill walking test to determine cardiorespiratory fitness, each child was randomly assigned to counterbalanced conditions of treadmill walking at an intensity of 65 - 75% of  $VO_2$  peak or quiet rest. Responses were compared with a group of control participants equated with the ADHD group on several key variables. Results indicated that maximal exercise in ADHD boys caused an increase in spontaneous blink rate and ASER amplitude, as well as a decrease in motor impulsiveness. The ADHD girls showed a moderately large increase in ASER amplitude after submaximal exercise, however no significant concomitant decrease in motor impulsiveness was found. The differences found between genders in the study are possibly due to the fact that ADHD is most commonly found in males. According to the DSM-IV, boys outnumber girls by approximately 4:1 to 9:1, depending on the population (Anastopoulos & Shelton, 2001). This suggests that there may be possible etiology differences between genders which have yet to be investigated. Although the methods of this study do not permit the conclusion that exercise had a

dopaminergic effect, the decrease in motor impersistence found in boys after maximal exercise is promising.

Until the precise causes and thus, mechanisms of ADHD can be solved, a large percentage of children are left battling the symptoms that the disorder presents. Before costly and expensive studies investigating the mechanisms of exercise can be studied, it is important that an efficacious relationship between exercise and the symptoms of ADHD be established. The preliminary evidence indicating that exercise may be an effective treatment for the symptoms of ADHD, as well as the equivocal findings, suggest that further investigation is necessary. Exercise is a socially acceptable, healthy treatment with a benign side effect profile that has received limited attention and thus, further research is warranted. This study would be the first in the ADHD literature to specifically explore the relationship between physical activity and the symptoms of ADHD in a sample of Canadian children diagnosed with the disorder. Not only would this study add to the limited literature available, but it may provide a basis for further research in this particular area.

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## CHAPTER 2: MANUSCRIPT

### *INTRODUCTION*

Attention-Deficit Hyperactivity Disorder (ADHD) is a developmental disorder characterized by the broadly defined symptoms, attention-deficit, hyperactivity and impulsivity (Barkley, 2004; Koziol et al., 1993; Anastopoulos & Shelton, 2001; Tantillo et al., 2002). With prevalence rates of the disorder estimated at approximately 2 – 17% of school children (St. Sauver et. al., 2004; Anastopoulos & Shelton, 2001; Tantillo et. al., 2002; Nair et. al, 2006), depending upon the diagnostic criteria, the population sample and assessment methods, ADHD is one of the most frequently diagnosed psychiatric disorders of childhood. Children with ADHD have a high rate of disciplinary problems in school, experience social and academic difficulties, and encompass 30 - 40% of the referrals to child guidance clinics (Barkley, 1998). Furthermore, children with ADHD are at a high risk for adverse personal and social outcomes, health problems, and increased health care costs and health care utilization that may persist from adolescence into adulthood (St. Sauver et. al., 2004; Clarke et. al., 2003; Wender, 1995; Spencer et al., 1997). Given the frequent occurrence of ADHD and the co-morbidity associated with the disorder, effective and appropriate treatment has become a critical issue.

Psychostimulant medications, primarily methylphenidate (Ritalin), are the most studied and most commonly prescribed treatments for the symptomatic management of ADHD (Koziol, Stout & Ruben, 1993; Anastopoulos & Shelton, 2001; Barkley, 2004; Tantillo et al., 2002; Clarke et al., 2003; Kimko et al., 1999; Spencer et al., 1997; Miller et al., 2001). Numerous studies have noted dramatic increases in the rate of prescriptions of methylphenidate for children in the past few decades, most specifically in the US, but in Canada and the UK as well (Parr et al, 2003; Miller et al., 2001). Although literature has provided evidence that psychostimulant medications are the most effective treatment for ADHD (Barkley, 2004; Stockl, 2003; Spencer, 1997; Pelham et al., 2000), the alleviating effects are not universal as approximately 20 – 30% of children are non-responders (Etscheidt & Ayllon, 1987; Koziol

et al., 1993; Pelham & Smith, 2000). Furthermore, psychostimulants are insufficiently effective in improving all domains of impairment in ADHD children (Barkley, 2004; Koziol et al., 1993; Pelham & Smith, 2000). A primary criticism of stimulant medication is the lack of evidence that stimulants produce either short or long-term changes in academic improvements, or improvements in long-term prognosis (Daly et al., 2007). It is unlikely that stimulant medication will be replaced by more effective alternative therapies, however due to the presence of non-responders, as well as domains of impairment unaffected by stimulant medication, adjuvant interventions for managing the symptoms for ADHD warrant investigation.

Beyond pharmacological approaches, a variety of treatments for children with ADHD have been tested over the past century. Therapies such as EEG biofeedback, sensory integrative therapy, dietary interventions, cognitive interventions, and behavioral skills training are all therapies that have poor empirical support (Barkley, 2004; Koziol, et al., 1993; Wolraich, 1997). An intervention that has received less attention, but has been suggested is physical activity (Barkley, 2004; Tantillo et al, 2002).

The mechanisms by which physical activity may be effective are similar to that of methylphenidate. Research suggests that abnormalities in the structure of the brain exist in individuals with ADHD (Anastopoulos & Shelton, 2001; Koziol et al., 1993; Nair, 2006). Studies have found evidence of an associated catecholamine dysfunction in the dopaminergic, norephrinergic, and epinephrinergic systems; however, the most implicated catecholamine is dopamine (Wigal et al., 2003; Vallone et al., 2000; Konrad et al., 2003). Dopamine is a catecholamine important in regulating movement, emotional and cognitive functioning, including attention (Wang et. al., 2000; Konrad et al., 2003). Previous research, focused mostly on rats, have shown that acute exercise triggers the release of dopamine in the brain, and habitual exercise leads to an increase in the enzymes that make dopamine (Wang et al., 2000).

Despite this evidence for physical activity as a potential treatment for ADHD, very little research has been conducted in this area. A possible explanation of this may be due to the challenges associated with diagnosing ADHD. The symptomatology of the disorder can not be defined within a single scope and the chief manifestations of the syndrome appear to shift with development causing an absence of an identified core deficit (Anastopoulos & Shelton, 2001). Additionally, evidence has indicated a high incidence of co-morbidity associated with ADHD, reporting a rate as high as 85% for clinical samples with at least one other disorder (Gillberg et al., 2004; Barkley, 2004, Spencer et al. 1997, Koziol et al., 1993).

Due to the challenges associated with ADHD, many researchers have examined the effects of exercise with children who have not been diagnosed as having ADHD specifically, but possess similar symptoms of the disorder. Preliminary studies investigating the effects of exercise on disruptive behaviors have shown positive results. Allison, Faith and Franklin (1995) published a meta-analytic review investigating antecedent exercise as a treatment for disruptive behavior. Antecedent exercise was defined as exercise that was applied non-contingently with the intent of decreasing later disruptive behavior (Alison, Faith & Franklin, 1995). The forty-two studies reviewed include various behaviorally disordered populations, and ages. Of the forty-two studies, thirty-four studies produced positive results ( $d = 0.33$  for group studies and  $d = 1.99$  for single case studies), suggesting that antecedent exercise is a socially acceptable strategy with treatment integrity and a benign side effect profile. Although these results provide insight into how physical activity may affect behavior in a wide range of individuals, it unfortunately does not provide a precise insight into the exact population of interest. Further research focusing on ADHD and children in particular, is needed in order to fully understand the relationship between physical activity and ADHD symptoms.

There currently exist only three studies which have specifically examined the effects of exercise on children with ADHD (Tantillo et al., 2002). In 2002, Tantillo and colleagues conducted the first

controlled, experimental study of the effects of exercise on behavioral and dopaminergic-like responses in children diagnosed as having ADHD. Results indicated that exercise showed a promising reduction of motor impulsiveness in boys, specifically. Limitations of this study included focus on the physiological findings typically associated with ADHD, rather than the symptoms, and the use of a laboratory setting. Additionally, measurements were not repeated.

The two other studies that have investigated the effects of exercise on ADHD were conducted by Silverstein and Allison in 1994, and Azrin and colleagues in 2006. Silverstein and Allison examined the effects of antecedent exercise in the reduction of hyperactive behavior in a pre-school boy with ADHD. Results indicated that exercise was generally ineffective at reducing his hyperactive behavior. Azrin and colleagues (2006) investigated the efficacy of using exercise as a reinforcer to reduce inattention and hyperactive behavior in a four year-old boy with ADHD. Azrin concluded that physical activity was an effective reinforcer to reduce inattention and hyperactive behavior for their subject. Although the results of these two studies are contradictory, both studies suffer from methodological problems and single-case designs lack the ability to generalize to the larger population. The limited research does suggest however, that physical activity may benefit children with ADHD and future research has been recommended.

The preliminary evidence indicating that physical activity may be an effective treatment for the symptoms of ADHD, as well as the equivocal findings, suggest that further investigation is necessary. Previous research focused on physical activity and ADHD has been limited primarily to laboratory settings, single-subject analyses and testimonials (Wolraich, 1997). Currently, no studies have explored the relationship between physical activity and the symptoms of ADHD in a natural setting or in Canadian child populations. Additionally, specific data on the physical activity practices of this population has not been conducted. Thus, the purpose of this study was to extend the limited research by investigating the present physical activity practices of ADHD children, as well as explore the

relationship between physical activity and the symptoms of ADHD through a parental survey on a sample of Canadian children diagnosed as having ADHD. Specifically, it was hypothesized that the results will indicate that (1) a large proportion of children with ADHD engage in physical activity below recommended Canadian national guidelines, and that their parents do not use physical activity as a therapy (2) physical activity will demonstrate a negative association with ADHD symptoms, and the symptom most affected by physical activity will be hyperactivity. Additional exploratory objectives of this study were to determine what particular intensity and duration of physical activity has been successful, if any, and to determine any other moderators that may influence the relationship between physical activity and ADHD symptoms. It was hypothesized that strenuous intensities of physical activity, rather than mild, would produce greater reductions in the symptoms of ADHD.

## ***METHODS***

### ***Procedure***

Ethical approval for this study was sought and approved through the University of Victoria Human Research Ethics Board. Participants for this study included both male and female parents of children seven to twelve years of age, whose children have ADHD. The target sample for this study ( $N = 60$ ) was calculated using G-power (Erdfelder et al., 1996) and Cohen's medium effect size (1988).

Participants were recruited for this study through collaboration with the Learning Disabilities Association of BC – South Vancouver Island Chapter (LDA-SVIC). Participants were recruited via mail packets sent to the LDA-SVIC's members (by the LDA-SVIC) and included a letter of information and consent, the questionnaire, and return envelope. Parents were given the primary investigator's contact email and telephone number in case they had any questions or concerns about the study or the questionnaire. The LDA-SVIC was given a total of 500 packets. Of the 500 questionnaires, 17 were returned. Since the LDA-SVIC supports families with children of various disorders, the number of targeted eligible participants using the mail-out is unknown. Due to the insufficient number of returned questionnaires, an online questionnaire was created using surveymonkey.com (1999), following ethics approval. The LDA-SVIC posted the online questionnaire on the front page of their website, allowing anyone who logged on to their website to see the link for the study, and participate, provided they read the information and consent letter and met the criterion for our target sample. As an incentive, LDA-SVIC members were also told that for every questionnaire filled out and returned, five dollars would be donated to the LDA-SVIC.

Various internet parental community forums were contacted via email to obtain permission to post a thread about this study. The post included a link to the information and consent letter and a link to the study questionnaire. The following forums gave permission to post this study on their forum websites: Kids in Victoria.com (KIV), Canadian Parents.com (CP), Parents in BC (PIBC), Families.com

(F), LD Online (LDO), ADHD News Forum (ADHDNF), and Attention Deficit Disorder Forums (ADDF). Threads were posted in the 'General', 'Special Needs', 'Research' and 'ADHD' sections of the forums. In total, this study was advertised on seven different parental community forums. Each thread was posted for a total of two months. The thread was re-posted on a forum site if the original thread was not currently on the first page of threads. Parents had the opportunity to post or send private messages to the principal investigator if they had questions about the study or filling out the questionnaire. Each questionnaire could be completed only once per computer. Respondents were not required to answer every question on the questionnaire, thus a completion check was not applicable. Reviews or changes to answers were only allowed before a respondent hit the 'submit' button. Before completing the questionnaire, respondents were asked to read the information and consent letter provided, notifying them that if they submitted their questionnaire their consent was implied. Respondents were also informed that there would be no way to eliminate their questionnaire if they later chose not to participate, as no personal information was collected or stored. Table 1 provides further data, in keeping with the Checklist for Reporting Results of Internet e-surveys (CHERRIES) (Eysenbach, 2004).

The online questionnaire data were collected in plain text in a password-protected database program developed by surveymonkey.com. Once the questionnaire was closed to respondents, the data was printed from the surveymonkey.com database and transferred to the same file as the paper questionnaires using Statistical Package for the Social Sciences version 15.0 for analysis.

During the two months that this study was posted on the internet parental forums, 99 questionnaires were received. Of the combined 116 returned questionnaires, 15 were unusable due to incompleteness of the questionnaire. In total, 101 participants returned completed questionnaires. Due to a portion of the study recruitment involving an internet questionnaire, the actual number of eligible participants is unknown. Thus, an accurate response rate was unattainable.

**Table 1** CHERRIES checklist for ADHD online questionnaire

	FORUM						
	KIV	PIBC	CP	F	LDO	ADHDF	ADDF
<b>Date questionnaire went online</b>	2/18/07	2/22/07	2/26/07	2/28/07	2/26/07	2/28/07	2/28/07
<b>Date questionnaire went offline</b>	4/25/07	4/25/07	4/25/07	4/25/07	4/25/07	4/25/07	4/25/07
<b>Number of question items</b>	32	32	32	32	32	32	32
<b>Number of pages</b>	7	7	7	7	7	7	7

*Parental Forums:* KIV: Kids in Victoria; PIBC: Parents in BC; CP: Canadian Parents; F: Families.com; LDO: Learning Disabilities Online; ADHDF: ADHD News Forum; ADFF: Attention Deficit Disorder Forums

### *Participants*

The original purpose of this study was to investigate the relationship between physical activity and the symptoms of ADHD using an exclusively Canadian sample. Due to the accessibility of the internet, however, a portion of the sample included US participants. Of the 101 respondents, 71.3% ( $n = 72$ ) of the children were males and 28.7% ( $n = 29$ ) were females, with mean ages of 9.18 (SD = 2.42) and 9.57 (SD = 2.47), respectively. The majority of the total participants (49.5%) resided in British Columbia, 6.2% resided in Ontario, 4.2% resided in the Maritimes provinces and 1.0% resided in Quebec. Of the total participants, 39.8% resided in the United States; 13.5% resided in California, 24.3% resided in Indiana, New York and Pennsylvania; 27.1% resided in Washington, Ohio, Texas, Michigan and Missouri, and 35.1% resided in North Dakota, Wisconsin, Oklahoma, Oregon, Alabama,

Colorado, Delaware, Florida, Georgia, Illinois, Massachusetts, Minnesota and Mississippi. Parents reported themselves as well educated; only 2.0% of the sample had not graduated from high school, whereas, 60.6% had obtained a diploma from a college or university, and 20.2% had a professional or graduate degree. The percentage of parents who had obtained a diploma from a college or university was considerably larger than the Canadian average of 22.4% (Statistics Canada, 2004). Only 5.1% were unemployed, with 33.3% retired or a homemaker and 61.6% employed. Annual family income revealed that 11.5% made less than \$20,000 dollars a year, with 13.5% making \$20,000 - \$40,000 per year, and 75.0% having a household income over \$40,000 per year. A census of Canada in 2001 revealed that the average annual earnings for Canadians was \$31, 757 (Statistics Canada, 2004), thus, our sample was quite affluent in comparison. Of those participants reporting ethnicity (N = 99), the majority were Caucasian (93.9%). Finally, in terms of PA participation, 76.0% of the child sample failed to meet the minimum guideline for recommended regular weekly physical activity as measured by the Godin Leisure Time Exercise Questionnaire (see measures section), which is similar to the Canadian average for children and youth of 84.0% (CFLRI, 2005).

### *Measures*

The following measures and specific question items can be found in the Physical Activity and ADHD Questionnaire Mail-Out version in Appendix C of this thesis.

### *Medical History and Demographics*

Medical history was measured using items borrowed from a standard patient form used at a psychological clinic in Victoria, BC (Kerns, 2005). Additional items were created specifically for this study. Specific items included questions related to ADHD diagnosis, medication, additional health problems and therapeutic practices. Demographic characteristics were assessed using items that have

been validated in previous population health studies (Rhodes et al., 2006; Rhodes & Blanchard, 2007). Demographic items included ethnicity, education, marital status, employment and annual income.

#### *ADHD Measures*

ADHD symptoms were measured using the Connors' ADHD Short Form Parent Rating Scale-Revised (Connors, 2001). This rating scale was paid for and permission to utilize the measure was given by its publisher Multi-Health Systems Incorporated (MHS, 2005). Parents indicate on a four point scale the degree the specific items characterize their child's ADHD behavior over the last seven days. The parent short form contains twenty-seven items on domains of Oppositional, Cognitive Problems/Inattention, Hyperactivity and ADHD Index. The Connors' Rating Scales are one of the most commonly used rating scales for evaluating ADHD symptomatology (Anastopoulos & Shelton, 2001). Norms for the parent scales were drawn from over 200 data collection sites, using ratings from more than 2,000 parents (Connors' et. al, 1998a&b). As with the previous versions, the new parent rating scales have excellent psychometric characteristics (Anastopoulos & Shelton, 2001). Internal reliability coefficients average 0.80 with factor analyses supporting the validity of the subscales. The Connors' parent rating scales reliably distinguish between children with and without ADHD, with an overall correct classification rate greater than 90% (Anastopoulos & Shelton, 2001). Estimates of internal consistency in the present study ranged from 0.84 – 0.90 for the four Connors' subscales.

#### *Physical Activity Measures*

The assessment of physical activity among children and adolescents presents many challenges and a standard self-report measure has yet to be validated (Kohl et al., 2000). Kohl and colleagues (2000) recommend that self-report physical activity data for children younger than 10 years should not be collected due to insignificant validation coefficients. As the age range for our sample was seven to twelve years, a proxy measurement was used in this study. Overall, previous literature suggests that there is limited information for proxy measures of physical activity and a valid and reliable proxy

measure for children has yet to be developed (Sirard & Pate, 2001). With the desire to use a physical activity measure that is relatively non-invasive, inexpensive and easy to understand and also avoid recall errors caused by children's cognitive limitations, child physical activity behaviors were reported by parents, using the Godin Leisure Time Exercise Questionnaire (GLTEQ) (Godin & Shepard, 1985; Bates, 2006). The GLTEQ consists of three items pertaining to the frequency and average duration of mild (i.e., minimal effort, no perspiration), moderate (i.e., not exhausting, light perspiration) and strenuous (i.e., heart beats rapidly, sweating) intensity activity during an individual's free time within a typical week. Each physical activity intensity item for the child participant's was scored by multiplying their frequency and average duration resulting in total mild, moderate and vigorous minutes. This instrument is frequently used in physical activity research because of its relative ease of use and its ability to measure the intensity, frequency and duration of exercise behaviors. The GLTEQ has been well validated in the physical activity domain and contains open-ended questions, which allow participants to express their opinions without being restricted. An independent evaluation of the GLTEQ reported its reliability and validity to compare favorably to nine other self-report measures of exercise (Jacobs et al., 1993). Test-retest reliability coefficients are high for strenuous activity, and adequate for moderate and mild activity (Godin & Shepard, 1985; Gionet & Godin, 1989; Jacobs et al., 1993).

#### *Physical Activity Practices Measures*

Child physical activity practices and parental opinion about the utility of physical activity for their children in general were measured using self-report items developed specifically for this study. These items included questions about structured physical activities, sedentary behaviors, whether parents use physical activity as a form of therapy and their opinion about the effects of physical activity on their child's ADHD symptoms (please see Appendix C). Structured physical activities were assessed using the following item: "Does your child participate in any structured physical activities?". If they answered "yes", they were then asked to describe the type of structured activity their child participates

in, and report the weekly frequency and duration. Sedentary activities were assessed using the following item: "What types of sedentary activities does your child spend most of their time engaging in?". Parents were asked to choose from a variety of sedentary activity items that pertained to their child, including the number of times per week their child engaged in each activity and the average duration per session. Parents were also asked whether they used physical activity as a form of therapy. If they answered "yes", they were then asked whether they found it successful using a five point scale from not at all (1) to extremely (5). The parental opinion about the utility of physical activity variable consisted of the following: (1) "Do you notice a decrease in your child's ADHD symptoms on days when your child participates in physical education classes in school?" (2) "Do you notice a decrease in your child's ADHD symptoms on days when your child is physically active?", and (3) "Do you notice an increase in your child's ADHD symptoms on days when your child is in-active?". All parental opinion items were answered using a five-point scale from not at all (1) to extremely (5). Factor analyses of this variable indicated an internal reliability coefficient of 0.78, thus supporting its reliability as a measure. Additionally, parents were also asked about the validity of physical activity as a form of treatment for ADHD using the following item: "If physical activity was scientifically proven to decrease symptoms of ADHD, would you be more inclined to use physical activity as a form of therapy?". This item was scored on a four-point scale from yes (1) to no (4).

### ***Creation of Variables***

#### ***BMI***

Each child's body mass index (BMI) was calculated by dividing their body weight by the square of their height ( $\text{kg}/\text{m}^2$ ). BMI was coded as a continuous variable.

### *Connors' subscales*

The four Connors' subscale variables were created by aggregating and then averaging each participant's score on each item within each Connors' subscale. For example, within the 27 item Connors' ADHD Short Form Parent Rating Scale-Revised, six items are related to oppositional behavior. Each parent's score (0, 1, 2 or 3; please see Appendix C) on these six items was aggregated and then averaged to get a total score for the oppositional behavior domain for each participant. This procedure was repeated for the remaining three subscales: cognitive problems/inattention, hyperactivity and ADHD Index.

Additionally, a variable entitled 'Connors' hyperactivity revised' was created. There was concern that some of the hyperactivity items included in the Connors' hyperactivity subscale might be cross-contaminated and may not precisely measure an ADHD described child that demonstrates developmentally inappropriate degrees of hyperactivity (Koziol et al, 1993), rather than just an active child. Connors' subscale items specific to hyperactivity were revisited and any items that could possibly apply to a 'typical' child, rather than 'atypical', were eliminated and a new scale (Connors' hyperactivity revised) was created (Kerns, 2007; personal communication). The following two items were eliminated: (1) "Is always on the go or acts as if driven by a motor" and (2) "Hard to control in malls or while grocery shopping". No differences were found between the Connors' hyperactivity and the Connors' hyperactivity revised variables. Thus, analyses focused on the original Connors' hyperactivity variable.

### *PA Guidelines*

The variable PA guidelines was created by dichotomizing participants into two groups, either 'guidelines met' or 'guidelines not met' according to Health Canada's Physical Activity Guidelines for children (2002) and the Canadian Fitness and Lifestyle Research Institute (2005 & 2006). To be considered in the 'guidelines met' group, participants needed to engage in a minimum of 60 minutes of

daily physical activity within a typical week at a moderate or strenuous intensity. Those participants who did not meet this guideline were coded in the 'guidelines not met' group.

#### *Parental opinion about the utility of PA*

The parental opinion about the utility of physical activity variable was a combination of the following three question items: (1) "Do you notice a decrease in your child's ADHD symptoms on days when your child participates in physical education classes in school?" (2) "Do you notice a decrease in your child's ADHD symptoms on days when your child is physically active?", and (3) "Do you notice an increase in your child's ADHD symptoms on days when your child is in-active?". Each participant's score (1, 2, 3, 4, or 5; please see Appendix C) on each of these items was aggregated and averaged to obtain a total value for the parental opinion about the utility of physical activity variable.

#### *Co-morbidity*

A co-morbidity variable was created separating participants into two categories. First, participants that had suffered any head injuries were deleted from both groups, as these participants bias the ADHD sample due to a possible differing mechanism for their ADHD symptoms. Participants were then separated into either a 'no co-morbidity' group or a 'co-morbidity' group. Participants in the 'co-morbidity' group included those children who had been diagnosed with common co-morbidities associated with ADHD such as oppositional defiant disorder, obsessive compulsive disorder, anxiety, depression, learning disabilities, mood disorders and tics.

#### *Medication*

Participants were separated into two medication categories: 'no medication' or 'medication'. Participants in the 'medication' group included those children who were taking any kind of medication, including medication for ADHD, and/or co-morbidities.

### *Head Injuries*

A head injury variable was created by separating participants into two groups based on their medical history. If a child had suffered any kind of head injury they were put into the 'head injury' group, and if they had not experienced any head injuries they were put into the 'no head injury' group.

### *Country*

Participants were separated into either a 'Canada' or 'US' group according to their respective postal codes or zip codes.

### *Analyses*

All analyses were conducted using the Statistical Package for the Social Sciences version 15.0 for Windows, and all data were coded, cross-checked, and cleaned. All variables were checked for normality and outliers with z-scores of 3.3 or higher were removed to ensure that they were not biasing the data (Tabachnick & Fidell, 2001). The removal of outliers was done prior to conducting any statistical analyses.

The analysis plan included analyzing Hypothesis 1 using detailed descriptives about the participant sample and Hypothesis 2 was analyzed using Pearson  $r$  bivariate correlations of the various physical activity behaviors, ADHD and demographic variables. Categories for physical activity were total strenuous, total moderate, total moderate and strenuous and total all intensities minutes (frequency times duration), as well as total Canadian guideline physical activity (PA Guidelines).

Additional exploratory objectives were analyzed by moderator analyses using hierarchical ordinary least squares multiple regression with mean centered variables (Aiken & West, 1991). Mean centering the variables has no impact on the slope of the interaction term; however, it minimizes problems associated with predictor multicollinearity and eases interpretation of the nonproduct terms in the final regression model (Aiken & West, 1991). Many variables were considered as potential

moderators of the physical activity/ADHD symptom relationship; however, an initial power analysis was conducted to examine the power of subgroup analyses. It was found that in order to detect a large effect size ( $r = 0.50$ ), a minimum sample of 21 participants is required. Thus, sub-analyses whereby cells were smaller than  $N = 21$  were not considered. The following variables were analyzed as potential moderators of the physical activity/ADHD symptom relationship: gender, age, BMI, education, income, therapeutic physical activity, co-morbidities, and parental opinion about the utility of physical activity. The two physical activity variables used in the moderator analysis were total strenuous physical activity and PA guidelines. The four Connors' subscales, separately, were the dependent variable and each moderator along with each physical activity variable were the independent variables. Specifically, each moderator and physical activity variable were entered into the regression equation first, followed by the interaction term in the second block. Any significant interactions were evaluated using slope analysis (Aiken & West, 1991).

For all analyses the p level for entry was set at 0.05 and the analyses were sufficiently powered to detect a small to medium effect size (Cohen, 1988).

## **RESULTS**

### ***Descriptives***

Demographics and various health and diagnostic categories of ADHD children and their parents can be found in Table 2. The mean BMI ( $\text{kg}/\text{m}^2$ ) of the child participants was 18.3 (SD = 5.12) for males and 16.5 (SD = 4.24) for females. Diagnosis of ADHD included 97.0% of the participant sample, with the majority of children diagnosed by their Pediatrician (34.0%), Psychiatrist (25.0%) or Psychologist (25.0%); the rest of the participant sample (13.0%) was diagnosed by other professionals. Most of the participant sample (78.0%) was currently taking some form of medication for their symptoms, with stimulants as the most common medication. Mean length of time for taking ADHD related medication was 27.7 months (SD = 24.11). Other common medical problems included a variety of physiological problems, asthma, allergies, anxiety, depression, Oppositional Defiant Disorder and Fetal Alcohol Syndrome. Past head injuries were experienced by 16.0% of the sample. Physical activity was used as a form of therapy by 48.5% of the participant sample (Boys = 50.7% & Girls = 42.9%). Other common forms of therapy included behavioral modification (34%) and dietary interventions (16%).

**Table 2 Number of Participants and Distribution of Sex and Mean Age Across Various Health and Diagnostic Categories**

Category	Frequency	Sex (%)		Age (yr)	
		Male	Female	Mean	SD
<i>Child Categories</i>					
	N = 101	71.3	28.7	9.29	2.43
*BMI MEAN (kg/m <sup>2</sup> )	17.8 (4.95)	18.3 (5.12)	16.5 (4.24)		
Formal Diagnosis					
Yes	98	97.2	96.6	9.31	2.44
Diagnosed By					
Physician	7	8.6	3.6	9.57	1.72
Pediatrician	34	31.4	42.9	9.15	2.29
Psychiatrist	25	18.6	42.9	9.32	2.82
Psychologist	25	34.3	3.6	9.28	2.34
Other	7	4.3	7.1	8.40	3.85
Medication					
No medication	22	25.0	14.3	10.18	2.77
ADHD medication only	56	56.9	53.6	8.88	2.26
ADHD medication + Co-morbid medication	19	15.3	28.6	9.39	2.38
Other medication only	4	2.8	3.6	9.33	2.89
*Length of time taking medication MEAN (mths)	27.7 (24.11)	25.4 (21.6)	32.06 (28.9)		
Other Medical Problems					
Asperger's Syndrome	2	2.8	0	8.00	2.83
OCD	4	2.8	6.9	7.75	2.99
ODD	5	4.2	6.9	10.8	2.86
Sensory Integration Disorder	3	4.2	0	8.00	2.00
Dyslexia	4	4.2	3.4	7.75	2.22
Anxiety	5	4.2	6.9	9.60	2.88
FAS	5	2.8	10.2	8.34	1.53
Physiological Problems	13	14.0	10.2		
Asthma	9	6.9	13.8	9.44	2.07
Allergies	5	4.2	6.9	8.20	2.77
Head Injuries					
Yes	16	14.1	20.7	9.93	2.49
No	84	85.9	79.3	9.21	2.41
Use PA as Therapy					
Yes	48	50.7	42.9	9.04	2.48
No	52	49.3	57.1	9.58	2.37
Other Forms of Therapy					
Cognitive	3	4.2	0	9.67	1.15
Massage	1	1.4	0	11.00	
Occupational	1	1.4	0	8.00	
Auditory	2	1.4	3.4	9.50	2.12
Tutoring	2	2.8	0	11.00	
Art Therapy	2	2.8	0	9.00	4.24
Dietary	16	13.9	20.7	9.44	2.66
Behavioral Modification	34	34.7	31.0	9.32	2.16
Herbal Treatment	7	9.7	0	9.57	2.64
<i>Parental Categories</i>					
Demographics					
%Caucasian	93.9				
%Completed University	64.6				
%Married/Common Law	80.8				
%Currently Employed	61.6				
Annual Income					
%0 - \$20,000	11.5				
%\$20,001 - \$40,000	13.5				
%\$40,001 - \$75,000	32.3				
%\$75,001 - \$100,000	25.0				
%More than \$100,000	17.7				

\* ( ) = Standard Deviation

### ***Bivariate Correlations***

All Pearson  $r$  bivariate correlations for the various demographic, health and diagnostic categories (including the four different Connors' subscales) and all physical activity variables can be found in Tables 3 and 4.

T scores from each Connors' subscale indicated 85% (MEAN average of all four subscales) of the sample ranged from markedly atypical (indicates a significant problem) to slightly atypical (borderline: should raise concern) for ADHD ratings in comparison to norms (Connors, 2001). Correction using this sample only did not significantly change the Pearson  $r$  bivariate correlations. Thus, in order to retain the power in our sample, the entire sample was used in the analyses.

Mean levels for the Connors' subscales ranged from 1.65 to 2.01, and standard deviations ranged from 0.65 to 0.75, of a unit on a four-point scale. Mean levels for demographic variables, including education, employment status and annual income, ranged from 2.53 to 4.63, and standard deviations ranged from 1.08 to 1.36, respectively. All Connors' subscales correlated with one another, with a range of  $r = 0.66$  to  $r = 0.97$ ;  $p < 0.05$ . Overall, all physical activity variables, with the exception of total mild PA minutes, correlated with one another ( $r = 0.44 - r = 0.88$ ;  $p < 0.05$ ). Significant associations with physical activity variables were found between Connors' subscale of hyperactivity and total strenuous PA minutes ( $r = 0.23$ ;  $p < 0.05$ ), Connors' subscale of hyperactivity revised and total strenuous PA minutes ( $r = 0.21$ ;  $p < 0.05$ ), as well as Connors' subscale of hyperactivity and PA as therapy ( $r = -0.21$ ;  $p < 0.05$ ) (Table 2). Significant associations with demographic variables were found between all of the Connors' subscales and parental level of education ( $r = -0.23 - r = -0.31$ ;  $p < 0.05$ ). All Connors' subscales, except Connors' subscale of cognitive problems/inattention, had significant associations with parental annual income ( $r = -0.20 - r = -0.27$ ;  $p < 0.05$ ). No significant associations were found between the ADHD descriptive variables and employment status.

Due to the significant associations between the Connors' subscales and the demographic variables of education and annual income, partial correlations between the Connors' subscales and all physical activity variables were conducted controlling for these two demographic variables. Results indicated no significant change in the correlations ( $r = 0.24$ ;  $p < 0.05$ ), thus suggesting that the relationship between the physical activity variables and education and annual income are independent.

Systematic error within specific items of our questionnaire was tested via a bivariate correlation between the parental opinion about the utility of PA and PA as therapy variables. A significant correlation ( $r = -0.31$ ;  $p < 0.05$ ) was found. This result indicates that, logically, there is internal consistency between the two variables; however, the two variables are not synonymous. Thus, suggesting these two variables are somewhat independent.

Table 3 Bivariate Correlations of Descriptive ADHD Variables

	Total Strenuous PA	Total Moderate PA	Total All Intensities	Total Moderate & Vigorous PA	Total PA Guidelines	PA as Therapy	PA Effectiveness Summary	MEAN	SD
Gender	.07	.09	.20	.11	.15	.07	-.03	1.29	.45
Age	.10	.16	.20	.17	.06	.11	.10	9.29	2.43
BMI	-.06	.06	-.09	.01	-.10	.09	-.01	17.83	4.95
C. Oppositional	.15	.03	.01	.11	-.09	-.07	.07	1.72	.72
C. Cognitive Prob/ Inattention	.19	-.04	.01	.06	-.05	-.09	.10	2.01	.72
C. Hyperactivity	.23*	-.02	-.01	.10	.01	-.21*	.11	1.65	.75
C. ADHD Index	.20	-.04	-.02	.07	-.08	-.09	.05	1.93	.65
C. Hyperactivity Revised	.21*	-.03	-.00	.09	.00	-.17	.09	1.66	.71
Head Injuries	.18	-.07	-.04	.04	.02	.04	.05	1.16	.37
Education	-.08	.03	-.13	-.03	.03	-.02	.06	4.63	1.08
Employment Status	-.01	.10	-.07	.07	.09	-.09	.09	2.53	1.17
Annual Income	.02	-.03	-.03	-.02	.02	.10	-.13	4.18	1.36

\*\*  $p < 0.01$   
\*  $p < 0.05$

Connors' ADHD Subscales: Oppositional; Cognitive Problems/ Inattention; Hyperactivity; ADHD Index; Hyperactivity Revised

Table 4 Bivariate Correlations of Demographic and ADHD Descriptive Variables

	Education	Employment Status	Annual Income	MEAN	SD
Gender	-.10	-.02	-.15	1.29	.45
Age	-.07	.14	-.06	9.29	2.43
BMI	.08	.13	-.10	17.83	4.95
C. Oppositional	-.30**	.03	-.27**	1.72	.72
C. Cognitive Prob/ Inattention	-.25*	.04	-.13	2.01	.72
C. Hyperactivity	-.23*	-.02	-.23*	1.65	.75
C. ADHD Index	-.31**	-.01	-.20*	1.93	.65
C. Hyperactivity Revised	-.26**	.01	-.23*	1.66	.71
Head Injuries	.04	.12	-.12	1.16	.37

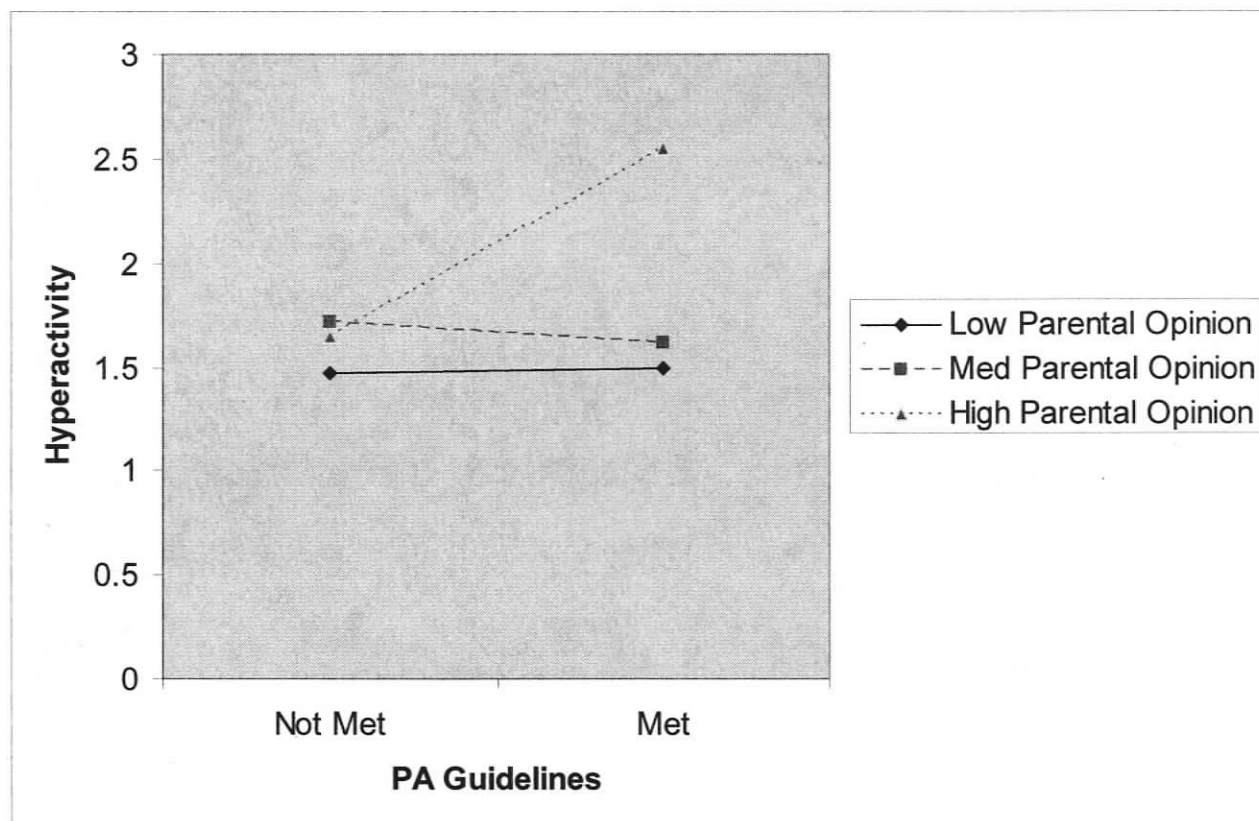
\*\*  $p < 0.01$   
\*  $p < 0.05$

Connors' ADHD Subscales:

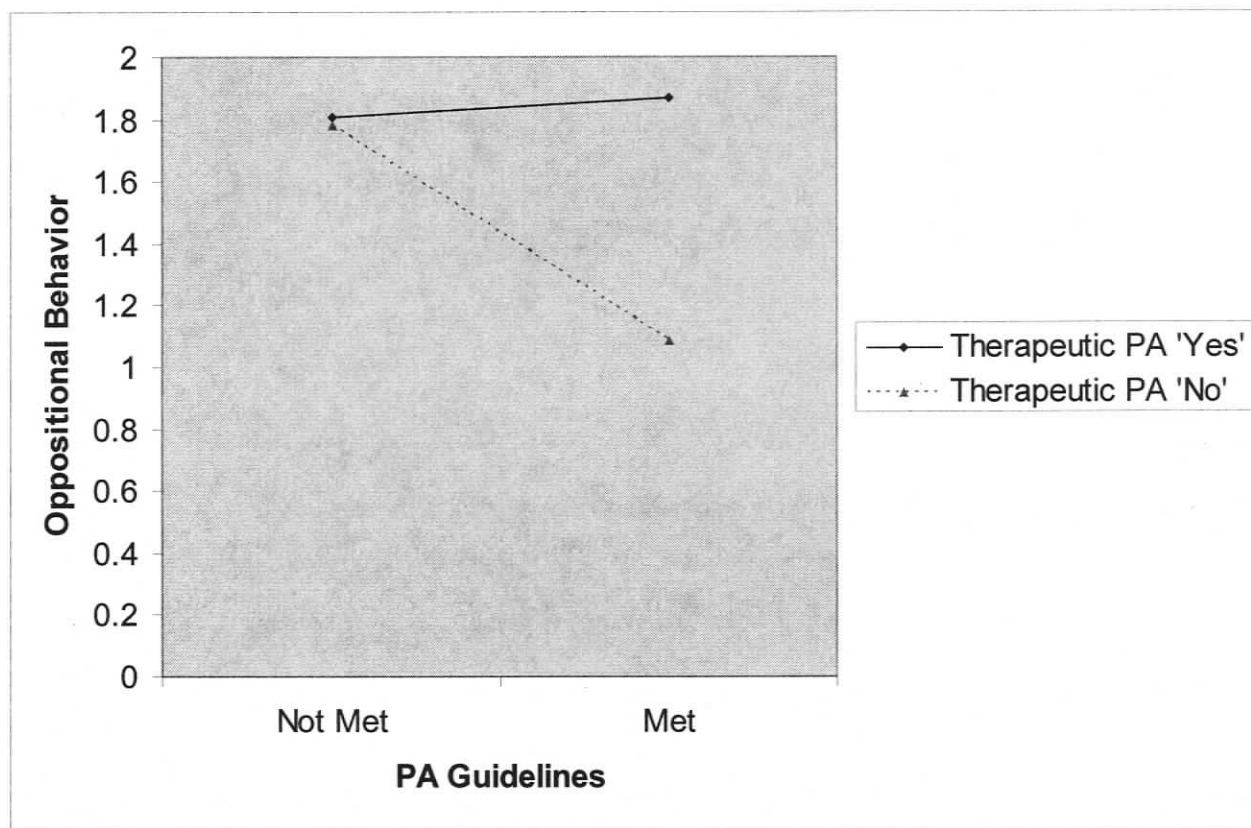
Oppositional; Cognitive Problems/ Inattention; Hyperactivity; ADHD Index; Hyperactivity Revised

### *Tests of Moderation*

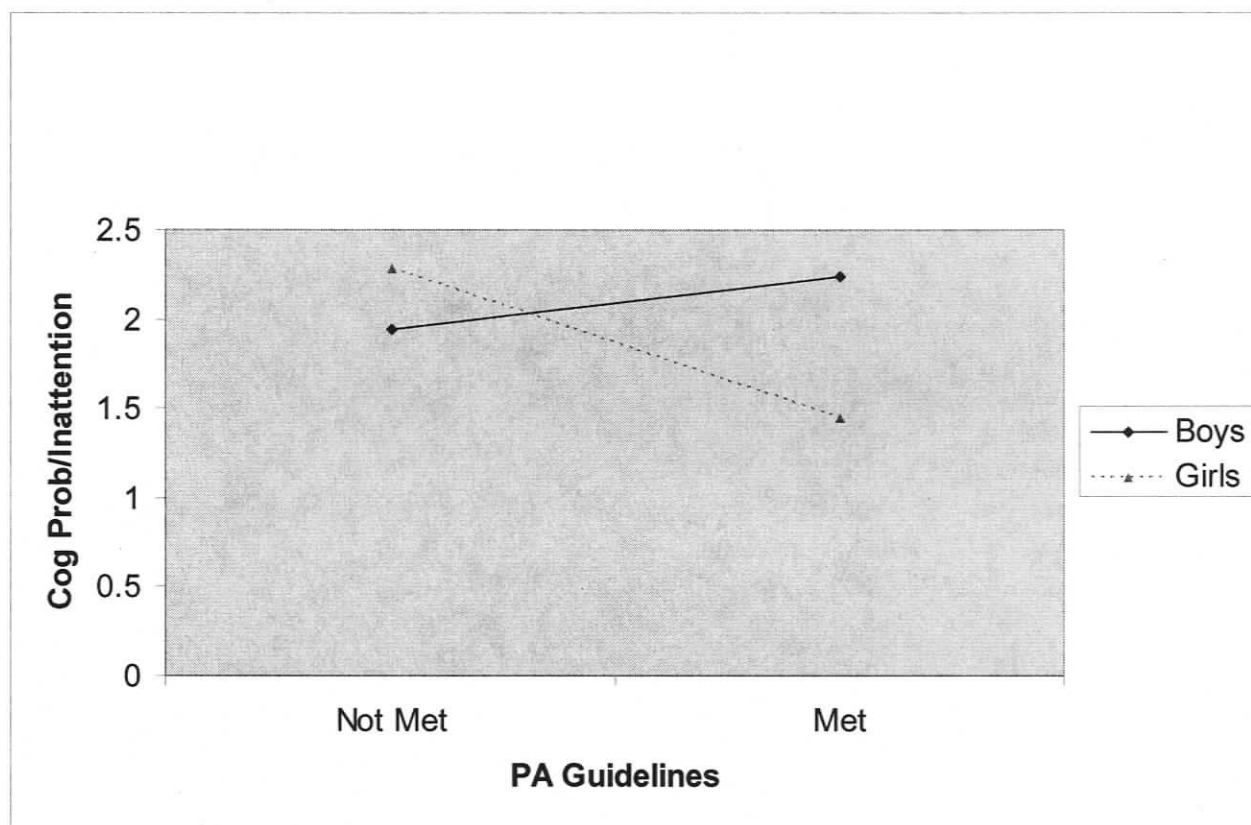
The main analyses that tested for moderators between physical activity and ADHD symptoms included a total of thirty-two multiple regressions. From this total, three significant relationships were found. Specifically, parental opinion about the utility of PA moderated the relationship between PA Guidelines and the subscale of hyperactivity ( $\Delta F_{(1, 88)} = 5.25, p < .05; \Delta R^2 = .06$ ), PA as therapy moderated the relationship between PA Guidelines and the subscale of oppositional behavior ( $\Delta F_{(1, 90)} = 4.21, p < .05; \Delta R^2 = .04$ ) and gender moderated the relationship between PA Guidelines and the subscale of cognitive problems/inattention ( $\Delta F_{(1, 92)} = 9.58, p < .05; \Delta R^2 = .09$ ). Follow-up slope analyses are presented in Figure 1, Figure 2 and Figure 3, respectively. Comparing PA Guidelines and Connors' subscale of hyperactivity across the parental opinion groups of low, medium and high, it is apparent that the high parental opinion group is significantly different than the low and medium parental opinion groups. The high parental opinion group showed a strong positive relationship between PA Guidelines and Connors' subscale of hyperactivity. Comparing PA Guidelines and Connors' subscale of oppositional behavior, a split between the PA as therapy groups (yes or no to using physical activity as therapy) is apparent. Parents that do not use physical activity as a form of therapy showed a strong negative relationship between PA Guidelines and Connors' subscale of oppositional behavior, while the group that uses physical activity as a form of therapy showed no relationship with Connors' subscale of oppositional behavior. Lastly, comparing PA Guidelines and Connors' subscale of cognitive problems/inattention, there is an obvious split between genders. Girls showed a strong negative relationship between PA Guidelines and Connors' subscale of cognitive problems/inattention, while the boys showed a weak positive relationship.



**Figure 1** Relationship between PA Guidelines and hyperactivity moderated by parental opinion about the utility of physical activity



**Figure 2** Relationship between PA Guidelines and oppositional behavior moderated by therapeutic physical activity



**Figure 3** Relationship between PA Guidelines and cognitive problems/inattention moderated by gender

## ***DISCUSSION***

ADHD is one of the most frequently diagnosed developmental disorders of childhood (St. Sauver et. al., 2004; Anastopoulos & Shelton, 2001; Tantillo et. al., 2002; Nair et. al, 2006). Although psychostimulants are the most commonly prescribed treatments for ADHD, approximately 20 – 30% of children are non-responders and psychostimulants are insufficiently effective in improving all domains of impairment (Etscheidt & Ayllon, 1987; Koziol et al., 1993; Pelham & Smith, 2000; Barkley, 2004). Thus, investigating adjuvant interventions for managing the symptoms of ADHD is necessary. Preliminary evidence has suggested that physical activity may be an effective treatment for the symptoms of ADHD (Barkley, 2004; Tantillo et. al, 2002; Burdette, 2005; Allison et al., 1995). The purpose of this study was to extend the limited research by investigating the present physical activity practices of ADHD children, as well as explore the relationship between physical activity and the symptoms of ADHD through a parental survey on a sample of Canadian children diagnosed as having ADHD. Additional exploratory objectives were also to determine what particular intensity and duration of physical activity has been successful, if any, and to determine any other moderators that may influence the relationship between physical activity and ADHD symptoms. This study was the first within the literature to explore the relationship between physical activity and the symptoms of ADHD using a parental survey in a North American sample of diagnosed ADHD children.

Two main hypotheses and exploratory objectives were included in this study. The following sections discuss the implications of the results with the purpose of the study and related hypotheses.

### *Descriptive Findings*

A unique element of this study is the descriptive information collected as this particular information is the first of its kind for specifically Canadian ADHD populations. Analyses of the descriptive information indicated that the gender breakdown and incidence of co-morbid disorders in

this sample was generally representative of other ADHD samples found in current literature. Gender distribution in community or epidemiological samples has been found to have a range of frequency between 2:1 to 3:1 (Spencer et al., 1997; Harvey & Reid, 2005), male to female ratio; a frequency that is comparative to this sample frequency of 2.5:1, male to female ratio. Additionally, 38% of the participants in this sample had at least one other disorder, which is fairly similar to the 44% of community samples previously reported in past literature (Barkley, 2004; Koziol et al., 1993; Nair, 2006). Statistics of head injuries in this sample indicated that 16% of the participants had suffered a head injury in their past. This particular statistic has been implicated in the ADHD literature as a possible explanation for the etiology of ADHD (Brown et al., 1981; Gerring et al., 1998). A study conducted by Gerring and his colleagues (1998) investigated the prevalence of developing secondary characteristics of ADHD in children who previously did not have premorbid tendencies. Findings indicated a prevalence level of secondary ADHD of 19%. This statistic has comparative similarities to this study sample, and could possibly support further research with Canadian ADHD populations in this area.

The most unique element of the descriptive information was the physical activity information collected. The first hypothesis of this study was that a large proportion of children with ADHD engage in physical activity below recommended national guidelines, and that parents do not use physical activity as a therapy. This hypothesis was partially supported. First, 76% of the participants did not meet Canadian physical activity guidelines. This result is similar to the national Canadian average for children and youth of 84.0% (CFLRI, 2005). Although the benefits of physical activity are well established, literature repeatedly indicates that the majority of populations in developed countries consistently do not meet these guidelines (US Department of Health & Human Services, 1996; Colditz, 1999; Katzmarzyk et al., 2000; CFLRI, 2005). Our results suggest that ADHD populations are no different from this finding. Beyond the possibility of reducing the symptoms of ADHD, physical

activity is also important in the primary and secondary prevention of varied chronic diseases (American College of Sports Medicine 1998a; Blair & Brodney, 1999; Blair et al., 2001; Blair et al., 1989, Bouchard & Shepard, 1994, Lee & Skerrett, 2001, McAuley, 1994, Warburton et al., 2006a, 2006b). Additionally, literature suggests that physical activity decreases depressive and anxiety related symptoms, and can increase health related quality of life, global self-esteem and musculoskeletal fitness and health (Cooper-Patrick et al., 1997; Farmer et al., 1988; Lampinen et al., 2000; Paffenbarger et al., 1994; O'Connor et al., 2000; Blacklock et al., 2007; Brown et al., 2004; Spence et al., 2005; Warburton et al. 2006a; Warburton et al., in press). Literature consistently indicates that depression and anxiety disorders are common co-morbidities of ADHD (Gillberg et al., 2004; Barkley, 2004, Spencer et al. 1997, Koziol et al., 1993). A low quality of life and global self-esteem have also been significantly correlated with having ADHD and literature also indicates poor motor coordination in ADHD child populations (Bastiaansen et al., 2004; Pongwilairat et al., 2005, Lopez-Williams et al., 2005; Harvey & Reid, 2003). As the results from this study indicate that the majority of the sample did not meet recommended physical activity guidelines; these data provide researchers with more insight as to the physical activity behavior practices of ADHD populations specifically, and also provide support for further research and the promotion of physical activity, if only for its secondary benefits beyond the possibility of reducing the symptoms of ADHD.

Second, contrary to the hypothesis that the majority of parents would not be using physical activity as a therapy for their child's symptoms, results indicate that 48% of parents reported that they did; however, further analyses into this group of parents found that only 27% of their children met recommended Canadian physical activity guidelines. This result suggests that the majority of parents who use physical activity as a form of therapy are not using physical activity in recommended doses. There may be considerable room for change both in physical activity practices in general and also for

using physical activity as a therapy in this specific group, possibly suggesting further implications for physical activity and ADHD research.

### *Physical Activity and ADHD Symptoms*

The second hypothesis of this study was that physical activity will demonstrate a negative relationship with ADHD symptoms, and the symptom physical activity will reduce most will be hyperactivity. This hypothesis was analyzed by means of bivariate associations between the different physical activity variables and the four Connors' subscales, and it was not supported. Surprisingly, null effects were found between physical activity and most of the Connors' subscales, except for hyperactivity. However, contrary to the hypothesis, results demonstrated a positive association between hyperactivity and strenuous physical activity ( $r = 0.23$ ). Previous literature has suggested that physical activity is an intervention that has received limited attention, but has shown potential for reducing disruptive behaviors, improving visual and auditory attention span, and reducing impulsive and defiant behaviors (Barkley, 2004; Basile et al., 1995; Allison et al., 1995; Bass, 1985). Furthermore, previous evidence suggests that physical activity most strongly affects hyperactive subjects by significantly reducing their hyperactive behavior (Allison et al., 1995; Etscheidt & Ayllon, 1987; Tuckman & Hinkle, 1986). Clearly, the results did not support past literature.

There are several possible explanations for these findings. The majority of the past literature did not focus specifically on ADHD diagnosed populations. Instead, participants were a mix of children with various disorders, as well as various physical and psychological disabilities (Allison et al., 1995). Children who are diagnosed with ADHD may react differently compared to other children with different disabilities when given the same treatment. Additionally, the age range of participants included in past literature varied extensively from six to thirty-five years. Literature suggests that symptoms of ADHD differ from childhood to adulthood (Hallowell et al., 1994). It may be that an

intervention that is effective in one particular age range may not necessarily be effective in another. Furthermore, many of the studies investigating the relationship between physical activity and disruptive behaviors, including ADHD, lacked adequately powered samples. The majority of the studies that found significant associations involved clinical trials and case studies with participant samples ranging from one to six participants (Allison et al., 1995). Clearly, such small sample sizes lack generalizability.

Although it was hypothesized that hyperactivity would be the ADHD symptom most reduced by physical activity, results demonstrated a significant positive association between physical activity and the ADHD symptom of hyperactivity. Specifically, our findings suggest that the more hyperactive a child with ADHD might be the more physical activity they engage in, or, the more physical activity a child with ADHD engages in the more hyperactive they will be. Since previous literature indicates there is preliminary evidence to suggest that physical activity reduces hyperactivity, the former relationship is more logical. The positive association between hyperactivity and physical activity may suggest that these specific children are simply using physical activity as an outlet for their hyperactivity. Many parents remarked in the mail back survey that no matter how much physical activity their child engaged in during the day, their child still had endless amounts of energy. Extensions of this study might include focus groups with parents, so as to gain more insight about their child's specific symptoms, as well as their activity levels and behaviors. Moreover, collaboration with teachers would bring an additional subjective measurement about children's behaviors outside of the home environment and may possibly increase the validity of future studies.

*Exploratory Objectives*

Additional objectives of this study were to determine what particular intensity and duration of physical activity has been successful, if any, and to determine any other moderators that may influence the relationship between physical activity and ADHD symptoms. It was hypothesized that strenuous intensities of physical activity, rather than mild, would produce greater reductions in the symptoms of ADHD, and that gender may moderate the relationship between physical activity and the symptoms of ADHD. Results partially supported these hypotheses. Bivariate correlations demonstrated that total strenuous PA was the only physical activity variable that significantly correlated with any of the Connors' subscales. However, this correlation was found to be positive, rather than negative. Of the three significant relationships found from the multiple regression analyses, the PA Guidelines variable was included in all three. Although the results did not specifically indicate that more strenuous intensities of physical activity reduced symptoms of ADHD, the results did indicate that PA Guidelines is a significant variable that warrants further investigation. The criterion of the PA Guidelines variable was that children engage in a minimum of 60 minutes of moderate to strenuous physical activity each day. Whether children meet or do not meet this guideline seems to play an important role in this particular area of research.

Potential moderators of the relationship between physical activity and the symptoms of ADHD were analyzed by multiple regressions. Specific variables included were strenuous and PA Guidelines physical activity variables, and the four different symptom subscales of the Connors' scale for ADHD. The three significant moderators identified were parental therapeutic physical activity practices, gender, and parental opinion about the utility of PA. Results indicate that these three physical activity and ADHD symptom interactions account for a significant 4%, 9% and 6%, of the variance, respectively. Literature indicates that interaction terms are extremely difficult to detect in non-experimental designs (Champoux & Peters, 1987; Chaplin, 1991). Thus, an interaction term that

contributes between 1 – 3% to the total variance is considered important (Evans, 1985) as it is quite uncommon for non-experimental studies to yield moderator effects greater than this (Champoux & Peters, 1987; Chaplin, 1991). Since the analyses resulted in interactions bigger than 1 – 3%, these interactions may be quite meaningful.

Specifically, results demonstrated that parental therapeutic physical activity practices significantly moderated the relationship between PA Guidelines and oppositional behavior. Follow-up slope analysis indicated that parents who do not currently use physical activity as a therapy demonstrate a significant negative relationship between PA Guidelines and oppositional behavior. Thus, when physical activity is not used as a therapy, the less physical activity a child with ADHD engages in, the stronger their oppositional behavior will be. This finding has several interesting implications. First, the results partially support the notion that physical activity may benefit the symptoms of ADHD (Barkley, 2004). Given that a significant association was found in only one of the Connors' subscales, the results can not be applied to ADHD symptoms as a whole. However, these findings do provide encouraging evidence suggesting that physical activity interventions may benefit specific domains of ADHD symptoms, particularly that of oppositional behavior.

Second, demographics indicate that 52% of the sample does not use physical activity as a therapy. Since it was this specific group that demonstrated a significant negative relationship between PA Guidelines and oppositional behavior, future research using experimental designs focusing exclusively on an ADHD population that does not use physical activity as a therapy may be warranted. Interestingly, the descriptive data indicates that 76% of our sample did not meet Canadian physical activity guidelines (CFLRI, 2006; Public Agency of Canada, 2002). As stated previously, the data indicates that although 48% of parents reported that they use physical activity as a form of therapy, only 27% of their children met Canadian physical activity guidelines.

Third, although the results demonstrated null effects with the group who use physical activity as therapy, further investigation with this group controlling for appropriate doses of recommended physical activity may produce more meaningful results. In addition, this particular group in our sample may have possibly biased the results of Hypothesis 2 and caution should therefore be noted when interpreting the results of the bivariate correlations. Had our sample incorporated a larger percentage of parents who do not use physical activity as a therapy, the bivariate correlations from Hypothesis 2 may have indicated more significant associations between physical activity and ADHD symptoms.

Results also indicate that gender significantly moderated a negative relationship between PA Guidelines and the Connors' cognitive/inattention subscale, thus supporting the hypothesis. Specifically, follow-up slope analysis demonstrated that when girls with ADHD engage in less physical activity, their symptoms of cognitive/inattention problems are more pronounced. This particular finding is logical and agrees with ADHD literature as females with ADHD generally demonstrate predominantly inattentive behaviors (Nair, 2006; Spencer et al., 2007). These results lend support for future physical activity interventions specifically aimed at females and also demonstrate that boys and girls with ADHD may be affected differently by the same treatment modalities. Thus, future research should therefore consider separating groups by gender.

The final significant relationship from the multiple regression analyses indicated that parental opinion about the utility of PA positively moderated the relationship between PA Guidelines and the Connors' subscale of hyperactivity. This suggests that children with ADHD who engage in more physical activity and also have parents who strongly feel physical activity influences their child's ADHD symptoms, will have higher levels of hyperactivity. Although these parents indicated they strongly believe physical activity is successful in decreasing their child's ADHD symptoms, this relationship indicates the contrary. This result is, however, similar to the positive relationship found between strenuous PA and hyperactivity from the bivariate correlations and may lend support to the

previous argument that children with ADHD who are predominantly hyperactive may use physical activity as an outlet for their symptoms. A possible explanation may be that the alleviating effects of physical activity on hyperactivity may be short lasting, causing children with ADHD that are predominantly hyperactive to constantly need to participate in physical activity. Future research to further investigate this relationship is warranted.

Given that the moderator analysis resulted in significant associations between physical activity and ADHD symptoms, the results of this study lend some support to the suggested mechanism of how physical activity may affect ADHD. There are some results that are puzzling, however, and future replication of these findings and further research is suggested.

In addition, the participant sample was too small in order to investigate the possible differences between groups who are taking or not taking medication, as well as country differences. Further research with larger participant samples investigating these differences is also suggested.

### *Study Limitations*

Despite the novelty of this study and its addition to the limited literature, the results should be considered in the context of a few limitations. First, sampling in our study was not random. True random sampling is virtually impossible in this particular area of research as the delimitations of the study are quite specific. The purpose of random sampling is to obtain findings that represent and can be inferred back to the larger population (Thomas & Nelson, 2001). Research with ADHD populations presents many challenges as no national registries or specific statistical information currently exists. Despite these challenges, however, the descriptive information collected still suggests that the sample of this study was relatively representative of typical child ADHD population statistics, as well as similar physical activity practices of general child populations in Canada. Improved information and

access to these populations should be encouraged in order to gain more information about ADHD and ultimately benefit those children affected.

Second, the data were based on proxy measurement. Although, past literature has recommended that self-report data for children younger than ten years of age should not be collected due to insignificant validation coefficients (Kohl et al., 2000), proxy measures for children present its own limitations. Currently, there is limited information for proxy measures of physical activity and a valid and reliable proxy measure for children has yet to be developed (Sirard & Pate, 2001). Due to these limitations, a self-report physical activity measure that is well validated in the physical activity domain (Godin & Shepard, 1985; CFLRI, 2006) was chosen as a proxy measure. Limitations of self-report measures include problems with selection bias and unreliable memory recall (Thomas & Nelson, 2001; CFLRI, 2006). In addition, self-report, as well as proxy measures tend to overestimate physical activity. Results, however, indicate that 76% of our sample did not meet recommended physical activity guidelines. This result may suggest that either our sample is more in-active than what was reported, or parents of children with ADHD are so practiced in filling out questionnaires about their children, for medical and psychological purposes, that they tend to be more honest about their child's activities than the general population. Objective monitoring of physical activity, such as accelerometry, would be most desirable and may yield different results. Additionally, examples of activities in the GLTEQ focus largely on structured physical activities and potentially do not measure more unstructured physical activities, such as free play. Nevertheless, literature reports that children with ADHD respond more positively to structured activities (Alessandri & Schramm, 1991), which may suggest that the structured nature of the GLTEQ is not a significant limitation.

Third, the p level for entry for all analyses was set at 0.05. Given that the analyses involved a series of multiple regressions and correlations, there is a possibility of type one family-wise error. Given that this study is the first of its kind in the literature, as well as having many exploratory

objectives a p level of 0.05 was deemed more appropriate, rather than a more conservative p level via Bonferroni correction. Nonetheless, replication to ensure reliability and validity of these data is warranted.

Fourth, this study was correlational in design. Since causation can only be established by experimental designs, the design restricts the degree of interpretation of relationships between variables. However, correlational studies do offer foundation for causation. Results from this study suggest that there is preliminary evidence that physical activity may influence specific elements of ADHD, indicating that further investigation using experimental studies and more objective instruments may be warranted.

In summary, this is the first study in the ADHD literature to investigate the relationship between physical activity and the symptoms of ADHD in a North American sample of diagnosed ADHD children. The findings suggest that the relationship between physical activity and the symptoms of ADHD is more complicated than originally assumed. Results indicate that 76% of the sample did not meet national recommended physical activity guidelines and 52% of the sample does not use physical activity as a therapy. A basic negative relationship between physical activity and ADHD symptoms generally, was not found; however, three moderating variables of the relationship between physical activity and symptoms of ADHD, including therapeutic physical activity practices, gender, and parental opinion about the utility of physical activity, were identified. Strenuous physical activity and whether children met or did not meet PA guidelines were found to be significant variables in this study. The findings lend support for further investigation into all three moderating variables identified by means of experimental and qualitative designs. Future studies investigating intensity and duration of physical activity, as well as specifically focusing on ADHD groups who do not meet physical activity guidelines are warranted. Additionally, promotion of physical activity in this specific population may be important in positively affecting secondary problems associated with ADHD.

Given that all subscales of the Connors' scale were not significantly identified, our results support the notion that ADHD symptom domains appear to be relatively distinct. Future research should therefore consider separating the measurement of ADHD symptoms by their respective behaviors. In addition, differences between genders appear to be significant, and further investigation separating samples by gender is warranted.

### *Conclusions*

Results indicate that 76% of the sample did not meet national recommended physical activity guidelines, and 52% of the sample does not use physical activity as a therapy. A negative relationship between physical activity and ADHD symptoms, generally, was not found; however, three significant moderating variables including parental use of therapeutic physical activity practices, gender, and parental opinion about the utility of physical activity were identified. The findings support the suggestion that physical activity may provide some benefit to the specific subscales of the symptoms of ADHD. Future research should include further investigation into physical activity practices of child ADHD populations, specifically focusing on ADHD groups that do not use physical activity as a therapy and further investigation into the three significant moderating variables is warranted. In addition, future studies focusing on strenuous and national recommended doses of physical activity, distinctively separating the symptoms of ADHD, as well as gender is recommended.

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**APPENDICES**

**Appendix A:** Project Information letter and Consent Form – Learning Disabilities Association  
South Vancouver Island Chapter

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### Physical Activity and ADHD Survey

You are being invited to participate in a study entitled "Exploring the Relationship between Physical Activity and the Symptoms of ADHD in Children" that is being conducted by Nicole Smith and the Learning Disabilities Association (LDA) South Vancouver Island Chapter. Nicole Smith is a graduate student at the University of Victoria in the School of Physical Education, and is required to conduct research as part of the requirements for a master's degree in the area of Behavioral Medicine. This research is being conducted under the supervision of Dr. Ryan Rhodes. You may contact Nicole Smith at 472-5488 or email at [nikks@uvic.ca](mailto:nikks@uvic.ca) or contact Dr. Ryan Rhodes at 721-8384 or email at [rhodes@uvic.ca](mailto:rhodes@uvic.ca), if you have further questions.

The purpose of this research project is to evaluate whether the use of physical activity decreases the symptoms of ADHD in children.

As you may be aware, Attention-Deficit Hyperactivity Disorder (ADHD) is one of the most frequently diagnosed psychiatric disorders of childhood. Little research exists on the effect of exercise on the behavioral symptoms of ADHD in children. It is hoped the knowledge that you provide will be useful to educators, health care practitioners, administrators and policy makers who wish to learn more about the effects of physical activity on the behavioral symptoms of ADHD. There is also potential to make a significant contribution in the areas of child mental health, ADHD health promotion, school classroom management and ADHD intervention.

If you agree to voluntarily participate in this research, your participation will include one 10 - 15 minute session completing the attached survey. Participation in this study may cause some inconvenience to you, including asking you to think about your child's previous exercise experiences. However, there are no known or anticipated risks to you by participating in this research. The LDA South Vancouver Island Chapter has agreed to deliver the survey and participate in this research project. All members of the LDA have been sent this survey by the LDA because we want the opinions and beliefs of as many LDA members as possible. Only the LDA administration and its departments are permitted to access LDA member contact information. Therefore, your name and contact information has not and will not be released to anyone other than the LDA. You will not be required to put your name on the survey. The survey will be strictly anonymous as no names will be mentioned and all results will be interpreted and displayed as group data only. You may choose not to answer any questions on the survey that you may find invasive, or offensive. Once the completed surveys are returned to the researcher (Nicole Smith), all data will be kept in a locked cabinet in the Behavioral Medicine Research Laboratory at the University of Victoria. The researcher will not know which questionnaire is yours because we do not ask for your name and, as a result, any information that we gather from you cannot be withdrawn from the study once you return the survey. Every completed survey returned will result in a five dollar donation to the LDA South Vancouver Island Chapter to aid in furthering education and support for children and youth with Learning Disabilities and Attention Deficit Disorders AD/HD and their families.

Upon consultation with the LDA Director and executive committee, it is anticipated that the results of this study will be shared in the following ways:

- A visual presentation, a research report and written recommendations to the LDA Director and Executive Committee, as well as members at large
- As a report to the BC Ministry of Health, as well as other BC ADHD societies
- As a part of the researcher's Master's Thesis
- As a report to be presented at scholarly conferences
- As a published article in a professional peer reviewed journal

In addition to being able to contact the researcher at the above numbers, you may verify the ethical approval of this study or raise any concerns you might have, by contacting the Associate Vice-President, Research at the University of Victoria (250-472-4362).

By returning the enclosed survey, you have indicated that you have read the above information and agree to participate in this research.

**If you agree to participate, please mail your completed survey in the return stamped envelope provided and keep this consent form for your records**

**Appendix B: Project Information Letter and Consent Form – Internet Forums**

## **Physical Activity and ADHD Survey**

You are being invited to participate in a study entitled "Exploring the Relationship between Physical Activity and the Symptoms of ADHD in Children" that is being conducted by Nicole Smith and the Learning Disabilities Association (LDA) – South Vancouver Island Chapter. Nicole Smith is a graduate student at the University of Victoria in the School of Physical Education, and is required to conduct research as part of the requirements for a master's degree in the area of Behavioral Medicine. This research is being conducted under the supervision of Dr. Ryan Rhodes. You may contact Nicole Smith at 472-5488 or email at [nikks@uvic.ca](mailto:nikks@uvic.ca) or contact Dr. Ryan Rhodes at 721-8384 or email at [rhodes@uvic.ca](mailto:rhodes@uvic.ca), if you have further questions.

The purpose of this research project is to evaluate whether the use of physical activity decreases the behavioral symptoms of Attention-Deficit Hyperactivity Disorder (ADHD) in children. If you are a parent of a child, who is between the ages of 7 – 12 years old, and currently has ADHD, we are interested in your participation within this study.

As you may be aware, ADHD is one of the most frequently diagnosed psychiatric disorders of childhood. Little research exists on the effect of exercise on the behavioral symptoms of ADHD in children. It is hoped the knowledge that you provide will be useful to educators, health care practitioners, administrators and policy makers who wish to learn more about the effects of physical activity on the behavioral symptoms of ADHD. There is also potential to make a significant contribution in the areas of child mental health, ADHD health promotion, school classroom management and ADHD intervention.

### **What do I Have to do to Participate?**

It is actually quite simple. If you agree to voluntarily participate in this research, your participation will include one 10 - 15 minute session completing the attached survey. You may refuse to answer any questions in the survey. If you fill out the survey and return it to us, you have consented to participate. We have provided instructions on the front of the survey. There are no further surveys or contact associated with this study.

### **Inconvenience, Risks & Benefits**

**Participation in this study may cause some inconvenience to you, including asking you to think about your child's previous exercise experiences. However, there are no known or anticipated risks to you by participating in this research. The potential benefits by participating in this research include providing you with information concerning your child's health and disruptive behaviors. This study will also provide preliminary information on which to build future physical activity intervention programs catered to children with ADHD.**

### **Anonymity and Confidentiality**

You will not be required to put your name on the survey. The survey will be strictly anonymous as no names will be mentioned and all results will be interpreted and displayed as group data only. Once the completed surveys are returned to the researcher (Nicole Smith), all data will be kept in a locked cabinet in the Behavioral Medicine

Research Laboratory at the University of Victoria. The researcher will not know which survey is yours because we do not ask for your name and, as a result, any information that we gather from you cannot be withdrawn from the study once you return the survey.

A Token of Appreciation:

**The Learning Disabilities Association - South Vancouver Island Chapter (LDA – SVIC) has agreed to participate in this research project. As a token of appreciation for your time, we will provide a donation of five dollars for every returned and completed survey to the LDA - SVIC in Victoria, BC. The LDA - SVIC is a not for profit organization that educates, supports and advocates for children and youth with Learning Disabilities and or Attention Deficit Disorders and their families. This organization does not currently receive government funding for operations and there is a continual demand and outreach for community support. This association raises, invests and stewards funds to provide support of the physical, mental and social well-being of children, youth and families primarily on Vancouver Island and British Columbia.**

Sharing of the Results

Upon consultation with the LDA-SVIC Director and executive committee, it is anticipated that the results of this study will be shared in the following ways:

- As a visual presentation, a research report and written recommendations to the LDA - SVIC Director and Executive Committee, as well as members at large
- As a report to the BC Ministry of Health, as well as other BC ADHD societies
- As a part of the researcher's Master's Thesis
- As a report to be presented at scholarly conferences
- As a published article in a professional peer reviewed journal

Do I have to participate?

No, your participation is completely voluntary. However, it is only through voluntary participation in research projects that we increase our knowledge about issues that are important to health. We hope you can spare the 15 minutes to help the research community out!

In addition to being able to contact the researcher at the above numbers, you may verify the ethical approval of this study or raise any concerns you might have, by contacting the Associate Vice-President, Research at the University of Victoria (250-472-4545).

By returning the enclosed survey, you have indicated that you have read the above information and agree to participate in this research.

Sincerely,

Nicole E. I. Smith, B.Sc.  
Graduate Student & MSFHR Scholar  
Behavioral Medicine Laboratory  
School of Physical Education  
University of Victoria  
(250) 472-5488, [nikks@uvic.ca](mailto:nikks@uvic.ca)

Dr. Ryan Rhodes  
Associate Professor & MSFHR Scholar  
Behavioral Medicine Laboratory  
School of Physical Education  
University of Victoria  
(250) 721-8384, rhodes@uvic.ca

**If you agree to participate, please complete the online survey and print this consent form for your records**

This research is being funded by the Michael Smith Foundation for Health Research



Michael Smith Foundation for  
**Health Research**

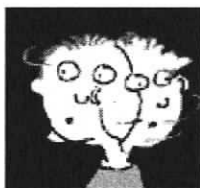
**Appendix C: Physical Activity and ADHD Questionnaire – Mail out version**



## “Exploring the Relationship between Physical Activity and the Symptoms of Attention Deficit Hyperactivity Disorder in Children”

Nicole Smith  
University of Victoria  
(250) 858-4346

Learning Disabilities Association  
South Vancouver Island Chapter



In this survey, you will be asked a series of questions about your child's ADHD symptoms and their physical activity and sedentary behaviors. There are no right and wrong answers and all we ask is that you provide responses that are as honest and accurate as possible. The survey should take about 10-15 minutes of your time. It is important to answer all questions so that we can include your responses in our analyses. If you have any questions, please feel free to forward them to Nicole Smith, primary researcher.

**PART 1: Medical History of your Child**

The following questions ask you about the medical history of your child. This information is necessary in gathering appropriate statistics about ADHD children. All information is held in strict confidence and its presentation to the public will be in the form of group data only. Please put checkmarks in the appropriate boxes, and write your answers on the line space provided.

A. Gender:  M  F D.O.B.: \_\_\_\_\_ Age: \_\_\_\_\_  
 Height: \_\_\_\_\_ Weight: \_\_\_\_\_

B. Does your child have a formal diagnosis of ADHD?

No  Yes

My child was diagnosed by:

Physician  Pediatrician  
 Psychiatrist  Psychologist

Other: \_\_\_\_\_

C. Is your child currently taking medication for ADHD or any other condition (including herbal medications?)

Yes

Name of medication	Dose (mg)	Frequency (times per day)

No

Has your child ever received medication for ADHD?

No  Yes: If so, for how long (months, years) ? \_\_\_\_\_

D. Are there any medical problems, other than ADHD, currently affecting your child? If yes, please explain.

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E. Has your child received or been involved in any of the following?

Grade / Age

- Learning Disabilities/Special Education Classes
- Behavioral Adjustment Class
- Tutoring
- Enrichment/Gifted
- Language Immersion
- Other

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F. Has your child ever suffered from any head injuries or other serious complications?

No     Yes

If yes, please explain:

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## PART 2: Conner's Abbreviated ADHD Symptom Parent Rating Scale

Below are a number of common problems that children have in school. Please rate each item according to how much of a problem it has been for your child in the **last 7 days** (one week). For each item, ask yourself, "How much of a problem has this been in the **last week?**", and circle the best answer for each one. If none, not at all, seldom, or very infrequently, you would circle 0. If very much true, or it occurs very often or frequently, you would circle 3. You would circle 1 or 2 for ratings in between. Please respond to each item.

	NOT TRUE AT ALL (Never, Seldom)	JUST A LITTLE TRUE (Occasionally)	PRETTY MUCH TRUE (Often, Quite a bit)	VERY MUCH TRUE (Very Often, Very Frequent)
1. Inattentive, easily distracted.....	0	1	2	3
2. Angry and resentful.....	0	1	2	3
3. Difficulty doing or completing homework.....	0	1	2	3
4. Is always "on the go" or acts as if driven by a motor.....	0	1	2	3
5. Short attention span.....	0	1	2	3
6. Argues with adults.....	0	1	2	3
7. Fidgets with hands or feet or squirms in seat.....	0	1	2	3
8. Fails to complete assignments.....	0	1	2	3
9. Hard to control in malls or while grocery shopping.....	0	1	2	3
10. Messy or disorganized at home or school.....	0	1	2	3
11. Loses temper.....	0	1	2	3
12. Needs close supervision to get through assignments.....	0	1	2	3
13. Only attends if it is something he/she is interested in.....	0	1	2	3
14. Runs about or climbs excessively in situations where it is inappropriate.....	0	1	2	3
15. Irritable.....	0	1	2	3

16. Avoids, expresses reluctance about, or has difficulties engaging in tasks that require sustained mental effort (such as schoolwork)	0	1	2	3
17. Restless in the "squirmy" sense.....	0	1	2	3
18. Gets distracted when given instructions to do something.....	0	1	2	3
19. Actively defies or refuses to comply with adults' requests.....	0	1	2	3
20. Has trouble concentrating in class.....	0	1	2	3
21. Distractibility or attention span a problem.....	0	1	2	3
22. Has difficulty waiting in lines or awaiting turn in games or group Situations.....	0	1	2	3
23. Leaves seat in classroom or in other situations in which Remaining seated is expected.....	0	1	2	3
24. Deliberately does things that annoy people.....	0	1	2	3
25. Does not follow through on instructions and fails to finish schoolwork, chores or duties in the workplace (not due to oppositional behavior or failure to understand directions).....	0	1	2	3
26. Has difficulty playing or engaging in leisure activities quietly..	0	1	2	3
27. Easily frustrated in efforts.....	0	1	2	3

### PART 3: Leisure Time Physical Activity

The questions in PART 3 and 4 of this survey ask you about your child's physical activity behaviors. Here, we define physical activity as all leisure and non-leisure body movement produced by our muscles resulting in energy loss. Physical activity is defined as any activity performed any time during the week, for any duration of time at a moderate intensity (i.e. not exhausting, light sweating). Some examples of moderate physical activities are brisk walking, biking, swimming, and dancing.

We would like to ask you about your child's average weekly physical activity. ***In the last 7 days*** (a week), how many times on average does your child do the following kinds of exercise for **more than 15 minutes** during their free time, and what was the duration of these activities (write on each line the appropriate number)?

When answering these questions please:

- Only count physical activity that was done during free time
- Note that the main difference between the three categories is the intensity of the physical activity
- Please write the average frequency on the first line and the average duration on the second line

**a) STRENUOUS EXERCISE  
(HEART BEATS RAPIDLY)**

(e.g., running, jogging, hockey, football, soccer, squash, basketball, cross country skiing, judo, roller skating, vigorous swimming, vigorous long distance bicycling)

**Times Per  
Week**

**Average Duration  
Per Session**

\_\_\_\_\_

\_\_\_\_\_

**b) MODERATE EXERCISE  
(NOT EXHAUSTING)**

(e.g., fast walking, baseball, tennis, easy bicycling, volleyball, badminton, easy swimming, alpine skiing, popular and folk dancing)

\_\_\_\_\_

\_\_\_\_\_

**c) MILD EXERCISE  
(MINIMAL EFFORT)**

(e.g., household chores, yoga, bowling, golf, easy walking)

\_\_\_\_\_

\_\_\_\_\_

### PART 4: Physical Activity Practices

The following questions will ask you about the physical activity and sedentary practices of your child, as well as your beliefs about using physical activity as a form of treatment for your child's ADHD symptoms. Please answer as honestly and openly as possible.

1. Does your child participate in any structured physical activities (e.g. soccer, baseball, rugby, etc.)?  
(Please check either yes or no)

Yes       No

If yes, what particular physical activity does your child participate in, how many times per week and for what duration? (Please write ALL physical activities down, if more than one)

Type of activity: _____	Type of activity: _____
Times per Week: _____	Times per Week: _____
Duration (mins/hours): _____	Duration (mins/hours): _____
Type of activity: _____	Type of activity: _____
Times per Week: _____	Times per Week: _____
Duration (mins/hours): _____	Duration (mins/hours): _____

2. Do you use physical activity as a form of therapy for your child's ADHD symptoms? (Please check either yes or no)

Yes       No

If yes, do you find it successful? (please circle only one)

1  
Not at all

2  
Slightly

3  
Neutral

4  
Quite a bit

5  
Extremely

3. Do you notice a decrease in your child's ADHD symptoms on days when your child participates in physical education classes in school? (Please circle only one)

1 Not at all                      2 Slightly                      3 Neutral                      4 Quite a bit                      5 Extremely

4. Do you notice a decrease in your child's ADHD symptoms on days when your child is physically active? (Please circle only one)

1 Not at all                      2 Slightly                      3 Neutral                      4 Quite a bit                      5 Extremely

5. Do you notice an increase in your child's ADHD symptoms on days when your child is in-active? (Please circle only one)

1 Not at all                      2 Slightly                      3 Neutral                      4 Quite a bit                      5 Extremely

6. What types of sedentary activities does your child spend most of their time engaging in? (Please check all that apply, and fill in number of times per week and average duration for each checked box)

	Times Per Week	Average Duration Per Session
<input type="checkbox"/> Watching Television/Movies	_____	_____
<input type="checkbox"/> Playing video games	_____	_____
<input type="checkbox"/> On the computer	_____	_____
<input type="checkbox"/> Doing homework	_____	_____
<input type="checkbox"/> Reading	_____	_____
<input type="checkbox"/> Listening to music/ Talking on the telephone	_____	_____
<input type="checkbox"/> Other (Please fill in) _____	_____	_____

7. If physical activity was scientifically proven to decrease symptoms of ADHD, would you be more inclined to use physical activity as a form of therapy? (Please check only one)

Yes

Maybe

Undecided

No

8. Other than medication, have you used any other forms of therapy to help control ADHD symptoms of your child? (Please check only one)

Yes

No

If yes, please list these forms of therapy:

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**PART 5: Demographics**

This part of the questionnaire is needed to help us understand the characteristics of the individuals participating in this study. Thus, this information is vital to us. All information is held in strict confidence and its presentation to the public will be in the form of group data only.

**A. Ethnicity / Race**

- Caucasian
- African American
- Hispanic, Latino
- North American Indian
- Asian, Pacific Islander
- Multi-racial
- Other

**B. What is the highest level of education that you completed? (Please check only one)**

- 8<sup>th</sup> grade or less
- Some high school
- High school diploma
- Vocational school or some college
- College/University
- Professional or graduate degree

**C. What is your current marital status? (Please check only one)**

- Never Married
- Married/common law
- Separated/divorced/widowed

D. What is your current job situation? (Please check one that fits you best)

- Homemaker
- Retired
- Paid full-time employment/self-employed
- Paid part-time employment/self-employed
- Temporarily unemployed

E. What is your annual family income? (Please check only one)

- \$10,000 or less
- \$10,001 to \$20,000
- \$20,001 to \$40,000
- \$40,001 to \$75,000
- \$75,001 to \$100,000
- More than \$100,000

F. What is your postal code? (Please fill in the blank)

\_\_\_\_\_

THIS IS THE END OF THE QUESTIONNAIRE

Thank you for taking the time to complete this questionnaire! Your help is greatly appreciated!

Once you have completed the questionnaire, please place it in the return envelope provided and place it in the mail

!!!THANK YOU!!!