Dimensions of Physical Activity as Related to Child Attention-Deficit/Hyperactivity Disorder Symptoms and Impairment

by

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Abstract

Empirically-supported treatments for attention-deficit/hyperactivity disorder (ADHD) are medication and behaviour management, but there is widespread consensus for a need for more treatment options. Increasing support suggests that physical activity (PA) may be an adjunct/alternative to existing treatment; however, little is known regarding how to best utilize PA to lower ADHD core symptoms and impairment. Important PA dimensions include intensity, frequency, and duration of the activity. Understanding how these PA dimensions relate to ADHD core symptoms and impairment may be the first step towards the goal of developing effective clinical guidelines regarding PA.

This study examined the associations between PA dimensions with children's ADHD symptoms and impairments. Stepwise regression analysis indicated that PA intensity and duration in combination explained some of the variance in ADHD core symptoms, above and beyond what ADHD impairment explained. The positive association between PA intensity and duration, and ADHD core symptoms suggests that the more ADHD core symptoms the child shows, the greater the services the child may need. Additional exploratory analysis showed that the more parents engage PA within their child's routine, the more their child engages in intense and longer durations of PA.

This study shows the link between dimensions of PA and ADHD core symptoms, and explores the importance of children's access to PA, especially for those with more severe symptoms of ADHD. It also highlights the role parents may play in their child's engagement in PA. PA may have the potential to be an evidence-based treatment option for children with ADHD, but this study underscores the need for more work in this area.

Preface

This thesis is an original work by Katrina Aranas. The research project, of which this thesis is a part, received ethics approval from the University of Alberta Research Ethics Board, No. Pro00090010 on June 26, 2019. The ethics on this project, named *Characteristics of physical activity as related to Attention-Deficit/Hyperactivity Disorder symptoms and impairment*, is open until June 25, 2020.

Dedication

To my nephew

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While attention-deficit/hyperactivity disorder (ADHD) is the most common neurodevelopmental disorder in children (Gordon Millichap, 2011), not a single form of treatment is universally and completely effective for treating ADHD (Smith & Shapiro, 2015). ADHD is a chronic disorder characterized by developmentally inappropriate levels of inattention, hyperactive, and/or impulsivity that involves profound effects at home, in school, and with peers (American Psychological Association [APA], 2013). Current treatment options for ADHD are stimulant medications and behaviour management therapy as suggested by the American Academy of Pediatrics (Subcommittee on Attention-Deficit/Hyperactivity et al., 2011), but there is widespread consensus of a need of additional treatment options (Chronis et al., 2006; Jiang & Johnston 2010; MTA Cooperative Group, 1999; Pelham & Fabiano, 2008; Smith & Shapiro, 2015; Vysniauske et al., 2016).

Physical activity or PA has been recently researched as a potential alternative or adjunct form of treatment for ADHD, as it has been associated with improvements in attention (Ahmed & Mohamed, 2011; Cerrillo-Urbina et al., 2015; Choi et al., 2015; Jensen & Kenny, 2004; Kang et al., 2011; Mckune et al., 2003; Medina et al., 2010; Pontifex et al., 2013; Reza & Hamid, 2011; Rommel et al., 2015; Suarez-Manzano et al., 2018; Verret et al., 2012), hyperactivity (Cerrillo-Urbina et al., 2015; Jensen & Kenny, 2004; Reza & Hamid, 2011; Pliszka, 2005; Rommel et al., 2015), and impulsivity (Cerrillo-Urbina et al., 2015; Jensen & Kenny, 2004; Kang et al., 2011; Medina et al., 2010; Pontifex et al., 2013; Rommel et al., 2015; Verret et al., 2012), amongst other things (see also Smith & Patterson, 2012). Yet, little is known how PA relates to ADHD core symptoms (Cornelius et al., 2017; Cerrillo-Urbina et al., 2015; Halperin et

al., 2014; Reeves & Bailey, 2016; Rommel et al., 2015; Suarez-Manzano, et al., 2018; Verret et al., 2012). Understanding how the dimensions of PA relate to reduced ADHD core symptoms can inform practitioners how to effectively recommend guidelines for PA. The purpose of this quantitative study is to examine how intensity, frequency, and duration of PA influence children diagnosed with ADHD. PA is defined as any bodily movement produced by skeletal muscles that uses energy expenditure (Dishman et al., 2006; Rommel et al., 2015). ADHD core symptoms are defined as inattention, hyperactivity, and impulsivity (APA, 2013). ADHD impairments are identified as consisting of suboptimal functioning in relationship with peers, relationship with siblings, relationship with parents, academic progress, self-esteem, influence on family functioning, and overall diminished performance. The present study involved parents of children ages 6 to 12 diagnosed with ADHD, who provided information regarding their child's PA, ADHD core symptoms, and related impairments through online questionnaires.

Review of the Literature

ADHD

This section presents the worldwide prevalence rate of ADHD, the diagnostic features of ADHD, and the associated functional consequences of having the disorder.

Prevalence Rate

Attention-deficit/hyperactivity disorder is the most common neurodevelopmental disorder in preschool-aged and school-aged children (Goldman et al., 1998; Gordon Millichap, 2011) and the third most common mental health disorder, following depression and anxiety (Polanczyk et al., 2015). There is an ongoing debate about the over-diagnoses and under-diagnoses of ADHD, as fueled by variations in country, time, and diagnostic criteria (Thomas et al., 2015). Prevalence estimates are important because these provide a comparative anchor for

parents and for diagnosing practitioners (Thomas et al., 2015), and these estimates also provide information regarding service planning, resource allocation, and research priorities around the world (Costello et al., 1993).

Thomas and colleagues (2015) conducted a meta-analysis of 175 studies to survey the national prevalence rate of ADHD in children 18 years and younger while taking into consideration time and the different editions of the *Diagnostic and Statistical Manual of Mental Disorders* (DSM), namely the Third Edition (DSM-III), the Revised Third Edition (DSM-III-R), and the Fourth Edition (DSM-IV). An example of a difference among the editions of DSMs is the criterion of pervasiveness. For example, the DSM-III-R indicates the requirement of symptoms to manifest usually but not necessarily in more than one setting, whereas the DSM-IV requires symptoms to appear in at least two or more than two settings. Thomas and colleagues contended that the pooled ADHD prevalence estimate is around 7.2%, with no statistically significant difference attributed to diagnoses based on distinct DSM editions. These authors also maintained that prevalence rates did not statistically increase over time.

In a similar study, Polanczyk and colleagues (2015) conducted a meta-analysis including 41 studies conducted in 27 countries to identify the global prevalence rate of mental disorders in children and adolescents. Here, diagnoses were derived from both the DSM (i.e., DSM-III, DSM-III-R, and DSM-IV) and the *International Statistical Classification of Diseases and Related Health Problems* (i.e., versions 9 and 10) were utilized. These two systems involve different diagnostic criteria for the same disorder which results in different prevalence rates (Anselmi et al., 2010). Based on their study, Polanczyk and colleagues (2015) concluded that the global prevalence rate for ADHD is at 3.4%, affecting 63 million people.

The discrepancies in the prevalence estimates of ADHD appear to be explained by differences in methodological procedures (Polanczyk et al., 2014, Polanczyk et al., 2015), which change from study to study. Nonetheless, a meta-analysis by Polanczyk and colleagues (2007) indicated no significant difference in prevalence rates among North America (6%), South America (12%,), Asia (4%), Europe (5%), or Oceania (5%). Thus, ADHD can be considered a universal condition found in all countries and cultures with rather consistent prevalence estimates (Roberts et al., 2015). Despite the slight discrepancies between studies, ADHD is undeniably the most common neurodevelopmental disorder affecting youth (Cornelius et al., 2017; Goldman et al., 1998; Gordon Millichap, 2011; Polanczyk et al., 2007).

ADHD Symptoms and the Diagnostic and Statistical Manual

The American Psychiatric Association (APA, 2000) placed ADHD under the category *Disorders Usually First Diagnosed in Infancy, Childhood, or Adolescence* in the DSM-IV. The disorder is characterized by having maladaptive and developmentally inappropriate levels of 6 or more symptoms of inattention and/or hyperactivity/impulsivity that persist for 6 months or more. The symptoms must be present before the age of 7 and must be present in two or more settings. There must also be clear evidence that the symptoms are causing impairments in the social, academic, or occupational functioning of the person.

In the DSM-5, ADHD is placed under the category of *Neurodevelopmental Disorders* (APA, 2013). APA (2013) characterizes the disorder as having persistent and developmentally inappropriate levels of 6 or more symptoms of inattention and/or hyperactivity/impulsivity that persist for 6 months or more. These symptoms must be present before the age of 12 and several symptoms must appear in two or more settings. There must be clear evidence that the symptoms are interfering with the quality of normal functioning.

The three types of presentation for ADHD in the DSM-5 are the predominantly inattentive presentation, the predominantly hyperactive-impulsive presentation, and the combined presentation (APA, 2013). The presentation of ADHD to be diagnosed depends on whether criteria is met for inattention, hyperactivity and impulsivity, or both.[1]

There are three notable distinctions between the DSM-IV and DSM-5 in the diagnosis of ADHD in children. First, the DSM-IV specifies symptoms to be present before age 7 whereas the DSM-5 requires the age of onset to be age 12 (APA, 2013). Next, while the DSM-IV required "clear evidence of clinically significant impairment in social, academic, or occupational functioning" (APA, 2000, p.93), the written language has been modified in the DSM-5 to be "clear evidence that the symptoms interfere with, or reduce the quality of, social, academic, or occupational functioning" (APA, 2013, p.60). Finally, in the DSM-5, a comorbid diagnosis with autism spectrum disorder is no longer an exclusionary condition for diagnosing ADHD (APA, 2013).

ADHD Impairment and Functional Consequences

There is an important distinction between symptoms and impairment (Roberts et al., 2015). Although the term "symptom" refers to a behaviour or set of behaviours that relate with one another and are believed to represent a dimension of psychopathology, the term "impairment" reflects the functional consequences or outcomes of the symptoms or symptom classes.

ADHD symptoms can have profound effects on the academic achievement and academic attainment, social interactions with peers, family functioning, and well-being of children (Subcommittee on Attention-Deficit/Hyperactivity et al., 2011). In school, for example,

[1] Due to the anticipated difficulty of recruiting clinical samples, including the small sample size, different subtypes of ADHD were not formally considered or included in this study.

symptoms of hyperactivity/impulsivity may make it difficult for children to sit still in class and symptoms of inattention may make it difficult for children to complete schoolwork successfully (Jones & Rabinovitch, 2014). Consequently, excessive levels of hyperactivity and impulsivity may lead children with ADHD symptoms to be disliked by peers (Whalen & Henker, 1992). Specifically, children with ADHD have been found to have difficulties in organizing and communicating information effectively, responding appropriately to others, and talking excessively (Roizen et al., 1994). Moreover, families of children with ADHD are often characterized by high levels of conflicted parent-child relationships (DuPaul et al., 2001), family stress (Deault, 2010), greater family discord (Wells et al., 2000), and higher rates of divorce (Wymbs et al., 2008) relative to families of children without ADHD. ADHD is also frequently associated with other childhood psychiatric conditions such as oppositional defiant disorder, conduct disorder, specific learning disorders, and mood and anxiety disorders (Biederman & Faraone, 2005; Van der Oord et al., 2008). Comorbid disorders may exacerbate the impairments relative to a standalone ADHD diagnosis. For example, children diagnosed with ADHD comorbid with depression have been found to experience greater social and academic impairments relative to children diagnosed with ADHD alone (Blackman et al., 2005).

The evidence that ADHD symptoms and impairments persist into adulthood suggests that it is a chronic disorder (Pary et al., 2002). Adults with ADHD have been identified as experiencing greater occupational difficulties (Mannuzza et al., 1997), having fewer intimate relationships (Weiss & Murray, 2003), and having poorer health outcomes (Harpin, 2005) in comparison to control participants. Given the important developmental implications associated with ADHD, if left untreated, ADHD places children at risk for significant impairments in a variety of domains over a lifetime (Jones & Rabinovitch, 2014).

Theories of Mechanisms of ADHD

There are two leading theories of the mechanisms underlying ADHD. Each theory involves a separate domain of functioning (Sonuga-Barke et al., 2008); namely, cognitive functioning (Barkley, 1997) and motivational functioning (Sonuga-Barke et al., 2008). This section summarizes the two leading theories of mechanisms in ADHD within these two separate domains of functioning, respectively: Barkley's theory of executive functioning dysregulation and Sonuga-Barke's delay aversion hypothesis.

Executive Functioning Dysregulation

The first theory involves a cognitive function approach to ADHD, as modeled in executive functioning dysregulation. Executive functioning is defined as a set of higher-order cognitive abilities that involves prefrontal cortex activation and other neuroanatomically adjacent brain circuits (Tekin & Cummings, 2002), modulated by catecholamine expressions (Mahone & Denckla, 2017). Barkley (1997) interprets ADHD deficits as a dysfunction in self-control systems, with response inhibition as the main core deficit. He suggests that response inhibition indirectly affects performance in four areas of executive functioning: working memory (e.g., holding events in mind, manipulating or acting on the events), self-regulation of affect-motivation-arousal (e.g., emotional self-control, self-regulation of drive and motivation), internalization of speech (e.g., problem-solving/self-questioning, moral reasoning), and reconstitution (e.g., analysis and synthesis of behaviour, syntax of behaviour).

With response inhibition as the primary deficit, these secondary executive functioning impairments in turn affect motor control (Barkley, 1997). Response inhibition refers to the ability to inhibit inappropriate reflexive response in favour of more appropriate alternative responses (Barkley, 1997). While clinical neuropsychological data provide support for the

association between executive functioning deficits and ADHD, it is not a necessary condition for diagnosing the disorder (Willcutt et al., 2005). For example, numerous children with ADHD do not have clinically observable executive functioning deficits (Sonuga-Barke et al., 2008). Nonetheless, Barkley's model is the most fully articulated cognitive model of the mechanisms underlying ADHD (Sonuga-Barke et al., 2008).

Delay Aversion Hypothesis

The other leading theory, the delay aversion hypothesis (DAv), involves a motivational functioning approach to ADHD (Sonuga-Barke et al., 2008). DAv is defined in terms of an integrated motivational framework that includes choosing immediate small rewards over large delayed rewards when a choice is available (Sonuga-Barke et al., 2008). When no choice is available and waiting is required, DAv is expressed in the form of inattention, hyperactivity, or frustration (Sonuga-Barke et al., 2008). In other words, according to DAv, those with ADHD find waiting to be aversive and therefore act impulsively to terminate the delay as quickly as possible (Johansen et al., 2002). DAv is based on the neurocircuitry of catecholamine-modulated rewards in the brain (Cardinal et al., 2001), with dopamine again as a key neuromodulator (Wightman & Robinson, 2002). The dual pathway circuits involved in DAv are segregated from the executive functioning circuits previously mentioned in discussion of Barkley's theory (Mahone & Denckla, 2017). The first circuit in the DAv is the dorsal-frontostriatal circuitry, which connects the nucleus accumbens to the frontal regions of the brain, particularly the anterior cingulate and orbitofrontal cortex (Sonuga-Barke et al., 2008) and is reflected behaviourally by inhibitory control problems (Mahone & Denckla, 2017). The second reward circuit in the DAv is the ventral frontostriatal circuity, which involves the ventral pallidum and related structures (Sonuga-Barke et al., 2008) and is reflected behaviourally in delay aversion

(Sonuga-Barke, 2003) and reward sensitivity (Luman et al., 2009). A third and recent expansion of the model (i.e., making it a triple pathway model) involves temporal processing deficits and is reflected behaviourally in dysfunctions in timing, time discrimination, reproduction, and motor synchronization (Sonuga-Barke et al., 2010). Although there is evidence associating DAv to ADHD, as in the case of executive functioning dysregulation, DAv has only been associated with a subgroup of ADHD cases (Sonuga-Barke et al., 2008).

Summary

Whereas executive functioning dysregulation and delay aversion models have traditionally been regarded as competing theories, recent accounts suggest they serve complimentary accounts of different pathways underlying ADHD (Sonuga-Barke, 2003). Both theories suggest that dopaminergic and noradrenergic neurotransmitters are implicated in the disorder. Furthermore, recent studies propose that a comprehensive neurocognitive model of ADHD likely involves dysfunction in numerous cognitive processes that are mediated by neural networks located throughout the brain (Willcutt, 2015). However, given the heterogeneity of ADHD at the neuropsychological level and the overlap with other disorders, there is no current individual neuropsychological marker that exists for ADHD at this time (Sonuga-Barke et al., 2008).

Current Evidence-Based Treatments for ADHD

The clinical practice guidelines set forth by the American Academy of Pediatrics states that the current established empirical treatments for alleviating symptoms of ADHD are medication and behaviour modification (Subcommittee on Attention-Deficit/Hyperactivity et al., 2011). For preschool children ages 4 to 5, the first line of treatment is parent- and/or teacher-administered behaviour intervention, followed by pharmacological treatment in the event that

behaviour therapy does not provide substantial improvements. For elementary-school children ages 6 to 11, the guidelines recommend the prescription of pharmacological treatment and/or evidence-based parent- and/or teacher-administered behavior therapy with combined treatment preferred. For adolescents ages 12 to 18, medications for ADHD with the assent of the adolescent and behavior therapy may be prescribed, preferably in combination.

This section provides an examination of the associated risks and benefits of the current evidence-based treatments for ADHD in greater depth starting with medication, followed by behaviour therapy, and finally the combination of both medication and behaviour therapy. This section illustrates the need for alternative or adjunct treatments to current evidence-based approaches for ADHD.

Medication

The most commonly prescribed medications for ADHD are methylphenidate, dex-methylphenidate, dextroamphetamine, and mixed amphetamine salts (Troksa et al., 2018). All of these stimulants act by increasing the synaptic levels of the catecholamines, dopamine and norepinephrine, by binding to catecholamine uptake transport proteins on the presynaptic neuron and blocking reuptake into the cell. This action allows the neurotransmitters to stay longer in the synaptic cleft. Meanwhile, amphetamine derivatives work uniquely by binding to dopamine transport proteins to prevent dopamine reuptake. These bound proteins then get transported into the presynaptic cell in exchange for a cytoplasmic dopamine molecule thus allowing for a substantial release of dopamine into the synapse. The difference in mechanisms between amphetamine and methylphenidate permits both stimulants to be tried when the patient does not show improvements from dosage of an initial stimulant trial (Elia et al., 1991).

Although there is ample literature on how stimulant medications decrease inattention, hyperactivity, impulsivity, and associated disruptive behaviours (Conners, 2002) and increase on-task behaviour, cooperation, predisposition, and self-esteem (Smith & Shapiro, 2015), there are several limitations in using stimulant medications. For example, researchers have found stimulants to have little effect on improving ADHD impairments such as academic achievement and peer relationships skills (Chronis et al., 2006). These researchers also reported that about 30% of children with ADHD do not show clinical improvements from methylphenidate treatment (Chronis et al., 2006). Moreover, even after a second prescription of stimulant medications to children who have not been responding well to the initial medication, up to 20% of the children still do not respond successfully (Greenhill et al., 2002). Stimulants have also been reported to have potential short-term side effects such as insomnia, mild anorexia, appetite suppression, headache, stomach ache, and elevations of heart rate and blood pressure (Smith & Shapiro, 2015); rare side-effects also include mania, psychosis, and increased risk of sudden death (Pliszka, 2007).

There is limited research on the long-term effects of medication in children; however, there are concerns of the growth trajectory of children from long-term use of medication (Faraone et al., 2008). Another limitation is that medications do not last 24 hours a day, allowing for a window of time which leaves the disorder untreated (Smith & Shapiro, 2015). Equally important to note is the issue of accessibility of medications for some families (i.e., cost and availability). Some families opt to limit their use of medications or not use them at all in fear that the medications may be abused (Connor, 2015). At the same time, several researchers have shown that stimulants do not have long-term benefits for children with ADHD (Loe & Feldman,

2007; Swanson et al., 1995). Therefore, alternative or adjunct interventions for enhancing the effects of stimulants while minimizing dosages could be explored.

Behaviour Management

Behaviour modification is another well-established treatment for ADHD, with some behavioural treatments meeting the rigorous requirements for efficacy, effectiveness, and clinical utility (Flay et al., 2005). Pelham and Fabiano (2008) contend that behaviour modification therapy primarily targets functional impairments rather than ADHD core symptoms. For example, behaviour modification therapy focuses on noncompliance and lack of independence, homework problems such as forgotten materials and lack of attention to details, and co-occurring aggression towards parents or siblings (Pfiffner & Haack, 2014). Consequently, dysfunctional parenting is often the target of behavioural interventions as parents of children with ADHD tend to exhibit less positive and warm parenting compared to parents of children without ADHD (Gerdes et al., 2003). Behaviour modification therapy, such as behavioural parent training, directly targets parenting styles to improve child behaviour and family relationships, as well as family conflict (Pfiffner & Haack, 2014). Accordingly, behavioural parent training (also referred to as parent management training, parent training, or behavioural family therapy) is the predominant mode of behaviour modification therapy targeting home-based problems for school-age children with ADHD. Behavioural parent training involves teaching parents the importance of positive attending skills to improve the parent-child relationship and family climate.

In addition, parent training involves the implementation of reinforcements to encourage appropriate child behaviour, the delivery of clear and specific directions to establish consistent expectations, and the effective use of negative consequences for rule violations (Pfiffner & Haack, 2014). Behavioural parent training may also be implemented in combination with school-

based interventions, such as daily report card systems and specific forms of child treatment, such as behavioural peer-interventions and group child skills training. Multiple studies have replicated the benefits of behavioural parent training. For example, in the most comprehensive meta-analysis of 174 studies by Fabiano and colleagues (2009), the effect of behaviour therapy treatment for students with ADHD was found to be empirically effective with an overall weighted effect size of .74 for between-group studies across study methods and designs for this population.

Although researchers have found behaviour modification therapy to be beneficial at home, in schools, and across peer settings (Fabiano et al., 2009), this form of therapy is costly and takes up significant time (Subcommittee on Attention-Deficit/Hyperactivity et al., 2011). Moreover, even though psychosocial treatments may offer improvements in areas that are less affected by pharmacological interventions, such as parenting and family functioning, the positive effects after the termination of behavioral treatment may be difficult to maintain (Chronis et al., 2006). Thus, it is important to note that behaviour interventions are time-limited while ADHD is a chronic condition (Chronis et al., 2006).

Behaviour interventions also pose a heavy burden on the adult in charge of implementations—the parents and/or teacher—as behaviour modification therapy requires long-term commitment to keep high levels of fidelity and intensity (Chronis et al., 2001). In fact, behavioural parent training, potentially the best studied form of effective intervention for children with ADHD, is associated with poor adherence to treatment on the part of families (Jones & Rabinovitch, 2014). For instance, Barkley and colleagues (2002) found that of the parents that sign up for behavioural parent training, there is poor attendance and many prematurely discontinue treatment. Furthermore, behavioural intervention outcomes tend to be

setting-specific, such that behavioural interventions implemented at home do not apply to other settings such as school unless behaviour interventions are implemented in that setting as well (Pfiffner & Haack, 2014). Cornelius and colleagues (2017) contend that behaviour modification treatments are not a suitable mono-treatment for children with ADHD.

Combined Treatment

At present, the integration of behaviour modification therapy and medication treatments appears to be an effective long-term treatment option for children with ADHD (Chronis et al., 2006; Majewicz-Hefley & Carlson, 2007). Although pharmacological stimulants aid in decreasing ADHD symptoms, psychosocial (behavioral) treatment in combination with medications effectively enhances social skills and strengthens the relationship of the parent with the child (Hinshaw et al., 2000). The optimal effect of the combination is achieved by taking into account the dose or intensity of each treatment (Pfiffner & Haack, 2014), allowing for the possibility of lowering stimulant doses (Evans et al., 2001; Fabiano et al., 2007). Nonetheless, even in combination, limitations still exist for both stimulant medications and behaviour modifications. For one, the treatment intensity that is needed for optimal effectiveness to be achieved is rarely feasible for most families and youth (Barkley, 2015). Additionally, the cost for two treatments in combination make it a luxury rather than a standard form of long-term approach for families and children (Barkley, 2015). The need for more evidence-based treatment options was made evident in the Multimodal Treatment Study of Children with ADHD (MTA Cooperative Group, 1999).

The Multimodal Treatment Study of Children with ADHD (MTA Cooperative Group, 1999), funded by the National Institutes of Mental Health, randomly assigned 579 children between the ages 7.0 to 9.9 years meeting the DSM-IV diagnostic criteria for ADHD combined

type into one of four treatment groups. The four groups included: (a) pharmacotherapy, (b) behaviour therapy, (c) combination of pharmacotherapy and behaviour therapy, and (d) community care. Treatment was delivered over 14-months and comprehensive assessments of functioning were held at baseline as well as at 3, 9, and 14 months. All treatment groups demonstrated a reduction in symptom severity, but pharmacotherapy was superior to behaviour therapy and community care. Because the combined treatment did not show significantly better outcomes than pharmacotherapy, the MTA authors concluded that pharmacotherapy has the most impact on ADHD symptoms. It was concluded that pharmacotherapy works best in the short-term and only for ADHD symptoms. In contrast, the combined treatment may have more advantages on improving broader impairments beyond ADHD symptoms alone (e.g., child anxiety symptoms, academic performance, social skills; MTA Cooperative Group, 1999; Smith & Shapiro, 2015). In terms of longer-term outcomes, an 8-year-follow up study by Molina and colleagues (2009) reported overall maintenance of improvement in functioning relative to pre-treatment levels. However, Molina and colleagues (2009) found that children were functioning significantly less well relative to typically developing classmates. This level of functioning was observed irrespective of whether the children with ADHD did or did not continue their medication intake after the 14-month MTA-study period. This points towards a need for more treatment options that are efficacious in the long term (Jones & Rabinovitch, 2014).

Smith and Shapiro (2015) explain that even though the combination of pharmacotherapy and behaviour therapy can be shown to be a superior form of treatment, two major caveats must be considered. First, the treatment intensity that is needed for optimal results is rarely feasible in a real-world community setting (Smith & Shapiro, 2015). Second, the high cost and lack of availability of many effective, evidence-based behaviour therapies make the combined approach

controversial (Smith & Shapiro, 2015). While children in the combination group in the MTA study took lower doses of medication than children in the medication group alone, the data from the follow up study points towards a crucial need for alternative or adjunct treatments that are efficacious throughout the lifespan (MTA Cooperative Group, 1999).

Thus, keeping in mind the pervasive and chronic nature of ADHD and the potential limitations of currently recommended treatments, an alternative or an adjunct to existing treatments that is more feasible, sustainable, and affordable requires exploration (Cornelius et al., 2016; Vysniauske et al., 2016). Indeed, Jiang and Johnston (2010) describe that parents are already using alternative treatments for ADHD and may not be satisfied with current evidence-based approaches. Ultimately, there is consensus that no one form of treatment is universally and completely effective for treating ADHD at the present time (Smith & Shapiro, 2015).

Physical Activity

Physical activity (PA) is defined as a contrived skeletal movement associated with an increase in the use of energy (Dishman et al., 2006; Rommel et al., 2015). PA involves, but is not limited to, spontaneous PA, organized PA classes, and sport competition; and it is proposed as a promising form of alternative treatment. This section will explore the two leading forms of evidence that support the potential utility of PA in children with ADHD: (a) the mechanisms of PA on executive functioning as it relates to Barkley's (1997) theory and (b) the benefits of PA on typically developing children. This section will then be followed by a summary of studies showing the benefits of PA in children with ADHD.

Mechanisms of PA on Executive Functioning

The first line of evidence is derived from neuropharmacological studies showing that stimulant medications act as dopaminergic and noradrenergic agonists or facilitators (Wigal et

al., 2012). Given that stimulant medications are effective in treating the core symptoms of ADHD, it has been argued that catecholamine dysfunction resulting in unbalanced levels of dopamine and norepinephrine might be the underlying cause of ADHD (Lenz, 2012; Wigal et al., 2012). This chemical imbalance then translates to a behavioural disturbance of executive function (Arnsten & Casey, 2011), which supports Barkley's (1997) theory of executive functioning dysregulation. Similar to medication, PA has been shown to increase the production of dopamine and norepinephrine, as well as their regulation, and PA has also been found to improve the executive functioning in children with ADHD (Choi et al., 2015). Following this line of evidence, if PA has been shown to improve executive functioning, an improvement in response inhibition might also be expected (Verret et al., 2012). Additionally, it has been posited that after some form of exercise, increased levels of dopamine serve to enhance attention, focus, and facilitate learning while increased levels of norepinephrine improve executive operations, reduce distractibility, modulate arousal, and enhance memory to assist in learning (Wilens & Dodson, 2004; Winter et al., 2007).

Executive functions are a family of control functions needed when one has to act on the self so as to alter a distant consequence (Barkley, 2015), especially when acting on impulse may be unwise (Diamond, 2012). There is general consensus in the literature that there are three core executive functions: inhibition, working memory, and cognitive flexibility (e.g., Diamond, 2012; Miyake et al., 2000). These core executive functions form higher-order functions such as reasoning, problems solving, and planning (Diamond, 2012). Executive functions are argued to be critical for success in school (Alloway & Alloway, 2010), in friendships (Rotenberg et al., 2008), for mental health (Miller et al., 2011) and for quality of life (Davis et al., 2010).

PA on Typically Developing Children

The second line of evidence comes from studies that show PA improves executive functioning in typically developing children (Verburgh et al., 2013). For instance, PA has been documented to have positive effects on cognition and learning. In a meta-analysis by Sibley and Etnier (2003) of 44 studies, a significant overall effect size using Hedge's g was calculated as .32 between PA and cognition in children. The authors noted that various cognitive functions such as perceptual skills, intellectual quotient, developmental level, academic achievement, and results on math and verbal tests were positively associated with PA in school-aged children. Also, in a randomized controlled trial by Mavilidi and colleagues (2016), the effectiveness of PA integrated into a geography task on children's learning performance and enjoyment was assessed. The study involved 87 children, aged 4 to 5 years, learning the names of typical animals from the six continents using a floor-mounted map and stuffed toys. Three conditions were involved: (a) physical activities integrated into learning, (b) physical activities unintegrated into learning, and (c) a control condition without physical activities. Results showed that the groups that involved physical activities, regardless of integration, showed higher performance in learning and more enjoyment than in the condition without physical activities.

The effect of acute PA on executive functioning is promising across all age groups (Verburgh et al., 2013). For example, in Verburgh and colleagues' (2013) meta-analysis of 19 studies, a moderate positive effect size ($d = 0.52$) was found for acute physical exercise on executive functions in preadolescent children to young adults. The findings that acute physical exercise exerts positive effects on the executive functions inhibition and inhibition are highly relevant given the importance of the two functions in daily life. The authors interpret the results as suggesting that acute physical activity enhances executive functioning. Overall, these results

appear to extend to serve children with hyperactivity, impulsivity, or attention concerns (Cornelius et al., 2017).

PA and Children with ADHD

The benefits of PA on children with ADHD have been consistently found in a multitude of studies. For example, the benefits of PA have been associated with reduced inattention (Ahmed & Mohamed, 2011; Cerrillo-Urbina et al., 2015; Choi et al., 2015; Jensen & Kenny, 2004; Kang et al., 2011; Mckune et al., 2003; Medina et al., 2010; Pontifex et al., 2013; Reza & Hamid, 2011; Rommel et al., 2015; Suarez-Manzano et al., 2018; Verret et al., 2012), hyperactivity (Cerrillo-Urbina et al., 2015; Jensen & Kenny, 2004; Reza & Hamid, 2011; Pliszka, 2005; Rommel et al., 2015), and impulsivity (Cerrillo-Urbina et al., 2015; Jensen & Kenny, 2004; Kang et al., 2011; Medina et al., 2010; Pontifex et al., 2013; Rommel et al., 2015; Verret et al., 2012), amongst other things. Intensity, frequency, and duration appear to be the important manipulated variables in experimental studies (Berwid & Halperin, 2012).

Intensity. Verret and colleagues (2012) studied the effects of moderate to vigorous physical activity (MVPA) on fitness, behaviour, and cognitive functions in 7- to 12-year-old children meeting the DSM-IV diagnostic criteria for ADHD. Ten children were assigned to the PA group and 11 children were assigned to the control group. The PA group involved various exercises (i.e., warm up, aerobic, muscular, and motor skills exercises, and a cool down) with each session lasting for 45 minutes, three times a week for 10 weeks. Fitness and motor performance were measured using the Test of Gross Motor Development-2 (Ulrich, 2000) and the Bruce treadmill protocol (Luong et al., 2016). Height, weight, body mass index, flexibility, muscular endurance, and resting and maximal heart rate were also measured. Behaviour problems and social competence in children were measured by having parents and teachers

complete the Child Behavior Checklist (Achenbach, 1991). Attention functions and response inhibitions were measured using the Test of Everyday Attention for Children (Manly et al., 1999). Participants were asked not to practice intense PA and to abstain from using medication on the day preceding testing so as not to influence study results. All evaluations were done pre- and post- treatment. In comparison to the control group, Verret and colleagues (2012) found that the PA group showed improvements in muscular capacities, motor skills, and behaviour reports by parents and teachers (i.e., parents reported improvements in total problems, social problems, thought problems, and attention problems and teachers reported improvements in anxiety-depression and social problems). As well, children in the exercise group showed better-sustained attention and a trend for faster visual search in comparison to the control group. This exploratory study suggests that long-term PA interventions for children with ADHD may be beneficial. However, limitations of this study include nonrandomized assignment to group, differential medication treatment across groups, and unblind parent and teacher reports.

In a meta-analysis by Cerrillo-Urbina and colleagues (2015), aerobic activity was shown to reduce symptoms of inattention, hyperactivity, and impulsivity and other related symptoms (i.e., anxiety, executive function, social disorders) in children with ADHD. In the review, the authors included eight studies that involved children ages 6 to 18 years diagnosed with ADHD. Studies included randomized controlled trials that involved evaluations of the effects of PA on ADHD symptoms, taking into consideration primary outcomes such as inattention, hyperactivity, and impulsivity as well as secondary outcomes such as anxiety, executive function, social disorders, and cognitive performance. The authors categorized the intensity of the programmes as either aerobic or yoga, and claimed that short-term aerobic exercises (6–10 weeks), based on several aerobic intervention formats, had a moderate to large effect on the following: reducing

inattention (*Standardized Mean Difference [SMD]* = 0.84), hyperactivity (*SMD* = 0.56), and impulsivity (*SMD* = 0.56), as well as on related symptoms such as anxiety (*SMD* = 0.66), executive function (*SMD* = 0.58), and social disorders (*SMD* = 0.59) in children diagnosed with ADHD. There were no restrictions placed on frequency or duration of training imposed in the studies that were included in their review.

Frequency. Research studies exploring the effect of frequency of exercise sessions are limited and mixed as is illustrated in this section. Ranging from one session per week to up to 7 sessions per week, these studies on children with ADHD vary widely in the frequency of each PA session.

Jensen and Kenny (2004) investigated the effects of a yoga program in boys aged 8 to 13 years meeting the DSM-IV diagnostic criteria for ADHD. A 20-week, 1-hour/week yoga session (n = 11) was compared to a monthly 1-hour control group of cooperative activities (n = 8). The yoga sessions involved respiratory training, postural training, relaxation training, and concentration training while the control group engaged in cooperative activities that involved talking, listening, turn-taking, and sharing. All participants receiving medication were stabilized after appropriate periods of titration of medication to address other symptoms such as anxiety and insomnia. The boys were assessed on different tests pre-and post-treatment, including the Conners' Parent Rating Scales—Revised: Long (CPRS—R:L; Conners, 1997) and the Conners' Teacher Rating Scales—Revised: Long (CTRS—R:L; Conners, 1997). These scales were used to measure parent and teacher behaviour ratings of the child when unmedicated to gauge yoga effects during medication withdrawal. In addition, the Test of Variables of Attention (Greenberg et al., 1997) was used to evaluate attention, and a Motionlogger Actigraph (Ambulatory Monitoring Inc., 1980) was used to measure motor activity in the naturalistic environment. In

considering the results of the study, it is noteworthy that parents and teachers were not blinded to the group assignment of boys, which could have affected the findings. However, parents were able to give anecdotal evidence about how the yoga intervention was benefitting their child. Results showed significant improvements for the yoga group on five subscales of the CPRS—R:L (i.e., Oppositional, Global Index Emotional Lability, Global Index Total, Global Index Restless/Impulsive, and ADHD Index) in comparison to the control group. However, the control group showed improvements on three subscales of the CPRS—R:L (i.e., Hyperactivity, Anxious/Shy, and Social Problems) in comparison to the yoga group. Overall, both groups improved significantly on CPRS—R:L Perfectionism, DSM-IV Hyperactive/Impulsive, and DSM-IV Total. Moreover, the more yoga sessions the boys attended, the greater the reduction in primary ADHD symptoms shown in the CTRS—R:L Inattentive and CTRS—R:L Hyperactive-Impulsive subscales. Despite the study having a small sample size and thus being under-powered to detect effects, Jensen and Kenny (2004) contend that the data provide support for the potential use of yoga as a complimentary treatment for boys with ADHD who are already stabilized on medication. The authors claim that this may be particularly the case during evening hours when medication has worn off. However, the authors suggest replicating the study on larger groups with more intensive supervised practice program to provide stronger support for the use of yoga with children with ADHD.

Gapin and Etnier (2010) examined the effects of PA on the executive functioning of 8- to 12-year-old boys diagnosed with ADHD. Eighteen stimulant-medicated boys performed the following neuropsychological tasks: Wechsler Intelligence Scale for Children, Fourth Edition Digit Span (Wechsler, 2003) to measure working memory, Tower of London-2[2] (Culbertson &

[2] Fewer and faster moves on the Tower of London-2 are indicative of improved planning.

Zillmer, 2005) to measure planning, Conners' Continuous Performance Test II (Conners, 2004) to measure inhibition, and Children's Color Trails Test 1 and 2 (Llorente et al., 2003) to measure processing speed. Participants were instructed not to engage in PA within 3 hours of the testing period to reduce the potential impact of acute PA on cognitive function. Participants were also instructed to take their medication as usual. For 7 days, children wore an accelerometer and completed a daily physical activity log. Data from both measures were combined to calculate the average minutes per day spent in MVPA. Results showed that the more time children spent engaging in MVPA, they engaged in fewer and faster moves on the Tower of London-2. Although not statistically significant, Gapin and Etnier's (2010) analyses showed a positive association between PA and the other executive function measures. Nonetheless, the findings are consistent with the notion that elevated engagement in PA may confer benefits on neuropsychological functioning in children with ADHD, over and above medication treatment benefits (Halperin et al., 2014).

Duration. Research studies aimed at exploring the effects of length of exercise sessions are also limited and mixed. Ranging from 20 minute per session up to 90 minutes per session, these studies on children with ADHD vary widely in the duration of each PA session.

Pontifex and colleagues (2013) examined the effect of single bouts of 20-minute moderate-intensity aerobic exercise (i.e., treadmill walking at 65%–75% of maximum heart rate) on 20 unmedicated children aged 8 to 10 years with ADHD. The ADHD Rating Scale-IV (DuPaul et al., 1998) was used to ensure that children with ADHD were exhibiting current ongoing ADHD symptoms and the ADHD supplement of the Kiddie Schedule for Affective Disorders and Schizophrenia, Present and Lifetime Version semi-structured diagnostic interview using DSM-IV (APA, 2000) was used to verify clinical status. Healthy matched control children

were yoked based on age, sex, socioeconomic status, and pubertal status to serve as a comparison to the treatment group. Using a within-subjects design, Pontifex and colleagues (2013) measured task performance and event-related brain potentials while participants performed an attentional-control task (i.e., flanker task; Jonkman, et al. 1999) following 20 minutes of exercise or 20 minutes of seated reading, during two separate, counterbalanced sessions. Event-related potentials were elicited using a Neuroscan Synamps 2 amplifier (Compumedics Neuroscan, 2003) and reading comprehension, spelling, and arithmetic were measured using the Wide Range Achievement Test, 3rd Edition (Wilkinson, 1993). Results showed that both groups exhibited greater stimulus-related processing and response accuracy during the flanker task as well as enhanced performance on tests of reading comprehension and arithmetic after they performed a 20-minute bout of exercise in comparison to when they performed 20-minute seated reading. Children with ADHD also displayed enhanced self-regulatory responses after exercise relative to seated reading, which was not observed with the healthy matched control children. The authors concluded that single bouts of 20-minute moderately intense PA may have positive implications for aspects of neurocognitive functioning and inhibitory control in children with ADHD.

Kang and colleagues (2011) identified whether sports activity improved attention, social competence, and cognitive functions over and above that provided by medications in a sample of Korean boys with ADHD. Children were randomly assigned to either a sport with medication therapy group (n = 15) or education for behaviour control with medication therapy group (n = 13). All children were titrated to 20 to 40mg of methylphenidate during the first week of intervention, and the therapeutic dose was held throughout the duration of the study. Sports/education with medication therapy was held twice a week for 6 weeks, totalling 12 sessions. Those in the sport with medication group engaged in 90-minutes of various athletic

activities (e.g., rope jumping, aerobic exercise, and goal-directed exercise such as throwing tennis balls and magnetic darts at a target) during each session while the education control group received information about behavioral control. Measures involved the following: the Korean version of the parent and teacher form of DuPaul's ADHD Rating Scale (K-ARS-PT; DuPaul, 1991) to assess parents' rated attention symptoms, the Digit Symbol Test and the Trail Making Test Part B (Reitan, 1958; Reitan & Wolfson, 1985) to measure children's cognitive functioning, and the Social Skills Rating System (SSRS; Gresham & Elliott, 1990) to evaluate the teachers' perception of children's social competence and adaptive functioning. The sports with medication group showed greater improvement in the K-ARS-PT Total scores and K-ARS-PT-Inattention scores, but not in the K-ARS-PT-Hyperactivity/Impulsivity scores. A significant improvement was found in the performance in Digital Symbol Test and Trail-Making Test Part B from the sports with medication group but not from the education with medication group. The sports with medication group also showed an increase in cooperativeness in the subscale of the SSRS compared to those of the education with medication group. These findings suggest that PA may augment the benefits of medication, as evidenced in the positive correlation between PA and improvement in attention symptoms, cognitive symptoms, and social skills.

Intensity, Frequency, and Duration. In Cornelius and colleagues' (2017) meta-analysis of 20 empirical studies examining the effectiveness of PA for children with ADHD, the possible moderating effect of the type (aerobic or nonaerobic exercise), intensity (i.e., low, moderate, vigorous), frequency (i.e., 1 time, 2 or more times per week, 5 or more times per week), duration (i.e., 0 min, 1–30 min, 31–60 min, more than 60 min), and length (i.e., 1 day, 2–30 days, 31–180 days) of activity were coded as well as the behavioural, cognitive, emotional treatment measures, and mood outcomes. The authors found that, on average, children in the PA treatment group

scored 59% higher on the coded positive outcomes compared to those in the control group (g = 0.81). Children in the PA group also had a 42% lower mean score in emotion/mood problems (g = -1.40) in comparison to the control group. However, the children in the treatment group were not significantly different from those in the control group in terms of attention, social problems, executive functioning, motor skills, disruptive behavior, or academic achievement. Furthermore, only aerobic activity interventions were found to have a statistically significant treatment effect, with those in the aerobic group showing 31% higher means on positive outcomes when compared to those in the anaerobic group (g = 0.88). Although the effectiveness of PA programs was not found to be associated with the intensity, frequency, and duration of activity, these investigators strongly argue that intensity, frequency, and duration of PA warrants continued exploration.

The Current Study

With several studies showing the possible benefits of PA on the functioning of children with ADHD, the purpose of the current study is to examine the primary effect of intensity (i.e., measured on a scale ranging from [a] never sweating and becoming breathless, [b] some sweating and becoming breathless, [c] heavy sweating and becoming breathless, [d] very heavy sweating and becoming breathless), frequency (i.e., days per week and months per year), and duration (i.e., hours and minutes per session) of PA on the core symptoms of ADHD: inattention, hyperactivity, and impulsiveness as well as impairments arising from ADHD. Given previous studies, two hypotheses are proposed.

Hypothesis 1: Intensity, frequency, and duration partly explain the variance in the negative association between PA and ADHD core symptoms and impairment.

Hypothesis 2: Engagement in higher levels of PA (i.e., more frequent PA sessions, higher PA intensity, and longer durations of PA sessions) will be strongly correlated with reduced ADHD symptoms and impairment.

Methods

Participants and Design

The present study included a total sample size of 51 guardians (i.e., caregivers). Participating guardians were required to have at least one child within the ages of 6 to 12 years with a primary DSM-IV and/or DSM-5 diagnosis of ADHD. The descriptive data are shown in Tables 1 and 2. Thirty percent of children reported on in the study were female, and seventy percent were male ($M = 0.30$, $SD = 0.46$).

Table 1

Child Characteristics

Variables	Min	Max	*M*	*SD*
Age (in years)	6	12	8.66	1.59
Currently Taking Medications for ADHD	0	1	0.74	0.44
Currently Taking a Second Medication for ADHD	0	1	0.36	0.49
Currently Taking a Third Medication for ADHD	0	1	0.31	0.48
Parent Ratings of Medication-Use Effectiveness	1	7	5.41	1.27
Use of Other Treatments for ADHD	0	1	0.34	0.48
Co-occurring Disorders	0	1	0.52	0.50
Age at Diagnosis	3	10	6.41	0.49

Note. $N = 50$; Missing 1 participant

1 = yes; 0 = no

Table 2

Parent Characteristics

Variables	Min	Max	*M*	*SD*
Age (in years)	27	49	37.62	5.21
Current ADHD Diagnosis	0	1	0.14	0.35
Identify as Canadian	3	10	9.40	1.60

Note. $N = 50$; Missing 1 participant

1 = yes; 0 = no

Participants were recruited from the province of Alberta using flyers (see Appendix D and E for flyers) posted in cafes (i.e., Remedy Café, Starbucks), flyers posted around the University of Alberta (i.e., Education Centre North, Van Vliet Complex, Central Academic Building, Students' Union Building, University Hospital), notices (see Appendix C for media recruitment blurb) distributed in different organizations (i.e., ADHD Association of Greater Edmonton, Child, Adolescent and Family Mental Health, St. Albert Daycare Society, and AdaptAbilities), the Department of Educational Psychology's Clinical Services Centre, advertisements on Facebook groups (i.e., St. Albert Chat, Alberta Parents ADD/ADHD/AUTISM/ANXIETY Support Group, Adult ADHD Edmonton, Edmonton ADHD SUPPORT GROUP, Fort Saskatchewan and Area Info, Event and Discussion Board, People helping People in Edmonton and area, ADHD Association of Greater Edmonton, Stony Plain/Spruce Grove ADHD, and Support for Moms with ADHD super stars! Edmonton and Area), social media (e.g., Facebook, Twitter), two Alberta-based charter schools, and general word of mouth. This study received ethical approval from the University of Alberta Research Ethics Board (Pro00090010) on June 26, 2019 (see

Appendix A). Guardians who have lived with the child for at least the past year, are legal guardians, and are fluent in English were included in the study.

Prior literature suggests that PA has a small to medium (Tan et al., 2016) and medium to large effect size (Cerrillo-Urbina et al., 2015) on children with ADHD. However, because of the anticipated difficulty of recruiting clinical samples (Martínez-Mesa et al., 2016), a large rather than a medium or a small effect size was used for the power calculation. A power calculation (G*Power 3.1; Faul et al., 2009) for linear multiple regression was conducted for a fixed effects model. A fixed, rather than a random effects model was used because by default, all explanatory variables are set as fixed effects (Kreft & de Leeuw, 1998). Estimating a large effect size of $f = 0.35$, a type-I error probability of .05, a power level of .80, and three predictors (i.e., intensity, frequency and duration of PA), the study required a minimum total sample size of 36. Thus, because of feasibility constraints, the use of a conservative, small/medium-sized effect was not used in the power analysis as this would have yielded the need for a sample size that would have been too large to realistically recruit. Not using a more conservative estimate of the effect size is one limitation of the study.

Considering the small population target (i.e., parents with children ages 6 to 12 diagnosed with ADHD), there were significant challenges in recruiting participants. Consider again that interested parents needed to (a) come across a flyer, advertisement on social media, or notice it from an organization; (b) following this, interested parents needed to email the principal investigator to acquire more information regarding the study; (c) and then, parents needed access to a computer device and required a Google email account to access the surveys on Google forms. As well, without access to vehicular transportation, physical flyers were only posted around University of Alberta and locations near the University.

Procedure

This study was designed to empirically examine the associations between the intensity, frequency, and duration of PA with ADHD symptoms and impairment. Thus, a correlational, cross-sectional survey method was adopted because it involved testing for associations among variables and allowed for a rapid turnaround in data collection (Creswell & Creswell, 2018).

Guardians who responded to the recruitment posts from June 26, 2019 to March 1, 2020 were emailed a consent form and a password to access the four online questionnaires on Google Forms through an online (i.e., the LEAFF Lab) website. The four surveys were combined into one Google Form, with each survey having its own page (see appendix F, G, H, and I for surveys/questionnaires). Consent was assumed when parents completed and submitted the questionnaires. The online questionnaires involved questions regarding the child's ADHD symptoms, impairment, physical activity, as well as the family's demographic information, mental health history, and medication use history. The survey materials used in the study are described in detail in the following section.

Materials and Measures

ADHD Rating Scale-IV

The ADHD Rating Scale-IV (ADHD RS-IV; DuPaul et al., 1998) is an 18-item norm-referenced survey questionnaire designed to assess a child's ADHD symptoms within the last 6 months. Ratings on the ADHD RS-IV are made using a 4-point Likert-type scale ranging from 0 (*Never or rarely*) to 3 (*Very often*) according to the diagnostic criteria found in the DSM-IV. Odd-numbered items represent the Inattention subscale while even-numbered items represent the Hyperactive-Impulsive subscale of ADHD symptoms. Normative data are available for ages 5 to 18, sampled from the U.S. Census data in 1990. While two versions exist for the ADHD RS-IV

(i.e., home version and school version), the home version was utilized in this study since parents are more acquainted with the child's behaviour at home. If children were taking medications for ADHD, parents were instructed to rate their child's functioning when they were off medications. Parents were required to answer all questions.

The ADHD RS-IV is considered to be a psychometrically reliable measure (DuPaul et al., 1998). For example, in a sample of 71 students (35 boys, 36 girls) within the ages of 5 to 17 years, the internal consistency of the ADHD RS-IV yielded coefficient alphas of .92 for Total score, .86 for Inattention, and .88 for Hyperactivity-Impulsivity. Using Pearson product-moment correlations (n = 43), the 4-month test-retest reliability of the ADHD RS-IV was found to be .85 for Total score, .78 for Inattention, and .86 for Hyperactivity-Impulsivity. The interrater agreement coefficient between parental ratings and teacher ratings of a sample of 62 students ages 5 to 17 (Kindergarten to Grade 12) resulted in moderate coefficients of .41 for Total score, .45 for Inattention, and .40 for Hyperactivity-Impulsivity. These moderate coefficients suggest that the presentation of the characteristics of ADHD might be different at home and at school.

The ADHD RS-IV is also considered to be a psychometrically valid measure (DuPaul et al., 1998). For example, the ADHD RS-IV has been shown to have discriminant validity in a sample of 92 children (24 girls, 68 boys). Of the 92 children categorized into one of three groups of (a) ADHD predominantly inattentive subtype, (b) ADHD combined inattentive and hyperactive/impulsive subtype, or (c) not meeting the criteria for any subtype, mean difference ratings for the Inattention subscale score ($F(2,87) = 7.56$, $p < .001$) and the Hyperactivity-Impulsivity subscale score ($F(2,87) = 5.60$, $p < .01$) were statistically different across the groups. The ADHD RS-IV has also been shown to have predictive validity with the parent Inattention

subscale scores. Specifically, the ADHD RS-IV accurately predicted inclusion in the ADHD, predominantly inattentive group subtype compared to the control group 68% of the time.

ADHD Impairment Rating Scale

The ADHD Impairment Rating Scale (ADHD IRS; Fabiano et al., 2006) is a 6-question survey questionnaire designed to assess the child's ADHD impairment in seven domains including relationship with peers, relationship with siblings, relationship with parents, academic progress, self-esteem, influence on family functioning, and overall impairment. While two versions exist for the ADHD IRS (i.e., parent version and teacher version), the parent version was utilized in this study. In Google Forms, the guardians were instructed to rate their child's problems in each domain using a 6-point Likert-type scale ranging from 0 (*No Problem—Definitely does not need treatment or special services*) to 5 (*Extreme problem—Definitely needs treatment or special services*). Guardians also had the opportunity to provide a narrative description of their view of the child under each impairment rating. Parents were required to answer all 6 questions.

The ADHD IRS is overall a psychometrically reliable measure; however, the range of reliability coefficients is broad (Fabiano et al., 2006). In a sample of 252 children within the ages of 3 years and 10 months to 7 years and 0 months, a one-year temporal test-retest reliability coefficient was calculated with correlations ranging from .54 to .76 ($Mdn = .67$, $p < .01$). Ratings that exhibited the strongest correlations were those for items that probed for overall impairment. Cross-informant interrater reliabilities for similar items between teacher and parent ADHD IRS were also calculated, yielding correlations from .47 to .64 ($p < .01$). Furthermore, in a sample of 125 boys within the ages of 6 and 12 years, stability correlations ranged from .60 to .89 ($Mdn = .80$; 6 months), .76 to .93 ($Mdn = .82$; 4 months) and .66 to .98 ($Mdn = .90$; 2 months). In the

same sample, cross-informant interrater reliabilities between teacher and parent ADHD IRS for the peer item yielded correlations of .64, .74 for academic progress, .60 for self-esteem, .87 for global impairment, and .81 for the average score. These correlations were all significant at $p <$ .01.

The ADHD IRS is a psychometrically valid measure (Fabiano et al., 2006). In a sample of 252 children within the ages of 3 years and 10 months to 7 years and 0 months, the concurrent validity of the ADHD IRS was measured by correlating it with ADHD symptom ratings and other common measures of impairment. Correlational analysis of the ADHD IRS and ratings of ADHD symptoms from the parent Diagnostic Interview Schedule for Children (Shaffer et al., 1996) yielded correlations ranging from .58 to .79 ($p < .01$). The ADHD IRS also correlated with other common measures of impairment when adjusting for the multiple "family" of correlations with Bonferroni-corrected significance levels. Additionally, bivariate correlations after Bonferroni corrections indicate, as expected, a moderate to high degree of correlation between the ADHD IRS and the Daily Hassles Scale (Crnic & Greenberg, 1990), the Impact on Family Scale (Sheeber & Johnson, 1992), the Woodcock-Johnson Academic Achievement Test dictation subtest (Woodcock, 1977), and the Children's Global Assessment Scale (Setterberg et al., 1992). Furthermore, in a sample of 125 boys within the ages of 6 and 12 years, correlations ranged from .79 to .93 (all r correlations at $p < .01$) between the parent IRS items and the Disruptive Behavior Disorders Rating Scale average ADHD symptom score (Pelham et al., 1992). In both samples, Fabiano and colleagues (2006) found the IRS to be stable over two administrations and to exhibit convergent validity as it correlated with behavioral measures of impairment. The researchers also found the IRS to be highly accurate in discriminating between children diagnosed with ADHD from those without ADHD.

Physical Activity Questionnaire

The Physical Activity Questionnaire (PAQ) is a two-part survey questionnaire designed to assess a child's PA engagement (Aranas, 2020). The first part of the PAQ prompts parents to identify and enumerate their child's PAs, if any, that have occurred more than once in the past six months. For each PA, parents report the intensity of each PA using a 4-point Likert-type scale ranging from "*Never sweating and becoming breathless*" to "*Very heavy sweating and becoming breathless*," the frequency of each PA activity in days per week and months per year, and the duration of each PA activity session in hours and minutes. In the second part of the PAQ, parents are asked to rate items associated with their perception of their child's involvement in PA for each PA they have listed. Specifically, parents are asked to rate three items on how much they prioritize the PA for their child (*Priority*), three items on how much they think their child enjoys the PA (*Enjoyment*), and three items on how much they engage their child in PA (*Engagement*) using a 5-point Likert-type scale ranging from "*Extremely*" to "*Not at all*."

The PAQ was designed specifically for this study and has not been evaluated for its validity or reliability. However, it is based on the Lifetime Physical Activity Questionnaire (LTPAQ; Friedenreich et al., 1998), which was designed to estimate PA from childhood to present in multiple domains (i.e., occupational & volunteer activities, household activities, and exercise and sports activities). The LTPAQ includes dimensions of PA (e.g., intensity, frequency, and duration). The LTPAQ has been shown to have a high test-retest reliability ranging from 0.72 to 0.87 (Friedenreich et al., 1998).

Child and Family Information Questionnaire

The Child and Family Information Questionnaire (CFIQ) is a two-part questionnaire with a total of 38 questions (Jiang, 2017). The CFIQ is designed to assess the child (Part I) and the

guardian's (Part II) demographic characteristics, mental health issues, and any treatment information. The questionnaire was created by Dr. Yuanyuan Jiang for the Attention, Behaviour, and Cognitions Lab at the University of Alberta.

Results

All analyses were conducted with IBM SPSS Statistics (Version 26 for Mac). This section includes a description of the internal consistency of the outcome variables, how the outcome and predictor variables were selected and transformed, the descriptive statistics of the outcome and predictor variables, and statistical analyses performed on the variables. Additionally, this section includes a presentation of exploratory analyses performed on the constructs *Priority*, *Enjoyment*, and *Engagement*.

Outcome Variables

With regards to the scale of the RS items, which range from 0 to 3, responses were recoded so that they reflected a range from 1–4. For example, 0 was recoded as 1; 1 was recoded as 2 and so on. This was done for two reasons. First, the RS scale is an interval scale, not a ratio scale, and the anchor of "*Never or Rarely*" is more accurately reflected as 1 instead of a 0, the latter of which assumes complete absence. Second, in the process of summing responses to the RS scale, the value of 0 resulted in a loss of information for statistical analyses. For these same reasons, the responses of the IRS scale were recoded, so they reflected a range from 1 to 6 instead of 0 to 5.

Given that the ADHD RS is a scale designed to measure the frequency of the construct of ADHD core symptoms, the items were evaluated for their internal consistency in the sample used for the present study. This was also done for the ADHD IRS scale, as it was also designed to measure another construct related to ADHD—the extent of impairment. The internal

consistency for ADHD RS calculated with Cronbach's alpha was within the high range in the present sample (r = .92, N = 18 items; Cortina, 1993).[3] All remaining analyses with the RS scale are conducted with items 1–18 as an aggregated variable. The internal consistency for ADHD IRS calculated with Cronbach's alpha was within the moderate range in the present sample (r = .69, N = 6 items; Cortina, 1993). All remaining analyses with the IRS scale were conducted with items 1–6 as an aggregate scale as well.

Given that both the ADHD RS and IRS scales were moderate to high in internal consistency, items within each scale were aggregated. The sum for ADHD RS was used to provide a single score for ADHD core symptoms, and the sum for ADHD IRS was used to provide a single score for ADHD impairment. The sums were taken instead of using means because there were no missing values, and sums provided greater variability in the distribution of ADHD core symptoms (M = 59.02, SD = 10.10) and impairment (M = 19.88, SD = 4.77), allowing for a wider range of differences to be detected in these constructs. Mean values or point estimates of scales provided less variation than sums. Specifically, there was less distribution of scores reflecting ADHD core symptoms (M = 3.28, SD = 0.56) and impairment (M = 3.31, SD = 0.79). Moreover, moderate to high internal consistency estimates justify the summing of items as the estimate indicates the presence of a single underlying construct.

Distribution of scores for both the ADHD RS and IRS scales showed approximate normality despite the small sample size. However, statistical tests for normality indicated that ADHD RS (KS = .14, df = 51, p = .010) did not meet the strict normality assumption while

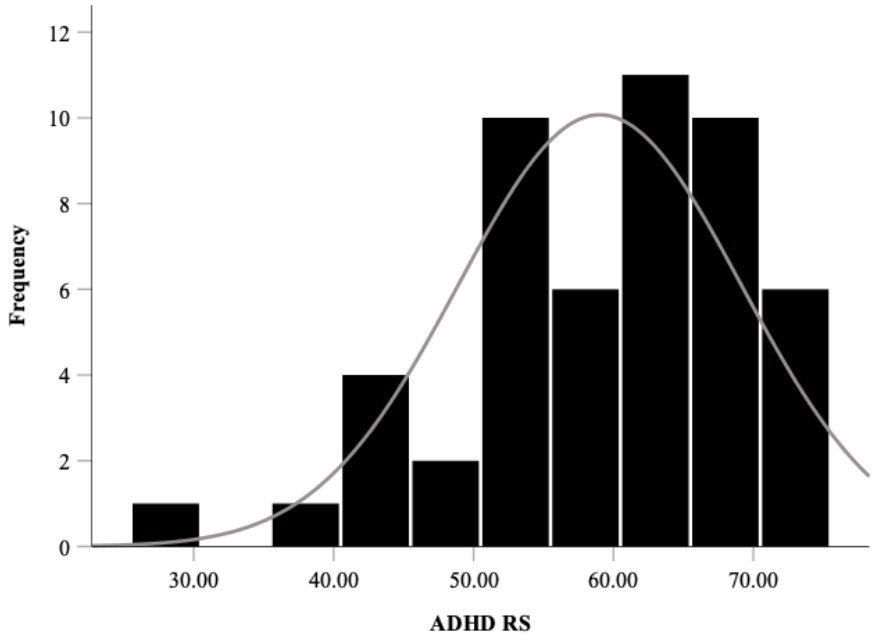
[3] Two additional questions were added to the scale when it was presented to guardians online. Questions 19 and 20 invited guardians to indicate their child's impairment. However, these were omitted from the analysis for ADHD RS, as these questions were not part of the original scale and primarily ask about ADHD related impairment as opposed to symptoms (DuPaul et al., 1998).

ADHD IRS did (KS = .09, df = 51, p = .200). The distribution of scores for ADHD RS and IRS are shown in Figures 1 and 2.

Not surprisingly, the ADHD RS and IRS were found to be significantly correlated (r = .43, p = .002) with each other. Because the IRS scale demonstrated a lower internal consistency compared to the RS scale, the RS scale was selected as the key outcome variable for additional analysis. ADHD IRS was instead used as a control variable in assessing the relationship between PA dimensions and ADHD core symptoms. The use of the ADHD IRS variable in this manner is elaborated when linear regression results are presented.

Figure 1

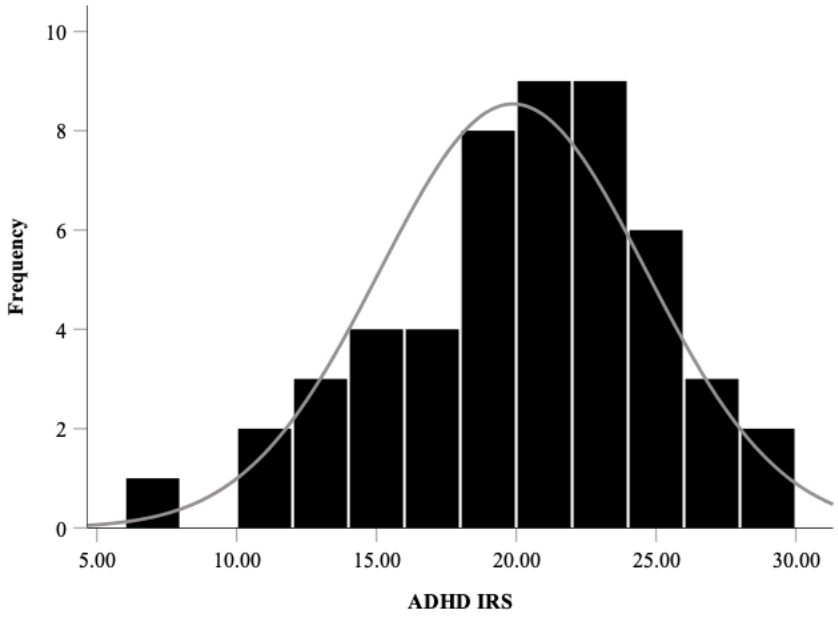
Histogram Frequency Distribution of ADHD RS



Note. The x-axis scale ranges from 18 to 72 given the range of recoded scale points and subsequent summation of the RS scale.

Figure 2

Histogram Frequency Distribution of ADHD IRS



Note. The x-axis scale ranges from 6 to 36 given the range of recoded scale points and subsequent summation of the IRS scale.

Predictor Variables

In testing the hypothesis that higher PA intensity and frequency, and longer PA duration are associated with reduced ADHD core symptoms, the maximum values for intensity, frequency, and duration for each participant were utilized irrespective of whether they came from different PAs. This was done for two reasons. First, choosing one set of values served to simplify the analysis given that varying levels of PA were reported by participants. Second, the main hypothesis for the present research was that higher PA engagement—in terms of intensity,

frequency, and duration—was associated with a reduction in ADHD core symptoms and impairment.[4] Thus, the maximum values of PA across intensity, frequency, and duration would represent the ideal or most relevant value for testing how PA dimensions are associated with ADHD core symptoms. These maximum values were then converted to Z scores to place them on a similar metric or scale. All remaining analyses were conducted with the Z scores.

Descriptive Statistics

Descriptive statistics for all key variables are presented in Table 3. In addition to the outcome and predictor variables, the descriptive statistics for the number of PAs reported by each participant are also presented.

Table 3

Descriptive Statistics of the Outcome and Predictor Variables

Variable	Minimum	Maximum	*M*	*SD*	Skew	Kurtosis
ADHD Core Symptoms	28.00	72.00	59.02	10.10	-0.90	0.53
ADHD Impairment	7.00	28.00	19.88	4.77	-0.46	-0.07
Sum – Intensity	0.00	21.00	5.33	4.59	1.44	2.65
Sum – Frequency	0.00	600.00	189.41	158.62	0.62	-0.41
Sum – Duration	0.00	990.00	198.24	219.88	2.38	6.24
Z score – Intensity	-1.88	1.09	0.00	1.00	-0.60	-0.63
Z score – Frequency	-1.27	2.13	0.00	1.00	0.62	-0.29
Z score – Duration	-0.99	4.13	0.00	1.00	2.25	6.32
PA	0.00	6.00	2.12	1.57	0.77	0.46

Note. $N = 51$

[4] Although ADHD IRS (impairment) was originally included as an outcome variable in this hypothesis, it is no longer used as an outcome variable given its lower than expected internal consistency.

Correlations

Pearson's product-moment correlation coefficients were calculated between each of the outcome and predictor variable pairs to investigate specific associations. While no statistically significant relationship was found for any pair of variables, PA intensity and ADHD RS (r = .26, p = .071) as well as PA duration and ADHD RS (r = .26, p = .063) were found to approach significance. There were no other relationships that approached significance. That both PA intensity and PA duration failed to meet statistical significance but approached significance could be explained by the study's lack of power given the small sample size and/or measurement error in the PA questions. Although nothing can be done about the sample size, select PA variables were considered for aggregation to create a broader measure of PA. This was considered in part because the PA variables of intensity and duration were highly correlated (r = .60, p < .001), and could arguably be combined to form a holistic and more stable measure of PA. All correlations between predictor and outcome variables are shown in Table 4.

Table 4

Correlations Matrix of Z PA Dimensions Scores and ADHD Scales

Variables	ADHD Core Symptoms		ADHD Impairment	
	r	*p*	*r*	*p*
Z score – Intensity	.26	.071	-.04	.781
Z score – Frequency	.10	.492	.01	.943
Z score – Duration	.26	.063	.03	.844
Z_INT+DUR	.29	.039*	-.01	.964

Note. * p < .05; Relationships involve Pearson correlations.

As shown in Table 4, the aggregated variable of PA encompassing intensity and duration (i.e., Z score intensity+duration or Z_INT+DUR) was significantly associated with ADHD core symptoms (r = .29, p = .039) but not impairment (r = -.01, p = .964). For this reason, it was deemed appropriate to use Z_INT+DUR as the holistic PA predictor variable in the main linear regression analysis. The absence of significance for the association between Z_INT+DUR and ADHD IRS is not surprising given the moderate internal consistency of the IRS variable compared to the RS variable.

Linear Regression

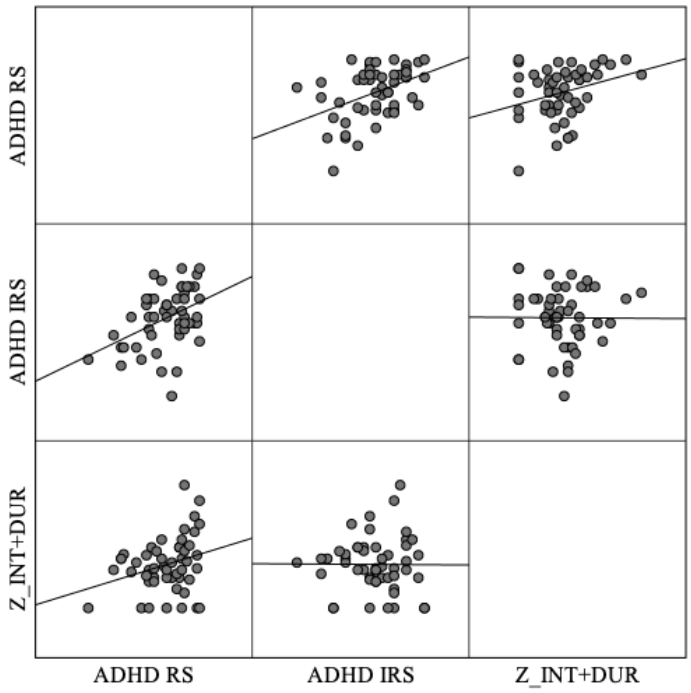
Main Analysis: The Relationship Between PA and ADHD Core Symptoms

Linear regression was the statistical analysis chosen to evaluate the predictive effects of the aggregated PA variable of intensity and duration (i.e., Z_INT+DUR) on ADHD core symptoms (i.e., ADHD RS), with ADHD impairment (i.e., ADHD IRS) as a control variable. Initial checks for linearity and outliers were met. Specifically, initial checks of matrix scatter plots depicted linear relationships between each potential predictor (i.e., Z_INT+DUR, ADHD IRS) and the outcome variable (i.e., ADHD RS), as shown in Figure 3.

With respect to the research study's hypothesis, stepwise linear regression was conducted to assess the predictive relationship between the aggregated PA variable of intensity and duration (Z_INT+DUR), and ADHD core symptoms. In order to properly evaluate the statistical strength of association between PA intensity/duration, and ADHD core symptoms, it was important to control for ADHD impairment. A significant association between PA intensity/duration, and ADHD core symptoms could be spurious if ADHD impairment functions as a third variable that is underlying the relationship between PA intensity/duration and ADHD core symptoms. Recall that ADHD core symptoms (RS) shares significant correlations with both ADHD impairment

Figure 3

Main Analysis: Matrix Scatter Plots of the Outcome and Predictor Variables



(IRS) and PA intensity/duration. Moreover, according to the APA (2013), impairment is required to be present along with ADHD core symptoms to diagnose ADHD. Thus, it was considered important to evaluate the effect of PA intensity/duration above and beyond any of the variance in ADHD core symptoms that could be explained by ADHD impairment. Although a stepwise linear regression was conducted, a hierarchical regression could have been conducted to yield similar results given the relatively few predictors (two) that were being entered into the model. The main intention was to evaluate the most parsimonious set of variables for accounting for the variance in ADHD core symptoms.

A stepwise linear regression was conducted with ADHD RS scores as the outcome variable, and ADHD IRS and Z_INT+DUR as predictors. The models and coefficients are shown in Tables 5 and 6. Stepwise regression indicated that ADHD IRS explained 17% of the variance

in ADHD RS (R^2 = .18, F(1,49) = 10.89, p = .002). Furthermore, Z_INT+DUR explained an additional 7% of the variance in ADHD RS above and beyond what ADHD IRS explained (R^2 = .27, F(1,48) = 5.61, p = .022). Examination of collinearity diagnostics showed no multicollinearity among the predictor variables, as all variance inflation factor (VIF) values were below 10 and tolerance statistics all above 0.20. The Durbin-Watson value of 1.95 indicated that the assumption of independent errors was also met. VIF, tolerance, and Durbin-Watson statistics are shown in Tables 5 and 6. Interestingly, both predictors were *positively* associated with ADHD core symptoms. A standard unit increase in ADHD IRS was found to predict a 0.43-unit increase in ADHD core symptoms; likewise, a standard unit increase in Z_INT+DUR was found to predict a 0.29-unit increase in ADHD core symptoms. The positive associations are discussed and elaborated in the discussion section. The standardized coefficient betas and adjusted R^2 for each level of the stepwise regression are shown in Tables 5 and 6.

Table 5

Model Summary of the Stepwise Linear Regression Predicting ADHD Core Symptoms

Model	*R*	R^2	Adjusted R^2	*SES*	R^2 Change	*F*	*df1*	*df2*	*p*	*DW*
1	.43	.18	.17	9.23	.18	10.89	1	49	.002	
2	.52	.27	.24	8.82	.09	5.61	1	48	.022	1.95

Note. *SES* = Standard Error of the Estimate, *DW* = Durbin-Watson

Model 1 Predictors: (Constant) and ADHD IRS

Model 2 Predictors: (Constant), ADHD IRS, and Z_INT+DUR

Table 6

Coefficient Analysis of the Stepwise Linear Regression Predicting ADHD Core Symptoms

		Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics	
	Model	*β*	*SE*	*β*	*t*	*p*	*Tolerance*	*VIF*
1	(Constant)	41.05	5.60		7.33	.000		
	ADHD IRS	0.90	0.27	0.43	3.30	.002	1.00	1.00
2	(Constant)	40.97	5.35		7.66	.000		
	ADHD IRS	0.91	0.26	0.43	3.47	.001	1.00	1.00
	Z_INT+DUR	1.65	0.70	0.29	2.37	.022	1.00	1.00

Note. *SE* = Standard Error

Additional checks were made about whether the variables met the assumptions for linear regression given the small sample size. For example, assumptions of normality and homoscedasticity were met based on descriptive statistics and evaluations of the P-P plot and scatterplot of residuals. Figure 4 shows that the expected cumulative distribution plotted against the observed cumulative distribution of the ADHD RS standardized residuals fall closely to the diagonal line, indicating that the normality assumption is met. Figure 5 shows the standardized residuals plotted against the predicted values, and the Loess curve in the middle of the data points shows that indeed residuals are randomly scattered around zero. The residuals of the ADHD RS scale were also evaluated for normality in order to ensure that the t-tests of coefficients and p values in the stepwise linear regression were valid. As shown in Figure 6, the residuals are shown to be normally distributed ($KS = .12$, $df = 51$, $p = .074$).

Figure 4

Normal P-P Plot of Regression Standardized Residual of ADHD RS

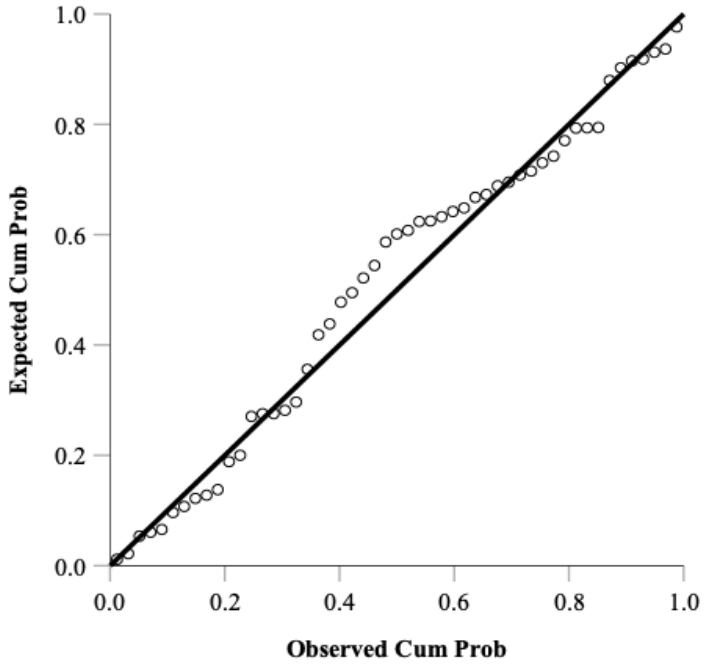


Figure 5

Scatterplot of Standardized Predicted Values and Standardized Residuals

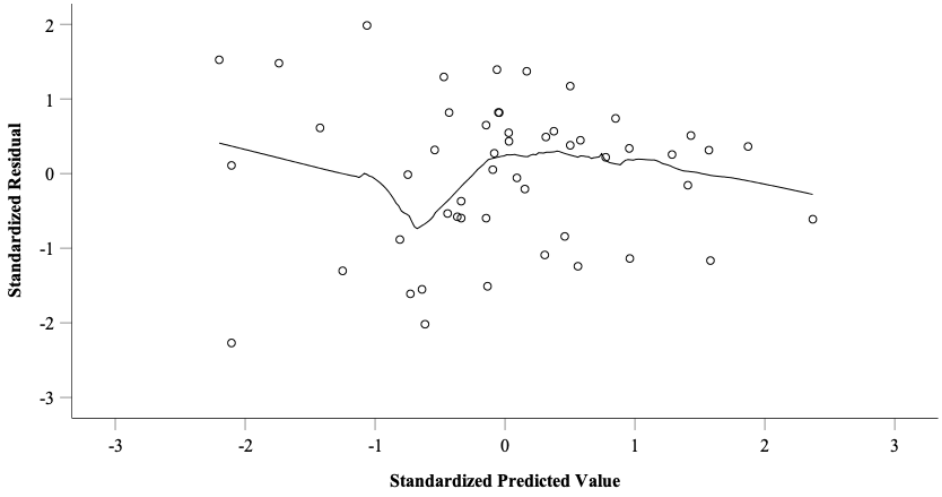
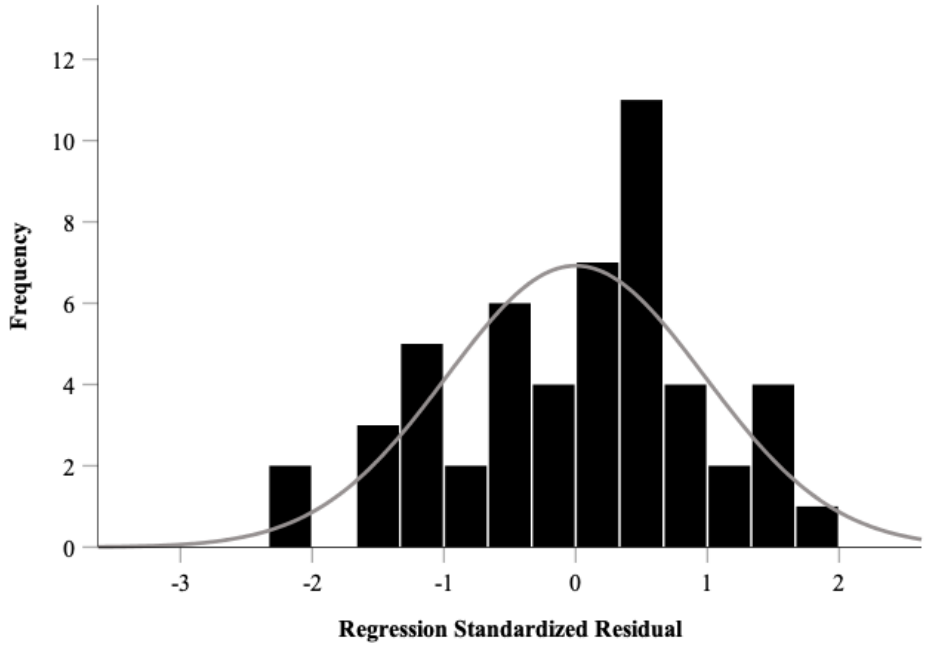


Figure 6

Histogram Frequency Distribution of ADHD RS Residuals



Exploratory Analysis: PA Priority, Enjoyment, and Engagement

Given that the Z_INT+DUR variable was found to explain some of the variance in ADHD core symptoms, it was considered relevant to evaluate variables that might help predict Z_INT+DUR. For each PA, parents also rated how much they prioritized the PA for their child (*Priority*), how much they thought their child enjoyed the PA (*Enjoyment*), and how much they engaged their child in PA (*Engagement*). Each construct (*Priority, Enjoyment*, and *Engagement*) involved three different questions, for a total of nine questions across the three constructs. The internal consistency for each of these constructs *Priority*, *Enjoyment*, and *Engagement* was calculated for the first PA reported. The rationale for doing so is because there were fewer participants reporting additional PAs (i.e., PA2, PA3… PA6). The internal consistencies (Cronbach alphas) for the three constructs of the first PA were as follows: *Priority* was $r = .89$, *Enjoyment* was $r = .92$, and *Engagement* was $r = .83$. Responses to the three questions for each

of the constructs were therefore summed. Pearson correlation analyses were performed for the sums of *Priority*, *Enjoyment*, and *Engagement*, Z_INT+DUR, and ADHD RS. Correlations among these variables are shown in Table 7.

Table 7

Correlations Matrix of Priority, Enjoyment, Engagement, PA Intensity/Duration, and ADHD RS

Variables	PA Intensity and Duration (Z_INT+DUR)		ADHD Core Symptoms	
	r	*p*	*r*	*p*
Priority	.33	.032*	.07	.684
Enjoyment	.17	.276	.04	.811
Engagement	.35	.025*	.13	.410

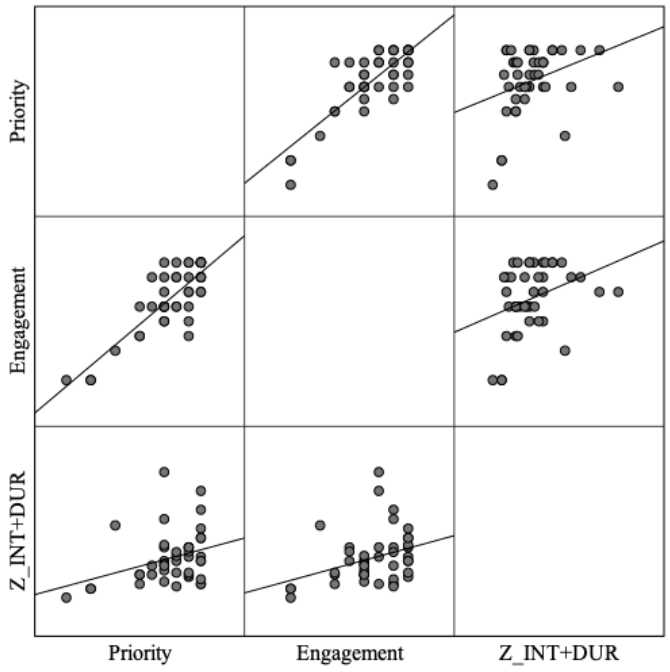
Note. * $p < .05$; Relationships involve Pearson correlations.

Given the statistically significant relationship between Z_INT+DUR and the constructs of *Priority* ($r = .33$, $p = .032$) and *Engagement* ($r = .35$, $p = .025$), another stepwise regression analysis was performed to explore the relationship between the affective variables of *Priority* and *Engagement* in predicting Z_INT+DUR. Initial checks for linearity and outliers were met. Specifically, initial checks of matrix scatter plots depicted linear relationships between each potential predictor (i.e., *Priority*, *Engagement*) and the outcome variable (i.e., Z_INT+DUR), as shown in Figure 7.

The stepwise linear regression involved the Z_INT+DUR as the outcome variable, and *Priority* and *Engagement* as predictors. Stepwise regression analysis showed that PA *Engagement* explained about 10% of the variance in Z_INT+DUR ($R^2 = .12$, $F(1,40) = 5.40$, $p = .025$). Interestingly, the stepwise regression analysis did not find the construct *Priority* as a significant variable in the explanation of Z_INT+DUR. It should be noted, however, that only a

Figure 7

Exploratory Analysis: Matrix Scatter Plots of the Outcome and Predictor Variables



total of three questions were used to asses each construct. The standardized coefficient and adjusted R^2 for each level of the stepwise regression are shown in Tables 8 and 9. Examination of collinearity diagnostics showed no multicollinearity among the predictor variables, as both VIF and tolerance values were 1.00. The Durbin-Watson statistic was 2.08, indicating that the independent error assumption was met as the value was close to 2. VIF, tolerance, and Durbin-Watson statistics are shown in Tables 8 and 9.

Table 8

Model Summary of the Stepwise Regression Analysis Predicting Z_INT+DUR

Model	*R*	R^2	Adjusted R^2	*SES*	R^2 Change	*F*	*df1*	*df2*	*p*	*DW*
1	.35	.12	.10	1.37	.12	5.40	1	40	.025	2.08

Note. *SES* = Standard Error of the Estimate, *DW* = Durbin-Watson

Model 1 Predictor: (Constant) and Engagement

Table 9

Coefficient Analysis of the Stepwise Linear Regression Predicting Z_INT+DUR

		Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics	
	Model	*β*	*SE*	*β*	*t*	*p*	*Tolerance*	*VIF*
1	(Constant)	-2.20	1.20		-1.83	.074		
	Engagement	0.22	0.09	0.35	2.32	.025	1.00	1.00

Note. *SE* = Standard Error

Additional checks were conducted for whether the variables met the assumptions for linear regression. The evaluation of the scatterplot of residuals did not violate assumptions of homoscedasticity, but the distribution shown in the P-P plot and histogram indicated the distribution was positively skewed, as shown in Figures 8 and 9.

Figure 8

Normal P-P plot of Regression Standardized Residual of Z_INT+DUR

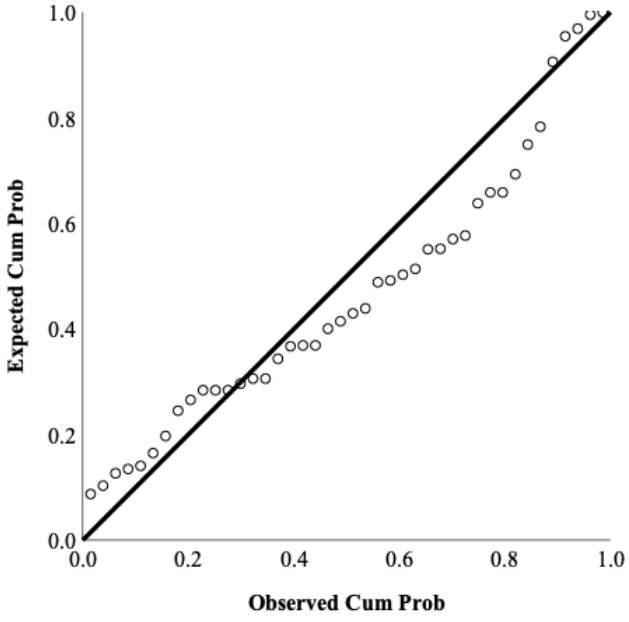
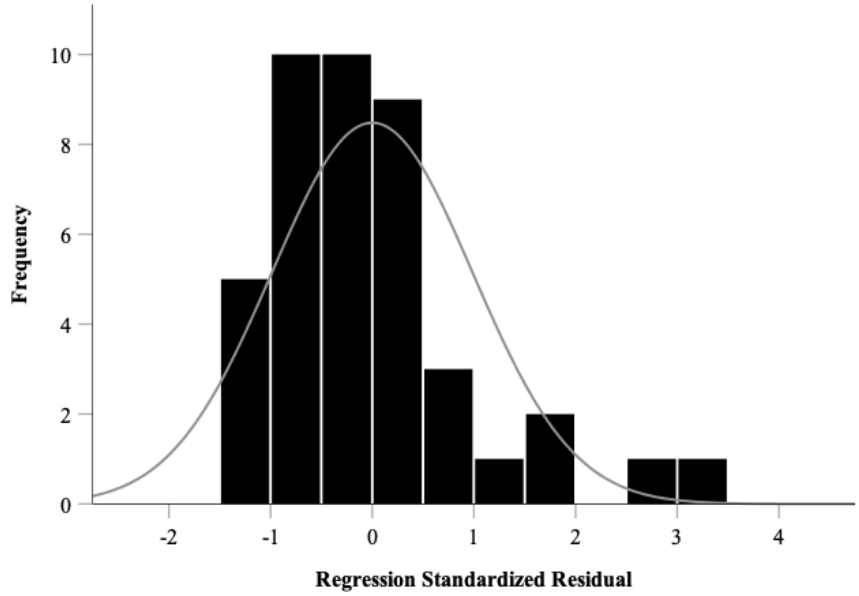


Figure 9

Histogram Frequency Distribution of Z_INT+DUR Residuals



Discussion

Previous studies suggest that the underlying cognitive mechanisms believed to contribute to ADHD core symptoms and impairment may benefit from engagement in PA. The aim of the current study was originally to investigate the relationship between PA dimensions—intensity, frequency, and duration—and ADHD core symptoms and impairment. It was hypothesized that these PA dimensions would partly explain the association between PA and ADHD core symptoms and impairment. It was also hypothesized that greater PA engagement would be associated with less ADHD symptoms and impairment. With the available data in the study, ADHD symptoms was used as the main outcome variable, and ADHD impairment was used as a control variable to better understand the relationship between PA and ADHD.

Main Findings

In the study, PA intensity and duration together explained the variance of ADHD core symptoms, above and beyond what ADHD impairment explained in ADHD core symptoms. The

positive association between PA intensity/duration and ADHD core symptoms indicated that as parents reported an increase in their child's PA intensity and duration engagement, they also reported an increase in the frequency of their child's ADHD symptom presentation. Note that this relationship only takes into account frequency of children's ADHD symptoms and not necessarily the number of separate ADHD symptoms. Although contradictory to the initial hypothesis, this positive association is not entirely unexpected. This finding can be interpreted as suggesting that the more ADHD core symptoms the child shows, the greater the services they need. For instance, Silinskas and colleagues (2012) investigated the longitudinal association between children's academic performance and parental schoolwork assistance. In this study, reading and math skills were assessed three times during grades 1 and 2, and parents answered questionnaires regarding the type of homework assistance they engaged in. Results showed that the poorer the child's performance in reading and math was, the more parents monitored and tried to help their children. In other words, there was a surprising association between parental help and poor academic performance. This is in line with the results from the present study. That is, the children identified as showing signs of more severe ADHD core symptoms were also identified as engaging in more intense and longer bouts of PAs. In fact, the American Academy of Pediatrics practice guidelines recommends incorporating multiple treatment modalities for children with ADHD experiencing moderate-to-severe disturbances in the child's functioning (Subcommittee on Attention-Deficit/Hyperactivity et al., 2011). Thus, children with more severe ADHD presentation may be needing more assistance to help them deal with symptoms, as evident in the present study.

It is also possible that the collective beneficial effects of PA may be yielded at a later stage in the lives of the participants in the study. Rommel and colleagues (2015) examined the

effects of PA during late adolescence on ADHD core symptoms in early adulthood in a sample of 232 monozygotic twin pairs. The authors measured ADHD core symptoms when participants were 16 to 17 years of age (baseline) and later again at 19 to 20 years of age (follow-up). Participants' weekly PA was measured by self-reports at baseline. Results showed that there was a significant negative association between weekly PA in adolescence and ADHD symptom levels in early adulthood, even when unmeasured confounding variables were controlled (e.g., all genetic and environmental factors shared within monozygotic twin pairs, ADHD symptoms, and body mass index at baseline). While the researchers did not explicitly report on the relationship between ADHD symptoms and PA levels during adolescence, it is possible that this relationship was initially positively associated, as is the case in the present study. Based on this possibility, it would be expected that a negative association between PA dimensions and ADHD core symptoms may present itself in early adulthood for the participants in the study. Further research and/or a potential follow-up of the participants in the present study is warranted to confirm this speculation.

Amongst the three PA dimensions evaluated in the study, frequency was the only variable that did not approach significance. This finding is still congruent with the study's hypothesis that more PA is required to achieve the positive outcomes of PA among children with ADHD. The results of the study indicate that the exertion the children expend on PA may matter more than the frequency of their participation in any kind of PA. That is, a child with ADHD who frequently engages in PA but does not move much may not yield the same benefits as a child with ADHD who engages in less frequent but more intense and longer durations of PA. These findings are congruent with Chang and colleagues' (2012) findings in their meta-analysis of 79 studies on the effects of acute exercise on cognitive performance. The researchers found that a

single bout of exercise had a positive and small effect (g = 0.10, n = 1,034) on cognitive performance that was significantly different from zero. Importantly, results from Chang and colleagues' (2012) study found that intensity and duration moderated the relationship between PA and cognitive performance. Tan and colleagues' (2016) meta-analysis of 22 studies also did not find number of sessions of PA, or frequency of PA, to moderate the effect of PA on cognitive functioning. Thus, consistent with these two findings, the present research also found intensity and duration to be key dimensions in PA.

While the study focused on the PA dimensions of intensity, frequency, and duration, a multitude of other factors may also play a role in the relationship between PA and children with ADHD. Aside from the way in which PA was operationalized in the present study, PA is a multidimensional construct that can be classified in different ways, including dimensions (e.g., intensity, frequency, duration, and type), domains (e.g., transportation-related, leisure-time), posture (e.g., lying, sitting, standing, ambulating), context (e.g., location, indoor versus outdoor, individual versus group, purposeful versus incidental), health benefits (e.g., bone building, muscle strengthening, flexibility enhancing), and gait (e.g., speed, step length, step frequency, stance time; Bassett et al., 2015). Therefore, while the present study focused on three PA dimensions, a host of other factors may be playing a role in the relationship between PA and ADHD. Furthermore, the American Academy of Pediatrics contends that in some cases, the presence of comorbid disorders may alter the treatment of ADHD (Subcommittee on Attention-Deficit/Hyperactivity et al., 2011). This is important because 52% of the participants in the study had existing comorbid disorders. Wigal and colleagues (2012) also maintain that individual differences in overall conditioning and physical fitness may be key mediators in the relationship between PA and positive outcomes in children with ADHD. In fact, Chang and colleagues'

(2012) meta-analysis found physical fitness to moderate the effects between PA and cognitive performance, with greater improvements among those who are fitter. Given that the present study did not measure for physical fitness, it was not possible to include a range of physical fitness levels in the analysis. However, given the small sample size, it is quite unlikely that the sample size would have reflected a balanced representation of sedentary, low, moderate, and high fit participants. Thus, the relationship between PA and ADHD is complex and likely moderated by many other factors such as individual differences and parental life circumstances (e.g., time, history of activity, fitness level, diagnoses; Chang et al., 2012; Tan et al., 2016; see also Smith & Patterson). Given the heterogeneity of ADHD, it is also possible that PA may be more beneficial for some compared to others, and that different intensities and duration of PA affect individuals differently (Halperin et al., 2014). These possibilities are, at this point, speculations that await further study.

In terms of what might motivate children to participate in PA, the results also show that parents who prioritize and engage PA in their child's routine reported that their children are engaging in more intense and longer durations of PA, as expected. Further analysis show that only parental engagement of PA in their child's routine partially explained how much intensity and duration the child expended in PA. This may be the case because prioritizing PA for one's child may not necessarily equate to actually engaging one's child in PA. This highlights the gate-keeping role parents play in their child's PA engagement, which may involve driving their child to sporting events, registering them in exercise classes or sports lessons, or providing equipment, access, or opportunities to be active (Gustafson & Rhodes, 2006). Nonetheless, the findings in the study are congruent with previous literature indicating that parental facilitation of PA strongly correlates with children's physical activity levels (Welk et al., 2003).

Limitations and Directions for Future Research

This study has several limitations. For one, the power calculation of the sample size was calculated with the use of a large effect size, despite previous meta-analyses indicating the effect size of PA on ADHD ranges between small to medium (Tan et al., 2016) and medium to large (Cerrillo-Urbina et al., 2015). The study adhered to a less conservative approach due to the anticipated feasibility constraints in recruiting clinical samples. While the study took an unconservative approach by utilizing a large effect size in the power calculation, a sample size of 51 participants is over the minimum criteria for a large effect size calculation but not enough to meet a moderate one. Thus, the current study is still under powered, risking the detection of the effect of PA on both ADHD symptoms and impairment. Future studies should consider using a conservative approach in the power calculation by using a small effect size. Overall, a larger sample is still needed to help clarify and support the relationship between the dimensions of PA and ADHD core symptoms and impairment.

The most common and feasible method of measuring PA at the population level is through the use of indirect measures such as questionnaires (Adamo et al., 2009) for issues of practicality, low cost, low participant burden, and general acceptance (Dishman et al., 2001). However, the risks involve the over- or under-estimation of true PA energy expenditure (Adamo et al., 2009). Reliability may be compromised by recall difficulties and biases, and validity may be compromised by social-desirability bias (Adamo et al., 2009). Because self-report methods possess several limitations in terms of reliability and validity (Shepard, 2003), future research should consider the use of objective measures in the assessment of PA in conjunction with self-reports. Physiological markers such as heart rate monitoring and respiratory rate, motion sensors such as accelerometers and pedometers, and direct observations may be used as objective

measures (Adamo et al., 2009). Furthermore, Nascimento-Ferreira and colleagues' (2017) systematic reviews on the assessment of PA intensity and duration in a pediatric population found a weak to moderate association between the use of subjective and objective methods. The authors noted that sample sizes ranging from 50 to 99 subjects provide stable agreement with the subjective and objective methods for almost all kinds of PA intensity and duration. Given that the present study's sample size barely meets this specified range, further studies should either increase the sample size or use both objective and subjective measures for PA dimensions. In addition, the study is also limited in that it used a new questionnaire for measuring PA in children with ADHD. The PAQ was constructed for this study as a means to measure PA intensity, frequency, duration, and parent perceptions about PA engagement in their child diagnosed with ADHD. While it was based on the measurement of a construct previously used in the literature, its validity and reliability has not yet been established.

While Visser and colleagues (2013) contend that primary caregivers are fairly accurate reporters of ADHD diagnosis, ADHD diagnosis is complex and requires reports regarding the child's functioning in different settings (APA, 2013). Children typically undergo formal assessments and fulfill certain criteria in the DSM. Concurrent mental health disorders may exacerbate the ADHD symptoms, which may result in a child erroneously meeting ADHD criteria (Mercurio et al., 2019); nonetheless, clinicians may also use less rigid criteria than required by the DSM when the child is deemed in need for services (Song et al., 2019). The present study aimed to recruit parents with children with a professional diagnosis of ADHD and due to the nature of the study, ADHD status was ultimately determined by parental response. As such, there was no guarantee that the parents who signed up for the study had a child with a professional diagnosis of ADHD. Future studies may need to verify ADHD diagnosis by

administering rating scales such as Conners-3 (Conners, 2008) or conducting clinical interviews with a qualified clinician.

With respect to the previously mentioned limitations, future research should consider increasing the sample size and utilizing multiple resources for measuring PA and ADHD core symptoms and impairment. This study involves a non-random, convenience sample given feasibility issues encountered with recruitment, as previously mentioned in the methods section. As such, it would be important to be mindful of the demographic information found in the present sample with regards to generalizing the results of this study. As more studies are conducted in this area, it will be possible to discern with greater confidence the relationship between PA and ADHD. It is therefore important to interpret the current findings with caution until a larger body of research is conducted.

Implications

The efficacy and effectiveness of PA as an alternative or adjunct intervention for children with ADHD is still in its infancy. This research study has added to the literature by providing more insight in the relationship between PA dimensions and ADHD symptoms, as well as how parents may play a role in this relationship. The results of this study have implications both for families with youth with ADHD and for future research.

PA can ultimately be considered as an evidence-based intervention (Cornelius et al., 2017), and appreciating the relationship between PA and ADHD may be the first step towards understanding how PA guidelines can be developed for children with ADHD. At present, this study highlights the need for more provisions of resources for children with ADHD, especially with those experiencing more severe symptoms. It acknowledges the need for enhanced education and facilitation of PA in the lives of children with ADHD. Caregivers such as parents,

teachers, and health care providers can affect change at the individual level by advocating for PA in the home and school. School psychologists and teachers can collaborate and develop the implementation of PA breaks to those children who may need access to it. At a global level, the findings from the study should promote the improved access to PA among children with ADHD. With regards to research, this study provides further support for the need for more research in the area of PA in this population. It is still unclear what the optimal levels of PA are to maximize the benefits of PA for those with ADHD. The findings in the study can form the basis of these next studies by highlighting that children presenting with more ADHD core symptoms were found to be engaging in more intense and longer durations of PA.

PA could provide a longer lasting effect than medication or could be used in combination with medication or behaviour therapy. Although the MTA study found that medication alone and the combination of medication and behavior therapy provided positive effects for children with ADHD, an eight year follow up by Molina and colleagues (2009) found that these initial treatments did not carry over in showing a long-term effect. Furthermore, Sanchez and colleagues (2005) contend that very few individuals with ADHD are effectively treated throughout the course of their disorder. As such, treatment gains tend to be short-lived, with limited, if any, long-term beneficial effects. It is therefore important to consider alternative and adjunct options given the chronic nature of ADHD. PA may provide long-term effects that current evidence-based treatment options lack (Rommel et al., 2015). Because analyses from the present study potentially adhere to the trend found by Rommel and colleagues (2015), it may suggest that PA may be a viable alternative and adjunct treatment option for families that could provide long-term benefits. Specifically, PA in childhood may be particularly helpful for these children when they journey through middle school and high school, where planning, time

management, note taking, and studying become a requirement of students but is often deficient for those with ADHD (Evan et al., 2005). PA may be an option free of pharmacological side effects that may provide long-term effects. PA may be especially helpful for families who do not have access to medications or behavior therapy or are looking for more viable, cost-free alternatives. With regards to research, this study further highlights the importance of understanding the long-term effect of PA in this population. Longer follow-up studies are warranted to determine the longevity of treatment benefits of PA in children with ADHD.

Recent studies have found that an ADHD diagnosis is negatively associated with health-related quality of life scores, diet, and sports participation (Ahn et al., 2017; Klassen et al., 2004; Suchert et al., 2017) and positively associated with odds of screen time, obesity, depression, and overeating. Warburton and colleagues (2006) contend that there is irrefutable evidence of the effectiveness of PA on obesity, depression, and even premature death. While previous research has found that children with ADHD are less likely to engage in PA in comparison to their typically developing peers (Kim et al., 2011; Mercurio et al., 2019), findings from this study found that parents who involve their children in PA also have children engaging in more intense and longer durations of PA. This research study therefore highlights the roles parents play in their child's PA involvement. It emphasises the importance of parental facilitation of PA in their child's routine. PA has also been found to mitigate anxiety and mood disorders (Kiluk et al., 2009), which are comorbid with ADHD (APA, 2013). Some studies suggest PA to improve school commitment (Owen et al., 2016). Thus, with PA linked with numerous benefits for children with ADHD, it seems necessary to establish programs with regard to the intensity and duration of PA to improve cognition and behavior in children with ADHD. With regards to research, future studies should continue to investigate whether there is a direct relationship

between parental support and child PA, or whether other variables play a role in this relationship (e.g., parental support may be increasing the child's self-efficacy, which in turn increases the child's engagement in PA; Gustafson & Rhodes, 20016).

Conclusion

The findings of this study may provide the basis for tentative conclusions in guiding future research and future large-scale randomized-controlled trials, as more studies are required to validate the current findings. ADHD is a lifelong disorder and understanding alternative and/or adjunct forms of treatment such as PA with minimal risks imposed is warranted. This study is an attempt to fill the gap in the literature by examining the relationship between PA dimensions and ADHD symptoms. Further research is needed to clarify the results of the study and more research is needed to establish the most effective PA programs with regard to intensity and duration for children with ADHD.

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Appendix A

Statement of Ethics Approval

Date:	June 26, 2019
Study ID:	Pro00090010
Principal Investigator:	Katrina Aranas
Study Supervisor:	Jacqueline Leighton
Study Title:	Characteristics of physical activity as related to Attention-Deficit/Hyperactivity Disorder (ADHD) symptoms and impairments
Approval Expiry Date:	June 25, 2020

Approved Consent Form:	Approval Date	Approved Document
	6/26/2019	Parent Consent

Thank you for submitting the above study to the Research Ethics Board 2. Your application has been reviewed and approved on behalf of the committee.

A renewal report must be submitted next year prior to the expiry of this approval if your study still requires ethics approval. If you do not renew on or before the renewal expiry date, you will have to re-submit an ethics application.

Approval by the Research Ethics Board does not encompass authorization to access the staff, students, facilities or resources of local institutions for the purposes of the research.

Sincerely,

Ubaka Ogbogu, LLB, BL, LLM, SJD
Chair, Research Ethics Board 2

Note: This correspondence includes an electronic signature (validation and approval via an online system).

Appendix B

Consent Form

UNIVERSITY OF ALBERTA

DEPARTMENT OF EDUCATIONAL PSYCHOLOGY

6-102 Education North
Edmonton, Alberta, Canada T6G 2G5
Tel: 780.492.5245
Fax: 780.492.1318
www.edpsychology.ualberta.ca

Physical Activity Study: Parent Online Questionnaires Consent Form

Graduate Student: Katrina Aranas, Hon. B. Sc.
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780-492-1167

Background
You are being asked to be in this study because you are a parent of a child between the ages of 6 and 11 with Attention-Deficit/Hyperactivity Disorder (ADHD). We are researchers at the LEAFF Lab at the University of Alberta. We are doing a study to see whether the kind of physical activity a child with ADHD does relates to their symptoms and impairment.

Purpose
Exercise appears to have benefits for self-regulation in children with ADHD (Cerrillo-Urbina et al., 2015), but we do not know exactly what it is about exercise that is related to self-regulation (Reeves & Bailey, 2016). This study looks at different dimensions of exercise, such as intensity, frequency, and duration to help us understand how exercise is related to better self-regulation in children with ADHD. The results of this study will be used to learn more about factors that are related to physical activity, with the potential to contribute to research on families, which may lead to possible benefits for families in the wider community.

Study Procedures
You are being asked to complete approximately 20 minutes of online questionnaires related to this study.

Benefits
If you are interested in receiving a summary of the research findings, you can email us to inquire about study results. We hope that this research will provide important information to promoting positive child outcomes.

Risks
We do not expect that taking part in this study will be harmful to you.

Voluntary Participation
You are under no obligation to participate in this study. Participation is completely voluntary. You can opt out of this study at any time without penalty and can ask to have any collected data withdrawn from the database and not included in the study as long as you let us know within two weeks of the date of your questionnaire submission. For instance, even if you agree to be in this study, you can change your mind and withdraw at any time within two weeks after participating. If you ask to withdraw your data in the study, we will destroy all data that you have provided.

Confidentiality and Anonymity
All questionnaires will be identified by a participant number and separated from identifying information in the lab. All information will be kept in a locked filing cabinet at the University of Alberta, and computer files will be kept on password-protected computers. Only the researchers will have access to your information. My research team and I will analyze the information collected, and the overall results of this study may be presented in future research articles and presentations or discussed publicly. This information will NEVER include personally-identifying information such as your name or your child's name. Information that discloses your identity will not be released without your consent unless required by law. For instance, if the researchers suspect or have information disclosed to them about possible child abuse or neglect, or risk of harm to oneself or others, they are required by law to report that information.

Contact Information
If you have any questions regarding this study, please do not hesitate to contact Katrina Aranas, the graduate student, at 6647-988-0014. The plan for this study has been reviewed by a Research Ethics Board at the University of Alberta. If you have questions about your rights or how research should be conducted, you can call 780-492-2615. This office is independent of the researchers.

Consent for Self
By clicking the link and completing the survey you are providing your consent to participate in this research.

Appendix C

Media Recruitment Blurb

Parents with 6 to 11 year old children with ADHD are needed to fill out questionnaires to help us learn about how to support kids with ADHD. This study takes about 20 minutes. For more info, email karanas@ualberta.ca

Appendix D

Large Recruitment Flyer

HELLO, MOMS & DADS!

DO YOU HAVE A 6- TO 11-YEAR-OLD CHILD DIAGNOSED WITH ADHD?

We need your help with a study at the University of Alberta!

We are studying the relationship between children's physical activities and ADHD symptoms and impairment. Parents will fill out questionnaires regarding their child's physical activities, ADHD symptoms and impairment, and medication use.

This study takes about 20 minutes
5 minutes for each questionnaire with a total of 4 questionnaires

HOW TO GET INVOLVED

Parents can fill out questionnaires at a time convenient for them. Participation in this research project is entirely voluntary.

This research is being conducted by Katrina Aranas, graduate student and Dr. Jacqueline Leighton, Professor of School and Clinical Child Psychology at the University of Alberta.

Contact us for more details:
Email: karanas@ualberta.ca

UNIVERSITY OF ALBERTA

Appendix E

Small Recruitment Flyer

Appendix F

ADHD IRS

Survey #1

Please describe what you see as your child's primary problems, both at home and at school. Please describe if you can how your child's problems have affected the following areas and complete the rating at the end of each: (1) his or her relationship with playmates and brothers or sisters, (2) his or her relationship with you (and your spouse if present) (3) his or her academic progress at school, (4) his or her self-esteem, and (5) your family in general. For the ratings, please rate the points that you believe reflect the impact of the child's problems on this area and whether he or she needs treatment or special services for the problems.

(1a) Please describe if you can how your child's problems affect his or her relationship with playmates.

(1b) Please rate how your child's problems affect his or her relationship with playmates

- 0 No problem—Definitely does not need treatment or special services
- 1
- 2
- 3
- 4
- 5 Extreme problem—Definitely needs treatment or special services

(1c) Regardless of whether this child is popular or unpopular with peers, please indicate whether he or she has a special, close "best friend" that he or she has kept for more than a few months?

- Yes
- No

(1d) Please describe if you can how your child's problems affect his or her relationship with brothers or sisters (If has no brothers or sisters, skip to #2a)

(2a) Please describe if you can how your child's problems affect his or her relationship with you (and your spouse if present)

(2b) Please rate how your child's problems affect his or her relationship with you (and your spouse if present)

- 0 No problem—Definitely does not need treatment or special services
- 1
- 2
- 3
- 4

- 5 Extreme problem—Definitely needs treatment or special services

(3a) Please describe if you can how your child's problems affect his or her academic progress at school

_____

(3b) Please rate how your child's problems affect his or her academic progress at school

- 0 No problem—Definitely does not need treatment or special services
- 1
- 2
- 3
- 4
- 5 Extreme problem—Definitely needs treatment or special services

(4a) Please describe if you can how your child's problems affect his or her self-esteem

_____

4b) Please rate how your child's problems affect his or her self-esteem

- 0 No problem—Definitely does not need treatment or special services
- 1
- 2
- 3
- 4
- 5 Extreme problem—Definitely needs treatment or special services

5a) Please describe if you can how your child's problems affect your family in general

_____

(5b) Please rate how your child's problems affect your family in general

- 0 No problem—Definitely does not need treatment or special services
- 1
- 2
- 3
- 4
- 5 Extreme problem—Definitely needs treatment or special services

(6) Please rate the overall severity of this child's problem in functioning and overall need for treatment.

- 0 No problem—Definitely does not need treatment or special services
- 1
- 2
- 3
- 4
- 5 Extreme problem—Definitely needs treatment or special services

Appendix G

ADHD RS

Survey #2

Choose the option that best describes this child's behaviour over the past 6 months.
If this child is taking medication to treat ADHD, please rate their behavior as it would be OFF the medication.

	Never or rarely	Some-times	Often	Very Often
1. Fails to give close attention to details or makes careless mistakes in schoolwork.	0	1	2	3
2. Fidgets with hands or feet or squirms in seat.	0	1	2	3
3. Has difficulty sustaining attention in tasks or play activities.	0	1	2	3
4. Leaves seat in classroom or in other situations in which remaining seated is expected.	0	1	2	3
5. Does not seem to listen when spoken to directly.	0	1	2	3
6. Runs about or climbs excessively in situations in which it is inappropriate.	0	1	2	3
7. Does not follow through on instructions and fails to finish work.	0	1	2	3
8. Has difficulty playing or engaging in leisure activities quietly.	0	1	2	3
9. Has difficulty organizing tasks and activities.	0	1	2	3
10. Is "on the go" or acts as if "driven by a motor."	0	1	2	3
11. Avoids tasks (e.g., schoolwork, homework) that require sustained mental effort.	0	1	2	3
12. Talks excessively.	0	1	2	3
13. Loses things necessary for tasks or activities.	0	1	2	3
14. Blurts out answers before questions have been completed.	0	1	2	3
15. Is easily distracted.	0	1	2	3
16. Has difficulty awaiting turn.	0	1	2	3
17. Is forgetful in daily activities.	0	1	2	3
18. Interrupts or intrudes on others.	0	1	2	3
19. How much does this child's problems with inattention, hyperactivity, and/or impulsivity impair his ability to function at home?	0	1	2	3

20. How much does this child's problems with inattention, hyperactivity, and/or impulsivity impair his ability to function at school?	0	1	2	3

At what age did this child's problems with inattention and/or hyperactivity/impulsivity first appear? _____

Appendix H

PAQ

Survey #3

Is your child involved in any physical activity or has your child been involved in any physical activity? Please list only those activities that they have been involved in for more than one time in the past 6 months.

If you cannot recall the exact day, please try to estimate the closest date possible.
Physical activities may include but are not limited to: playing in the playground, walking to school, running, hiking, gym class, gymnastics, playing on the trampoline, dancing, skiing, skating, hockey, soccer, etc.

You do not need to fill out the entire survey #3.

Physical Activity #1
Is your child involved in any physical activity or has your child been involved in any physical activity? Please list only those activities that they have been involved in for more than one time in the past 6 months.

- Yes
- No (Scroll all the way down and move on to next survey)

I.1) Please list the first activity here. This will be referred to as physical activity #1 in later questions. _____
I.2) Date your child started physical activity #1 _____ (dd/mm/yy)
I.3) Date your child ended or will end physical activity #1 _____ (dd/mm/yy)
- Optional: feel free to add comments about the start and end dates of physical activity #1 _____

I.4) How intense is physical activity #1 on average for your child
- Never sweating and becoming breathless (i.e.: walking)
- Some sweating and becoming breathless (i.e.: jogging)
- Heavy sweating and becoming breathless (i.e.: running)
- Very heavy sweating and becoming breathless (i.e.: fast running)

I.5) How frequently is your child involved in physical activity #1 on average. How many days/week: _____
I.6) How frequently is your child involved in physical activity #1 on average. How many months/year: _____
I.7) How long on average is physical activity #1 for your child each time your child engages in the activity. Provide number in hours. _____
I.8) How long on average is physical activity #1 for your child each time your child engages in the activity. Provide number in minutes. _____
I.9) How much do you prioritize physical activity #1 for your child?
- Extremely
- Very

- Moderately
- Slightly
- Not at all

I.10) How much does your child like doing physical activity #1?

- Extremely
- Very
- Moderately
- Slightly
- Not at all

I.11) How much do you involve your child in physical activity #1 on a regular basis?

- All the time
- Very much of the time
- Some of the time
- Relatively little time
- Not at all

I.12) How much do you value having your child be involved in physical activity #1?

- Extremely
- Very
- Moderately
- Slightly
- Not at all

I.13) How much do you involve physical activity #1 in your child's routine?

- All the time
- Very much of the time
- Some of the time
- Relatively little time
- Not at all

I.14) How much enjoyment does your child get from engaging in physical activity #1?

- Extreme enjoyment
- Much enjoyment
- Moderate enjoyment
- Slight enjoyment
- No enjoyment

I.15) How much do you engage your child in physical activity #1 on a recurring basis?

- All the time
- Very much of the time
- Some of the time
- Relatively little time
- Not at all

I.16) How pleasurable is physical activity #1 for your child?

- Extremely
- Very
- Moderately
- Slightly
- Not at all

I.17) How important is it for you to have your child be involved in physical activity #1?

- Extremely
- Very
- Moderately
- Slightly
- Not at all

Physical Activity #2

If no second activity, please scroll all the way down and move on to next survey.

II.1) Please list the second activity here. _____

II.2) Date your child started physical activity #2 _____ (dd/mm/yy)

II.3) Date your child ended or will end physical activity #2 _____ (dd/mm/yy)

- Optional: feel free to add comments about the start and end dates of physical activity #2 _____

II.4) How intense is physical activity #2 on average for your child?
- Never sweating and becoming breathless (i.e.: walking)
- Some sweating and becoming breathless (i.e.: jogging)
- Heavy sweating and becoming breathless (i.e.: running)
- Very heavy sweating and becoming breathless (i.e.: fast running)

II.5) How frequently is your child involved in physical activity #2 on average. How many days/week: _____

II.6) How frequently is your child involved in physical activity #2 on average. How many months/year: _____

II.7) How long on average is physical activity #2 for your child each time your child engages in the activity. Provide number in hours. _____

II.8) How long on average is physical activity #2 for your child each time your child engages in the activity. Provide number in minutes. _____

II.9) How much do you prioritize physical activity #2 for your child?
- Extremely
- Very
- Moderately
- Slightly
- Not at all

II.10) How much does your child like doing physical activity #2?
- Extremely
- Very
- Moderately
- Slightly
- Not at all

II.11) How much do you involve your child in physical activity #2 on a regular basis?
- All the time
- Very much of the time
- Some of the time
- Relatively little time
- Not at all

II.12) How much do you value having your child be involved in physical activity #2?

- Extremely
- Very
- Moderately
- Slightly
- Not at all

II.13) How much do you involve physical activity #2 in your child's routine?

- All the time
- Very much of the time
- Some of the time
- Relatively little time
- Not at all

II.14) How much enjoyment does your child get from engaging in physical activity #2?

- Extreme enjoyment
- Much enjoyment
- Moderate enjoyment
- Slight enjoyment
- No enjoyment

II.15) How much do you engage your child in physical activity #2 on a recurring basis?

- All the time
- Very much of the time
- Some of the time
- Relatively little time
- Not at all

II.16) How pleasurable is physical activity #1 for your child?

- Extremely
- Very
- Moderately
- Slightly
- Not at all

II.17) How important is it for you to have your child be involved in physical activity #1?

- Extremely
- Very
- Moderately
- Slightly
- Not at all

Physical Activity #3

If no third activity, please scroll all the way down and move on to next survey.

III.1) Please list the third activity here. _____

III.2) Date your child started physical activity #3 _____ (dd/mm/yy)

III.3) Date your child ended or will end physical activity #3 _____ (dd/mm/yy)

- Optional: feel free to add comments about the start and end dates of physical activity #3

_____

III.4) How intense is physical activity #3 on average for your child?

- Never sweating and becoming breathless (i.e.: walking)

- Some sweating and becoming breathless (i.e.: jogging)
- Heavy sweating and becoming breathless (i.e.: running)
- Very heavy sweating and becoming breathless (i.e.: fast running)

III.5) How frequently is your child involved in physical activity #3 on average. How many days/week: _____

III.6) How frequently is your child involved in physical activity #3 on average. How many months/year: _____

III.7) How long on average is physical activity #3 for your child each time your child engages in the activity. Provide number in hours. _____

III.8) How long on average is physical activity #3 for your child each time your child engages in the activity. Provide number in minutes. _____

III.9) How much do you prioritize physical activity #3 for your child?

- Extremely
- Very
- Moderately
- Slightly
- Not at all

III.10) How much does your child like doing physical activity #3?

- Extremely
- Very
- Moderately
- Slightly
- Not at all

III.11) How much do you involve your child in physical activity #3 on a regular basis?

- All the time
- Very much of the time
- Some of the time
- Relatively little time
- Not at all

III.12) How much do you value having your child be involved in physical activity #3?

- Extremely
- Very
- Moderately
- Slightly
- Not at all

III.13) How much do you involve physical activity #3 in your child's routine?

- All the time
- Very much of the time
- Some of the time
- Relatively little time
- Not at all

III.14) How much enjoyment does your child get from engaging in physical activity #3?

- Extreme enjoyment
- Much enjoyment
- Moderate enjoyment
- Slight enjoyment

- No enjoyment

III.15) How much do you engage your child in physical activity #3 on a recurring basis?
- All the time
- Very much of the time
- Some of the time
- Relatively little time
- Not at all

III.16) How pleasurable is physical activity #3 for your child?
- Extremely
- Very
- Moderately
- Slightly
- Not at all

III.17) How important is it for you to have your child be involved in physical activity #3?
- Extremely
- Very
- Moderately
- Slightly
- Not at all

Physical Activity #4

If no fourth activity, please scroll all the way down and move on to next survey.

IV.1) Please list the fourth activity here. _____

IV.2) Date your child started physical activity #4 _____ (dd/mm/yy)

IV.3) Date your child ended or will end physical activity #4 _____ (dd/mm/yy)

- Optional: feel free to add comments about the start and end dates of physical activity #4 _____

IV.4) How intense is physical activity #4 on average for your child?
- Never sweating and becoming breathless (i.e.: walking)
- Some sweating and becoming breathless (i.e.: jogging)
- Heavy sweating and becoming breathless (i.e.: running)
- Very heavy sweating and becoming breathless (i.e.: fast running)

IV.5) How frequently is your child involved in physical activity #4 on average. How many days/week: _____

IV.6) How frequently is your child involved in physical activity #4 on average. How many months/year: _____

IV.7) How long on average is physical activity #4 for your child each time your child engages in the activity. Provide number in hours. _____

IV.8) How long on average is physical activity #4 for your child each time your child engages in the activity. Provide number in minutes. _____

IV.9) How much do you prioritize physical activity #4 for your child?
- Extremely
- Very
- Moderately
- Slightly

- Not at all

IV.10) How much does your child like doing physical activity #4?
- Extremely
- Very
- Moderately
- Slightly
- Not at all

IV.11) How much do you involve your child in physical activity #4 on a regular basis?
- All the time
- Very much of the time
- Some of the time
- Relatively little time
- Not at all

IV.12) How much do you value having your child be involved in physical activity #4?
- Extremely
- Very
- Moderately
- Slightly
- Not at all

IV.13) How much do you involve physical activity #4 in your child's routine?
- All the time
- Very much of the time
- Some of the time
- Relatively little time
- Not at all

IV.14) How much enjoyment does your child get from engaging in physical activity #4?
- Extreme enjoyment
- Much enjoyment
- Moderate enjoyment
- Slight enjoyment
- No enjoyment

IV.15) How much do you engage your child in physical activity #4 on a recurring basis?
- All the time
- Very much of the time
- Some of the time
- Relatively little time
- Not at all

IV.16) How pleasurable is physical activity #4 for your child?
- Extremely
- Very
- Moderately
- Slightly
- Not at all

IV.17) How important is it for you to have your child be involved in physical activity #4?
- Extremely
- Very

- Moderately
- Slightly
- Not at all

Physical Activity #5

If no fifth activity, please scroll all the way down and move on to next survey.

V.1) Please list the fifth activity here. _____

V.2) Date your child started physical activity #5 _____ (dd/mm/yy)

V.3) Date your child ended or will end physical activity #5 _____ (dd/mm/yy)

- Optional: feel free to add comments about the start and end dates of physical activity #5 _____

V.4) How intense is physical activity #5 on average for your child?
- Never sweating and becoming breathless (i.e.: walking)
- Some sweating and becoming breathless (i.e.: jogging)
- Heavy sweating and becoming breathless (i.e.: running)
- Very heavy sweating and becoming breathless (i.e.: fast running)

V.5) How frequently is your child involved in physical activity #5 on average. How many days/week: _____

V.6) How frequently is your child involved in physical activity #5 on average. How many months/year: _____

V.7) How long on average is physical activity #5 for your child each time your child engages in the activity. Provide number in hours. _____

V.8) How long on average is physical activity #5 for your child each time your child engages in the activity. Provide number in minutes. _____

V.9) How much do you prioritize physical activity #5 for your child?
- Extremely
- Very
- Moderately
- Slightly
- Not at all

V.10) How much does your child like doing physical activity #5?
- Extremely
- Very
- Moderately
- Slightly
- Not at all

V.11) How much do you involve your child in physical activity #5 on a regular basis?
- All the time
- Very much of the time
- Some of the time
- Relatively little time
- Not at all

V.12) How much do you value having your child be involved in physical activity #5?
- Extremely
- Very

- Moderately
- Slightly
- Not at all

V.13) How much do you involve physical activity #5 in your child's routine?
- All the time
- Very much of the time
- Some of the time
- Relatively little time
- Not at all

V.14) How much enjoyment does your child get from engaging in physical activity #5?
- Extreme enjoyment
- Much enjoyment
- Moderate enjoyment
- Slight enjoyment
- No enjoyment

V.15) How much do you engage your child in physical activity #5 on a recurring basis?
- All the time
- Very much of the time
- Some of the time
- Relatively little time
- Not at all

V.16) How pleasurable is physical activity #5 for your child?
- Extremely
- Very
- Moderately
- Slightly
- Not at all

V.17) How important is it for you to have your child be involved in physical activity #5?
- Extremely
- Very
- Moderately
- Slightly
- Not at all

Physical Activity #6

If no sixth activity, please scroll all the way down and move on to next survey.

VI.1) Please list the sixth activity here. _____

VI.2) Date your child started physical activity #6 _____ (dd/mm/yy)

VI.3) Date your child ended or will end physical activity #6 _____ (dd/mm/yy)

- Optional: feel free to add comments about the start and end dates of physical activity #6 _____

VI.4) How intense is physical activity #6 on average for your child?
- Never sweating and becoming breathless (i.e.: walking)
- Some sweating and becoming breathless (i.e.: jogging)
- Heavy sweating and becoming breathless (i.e.: running)

- Very heavy sweating and becoming breathless (i.e.: fast running)

VI.5) How frequently is your child involved in physical activity #6 on average. How many days/week: _____

VI.6) How frequently is your child involved in physical activity #6 on average. How many months/year: _____

VI.7) How long on average is physical activity #6 for your child each time your child engages in the activity. Provide number in hours. _____

VI.8) How long on average is physical activity #6 for your child each time your child engages in the activity. Provide number in minutes. _____

VI.9) How much do you prioritize physical activity #6 for your child?
- Extremely
- Very
- Moderately
- Slightly
- Not at all

VI.10) How much does your child like doing physical activity #6?
- Extremely
- Very
- Moderately
- Slightly
- Not at all

VI.11) How much do you involve your child in physical activity #6 on a regular basis?
- All the time
- Very much of the time
- Some of the time
- Relatively little time
- Not at all

VI.12) How much do you value having your child be involved in physical activity #6?
- Extremely
- Very
- Moderately
- Slightly
- Not at all

VI.13) How much do you involve physical activity #6 in your child's routine?
- All the time
- Very much of the time
- Some of the time
- Relatively little time
- Not at all

VI.14) How much enjoyment does your child get from engaging in physical activity #6?
- Extreme enjoyment
- Much enjoyment
- Moderate enjoyment
- Slight enjoyment
- No enjoyment

VI.15) How much do you engage your child in physical activity #6 on a recurring basis?

- All the time
- Very much of the time
- Some of the time
- Relatively little time
- Not at all

VI.16) How pleasurable is physical activity #6 for your child?
- Extremely
- Very
- Moderately
- Slightly
- Not at all

VI.17) How important is it for you to have your child be involved in physical activity #6?
- Extremely
- Very
- Moderately
- Slightly
- Not at all

Physical Activity #7

If no seventh activity, please scroll all the way down and move on to next survey.

VII.1) Please list the seventh activity here. _____

VII.2) Date your child started physical activity #7 _____ (dd/mm/yy)

VII.3) Date your child ended or will end physical activity #7 _____ (dd/mm/yy)

- Optional: feel free to add comments about the start and end dates of physical activity #7 _____

VII.4) How intense is physical activity #7 on average for your child?
- Never sweating and becoming breathless (i.e.: walking)
- Some sweating and becoming breathless (i.e.: jogging)
- Heavy sweating and becoming breathless (i.e.: running)
- Very heavy sweating and becoming breathless (i.e.: fast running)

VII.5) How frequently is your child involved in physical activity #7 on average. How many days/week: _____

VII.6) How frequently is your child involved in physical activity #7 on average. How many months/year: _____

VII.7) How long on average is physical activity #7 for your child each time your child engages in the activity. Provide number in hours. _____

VII.8) How long on average is physical activity #7 for your child each time your child engages in the activity. Provide number in minutes. _____

VII.9) How much do you prioritize physical activity #7 for your child?
- Extremely
- Very
- Moderately
- Slightly
- Not at all

VII.10) How much does your child like doing physical activity #7?

- Extremely
- Very
- Moderately
- Slightly
- Not at all

VII.11) How much do you involve your child in physical activity #7 on a regular basis?

- All the time
- Very much of the time
- Some of the time
- Relatively little time
- Not at all

VII.12) How much do you value having your child be involved in physical activity #7?

- Extremely
- Very
- Moderately
- Slightly
- Not at all

VII.13) How much do you involve physical activity #7 in your child's routine?

- All the time
- Very much of the time
- Some of the time
- Relatively little time
- Not at all

VII.14) How much enjoyment does your child get from engaging in physical activity #7?

- Extreme enjoyment
- Much enjoyment
- Moderate enjoyment
- Slight enjoyment
- No enjoyment

VII.15) How much do you engage your child in physical activity #7 on a recurring basis?

- All the time
- Very much of the time
- Some of the time
- Relatively little time
- Not at all

VII.16) How pleasurable is physical activity #7 for your child?

- Extremely
- Very
- Moderately
- Slightly
- Not at all

VII.17) How important is it for you to have your child be involved in physical activity #7?

- Extremely
- Very
- Moderately
- Slightly

- Not at all

Physical Activity #8

If no eighth activity, please scroll all the way down and move on to next survey.

VIII.1) Please list the eighth activity here. _____

VIII.2) Date your child started physical activity #8 _____ (dd/mm/yy)

VIII.3) Date your child ended or will end physical activity #8 _____ (dd/mm/yy)

- Optional: feel free to add comments about the start and end dates of physical activity #8 _____

VIII.4) How intense is physical activity #8 on average for your child?
- Never sweating and becoming breathless (i.e.: walking)
- Some sweating and becoming breathless (i.e.: jogging)
- Heavy sweating and becoming breathless (i.e.: running)
- Very heavy sweating and becoming breathless (i.e.: fast running)

VIII.5) How frequently is your child involved in physical activity #8 on average. How many days/week: _____

VIII.6) How frequently is your child involved in physical activity #8 on average. How many months/year: _____

VIII.7) How long on average is physical activity #8 for your child each time your child engages in the activity. Provide number in hours. _____

VIII.8) How long on average is physical activity #8 for your child each time your child engages in the activity. Provide number in minutes. _____

VIII.9) How much do you prioritize physical activity #8 for your child?
- Extremely
- Very
- Moderately
- Slightly
- Not at all

VIII.10) How much does your child like doing physical activity #8?
- Extremely
- Very
- Moderately
- Slightly
- Not at all

VIII.11) How much do you involve your child in physical activity #8 on a regular basis?
- All the time
- Very much of the time
- Some of the time
- Relatively little time
- Not at all

VIII.12) How much do you value having your child be involved in physical activity #8?
- Extremely
- Very
- Moderately
- Slightly

- Not at all

VIII.13) How much do you involve physical activity #8 in your child's routine?
- All the time
- Very much of the time
- Some of the time
- Relatively little time
- Not at all

VIII.14) How much enjoyment does your child get from engaging in physical activity #8?
- Extreme enjoyment
- Much enjoyment
- Moderate enjoyment
- Slight enjoyment
- No enjoyment

VIII.15) How much do you engage your child in physical activity #8 on a recurring basis?
- All the time
- Very much of the time
- Some of the time
- Relatively little time
- Not at all

VIII.16) How pleasurable is physical activity #8 for your child?
- Extremely
- Very
- Moderately
- Slightly
- Not at all

VIII.17) How important is it for you to have your child be involved in physical activity #8?
- Extremely
- Very
- Moderately
- Slightly
- Not at all

Physical Activity #9

If no ninth activity, please scroll all the way down and move on to next survey.

IX.1) Please list the ninth activity here. _____

IX.2) Date your child started physical activity #9 _____ (dd/mm/yy)

IX.3) Date your child ended or will end physical activity #9 _____ (dd/mm/yy)

- Optional: feel free to add comments about the start and end dates of physical activity #9 _____

IX.4) How intense is physical activity #9 on average for your child?
- Never sweating and becoming breathless (i.e.: walking)
- Some sweating and becoming breathless (i.e.: jogging)
- Heavy sweating and becoming breathless (i.e.: running)
- Very heavy sweating and becoming breathless (i.e.: fast running)

IX.5) How frequently is your child involved in physical activity #9 on average. How many days/week: _____

IX.6) How frequently is your child involved in physical activity #9 on average. How many months/year: _____

IX.7) How long on average is physical activity #9 for your child each time your child engages in the activity. Provide number in hours. _____

IX.8) How long on average is physical activity #9 for your child each time your child engages in the activity. Provide number in minutes. _____

IX.9) How much do you prioritize physical activity #9 for your child?
- Extremely
- Very
- Moderately
- Slightly
- Not at all

IX.10) How much does your child like doing physical activity #9?
- Extremely
- Very
- Moderately
- Slightly
- Not at all

IX.11) How much do you involve your child in physical activity #9 on a regular basis?
- All the time
- Very much of the time
- Some of the time
- Relatively little time
- Not at all

IX.12) How much do you value having your child be involved in physical activity #9?
- Extremely
- Very
- Moderately
- Slightly
- Not at all

IX.13) How much do you involve physical activity #9 in your child's routine?
- All the time
- Very much of the time
- Some of the time
- Relatively little time
- Not at all

IX.14) How much enjoyment does your child get from engaging in physical activity #9?
- Extreme enjoyment
- Much enjoyment
- Moderate enjoyment
- Slight enjoyment
- No enjoyment

IX.15) How much do you engage your child in physical activity #9 on a recurring basis?
- All the time

- Very much of the time
- Some of the time
- Relatively little time
- Not at all

IX.16) How pleasurable is physical activity #9 for your child?
- Extremely
- Very
- Moderately
- Slightly
- Not at all

IX.17) How important is it for you to have your child be involved in physical activity #9?
- Extremely
- Very
- Moderately
- Slightly
- Not at all

Physical Activity #10

If no tenth activity, please scroll all the way down and move on to next survey.

X.1) Please list the tenth activity here. _____

X.2) Date your child started physical activity #10 _____ (dd/mm/yy)

X.3) Date your child ended or will end physical activity #10 _____ (dd/mm/yy)

- Optional: feel free to add comments about the start and end dates of physical activity #10 _____

X.4) How intense is physical activity #10 on average for your child?
- Never sweating and becoming breathless (i.e.: walking)
- Some sweating and becoming breathless (i.e.: jogging)
- Heavy sweating and becoming breathless (i.e.: running)
- Very heavy sweating and becoming breathless (i.e.: fast running)

X.5) How frequently is your child involved in physical activity #10 on average. How many days/week: _____

X.6) How frequently is your child involved in physical activity #10 on average. How many months/year: _____

X.7) How long on average is physical activity #10 for your child each time your child engages in the activity. Provide number in hours. _____

X.8) How long on average is physical activity #10 for your child each time your child engages in the activity. Provide number in minutes. _____

X.9) How much do you prioritize physical activity #10 for your child?
- Extremely
- Very
- Moderately
- Slightly
- Not at all

X.10) How much does your child like doing physical activity #10?
- Extremely

- Very
- Moderately
- Slightly
- Not at all

X.11) How much do you involve your child in physical activity #10 on a regular basis?

- All the time
- Very much of the time
- Some of the time
- Relatively little time
- Not at all

X.12) How much do you value having your child be involved in physical activity #10?

- Extremely
- Very
- Moderately
- Slightly
- Not at all

X.13) How much do you involve physical activity #10 in your child's routine?

- All the time
- Very much of the time
- Some of the time
- Relatively little time
- Not at all

X.14) How much enjoyment does your child get from engaging in physical activity #10?

- Extreme enjoyment
- Much enjoyment
- Moderate enjoyment
- Slight enjoyment
- No enjoyment

X.15) How much do you engage your child in physical activity #10 on a recurring basis?

- All the time
- Very much of the time
- Some of the time
- Relatively little time
- Not at all

X.16) How pleasurable is physical activity #10 for your child?

- Extremely
- Very
- Moderately
- Slightly
- Not at all

X.17) How important is it for you to have your child be involved in physical activity #10?

- Extremely
- Very
- Moderately
- Slightly
- Not at all

Appendix I

CFIQ

Survey #4

Part 1: Child Information

What region of Alberta do you reside in?

- Calgary Metropolitan Region
- Edmonton Metropolitan Region
- Southern Alberta
- Central Alberta
- Northern Alberta

1. How old is your child? _____(years)

2. What is your child's birth date? _____ (dd/mm/yy)

3. What is your child's gender?
   - ❑ Male
   - ❑ Female

4. Is your child adopted?
   - ❑ Yes. Age at adoption: _____
   - ❑ No, my child is not adopted.

5. Do you have any other children?
   - ❑ Yes. Please write their ages and genders below.

     _____ _____ _____ _____

     _____ _____ _____ _____
   - ❑ No, I do not have any other children.

6. How old was your child when he was first diagnosed with ADHD? _____

7. How old was your child when you first started noticing symptoms of ADHD? _____

8. Currently, is your child taking medication or a combination of medications for ADHD?
   - ☐ No
   - ☐ Yes. Please describe: _____

   A. When was the last time your child took this medication? _____(day)_____(time)
   B. When did your child start taking this medication? _____
   (year/month/day)
   C. How often does your child take this medication? _____

D. What is his daily dosage of the medication (in mg)? (Please remember to total the mgs for all doses taken each day) _____

E. Is your child currently taking a second medication for ADHD?
☐ No (Skip to #8G if applicable and #9 if not)
☐ Yes. Please describe: (name) _____ (dosage) _____
- When was the last time your child took this medication? _____

F. Is your child currently taking a third medication for ADHD?
☐ No (Skip to #8G if applicable and #9 if not)
☐ Yes. Please describe: (name) _____ (dosage) _____
- When was the last time your child took this medication? _____

G. Identify the number that best describes how effective you feel the medication(s) is/are for your child?
1----------2----------3----------4----------5----------6----------7
Very ineffective Very effective

9. Currently, is your child receiving other types of treatments for ADHD?
☐ No
☐ Yes. Please describe: _____

10. In the past, has your child (who is participating in this study) been diagnosed with any disorders, behavior problems, or learning, developmental, or neurological problems other than ADHD?
☐ No
☐ Yes. Please describe: _____

11. Currently, is your child experiencing any disorders, behavior problems, or learning, developmental, or neurological problems other than ADHD?
☐ No
☐ Yes. Please describe: _____

12. In the past, has your child seen a counsellor, psychologist, psychiatrist, or other mental health professional for any reason other than ADHD?
☐ No (Skip to #13)
☐ Yes. Please describe: _____

A. How often did your child see this mental health professional?
☐ A few times ☐ Sometimes
☐ Quite a bit ☐ A lot

B. What was the reason for seeing this mental health professional? _____
_____

13. Currently, does your child see a counsellor, psychologist, psychiatrist, or other mental health professional for any reason other than ADHD?

☐ No (Skip to #14)
☐ Yes. Please describe the treatment: _____

A. How often does your child see this mental health professional?

☐ A few times ☐ Sometimes
☐ Quite a bit ☐ A lot

B. What is the reason for seeing this mental health professional? _____
_____

14. In the past, has your child taken medication for mental health problems for any reason other than ADHD?

☐ No (Skip to #15)
☐ Yes. Please describe: _____

A. When was the last time your child took this medication? _____

B. What is the reason for taking this medication? _____

C. Identify the number that best describes how effective you feel the medication(s) was/were for your child?

1----------2----------3----------4----------5----------6----------7
Very ineffective Very effective

15. Currently, is your child taking medication or a combination of medications for any mental health problems other than ADHD?

☐ No (Skip to #16)
☐ Yes. Please describe: _____

A. When did your child start taking this medication? _____

B. What is the reason for taking this medication? _____

C. Identify the number that best describes how effective you feel the medication(s) is/are for your child?

1----------2----------3----------4----------5----------6----------7
Very ineffective Very effective

16. Currently, are you using any behavior management techniques to help your child's ADHD? (Please check all that apply)

☐ I do not currently use behavior management techniques (SKIP to # 17)
☐ Star Charts or Reward Charts (e.g., stickers for completing chores)
☐ Time out
☐ Loss of privileges (e.g., grounding, no TV)

☐ Praise
☐ Special privileges (e.g., having friends over)
☐ Other (please describe):
_____

A. When did you start using these behavior management techniques?
☐ Less than 1 month ago ☐ 1 to 2 years ago
☐ 1-6 months ago ☐ More than 2 years ago
☐ 6 months to 1 year ago

B. How often would you say you use these techniques?
☐ Rarely (less than once a week)
☐ Occasionally (2 or 3 times a week)
☐ Frequently (daily)

C. Identify the number that best describes how effective you feel these behavior management techniques are for your child?
1----------2----------3----------4----------5----------6----------7
Very ineffective Very effective

17. Has your child ever participated in individual child therapy for his ADHD?
Refers to both current and past types of treatment
☐ No
☐ Yes. How effective was this individual child therapy for your child?
1----------2----------3----------4----------5----------6----------7
Very ineffective Very effective

18. Has your family ever participated in any type of family therapy for your child's ADHD?
Refers to both current and past types of treatment
☐ No
☐ Yes. How effective was this family therapy for your child?
1----------2----------3----------4----------5----------6----------7
Very ineffective Very effective

19. Has your child ever participated in biofeedback or neurofeedback therapy for his ADHD?
Refers to both current and past types of treatment. Biofeedback/Neurofeedback/EEG involves having electrodes attached to the head and responding to certain stimuli while special technology shows the person's brainwave
☐ No
☐ Yes. How effective was this biofeedback or neurofeedback therapy for your child?
1----------2----------3----------4----------5----------6----------7
Very ineffective Very effective

20. Has your child ever received any type of vitamin therapy or naturopathic treatment for his ADHD?

Refers to both current and past types of treatment

☐ No
☐ Yes. How effective was this vitamin or naturopathic therapy for your child?
1----------2----------3----------4----------5----------6----------7
Very ineffective Very effective

21. Have you ever given your child a special diet or supplement to treat his ADHD?
Refers to both current and past types of treatment

☐ No
☐ Yes. How effective was this diet or supplement for your child?
1----------2----------3----------4----------5----------6----------7
Very ineffective Very effective

22. Does your child receive special help at school for his ADHD?
Refers to both current and past types of treatment

☐ No
☐ Yes. How effective is this help for your child?
1----------2----------3----------4----------5----------6----------7
Very ineffective Very effective

23. Has your child received any other form of therapy or treatment to help his ADHD?
Refers to both current and past types of treatment

☐ No
☐ Yes. Please describe: _____
How effective was this therapy?
1----------2----------3----------4----------5----------6----------7
Very ineffective Very effective

Part 2: Parent Information

1. What is your relationship to your child? (check one)
   - ❑ Biological mother/father
   - ❑ Step-mother/step-father
   - ❑ Adoptive mother/father
   - ❑ Other, please explain: _____

2. How old are you? _____(years)

3. How would you describe your ethnicity?
   - ❑ Canadian
   - ❑ First Nations
   - ❑ European-Canadian
   - ❑ European
   - ❑ Hispanic-Canadian

- ❑ Hispanic
- ❑ Asian-Canadian
- ❑ Asian
- ❑ African-Canadian
- ❑ African
- ❑ Indo-Canadian
- ❑ East Indian
- ❑ Jewish
- ❑ Caucasian
- ❑ Other:_____

4. On a scale of 1 to 10, where 1 is not at all, and 10 is completely, how much do you identify yourself as Canadian?

1-------2-------3-------4-------5-------6-------7-------8-------9-------10
Not at all Completely

5. What is your level of education?
   - ❑ Less than grade 7
   - ❑ Junior high school
   - ❑ Partial high school (grade 10 or 11)
   - ❑ High school graduate
   - ❑ Partial college/university (min. 1 year) or special training
   - ❑ Standard college or university graduate (i.e., B.A., B.Ed.)
   - ❑ Graduate or professional training (i.e., M.A., PhD.)

6. Are you currently employed?
   - ❑ Yes. What is your occupation? _____
   - ❑ No. What is your occupation during periods of employment? _____

7. Please check your household income category (before taxes) for this past year:
   - ❑ Less than $5 000
   - ❑ $5 000-$19 999
   - ❑ $20 000-$34 999
   - ❑ $35 000-$49 999
   - ❑ $50 000-$74 999
   - ❑ $75 000-$99 999
   - ❑ $100 000-$149 999
   - ❑ $150 000-$199 999
   - ❑ $200 000 and higher

8. What is your marital status? (check one)
   - ❑ Married or common law

- ❑ Divorced or separated
- ❑ Widowed
- ❑ Single

9. In the past, were you ever diagnosed with a psychological disorder?
   - ❑ No (Skip to #10)
   - ❑ Yes.
     A. What psychological disorder(s): _____
     B. Were you ever treated for it?
        - ❑ No
        - ❑ Yes: What treatments? _____

10. In the past, were you ever diagnosed with Attention-Deficit/Hyperactivity Disorder (ADHD)?
   - ❑ No (Skip to #11)
   - ❑ Yes
     A. How old were you when you were first diagnosed? _____ (years)
     B. Were you ever treated for it?
        - ❑ No
        - ❑ Yes: What treatments? _____

11. Currently, do you experience ADHD or any other psychological disorder?
   - ❑ No (Skip to #12)
   - ❑ Yes.
     A. What psychological disorder(s): _____
     B. Are you being treated for it?
        - ❑ No
        - ❑ Yes: What treatments? _____

12. As an adult, have you seen a counsellor, psychologist, or psychiatrist for any reason?
   - ☐ No (Skip to #13)
   - ☐ Yes
     A. Please describe if different from answers to Question 9B, 10B or 11B: _____
     B. How many times have you seen this counsellor, psychologist, or psychiatrist?
        - ☐ A few times
        - ☐ Sometimes
        - ☐ Quite a bit
        - ☐ A lot

13. As an adult, have you taken any medications for mental health problems?
   - ☐ No (Skip to #14)
   - ☐ Yes
     A. Please describe if different from answers to Question 9B, 10B or 11B: _____
     B. How many times do you take this medication?

☐ A few times ☐ Sometimes
☐ Quite a bit ☐ A lot

14. Is there anyone in your immediate family (e.g., parents, brothers, or sisters) who you think may have, or may have had ADHD, whether or not they were ever diagnosed or treated?

☐ No
☐ Yes. Who? _____