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Summer Treatment Program for ADHD and ASD: The Role of Physical Activity, Sleep and Inhibitory Control

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Summer Treatment Program for ADHD and ASD: The Role of Physical Activity, Sleep and Inhibitory Control

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Dedication

I dedicate this manuscript first and foremost to my parents, without whom my success would have been impossible. Your constant and unfailing support allowed me to make this dream a reality. To Spencer, your patience and tenacity kept me grounded and motivated, thank you for being my rock. To my friends and your endless cheerleading. To Dr. David G. Stewart, for giving me the room to deviate from the plan. Finally, and most importantly, to my son, thank you for helping me endure.

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Abstract

Erin G. Underbrink

184 words

The purpose of this study was to identify pathways that lead to improved behavioral outcomes in children with symptoms of Autism Spectrum Disorder (ASD), Attention Deficit Hyperactivity Disorder (ADHD), and/or related social and behavioral difficulties. Specifically, this study sought to understand the relationship between physical activity, sleep, and inhibitory control and their impact on behavior in children participating in a Summer Treatment Program. This research analyzed the potential mediating effect of sleep and inhibitory control between physical activity and behavioral outcomes. This research examined the separate mediation models, as well as the overall serial mediation model, to inclusively examine the factors that may lead to behavioral improvement. Between-subjects results indicated that increased physical activity was associated with increased positive behavior through improved sleep and increased inhibitory control (R = 0.791, $F(3, 15) = 8.41$, $p < 0.001$). Additionally, within-subjects results suggest increased physical activity significantly predicts improvements in inhibitory control, which in turn predicted increased positive behaviors ($R = 0.48$, $F(2, 71) = 10.71$, $p < 0.0001$). Results highlight the importance of physical activity as a component of treatment for children with ADHD and/or ASD.

CHAPTER I

Introduction and Review of Literature

Purpose

The purpose of this study was to identify pathways that lead to improved behavioral outcomes in children with symptoms of Autism Spectrum Disorder (ASD), Attention Deficit Hyperactivity Disorder (ADHD), and/or related social and behavioral difficulties. Specifically, this study sought to understand the relationship between physical activity, sleep, and inhibitory control and their impact on behavior in children over the duration of a Summer Treatment Program. Although previous literature has examined direct associations between these factors, little research has examined these constructs within an overarching model examining mechanisms of improved behavior. The aim of the current study was to examine the acute effect of physical activity on behavior., and to analyzed the potential mediating effect of sleep and inhibitory control on physical activity and behavioral outcomes. This research examined the separate mediation models, as well as the overall serial mediation model, to inclusively examine the factors that may lead to behavioral improvement. Further, this research investigated the positive impact of physical activity on sleep, inhibitory control and behavioral and diagnostic outcomes for children within the context of a summer treatment program.

Introduction

Attention deficit hyperactivity disorder (ADHD) and autism spectrum disorder (ASD) are common neurodevelopmental disorders that begin in childhood (APA, 2013). According to the Diagnostic and Statistical Manual of Mental Disorders (DSM-5; American Psychiatric Association [APA], 2013) these disorders often share common symptoms; Children who have ASD might also have symptoms of ADHD and vice versa (APA, 2013). Further, both children

with ASD and those with ADHD display impairments in social and academic functioning. Additionally, because ADHD and ASD have similar genetic components, they often occur in the same families; children with ASD or ADHD have an increased likelihood of having a sibling with a similar diagnosis (Rommelse, Franke, Geurts, Hartman, & Buitelaar, 2010).

Children with ADHD display deficits in components of executive functioning including response inhibition and cognitive flexibility (Larson, Russ, Kahn & Halfon, 2011). Similarly, studies have shown children with ASD have greater difficulty with cognitive inhibition and flexibility than typically developing peers (Hill, 2006). ADHD has also been linked with difficulties in peer relationships, specifically due to poor social skills and problematic boundaries (Macintosh & Dissanayake, 2006). In addition, impairments in social communication and interactions which are characteristic of ASD often lead to difficulty initiating and maintaining peer relationships. Overall, ASD or ADHD are both associated with social impairments, behavioral and affective dysregulation, as well as academic and familial difficulties. Thus, interventions designed to target not just primary symptoms, but associated problems are essential to adequately treat children within this population.

Treatment for ADHD often include stimulant medication and/or behavioral training (MTA Cooperative Group, 2004). Similarly, treatment for ASD often involves intensive behavioral treatment, such as Applied Behavior Analysis (ABA therapy), and social skills interventions (Virués-Ortega, 2010; Reichow & Volkmar, 2010). However, interventions utilizing treatments such as skills training, sports related treatments, and behavioral reinforcement treatments have also been used (Hupp, Reitman, Northup, O'Callaghan, & LeBlanc, 2002; Verret, Guay, Berthiaume, Gardiner, & Beliveau, 2012; Yanardag, Yilmaz, & Aras, 2010). Multimodal treatment is often recommended, but difficult to obtain. One exception

is the summer treatment programs (STPs) model, which often implement a combination of these strategies to provide an effective treatment intervention (Pelham & Hoza, 1996). STPs are clinical interventions in the form of summer day camps that include behavioral reinforcement and skills training to target symptoms of ADHD and/or ASD. STPs have been used to treat both ADHD and ASD (Walker, Barry, & Bader, 2010). Further, treatment within a STP often includes components of physical activity sports training, behavioral management strategies, and peer social skills (Brookman et al., 2003; Chronis et al., 2004; Pelham & Hoza, 1996; Walker, Barry, & Bader, 2010).

In addition to behavioral and cognitive symptoms, children with ADHD often display significant difficulties with sleep compared to typically developing children (Cortese et al., 2013; Dagan et al., 1997; Paavonen et al., 2009; Stein, 2009). Similar results have been found for children with ASD (Krakowiak, Goodlin-Jones, Hertz-Picciotto, Croen, & Hansen, 2008). Further, literature suggests sleep difficulties may be associated with greater behavioral and symptomatic problems (Sung et al., 2008; Stein et al., 2001). A separate line of research has investigated the impact of physical activity on inhibitory control or response inhibition, effortful control and behavioral and emotional self-regulation (Berwid & Halperin, 2012; Best, 2010; Chang, Lui, Yu & Lee, 2012; Grassmann et al., 2014; Schneider et al., 2006;) as well as overall ADHD symptoms (Smith et al., 2013) and ASD symptoms (Sowa & Meulenbroek, 2012).

Research examining treatment outcomes for children with either ADHD or ASD are often studies separately, as they differences in core symptoms. For example, inattention and/or hyperactivity are often core symptoms of ADHD, while social impairments are often core symptoms of ASD. There are also notable comorbidities between the two disorders (Leitner, 2014). Additionally, children with ASD often struggle with primary ADHD symptoms, including

inattention or hyperactivity (Sinzig, Morsch, Bruning, Schmidt, & Lehmkuhl, 2008). Similarly, social difficulties and other common factors of ASD are often associated with primary symptoms for children with ADHD (Clark, Feehan, Tinline, & Vostanis, 1999). The high rate of comorbidity in disorder and symptoms lends to overlap in common treatment targets for this population, including neurocognitive functioning, general behavior problems, and family and peer relational functioning. Interventions often include similar techniques, including behavior management, positive reinforcement and social skills training. Further, children with ADHD and children with ASD are commonly placed in similar settings, such as special education classrooms, school groups, or treatment groups, as well as frequently occurring in the same families. It is important to examine ways to treat common symptoms and impairments. Therefore, although ADHD and ASD are separate neurodevelopmental disorders, it is conceivable to treat children with these disorders in a combined setting, such as classroom or a Summer Treatment Program.

Sleep problems are common in both ADHD and ASD, along with specific treatments targeting sleep hygiene, such as cognitive behavioral therapy for insomnia (Etinger et al., 2001), physical activity has also been connected with improvements in sleep for typically developing children (Pesonen et al., 2011) and children with neurodevelopmental disorders such as ASD (Wachob & Lorenzi, 2015). Additionally, physical activity and sleep have both been linked with improvements in components of executive functioning including inhibitory control (Oriel et al., 2014). However, research is lacking on the link between increased physical activity and improved sleep in children with ADHD. Therefore, STPs utilizing behavior management and physical activity treatments are supported in treating key diagnostic symptoms of both ASD and ADHD, as well as other behavioral and social impairments commonly related to these diagnoses.

This study explored the relationship between physical activity, both in acute periods and ongoing, and behavioral outcomes. This research is crucial in understanding the impact of both brief physical activity periods, and overall increases in physical activity on behavioral outcomes in children with ADHD and/or ASD. The current study will investigate the use of physical activity as a mode of treatment for children, both at home and in school. The following sections provide an overview of current research and definitions of both ADHD and ASD, including common behavioral and diagnostic symptoms, physical activity, sleep and inhibitory control within these populations.

Neurodevelopmental Disorders

ADHD is a neurobehavioral disorder characterized by ongoing inattention and/or hyperactivity, as well as related symptoms that negatively impact functioning in multiple domains, including home and school (APA, 2013). In an article examining the trends of ADHD in children, Visser and colleagues reported that by 2011 more than 1 in 10 school-aged children have been diagnosed with ADHD (Visser et al., 2014). Diagnoses of ADHD by a primary healthcare provider have increased by 42% between 2003 and 2011. Further, reports indicated a significant treatment gap; approximately 17% of children with an ADHD diagnosis in 2011 were reported as not receiving pharmacological or behavioral treatment for ADHD (Visser et al., 2014). ADHD is often described as a disruptive behavior disorder characterized by inattention and/or hyperactivity and impulsivity (APA, 2013). This disorder was originally described as "attention deficit disorder" and has since been revised to attention deficit hyperactivity disorder, predominately inattentive, predominately hyperactive/impulsive, or combined type (APA, 2013). Etiology of ADHD is unknown, although much research suggests a combination of environmental and genetic factors lead to ADHD (Thapar, Langley, Asherson, & Gill, 2007). For

example, prenatal factors, low birth weight, and environmental exposure are linked with a greater risk of ADHD (Nigg, & Breslau, 2007; Mick, Biederman, Prince, Fischer, & Faraone, 2002; Knopik, 2005; Banerjee, Middleton, & Faraone, 2007).

Autism Spectrum Disorder describes a neurodevelopmental disorder with core features of impairment in reciprocal social communication, social interaction, and restricted or repetitive behaviors and interests (APA, 2013). Approximately 1 in 68 children aged 8-years-old have a diagnosis of ASD in 2012 (Christensen, 2016). Most children show signs and symptoms of ASD by age 2, and receive a diagnosis by age 4 (Kozlowski, Matson, Horovitz, Worley, & Neal, 2011; Lord et al., 2006). Similar to ADHD, research suggests both genetic and environmental factors combine to increase the risk of ASD (Hallmayer et al., 2011; Hertz-Picciotto, Croen, Hansen, Jones, van de Water, & Pessah, 2006). Environmental chemicals and maternal age have been associated with increased risk of developing ASD as well (Newschaffer, et al., 2007; Shelton, Tancredi, & Hertz-Picciotto, 2010). Finally, family history of similar developmental disorders has been linked with increased risk for both ADHD and ASD (Ronald & Hoekstra, 2011; APA, 2013; Larsson, Chang, D'Onofrio, & Lichtenstein, 2014).

Research often examines treatment outcomes as improvements in the core domains of diagnosis, such as impairment in academic, familial, social and behavioral contexts. While behavioral dysregulation is a key feature of ADHD, it is also associated with ASD. Children with both ASD and ADHD often experience difficulty with task completion, compliance, and components of adaptive functioning, including basic life skills. Similarly, peer and relational problems are not only a basic feature of ASD, but also commonly associated with ADHD. As such, social skills and peer relationships are often a primary target in ADHD and ASD interventions. The current study will seek to examine changes in behavior including compliance,

sharing, negative social behaviors such as name calling, refusal, and interrupting. These behavioral symptoms are often associated with key diagnostic features of ADHD and ASD. More specific diagnostic symptoms include impulsivity or inattention, rigidity, an inability to recognize and interpret social cues, and repetitive behaviors. There is substantial research attempting to develop best treatment strategies for both ADHD and ASD. Research suggests a mixture of pharmacological and behavioral treatment as the most effective for individuals with ADHD (MTA, 2004). However, there is increasing interest in examining the effects of additional treatment strategies, such as physical activity and sleep training (Mura, 2015; Chennaoui, Arnal, Sauvet & Leger, 2015). Similarly, interventions targeting components of executive functioning, including inhibitory control and self-regulation, have recently gained attention (Diamond, 2015). Given the recent interest in these constructs, it is important to summarize current literature and theory on physical activity, sleep, and inhibitory control interventions in treatment for children with ADHD and/or ASD.

Physical Activity

Physical Activity Overview

Physical activity can be described as aerobic activity, muscle strengthening, and/or bone strengthening activities (Center for Disease Control and Prevention [CDC], 2015)).). According to the Center for Disease Control and Prevention, children ages 6 to 17 should have at least 60 minutes of physical activity each day (CDC, 2015). Physical activity is often described by intensity: either moderate-intensity or vigorous intensity (CDC, 2015). In a systematic review, Janssen and LeBlanc (2010) showed that children should have up to several hours of moderate intensity physical activity daily, and that more vigorous intensity activities should be incorporated when possible. The authors found significant benefits from all intensity levels, and

increased benefits with vigorous-intensity activities. Literature is mixed on the exact recommended duration and intensity level, but several authors suggest that any time or level of activity can be beneficial (Mura, 2015). Benefits were shown for various physiological health outcomes, as well as psychological outcomes such as depression (Janssen & LeBlanc, 2010). Moderate intensity physical activities can include leisure biking, walking, rollerblading, or hiking. Vigorous intensity might include more active games, such as running, tag or similar chasing games, jump rope, and structured sports, including basketball and soccer (CDC, 2015). Research suggests physical activity leading to a host of physical and mental health benefits for children (Stensel, Gorely, & Biddle, 2008). Although substantial literature supports these claims concerning the benefits of physical activity, there are different theories behind the pathways of such benefits. Different methods of physical activity might have distinct physiological, cognitive, and social benefits that lead to positive outcomes. Physical activity has been associated with benefits in physiological components, such as brain volume matter and neural growth, functioning, and development (Smith et al., 2013; Best, 2010; Berwid & Halperin, 2012), as well as immune and heart health (Penedo & Dahn, 2005). Authors argue these physiological benefits might be the causal link between activity and related outcomes. Other research suggests physical activity has direct positive impacts on cognitive functioning, specifically on executive and inhibitory control (Smith et al., 2013). Physical activity interventions often argue that effects might be due to a combination of social, cognitive, and physical benefits (Best, 2010). Smith and colleagues argued that neural growth and cognitive functioning might be positively impacted by improved physical fitness following physical activity, which could all interact to significantly impact symptoms of ADHD (Smith et al., 2013). 2013).

Although it is clear there are primary behavioral, physical and cognitive impacts of physical activity, there is no clear proposal for frequency, intensity or duration (Neudecker, Reimers, Mewes, & Woll, 2015). As stated above, there are benefits for the differing levels of intensity of physical activity, although the frequency is still widely debated (CDC, 2015). There are two clear experimental designs commonly used within physical activity interventions: acute physical exercise, and chronic or long-term exercise. Acute physical activity, or single, short term sessions of physical activity, may lead to immediate benefits on cognitive functioning (Best 2010). Chronic, habitual physical activity has been shown to improve physiological functioning which might lead to a more lasting positive effect on cognition and executive functioning (Best, 2010). There is substantial research on the effects of both acute and chronic physical activity (Neudecker et al., 2015).) however, there is still a debate over the most effective intervention strategies for children with childhood disorders. Further, it may be difficult to design a physical activity intervention that will maintain attention and participation for children in special populations such as those with ADHD and/ or ASD (Neudecker et al., 2015). Interventions that follow strategies similar to those previously used may add to generalizability of effects of physical activity in children of this population. As such, it is increasingly important that research examine physical activity interventions and related outcomes in order to understand the best protocols for optimal treatment effects on physiological, cognitive, social, and behavioral outcomes for children with ADHD or ASD. The current study will follow this recommendation by examining changes in outcomes over a long-term, 5-week physical activity intervention, as well as cognitive and behavioral performance immediately following an acute physical activity intervention.

Physical Activity Treatment for ADHD and ASD

Common treatments for ADHD and ASD often utilize a combination of medication and behavioral training, along with parent training (MTA, 2004). In addition to treatments targeting specific diagnostic symptoms, treatments should attempt to improve skills and symptoms related to the diagnosis. These include other behavioral, cognitive and social impairments, and motor deficits (Clark et al., 2006; Koenig et al., 2010). Emerging research has begun to show that interventions containing deliberate, structured physical activity may have positive effects on motor, cognitive, behavioral, and social deficits (Smith et al., 2013). Smith and colleagues designed a pilot physical activity intervention for children in kindergarten through third grade. Results showed that participants displayed significant improvements in the symptoms associated with ADHD over the course of the intervention (Smith et al., 2013). This treatment study utilized moderate to vigorous physical activity, such as skipping, running, hopping and crab walking. Other research has focused on the effects of acute physical activity, or the effects immediately following a single physical activity session. Results suggest single sessions of moderate intensity physical activity show improvements on cognitive control and executive functioning (Hillman et al., 2009; Berwid & Halperin, 2012), social behavior (Kamp, Sperlich, & Holberg, 2014), and attention (Hillman et al., 2009). Further, single session exercise was shown to improve attention regardless of medication status (Medina et al., 2010). In a systematic review, Kamp and colleagues (2014) determined that all types of exercises used in research showed reductions in ADHD symptoms. Specifically, cooperation games, walking, aerobic exercise, jump rope, and ball games were all shown to have positive impacts on symptoms of ADHD.

Physical activity has also been used as an adjunctive? treatment for ASD. While traditional treatment for ASD often targets improving cognition, language, and social development and reducing maladaptive behavior patterns (Koenig, 2010), research has also

supported the use of physical activity as an additional treatment. Physical activity is associated with reduced maladaptive or stereotypic behavioral patterns core to ASD (Lancioni & O'Reilly, 1998; Elliot, Dobbin, Rose, Soper, 1994). Further, physical activity interventions have been linked with improvements in social skills, communication and affective and behavioral problems for children with ASD (Elliot Dobbin Rose Soper 1994). In a meta-analysis, Sowa and Meulenbroek (2014) found that activities including jogging, biking, walking, and other physical games showed improvements on the core symptoms of ASD as well as attention. It is clear significant research supports the use of physical activity within treatment interventions for children with ADHD and ASD. However, it is important to analyze the efficacy of physical activity for these children in different contexts, as well as examine the effects of physical activity on other factors, such as sleep, that may further increase functioning.

Sleep

Children with ADHD and ASD also often display sleep problems, such as snoring, daytime tiredness, and excessive time required to fall asleep (Stein, Mendelsohn, Obermeyer, Amromin, & Benca, 2001). Specifically, children with ADHD are reported as having significantly longer sleep onset latency than typically developing peers (Hvolby, Jorgensen, & Billenberg, 2008; Weiss, Wasdell, Bomben, Rea, & Freeman, 2006; Cortese, Faraone, Konofal, & Lecendreux, 2009). Recent literature has suggested sleep difficulties might be associated with combined or hyperactive subtypes of ADHD more than inattentive types (Mayes et al., 2009). Similar outcomes have been found with ASD. Considerable sleep problems were found in children with ASD when compared to typically developing peers (Souders et al., 2009). Further, impairments in sleep are associated with negative effects on cognitive and daily functioning in many areas, including memory and attention. These negative effects may further exacerbate

impairments already associated with ASD (Souders et al., 2009). In a study of children with ASD, parental and self-reports suggested children who were good sleepers had fewer affective problems and better social interactions than poor sleepers with ASD (Malow et al., 2006). Substantial research suggesting impairments in sleep to be a common problem for children with ADHD and ASD outline the importance of targeting questions about sleep in the diagnostic and evaluative process.

Impairments in sleep have consistently been found as important focal points in assessment and treatment. However, accurate assessment of child sleep functioning is difficult to obtain. Much of the literature suggests parental measures may not precisely evaluate childhood sleep (Wiggs, Montgomery, & Stores, 2005). Parents of children with ADHD often report significantly more sleep difficulties in their children than parents of typically developing peers (Corkum, Tannock, Moldofsky, Hogg-Johnson & Humphries, 2001). When sleep was tracked using actigraphy, or objective movement monitor watches, parent reported difficulties were often not corroborated (Corkum et al., 2001; Hvolby, Jorgensen, & Bilenberg, 2008). One theory suggests behavioral components of ADHD, including bedtime resistance and defiance might lead to perceived sleep difficulties (Corkum et al., 2001). Similarly, sleep hygiene has been shown to have positive effects on sleep, suggesting child behavior before bed plays to some role in initial sleep onset difficulties (Weiss et al., 2006). In contrast, Owens and colleagues suggest that children and parents with ADHD both reported significantly higher child sleep difficulties The authors found stronger correlations between parents and children with ADHD than control group parent-child dyads, suggesting a true perceived impairment in sleep for families of children with ADHD (Owens, Maxim, Nobile, McGuinn, & Msall, 2000). It is clear that children with both ADHD and ASD showed self, parental, and objective reports of sleep difficulties. Such

impairments in sleep can worsen behavioral, cognitive, and social deficits common with ADHD and ASD. Research also suggests difficulties in sleep are associated with greater parental stress and family discord (Souders et al., 2009; Sung, Hiscock, Sciberras, & Efron, 2008), which can in turn lead to worsened outcomes and greater difficulty managing symptoms. Due to these added detriments, sleep has become increasingly popular as a target for treatment and intervention.

Interventions for sleep in children commonly include supplemental treatment in the form of melatonin, as well as specific behavioral interventions. Melatonin has been shown to be an effective means of treatment for children with ADHD experiencing chronic sleep onset latency (der Heijden et al., 2007; Weiss et al., 2006). Behavior sleep hygiene has also been shown to be effective (Weiss et al., 2006). In a meta-analysis on treatment of ASD, Weaver argued research is significantly lacking on successful interventions for individuals with ASD (Weaver, 2015). Recent literature has since addressed the possible effects of physical activity on sleep in children with ADHD or ASD. Physical activity is associated with greater quality of sleep in typically developing children (Foti, Eaton, Lowry, & McKnight-Ely, 2011). Further, research suggests daytime physical activity to be associated with better sleep quality and affective outcomes the following morning (Kulman et al., 1999). Wachob and Lorenzi (2015) determined in a brief intervention that physical activity levels were significantly related to sleep patterns in children ages 9-16 with ASD. Specifically, greater levels of physical activity were associated with higher quality of sleep. This preliminary research suggests the possibility of utilizing physical activity as a target of intervention for improving sleep in typically developing children and children with ADHD or ASD. In addition to physical activity and sleep, inhibitory control has also been linked with improved outcomes.

Inhibitory Control

Along with primary symptoms of childhood disorders, children with ADHD and/or ASD often show significant difficulties with executive functioning. Executive functioning refers to goal oriented control behaviors of the prefrontal cortex (Best, Miller, & Jones, 2009). Deficits in executive functioning are highly associated with both ADHD and ASD. Specifically, children with these childhood disorders often have deficits in inhibitory control. Inhibitory control is defined as the capability to plan and anticipate future action while suppressing inappropriate responses (Best, Miller, & Jones, 2009). For children, inhibitory control is often expressed in the ability to stop a planned or immediate reaction, such as an impulse to blurt out the answer. Further, research suggests an association between impulsivity and inhibitory control, such that impulsive actions may be explained in part by a deficit in inhibitory control (Logan, Schachar, & Tannock, 1997). Children with ADHD and ASD often have greater impulsivity and impairment in inhibitory control relative to typically developing children (Christ, Holt, White & Green, 2007; Schacher, Tannock & Logan, 1993). Because inhibitory control is a primary difficulty for children with ADHD and/or ASD, it is an important target for intervention.

Previous research has suggested the efficacy of several treatments for improving executive functioning in children including some computer training programs, physical activity or aerobic exercise, mindfulness, and specific classroom curricula (Diamond & Lee, 2011). However, computer programs were shown to be limited in their effect on inhibitory control. In contrast, physical activity has been suggested as a possible effective treatment for children in this population. In a meta-analysis, Sibley and Etnier (2003) examined initial studies analyzing physical activity and subsequent impacts on cognitive functioning. They determined physical activity to be an important piece in cognitive development. Since then, research has continued to

seek answers as to whether components of cognitive functioning, such as inhibitory control are positively impacted by physical activity. Preliminary studies suggest physical activity to be associated with improvements in inhibitory control and attention (Chang, Lui, Yu & Lee, 2012). Gapin and colleagues argued the benefits of physical activity might be greater for children with original challenges to cognitive functioning (2011), which suggests this may also be true for children with ASD or ADHD, who often experience deficits in cognitive functioning. Similar research supports the theory that children with lower inhibitory control functioning may benefit the most from physical activity (Drollette, et al., 2014). One theory of the impact of physical activity argues it is the stimulation of neural functioning that leads to increases in executive functioning such as inhibitory control (Best, 2010). Others argue cognitive engagement inherent in physical activity might be the cause of greater cognitive functioning (Sibley & Etnier, 2003; Best, 2010). Further, physical activity for children is often performed in team sport contexts, requiring group cooperation and social attention, which might lead to increases in cognitive functioning (Best, 2010). Banich (2009) argued similarly that cognitive skills utilized within physical activity are responsible for increases in executive functioning.

Physical activity, both acute and chronic, is associated with improvements in effortful and inhibitory control (Campbell, 2002; Smith et al., 2013; Schneider et al., 2006). Children who participate in regular, ongoing physical activity might have increased development of executive functioning (Campbell, 2002; Hillman et al., 2014). Chronic, or long term physical exercise has been shown to increase inhibitory control and overall cognitive function (Verret, Guay, Berthiaume, Gardiner, & Beliveau, 2010; Vysniauske, Verburgh, Oosterlaan, & Molendijk, 2016). Similarly, acute bursts of physical activity have also been shown to increase cognitive functioning immediately following such activity (Grassman et al., 2014). Research in

this field has consistently concluded physical activity to be associated with immediate improvements in cognitive functioning, as well as improvements over time. This research further implies the possibility of physical activity as a way to improve cognitive functioning, including inhibitory control, which may in turn lead to decreases in behavioral problems and difficulties common within childhood disorders, including ADHD and/or ASD.

In addition to physical activity, sleep has been consistently associated with inhibitory control. Impairments in sleep have been shown to result in presence or exacerbation of the core symptoms of ADHD, including inattention, impulsivity, hyperactivity, and distractibility (O'Brien, 2009). Sleep-disordered breathing has been consistently associated with impairments in executive functioning (Rosen et al., 2002; Gottlieb et al., 2004). Specifically, impairments in inhibitory control have been linked with disrupted sleep. Given the robust literature supporting an association between problematic sleep and impairments in executive functioning, including inhibitory control, improving sleep may be an important intervention. Sadeh and colleagues (2002) found children improved on neurobehavioral tasks and showed fewer behavioral problems when they had better sleep. Additionally, when children and adolescents had better sleep quality, they showed improved performance in school (Dewald, Meijer, Oort, Kerkhof, & Bogels, 2010). It is plausible that improvements in sleep may lead to greater executive functioning capabilities and improved inhibitory control. However, there are still many questions to be answered in regards to the specific associations between inadequate sleep and inhibitory control (Beebe, 2011). Conducting research in children with neurodevelopmental disorders can further support the importance and efficacy of addressing sleep as a component of treatment.

Intervention: Summer Treatment Programs

As research has demonstrated, physical activity is an important variable in treating children with ADHD and ASD. Further, sleep and inhibitory control are also useful components to include within treatment interventions. Summer Treatment Programs (STPs) are highly useful and supported models of treatment through which these factors can be addressed. Vast research has supported the efficacy of STPs for reducing behavioral and core diagnostic symptoms for children with ADHD (Chronis et al., 2004; Pelham, 1996; Pelham et al., 2000; Sibley, Smith, Evans, Pelham, & Gnagy, 2012). STPs often utilize sports based peer interactions, physical activity components, social skills building, and structured behavioral management techniques (Pelham, 1996). Additionally, children with both ADHD and ASD benefit from STP interventions across several domains, including social, behavioral, academic, and cognitive skills. For these children, treatment delivered within socially relevant contexts is suggested to have better social outcomes (Bellini et al., 2007). Similar skills, including language ability, prosocial behavior, and reduction of problem behavior, have been associated with STPs (Banet et al., 2008). Children with ASD who participated in an STP show significant improvements in behavioral outcomes (Lopata, Thomeer, Volker, Nida, & Lee, 2008) and diagnostic symptoms including social difficulties (Brookman et al., 2003; Walker, Barry, & Bader, 2010) following STPs. Walker and colleagues (2010) found both parents and therapists perceived improvements in social and behavioral skills following an STP for children with ASD. This research underlies the efficacy of STPs as positive modes of treatment for children with ADHD or ASD.

Current Study: Proposed Model

While previous literature has shown a positive effect of physical activity on behavioral outcomes, as well as individual effects of sleep and inhibitory control on behavior, few studies

have analyzed this model as a whole. Specifically, little has been done analyzing a pathway between physical activity and positive behavioral outcomes through increased sleep and inhibitory control within children with ADHD and/or ASD symptoms. Therefore, the current research analyzed these variables within an intervention study. For the current study, the independent variable was amount or dose of physical activity determined by intervention week, A or B. A weeks were weeks with more physical activity, B weeks were more sedentary control weeks. Additionally, physical activity was analyzed using overall activity levels. The dependent variable of behavioral outcomes was defined as the presence of positive behavior and negative behavior and the daily ratio of points earned for each.

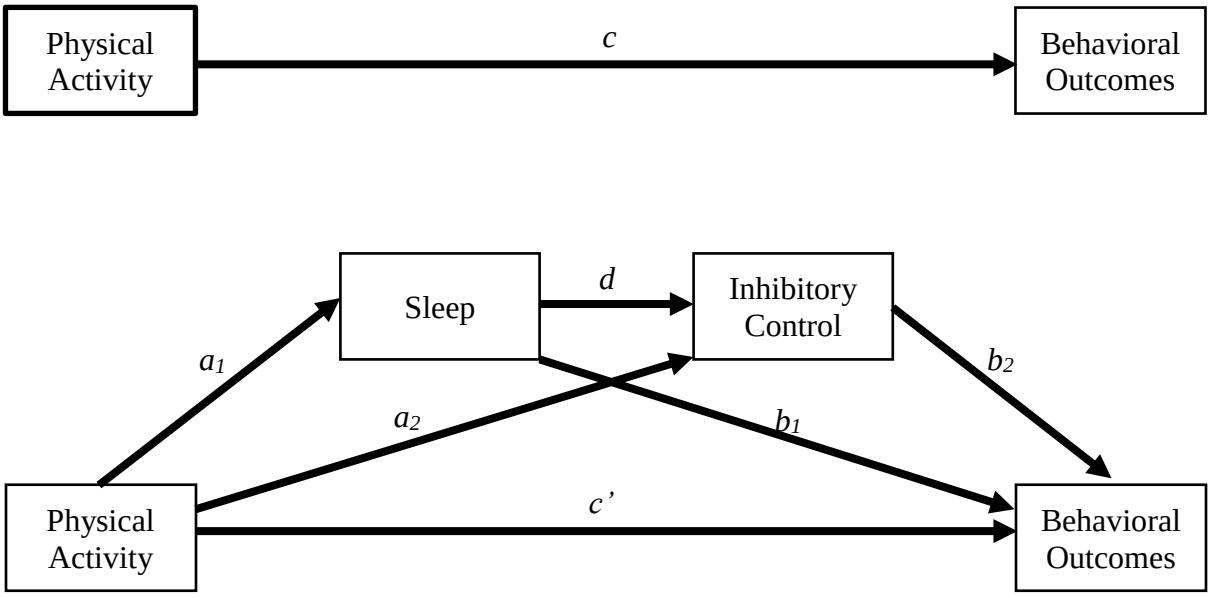
The current study first sought to investigate the direct relationship between physical activity and behavior in a sample of children ages 6:0 through 11:11 participating in a STP. Next, this study sought to clarify whether physical activity leads to improved sleep. Third, I investigated whether increased physical activity leads to improved inhibitory control. Then I examined the separate mediating effects of sleep and inhibitory control; whether physical activity leads to improved behavior through improved sleep, and whether physical activity leads to improved behavior through improved inhibitory control. Finally, this study sought to clarify whether physical activity leads to improved behavior through a serial mediation of improvements in sleep and inhibitory control. The model was examined as a serial mediation model because we hypothesize that sleep and inhibitory control will be positively correlated; this model is depicted in Figure 1. Below is a list of hypotheses.

Hypotheses

1. Increased physical activity will lead to improvements in behavior for children with ADHD and/or ASD symptoms. Specifically, I hypothesized during weeks children are more active, they will have better behavior. Comparisons were measured by analyzing the difference between weeks in the A (active) condition and weeks in the (B) less active condition. I also analyzed the impact of physical activity through ActiGraph data, comparing weeks of higher activity versus weeks of lower activity.
2. Physical activity will be positively associated with improved sleep, as measured by objective data of increased sleep efficiency, quality and quantity. Specifically, higher levels of physical activity were hypothesized to be associated with improved sleep efficiency above lower levels of physical activity.
3. Physical activity will be positively associated with inhibitory control, such that increased periods of physical activity will lead to improved inhibitory control. Weeks in the physical activity intervention were expected to be associated with greater inhibitory control, and overall higher levels of physical activity were expected to be associated with improved inhibitory control.
4. I hypothesized improved sleep efficiency will mediate the relationship between physical activity and behavior such that increased physical activity will lead to improved behavior through improved sleep. Behavior will be measured by examining overall positive behavior and a ratio between positive behavior and negative behavior.
5. Inhibitory control was hypothesized to mediate the relationship between physical activity and improved behavior. Increased physical activity will lead to improvements in behavior though improvements in inhibitory control.

6. Finally, I examined the effect of these constructs within a greater serial mediation model. Specifically, improved sleep and inhibitory control was hypothesized to mediate the relationship between physical activity and behavior such that increased physical activity will lead to improved behavior through improved sleep and inhibitory control.
7. These hypotheses were tested for each diagnosis, ADHD and ASD, separately in order to determine whether the relationships exist for both diagnoses independently.

Figure 1. Serial mediation model



CHAPTER II

Method

Participants

The proposed study occurred within the context of a larger study examining the effects of a Summer Treatment Program, Apex Camp and the SeaStar Program at Apex, for children with Attention Deficit Hyperactivity Disorder (ADHD) and/or Autism Spectrum Disorder (ASD). To determine adequate sample size for the current study, an a priori power analysis was conducting

using the statistical software G*Power, using a multiple regression design (Faul, Erdfelder, Buchner, & Lang, 2009). Three variables were initially entered as predictors: exercise condition, sleep efficiency and inhibitory control. As such, the power analysis was conducted again using all three variables as predictors. A conventional Cohen's effect size of $f^2 = .35$ was selected. A power level of 0.95 was chosen to increase expected sample size, reducing the risk of Type I error. With alpha level set at $\alpha = .05$ and power level at 0.95, a minimum of 54 participants would be necessary in order for the analyses to be adequately powered. Total analyses included a sample size of 74 children ages six to twelve in the greater Seattle area participating in Apex Camp/SeaStar Program, ranging in age from 6 to 11:11 (M = 8.4, SD = 1.57), and were primarily male (82%). A subsample was also analyzed for exploratory purposes utilizing ActiGraph data. Although a larger sample size is recommended, previous literature has utilized smaller sample sizes when utilizing ActiGraph data (Kushida et al., 2001). Within the ActiGraph subsample, after removing participants with missing data, a total of 24 participants were included in analyses with ActiGraph data; ages ranged from 6-11:11 (M = 8.5, SD = 1.61) and were primarily male (95%).

Recruitment. Participants were recruited for Camp participants who themselves were recruited through a variety of methods, including referral to camp from either their primary care providers, or specialty care providers within University of Washington Autism Center or Seattle Children's Hospital. Following a referral, all participants were screened for eligibility specific to camp by a care provider familiar with camp procedures, such as the camp director. Participants could also apply for Camp from the community. Fliers were distributed throughout the community in doctors' offices, universities, autism clinics, and mental health clinics in the greater Seattle area. Similarly, parents could also apply online for their children to participate in

Apex Camp/SeaStar Program. All recruitment materials provided general information and enrollment criteria for the study as well as instructions for applying and contact information. See appendix A for an example of the recruitment materials.

Eligibility screening. In order for participants to be eligible for Apex Camp/SeaStar Program children must meet criteria for ADHD or ASD, or other related childhood disorders, or present with primary social and/or behavior difficulties. Further, siblings of children with ADHD or ASD may also participate. For the purposes of the current study, only children with primary diagnoses of either ADHD or ASD, or both, were examined. The screening visit was conducted by either the camp director, Ben Aaronson within the University of Washington team, or a clinical psychologist with the PEARL Program at Seattle Children's Hospital (Program to Enhance Attention, Regulation and Learning). Screening criteria was designed to determine whether each child would benefit from treatment within a summer treatment program. Specific entrance criteria include behavioral and social difficulties, related childhood disorders, or siblings with either. Children must have a language ability of at least 6-years-old in order to be successful at camp, as determined by medical records, PCP or recruitment testing.

The Current Study

The present study was approved by University of Washington's Institutional Review Board, and both University of Washington Apex Camp and Seattle Children's Hospital Camp SeaStar Program directors (Appendix I). Camp design followed previously established protocol for summer treatment programs for children with ADHD and/or ASD (Pelham et al., 2010).

Informed consent was completed by the parent for both clinical treatment and research (Appendix B and C). Information regarding the purpose and procedures of the study was provided to both parent and child, and they were informed that participation in the present

research is entirely voluntary. The exercise schedule of this research was explained to parents as it is part of the overall camp structure. Specific components to this research including sleep analyses, physical activity tracking and ActiGraph research are voluntary and children were not required to participate in these factors in order to participate in camp. Participants and their guardians were able to withdraw from the portions of camp specific to this study at any time. Consent included specific information regarding the use of the ActiGraph watches, and the time and effort required by parents when their child is assigned to wear an ActiGraph watch. Parents were contacted by an individual other than their counselors by email or in person to provide consent. Parents also participated in a parent orientation in June, prior to the start of Camp. During this orientation, parents learned more about how to use an ActiGraph, and details regarding other outcome measures they are asked to complete throughout camp.

All children received an identification number following consent. all research data, measures, and ActiGraph data were coded according to the deidentified ID number and kept separate from clinical data.

Apex Camp/ SeaStar Program. Apex Summer Camp and the SeaStar Program was a 5-week intensive treatment program for children ages 6-12. Children were assigned to a ‘bunk’ or group of 10-12 children with 4-5 counselors. Bunk assignment was randomized within age groups; with the exception of clinical recommended specific assignments such as requests to assign siblings of similar ages to the same bunk. The schedule included four structured activity times: two sport-related activities, one board game or sedentary activity, and one open period following lunch. Behavioral data was collected by counselors consistently throughout each day by recording number of points given or taken during each activity. Camp Apex/ SeaStar Program

was designed with the focus of building social skills, self-esteem, and specific behavioral goals for increasing positive, appropriate behavior and self-regulation.

This camp utilized behavioral principles of reinforcement within a token economy, along with positive peer interactions and active play to improve social and behavioral skills. Specifically, camp protocol followed a social learning theory approach to include evidence-based cognitive-behavioral treatments within a controlled, clinical setting. Daily behavioral symptoms were documented via an intensive point chart system through bunk counselors (see Appendix D). Participants were rewarded with points for good behavior (following directions, on target behavior, improvements in individual goals, etc.) and points were deducted for undesirable or problem behaviors (e.g., off task behavior, back talk and tantrums). The point system involved a systematic response-reward cost program where children earn or lose points/tokens based on behavior. This system follows significant literature utilizing similar programs (Barkley, 2013; Pelham, 1996). Children could exchange their points for specific privileges. Social reinforcement involving praise and public acknowledgement was utilized to help children increase positive behaviors. Specific social skills were taught daily by use of instruction, modeling and role-playing. Children were encouraged to practice the skills and rewarded for participation and implementation. Daily report cards were sent home to parents specifically explaining target behaviors and how parents can implement home-based rewards to support the child. Daily small-group skills training for sports skills was utilized to help children improve motor skills, rule following and group activity participation. Finally, children participated in classroom based activities such as art skills and board games. Alongside children, a sub sample of parents participated in a weekly group training to assist with problem behaviors. See Appendix D for counselor behavior tracking sheets, daily report cards, and examples of parent training materials.

Present Study Intervention

Camp Bunk Organization. Once participants provided consent, they were first assigned to bunks. Bunks were randomly separated into two groups (Red group or Blue group) each group receiving the same amount of exercise weeks and control weeks. This separation was for logistical purposes, so all bunks are not on the same activity schedule. For the present study, bunks were directed to participate in either a physical activity (A) or an alternate activity (B) period of approximately 40 minutes each day following a set schedule. Red group were assigned ABAB. Blue group were assigned BABA. Within the physical activity intervention weeks (A), bunks participated in a physical activity during the target period, including structured and unstructured physical action such as kickball, playground play, or tag. During the control, or camp as usual weeks (B) bunks participated in a more stationary activity during the open period, such as board games, indoor games, or arts and crafts. All bunks received the same dose of exercise, or same number of weeks. The flow of participant assignment is depicted in Figures 2 and 3 below. Counselors tracked the week, activity and participant engagement information on a daily tracking form that will be provided to them (Appendix E). Further, specific designated physical activity and camp as usual stationary activities were outlined and explained to counselors, along with materials needed (Appendix F).

Figure 2. Camper Bunk Assignment Organization

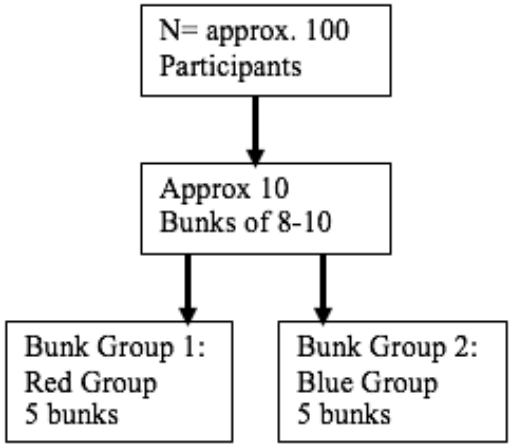


Figure 3. Example of Posted Camper Bunk Assignment and Bunk Schedule

Camp Bunk Assignment and Schedule

Red Group	**Blue Group**
Bunks 1, 3, 5, 7	Bunks 2, 4, 6, 8

Week of Camp	Red Group	Blue Group
Week 1 7/5- 7/8	Counselor's Choice	Counselor's Choice
Week 2 7/11- 7/15	Physical Activity (A)	Calm (B)
Week 3 7/18- 7/22	Calm (B)	Physical Activity (A)
Week 4 7/25- 7/29	Physical Activity (A)	Calm (B)
Week 5 8/1- 8/5	Calm (B)	Physical Activity (A)

Physical Activity Intervention. The current study utilized a 'free' or 'counselor's choice' period within the structured STP program as the primary manipulated dose of physical activity; during A weeks, counselors chose from a list of higher physical activity games and during B weeks counselors chose from a list of calm or low activity games (Pelham, 1996). During the active A weeks, camp counselors were instructed to lead their bunks in one of the outlined physical activities for the duration of the target hour. Counselors received a tracking sheet for each day where they will log intervention week (A vs B), chosen activity, and duration, as well as participant engagement notes. Specifically, if a participant did not engage in this activity, counselors were to note this with duration of refusal, reason and alternative activity (what the child did instead; i.e., sitting aside, tantrum behavior and so on) (Appendix G). Additional physical activities a counselor may want to do could also be approved by the PI.

Instructions on each game were provided on a notecard for counselors to select and use to explain to bunks. Sample instructions are provided in Appendix G.

During B weeks, camp counselors were to lead their bunks in one of the outlined sedentary activities for the duration of the target hour. Counselors were to log which activity they did each day, and for how long. Similarly, if any participant did not engage in this activity, counselors are to note this with duration of refusal, reason and alternative activity (what the child did instead, i.e., sitting aside, tantrum behavior etc.). Additional activities a counselor may want to do could be approved by the PI. Instructions and materials for each activity was provided on a notecard for counselors to select and use to explain to bunks.

ActiGraph Organization. In addition to the changes in dose of physical activity per week, the proposed research also utilized objective data using an ActiGraph to analyze physical activity and sleep within-subjects during the duration of camp, and comparing pre-treatment to post-treatment outcomes. After participants were screened into Camp and signed consent to participate in the present research, a group of 24 participants was be included for the ActiGraph portion. Participants wore an Acti-watch 2 (AW2), a small watch-like unobtrusive device on their non-dominant wrist to provide continuous Actigraphy monitoring of sleep and activity. Participants were randomly assigned into one of two experimental ActiGraph groups, either *Acti-Group 1*, or *Acti-Group 2*. Both groups received the same physical activity intervention as the rest of camp; the separation is necessary for scheduling and logistical purposes. Objective ActiGraph data was obtained for three days per week during the first two weeks of camp (weeks 1 and 2) for *Acti-Group 1*, and the next two weeks of camp (weeks 3 and 4) for Acti-Group 2, and following the completion of camp. *Acti-Group 1* and *Acti-Group 2* will then each received 3 days of ActiGraph data for an A week and a B week. The group was randomly assigned into two

groups, either *Acti-Group 1*, receiving measurements during the first two weeks, or *Acti-Group 2*, measured during the next two weeks.

Data collection. Physical activity data was collected by separating variable scores between A weeks and B weeks, then comparing scores, and with ActiGraph data. Behavioral data was consistently tracked during camp via the token economy by trained counselors. Sleep was measured via the ActiGraph data. Inhibitory control data was also obtained through counselor given measures. All measures and methods of collection are described in greater detail below.

Table 1.
Description of data collection

Variable	Informant	Time Collected
Physical Activity		
	Condition of Camp	Based on Week of Camp
	ActiGraph	Throughout Camp
Sleep		
	ActiGraph	Week
Inhibitory Control		
	Counselor Measured Whisper Task	Daily after Counselors Choice Target Period
	Counselor Recorded Behavior Data	Within Daily Point System
Behavior		
	Counselor Recorded Behavior Data	Within Daily Point System

Measures

Behavioral data. Counselors collected continuous daily measurements of behavioral data. Specific examples included positive behaviors such as general compliance, prosocial behavior, positive contributions, and negative behavior including interruptions, aggression, and noncompliance. This behavior was tracked daily. There were 4-5 counselors per bunk, which included 10-12 campers. During each activity period throughout the day, one of the bunk counselors was assigned to record point data via an electronic IPad system. The current STP

point recording system was modeled after original STP recommendations (Pelham, Date). Each activity period was separated into 4 quarters in order to ensure children had multiple opportunities to earn points. Counselors went through two weeks of extensive training including validity testing in order to ensure accurate behavioral data collection. The counselors rotated who oversaw recording points during each activity period. Counselors utilized an electronic tally system where they maintained a running total of points for each child. The counselor in charge of collecting data had no other responsibilities during that time in order to increase accuracy. The data that was collected were the number of points collected within the token economy, similar to how behavioral parent training recommends parents give points at home in order to manage child behavior (Barkley, 2013). This allows for structured, data-based monitoring of progress throughout camp. See appendices for behavioral data tracking sheet

ActiGraph Data. Physical activity and sleep data were collected using Actigraphy via ActiWatches. These small, unobtrusive watch-like devices monitor movement and are commonly used in research to track sleep and physical activity (Sadeh, 2011). For the purposes of the current study, ActiGraph data was used as a manipulation check to further examine level of physical activity and sleep. Specifically, ActiGraph data was collected during three weekdays and week nights in each intervention week; three week days and nights during A and B weeks alike for a total of 6 week days and nights during camp.

Although we examined outcomes following different amounts or doses of physical activity (A versus B weeks), there is a possibility that physical activity week assignment alone may not be sufficient to identify differences in outcomes. As such, ActiGraph data provided additional information to examine change in physical activity level. Specifically, I examined

whether increased activity level as documented by ActiGraph report and intervention week predicted outcomes.

For the current study, activity data collected via the ActiGraph included counts of total activity, average activity per minute, and max activity value per period. Sleep data included average sleep duration and sleep efficiency. Table 2 below describes these variables in greater detail.

Table 2. *Description of ActiGraph Measurements*

Construct	Sub-Measure	Definition
Activity		
	Total Activity Counts	The sum of all valid physical activity counts for all epochs for the given interval.
	Average Activity Counts/Minute	The average of all valid physical activity counts for all epochs for the given interval divided by the epoch length in minutes.
	Max Activity Counts	The largest valid physical activity value recorded during the given interval.
	SD of Activity Counts	The standard deviation of all valid physical activity counts for all epochs for the given interval
	Average Activity Counts/ Epoch	The average of all valid physical activity counts for all epochs for the given interval.
Sleep		
	Sleep Time	The total number of epochs for the given interval scored as sleep by Actiware (or manually set as sleep by you) multiplied by the epoch length in minutes.
	Sleep Efficiency	The percentage of time spent in bed sleeping. Scored total sleep time divided by (interval duration minus total invalid time (sleep/wake)) of the given rest interval multiplied by 100.
	Wake After Sleep Onset	This is the total number of epochs between the start time and the end time of the given sleep interval scored as wake by Actiware software (or manually set as wake by you using Actiware software) multiplied by the epoch length in minutes.

Inhibitory Control. Inhibitory control was measured through two methods. First, the current study analyzed specific behaviors of inhibitory control. Previous research described inhibitory control as withholding or inhibiting an impulsive response (Barkley, 1997). Similar research has described deficits of inhibitory control to include disruptive behaviors such as interrupting or acting out (Nigg, 2003). As such, inhibitory control was also be examined by extracting specific behaviors indicating positive inhibitory control of ignoring a negative stimulus (i.e., another child acting out), and behavior of interruption, which indicates a deficit in inhibitory control.

In addition to behavioral counts of inhibitory control, the current study also used the Whisper task (Kochanska et al., 1996). The task involved showing children pictures of 10 cartoons printed on laminated cards. Cards were presented one at a time with the counselor whispering "who's this?" Items were presented in random order with one reminder after 5 items to whisper (Sabbagh, Moses & Shiverick, 2006). The kids were instructed to whisper the names of the cartoons. The child responses were rated from 0 (shout), 1 (normal or mixed voice, and 2 (whisper). (Kochanska et al., 1996). Internal reliability was high (0.83), and interrater reliability was high (0.97) (Sabbagh Moses, & Shiverick, 2006; Carlson, Moses & Claxton, 2004).

This measure has previously been used within a battery of tasks measuring inhibitory control, including the day/night task, bear/dragon task and a card sort (Carlson, Moses, & Claxton, 2004). The measures in this battery were moderately intercorrelated and suggested to index the underlying construct of executive functioning ($\alpha = .76$) (Carlson, Moses, & Claxton, 2004). The Whisper task showed a higher correlation with other measures of inhibitory control or response conflict tasks, such as the Bear/Dragon and day/night task. Specifically, upon factor analysis the whisper task loaded highly onto a Conflict subscale of withholding an immediate

response to perform a conflicting response (whisper task factor loading = .64). In a study examining developmentally sensitive measures of executive functioning, Carlson (2005) concluded that the whisper task is appropriate to examine inhibitory control, and individual differences in correlations are due to differences in inhibitory control ability, which might be indicative of developmental age. The whisper task was found to have reliable cross-cultural correlations between American children and Chinese children (α =.73) (Sabbagh, Xu, Carlson, Moses, & Lee, 2008). It also has statistically significant convergent validity with teacher ratings scales of inhibitory control (α = .24, $p < .05$) and predictive validity (coefficients ranged from α =.25 to .37, $p < .01$).

This measure was originally included in a battery for younger children (up to age 5); it has not been used for older children. However, due to the impairment in inhibitory control commonly associated with children in the target population, this measure was selected. Additionally, this objective measure is easily conducted and therefore feasible for counselors to administer within the camp schedule. Counselors completed this measure daily for each child in their bunk following the target period. Instructions as well as sample images are shown below in the appendices. Further, counselors were instructed to divide campers in their bunks between counselors so each counselor only had 2-3 children to score. During training, counselors were taught how to administer and score the WT. Then, counselors were asked to score a practice administration and kappa coefficients were run to determine sufficient inter-rater reliability of coders. Results indicated high interrater reliability for the practice session (α= 0.98).

Variable Coding

Physical activity, the independent variable, was coded two ways. First, by week of intervention, A or B. Data was analyzed by within-subject comparison examining the differences

for each participant between A weeks and B weeks. A weeks represented a higher dose of physical activity, as documented by week of intervention as well as ActiGraph data. Second, physical activity data was analyzed by examining overall activity between- subjects.

Behavioral outcome data, the dependent variable, was coded based on the counselor behavior tracking sheet and the token economy. Specifically, the total number of points lost from bad behavior, and the total number of points earned from positive behavior was utilized. A total behavior score was calculated for each day, and then a weekly score were taken averaging each daily score. Finally, a total behavior score for each physical activity condition was calculated. For the physical activity intervention (A), behavior scores from the two A weeks were averaged. Similarly, the scores from the B weeks were averaged. Final analyses examined residual change scores between the average A behavior score and the average B behavior score. ActiGraph data was used to corroborate physical activity level by creating an overall continuous activity score for A and B weeks.

Sleep was examined by sleep duration and efficiency based on ActiGraph data. See table 1 above for definitions. A daily score was obtained by creating a quantity/quality sleep ratio. This score was averaged across the week within the ActiGraph coding. Total sleep scores for each intervention condition (A and B) were calculated.

Inhibitory control was measured through the whisper task and through specific behaviors of inhibitory control. Total scores for the whisper task were created for each day by averaging each item response on the whisper task. The daily whisper task total score was averaged to create a weekly score. Similarly, total behaviors of inhibitory control were summed for each condition.

Research Design

This research study was a between-subjects quasi-experimental design, with additional within-subjects analyses. Random sampling was not applicable because the participants were selected from a clinical group of children presenting to Apex Camp.

Data Analysis

Data analysis was conducted utilizing SPSS (Statistical Package for the Social Sciences) PROCESS Macro (Hayes, 2013). Serial multiple mediation is recommended when examining the direct relationship between an independent variable and dependent variable, as well as the indirect impact on the dependent variable through two or more mediators. Further, when there is reason to hypothesize that the mediators are related, a serial mediation is appropriate (Hayes, 2013). Thus a serial mediation model was utilized to examine the presented model. Bootstrap analysis, a nonparametric sampling procedure, will be used and set at 10,000, the default setting. Additionally, MEMORE was utilized to investigate whether the change in IC (mediator) between A conditions predicted the change in behavior between A conditions. MEMORE uses ordinary least squares regression within a path-analytic form (Hayes & Montoya, 21017).

Analyzes first utilized the entire sample (N =74) to examine the effect of the physical activity intervention (A weeks versus B weeks) on inhibitory control and behavior by first comparing means via t-tests, then using MEMORE to analyze the model.

Second, analyses examined a subsample of participants from the overall sample; these participants wore ActiGraph watches (N= 24). These analyses first examined the effect of the intervention on the variables (sleep, inhibitory control, and behavior) by comparing scores during A weeks versus B weeks.

Third, analyses were conducted using the ActiGraph subsample to examine correlations between variables over time (not comparing based on intervention week). These analyses utilized t-tests to compare means, and then employed PROCESS to examine mediation models.

Analyses were conducted without distinguishing diagnosis first, then by separating for each diagnosis (ADHD, ASD or both). Demographic data for both the overall sample and the subsample are listed in Table 3 below.

Table 3.
Demographics of all camp sample and ActiGraph sub-sample

Demographic		%	*Mean*	*SD*
ActiGraph Participants (*N* = 24)				
Age			8.5	1.61
Grade			3.0	1.56
Gender				
	Male	95		
	Female	5		
Diagnosis	ASD	41.7		
	ADHD	20.8		
	Both	12.5		
All Camp Participants (*N* = 74)				
Age			8.4	1.57
Grade			3.04	1.41
Gender				
	Male	82.4		
	Female	17.6		
Diagnosis	ASD	42.5		
	ADHD	28.6		
	Both	10.7		

Chapter III

Results

Primary Analyses: Effect of Intervention on the Full Sample

The primary hypotheses in the current study examined the impact of intervention between-subjects by comparing effects of weeks with greater physical activity (A) versus weeks

with less physical activity (B). Initial analyses were conducted across the sample, without distinguishing diagnosis, due to the small sample size when separated by diagnosis. Within analyses, activity level was used by compiling a total for all A weeks and all B weeks. Because sleep diary data was unusable, primary analyses only examined physical activity, inhibitory control and behavior. The sleep diary data was unusable because of a coding error that made the results anonymous and therefore impossible to separate by participant. These analyses investigated the hypothesis that increased physical activity would lead to increased positive behavior through increased inhibitory control, following the original hypotheses. For this analysis, inhibitory control was examined by analyzing a positive inhibitory control behavior (ignoring a negative stimulus), and a negative inhibitory control behavior (interruption). These analyses were conducting with the independent variable of physical activity dose (more or less activity), measured by week condition of camp, such that analyses compared A weeks versus B weeks. Descriptive statistics for the overall sample and variables for each condition are listed in Table 4.

Table 4
Descriptive Statistics for All Campers for both physical activity conditions (A and B)

	A		B	
	Mean	*SD*	Mean	*SD*
Inhibitory Control (*N*=74)				
Interruption	41	47.5	45.7	50.3
Ignoring negative stimulus	45.7	50.3	54.3	22.8
Behavior (*N*=74)				
Positive behaviors	213.98	86.24	221.01	99.05
Negative Behaviors	108.16	147.76	113.29	138.89

A= higher physical activity B= lower physical activity

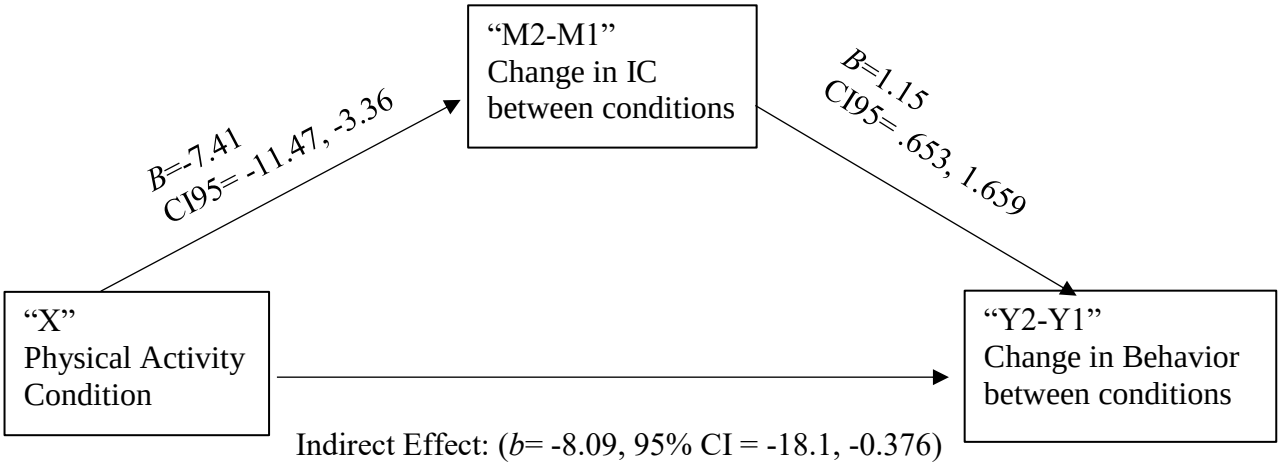
First, paired samples t-tests were utilized to examine the differences in inhibitory control (using positive and negative behavior counts) for A weeks versus B weeks. Analyses for all campers indicated higher frequency of positive IC behavior (ignoring a negative stimulus) during

A weeks (mean = 55.1, *SD* = 22.5) versus B weeks (mean = 47.7, *SD* = 19.9). This difference was statistically significant ($t(73) = -1.98$, $p < 0.05$). Analyses also indicated lower frequency of negative IC behavior (interruption) during A weeks (mean = 41.3, *SD* = 47.9) than B weeks (mean = 46.7, *SD* = 50.6). This difference was also statistically significant ($t(73) = -3.649$, $p < 0.0001$), or that during less active weeks, participants interrupted more or had worse inhibitory control.

Because t-tests indicated significant differences between intervention condition, further regression analyses were conducted to examine these variables within a mediation model. MEMORE was utilized to investigate whether the change in IC (mediator) between A conditions predicted the change in behavior between A conditions. In the current analyses, MEMORE was utilized to investigate whether the change in IC (mediator) between A conditions predicted the change in behavior between A conditions.

Individual effect analyses (a path effects of the IV on mediators; b path effects of mediators on DV) were conducted for both positive (ignoring) and negative (interruption) inhibitory control behaviors separately, and with an overall inhibitory control ratio score. Results indicated that increased physical activity was associated with a decrease in negative inhibitory control behavior of interruption (($t(73) = 4.62$ [0.87, 2.19 $p < 0.001$), which predicted an increase in overall positive behavior ($R = 0.48$, $F(2, 71) = 10.71 p < 0.0001$). The effect accounted for 23% of the variance. Further, the indirect effect of physical activity on positive behavior through increased inhibitory control was significant ($b = -8.09$, 95% CI = -18.1, -0.376). Results are depicted in figure 4.

Figure 4. Results of mediation between physical activity condition (A vs. B), behavior and inhibitory control.



Interestingly, analyses indicated the opposite effect for ignoring a negative stimulus. Results showed that increased physical activity significantly predicted a decrease in positive inhibitory control behaviors, or ignoring a negative stimulus ($t(73)$= -3.64 [-11.47, -3.36] p <0.01). The overall indirect effect of increased physical activity on increased positive behavior through decrease of inhibitory control behaviors was also significant (R = 0.48, $F(2, 71)$ = 10.59, $p < 0.0001$); (b = -8.58, 95% CI= -15.69, -3.26). It is possible that this difference is due to a decrease in negative stimulus behaviors from other children. It's also possible that the results are due to the small sample size and an inherent difference between children who had complete data and those who did not.

Secondary Analyses: ActiGraph Subsample

Effect of Intervention on Subsample

In order to utilize ActiGraph data, secondary analyses examined the effect of the intervention by comparing total activity for A weeks and B weeks. Sleep was also examined utilizing ActiGraph data for both conditions. After deleting participants missing full weeks of

data, or participants who only had ActiGraph data during one condition (i.e., only wore the ActiGraph during A week), the final sample of participants with ActiGraph data was $N = 24$. During active weeks, participants wore the ActiGraph for an average of 2.79 days ($SD = 0.884$). During less active weeks, participants wore the ActiGraph for an average of 2.96 days ($SD = 1.12$). When analyzing sleep data, participants wore the ActiGraph for an average of 2.92 nights during A weeks ($SD = 1.02$) and an average of 2.96 nights during B weeks ($SD = 1.54$). Demographics and descriptive statistics for physical activity and sleep during both A and B weeks are listed in Table 4 below. In addition to sleep and physical activity, secondary analyses examined the whisper task as a second mediator. When examining the whisper task, only 20 participants who wore the ActiGraph had valid whisper task data; 4 were removed from analyses due to missing days or missing scores (i.e., participant was in time out during measure). Participants had an average score of 1.85 ($SD = 0.170$) during active weeks and an average score of 1.65 ($SD = 0.232$) during less active weeks.

First, paired samples t-tests were utilized to analyze differences in means between conditions (weeks with higher doses of activity versus weeks with lower levels of activity). When analyzing differences between means of physical activity for each condition, results did not indicate any statistically significant differences; only the difference between total activity counts for A weeks versus B weeks neared significance ($t(24)=1.94$, $p <0.06$). Results did show higher levels of physical activity duration in minutes for A weeks (mean= 838.8, SD=85.3) than B weeks (mean= 814.0, SD =70.4). Additionally, results suggested higher total activity counts for A weeks (mean = 717623.04, SD = 201453.03) than B weeks (660875.69, SD= 209648.13). These tests served as a partial manipulation check and while the campers were not statistically

more active during A weeks the direction of difference is positive and the intervention did provide for increase time in structured physical activity.

Table 5
Descriptive Statistics and mean differences of all variables for ActiGraph Sample for both physical activity conditions (A and B)

Activity (*N*=24)	A (Active) Weeks		B (Less Active) Weeks			
	Mean	SD	Mean	SD	*t*(23)	*p*
Average duration (minutes)	838.88	85.34	814.04	70.41	1.21	.238
Average total AC counts	717623.04	201453.03	660875.69	209648.13	1.92	.066
Average of Avg AC/min (counts/min)	889.49	260.41	822.23	257.79	1.94	.064
Average of std AC counts	813.88	269.34	747.55	206.23	1.50	.146
Average of Max AC counts	5047.88	1423.57	4878.81	1549.01	.638	.530
Average of immobile time	18.81	13.41	17.96	11.92	.283	.780
Average of %immobile	2.27	1.59	2.22	1.33	.123	.903
#d of days data	2.79	0.88	2.96	1.12		

Sleep (*N*=24)	A (Active) Weeks		B (Less Active) Weeks			
	Mean	SD	Mean	SD	*t*	*p*
Average sleep duration minutes	548.32	43.24	584.30	54.18	.002	.998
Average sleep efficiency (%)	83.96	4.23	84.10	5.08	-.134	.895
Average WASO (Wake after sleep onset)	80.15	25.80	78.44	27.21	.291	.774
Average sleep time	468.08	49.27	469.85	49.46	-.201	.843
# of nights data	2.92	1.01	2.96	1.54		

Whisper Task (*N* =20)	A (Active) Weeks		B (Less Active) Weeks			
	Mean	SD	Mean	SD	*t(20)*	*p*
	1.85	0.17	1.65	0.23	1.39	.18

Similar to levels of physical activity, paired sample t-tests were utilized to examine differences in sleep and inhibitory control between activity conditions. However, no significant

differences were noted for sleep duration ($t(24)=0.002$, $p< 0.998$) or sleep efficiency ($t(24)=-0.134$, $p <0.895$) between A and B weeks. For inhibitory control, the whisper task was utilized originally, which showed no significant differences were between conditions ($t(20)=1.39$, $p <0.18$).

Although intervention specific between-subjects analyses for the larger sample indicated significance, it is possible that similar findings were not discovered for ActiGraph data due to a small sample size or because the target period that defined higher versus lower levels of activity may not have been powerful enough to detect a difference. As such, additional analyses were run to examine between-subjects correlations over time between variables for the subsample of participants with ActiGraph data.

Changes in Time Within ActiGraph Subsample

Additional analyses were run to examine pathways between physical activity, sleep, inhibitory control and behavior for the subsample of participants wearing an ActiGraph. For these analyses, physical activity was measured continuously with total activity counts via ActiGraph data. Sleep was also examined with Actigraphy by using sleep efficiency percentages. Inhibitory control was examined using a total ratio score of inhibitory control behaviors. Results of correlational analyses suggested significant correlations between total activity and sleep efficiency ($r = .489$, $p < 0.05$), total activity and positive behavior ($r = .526$, $p < 0.05$), and sleep efficiency and behavior ($r = .630$, $p < 0.01$), and inhibitory control and behavior ($r = .475$, $p <0.05$). Correlations are listed in table 6.

Table 6.
Correlations between variables

Comparison		Correlation
Total Activity	Sleep Efficiency	$r = .489$, $p < 0.05$
Total Activity	Behavior	$r = .526$, $p < 0.05$
Sleep Efficiency	Behavior	$r = .630$, $p < 0.01$
Inhibitory Control	Behavior	$r = .475$, $p <0.05$

*Behavior measured as ratio between positive and negative behaviors

Regression analysis was used with PROCESS to investigate the hypothesis that increased physical activity leads to increased positive behavior, mediated by increased sleep efficiency. Results indicated that total activity was a significant predictor of sleep efficiency (b = .0001, SE = .000, p <.05), and that sleep efficiency was a significant predictor of behavior (b = 0.031, SE = 0.0132, p < 0.01). These results supported a mediation model suggesting that increased activity leads to improved behavior through increased sleep efficiency (R = 0.68, F(2, 16) = 6.97, p < 0.01). Approximately 47% of the variance was accounted for by the predictors. These results support previous literature suggesting physical activity leads to improved sleep and subsequently improved behavior. Mediation results are depicted in table 7.

Table 7.
Regression analyses for mediation models with all data (N=74)

	R	R^2	F	*p*	*LLCI*	*ULCU*
PA→Sleep Efficiency→Behavior	0.68	.47	6.97	0.01	.0034	.0594
PA→IC→Behavior	0.67	.453	6.64	0.01	.0044	.1237
PA→Sleep Efficiency→IC→Behavior	0.791	0.627	8.41	0.001	.0100	.1124

Similar analyses were conducted to analyze the potential mediating factor of inhibitory control. For these analyses, inhibitory control was examined using the behavior counts because analyses did not indicate any significant findings using whisper task scores. For the current model, inhibitory control was measured with a change score of positive IC minus negative IC. A regression analysis was conducted to investigate the original hypothesis that increased activity will lead to increased positive behavior through increased inhibitory control. Results supported a mediation model (R = 0.673, F(2, 16) = 6.641, p < 0.01). Approximately 45% of the variance was accounted for by the predictors.

Finally, a serial mediation was examined to investigate whether increased A leads to improved behavior through increased sleep and increased IC. Results supported a serial mediation ($R = 0.791$, $F(3, 15) = 8.41$, $p < 0.001$). Approximately 63% of the variance was accounted for by the predictors ($R^2 = .627$). Results are indicated in table 6.

Chapter IV

Discussion

This study was designed to examine the impact of physical activity for children participating in a multimodal summer treatment program. The study examined participants who presented to the STP as a treatment intervention for either ADHD or ASD related symptoms, or both. The current study first sought to examine the effect of a physical activity intervention on outcome data. Investigators manipulated level of physical activity per week of camp, by utilizing a 'free' or 'counselor's choice' period within the structured STP program as the primary manipulated dose of physical activity; during A weeks, counselors chose from a list of higher physical activity games and during B weeks counselors chose from a list of calm or low activity games (Pelham, 1996). Examinations then compared differences in scores for each participant based on condition (week).

In primary analyses, the current study examined all campers utilizing the physical activity week conditions. Although the original hypotheses included the use of a diary card to analyze sleep information for participants not wearing an ActiGraph, this measure was unusable due to a coding error. The whisper test also not found to be reliable, therefore, total camper analyses could only examine the impact of physical activity based on week condition, inhibitory control based upon behavioral counts of inhibitory control, and observed behaviors.

Results indicated significant differences in inhibitory control for A versus B weeks; participants exhibited a greater level of positive inhibitory control during more active weeks than less active weeks. Further, when examining a negative inhibitory control behavior of interruption, or a behavior that indicates a lack of inhibitory control, increased physical activity led to a lower level of this behavior. This suggests that the intervention of increasing physical activity was associated with improvements in inhibitory control. Further, regression analyses supported a mediating effect of inhibitory control, such that that on weeks when participants were more physically active, they exhibited a decrease in negative IC behavior (interruption), which significantly predicted and increase in overall positive behavior. Using MEMORE, the results support the notion that the change in physical activity between conditions lead to the change in behavior through the change in inhibitory control. This is consistent with the original hypotheses and consistent with previous literature, which has supported the link between increased physical activity and improved inhibitory control (Diamond, 2015; Mura et al., 2015).

However, this mediation was only as expected for interruption, or negative inhibitory control behavior. When examining the positive IC behavior of ignoring a negative stimulus, the effects were the opposite as would be expected; when children were more active, they had less instances of ignoring a negative stimulus which led to better behavior. However, this might make sense if the increase in physical activity led to fewer negative stimuli for participants to ignore.

Analyses also sought to examine relationships between the between physical activity, sleep, inhibitory control and behavior using ActiGraph data. Results indicated that increased physical activity predicted increased sleep efficiency which, in turn, predicted increased positive behavior. Further, results depicted a serial mediation between the variable such that increased physical activity predicted increased positive behavior through increases in sleep and positive

inhibitory control. These results suggest as children's level of physical activity increases, they also experience improvements in sleep, inhibitory control and overall positive behavior. This is consistent with previous literature, which has supported a significant link between increased physical activity and improved sleep (Brand et al., 2010; Brand, Jossen, Holsboer-Trachsler, Puhse, & Gerber, 2015; Chennaoui, Arnal, Sauvet, & Leger, 2015). Research has specifically analyzed the positive impact of physical activity on sleep for children with ASD symptomatology (Brand, Jossen, Holsboer-Trachsler, Puhse, & Gerber, 2015), which is similar to the current study. Similar research has suggested incorporating physical activity into sleep hygiene results in positive outcomes (Jan et al., 2008). Although specific research has highlighted the importance of improved sleep on behavior and executive functioning (Keshavarzi et al., 2014), the current research adds to the literature by supporting a model of improvement through physical activity.

The current study also sought to examine within-subjects analyses in order to determine whether the effect of the intervention (increased physical activity by week) led to positive outcomes for each child individually. In analyses using the within-subjects ActiGraph data, paired samples t-tests did not indicate any significant differences between physical activity by week. It is possible this is due to the small sample size of participants wearing an ActiGraph. Although previous studies have found significant results with similar sample sizes, the small n along with a less powerful independent variable within the current study might be the cause of nonsignificant results. It is also possible that the insignificance is due to the limited amount of time manipulated (counselors' choice was only a 25-minute period of the entire day), and because this was the time campers were allowed to visit the prize store so the period was frequently interrupted. In addition to nonsignificant physical activity data, results did not indicate

any significant differences in sleep or inhibitory control based on the different condition week for the sub-sample. Similarly, original hypotheses sought to examine the relationship between variables for children with both diagnoses of ASD and ADHD. However, when separating participants in either group (ActiGraph or total camp), sample sizes were too small to detect any significant differences. As such, analyses examined participants collectively, regardless of diagnosis.

The current results support the notion that, for children with symptoms of ADHD or ASD, physical activity leads to improved outcomes across several measures. Children were not randomly assigned to participate because they were selected from a clinical sample. Additionally, the sample sizes of diagnoses were too small to determine effects of intervention per diagnosis. However, the results still provided important support to the impact of physical activity as a component of treatment for children within a range of neurodevelopmental disorders. This research provides additional evidence to the importance of including physical activity in daily routines in order to improve sleep, inhibitory control and overall behavior. Although this information has been supported with previous literature, the current results add additional strength to the argument by utilizing objective ActiGraph data and within-subjects designs. Although the current study primarily analyzed participants with diagnoses of ADHD or ASD, the majority of children participating in camp endorsed a multitude of symptoms related to both diagnoses. As such, the study lends to literature that physical activity may lead to positive outcomes for children experiencing any level of ADHD or ASD related symptomatology. Additionally, the current research involved a structured day camp that has similarities to academic settings (Pelham & Hoza, 1996).

These results suggest the potential importance of physical activity during school through either recess, structured physical education classes, or additional physical activities. Previous literature has supported the idea of utilizing physical activity within the school day in order to improve behavior (Brooke, Corder, Atkin, & van Sluijs, 2014; Dobbins, DeCorby, Robeson, & Tirilis, 2017). In addition to behavioral outcomes, significant research has supported the importance of sleep on cognitive and academic outcomes (Bartel, Gradisar, & Williamson, 2015). The current research may further highlight the importance of incorporating physical activity and a focus on improved sleep in order to obtain better outcomes for current behavior and later achievement. Further, recent literature has supported the notion of physical activity as comparable to medication in the treatment of both psychiatric, neurodevelopmental and medical diagnoses in adults (Pedersen & Saltin, 2015). The current research may lead to greater focus on physical activity as a component of treatment comparable to medication for children with specific neurodevelopmental symptoms.

Limitations

Although the current research yielded significant findings, several limitations must be addressed. Primarily, the original research hypotheses sought to examine the difference in models between children with ADHD, ASD or those with both. However, because the sample sizes were to small when separating diagnosis, the current research was unable to analyze the links between variables for each diagnosis, but instead only analyzed the relationships for the sample as a whole. Future research should specifically analyze the links between diagnoses and investigate a comparison of the data. Additionally, daily sleep diary data was incorrectly coded and the researcher was unable to connect each diary card to participants. Therefore, it was left out of the final analyses. However, several researchers have suggested that ActiGraph data is

significantly more accurate in describing child sleep than parent report (Corkum et al., 2001). Still, future research could conduct similar analyses with parent or child self-report of sleep variables.

In addition to limitations with sleep diary and demographic coding, the whisper task was an objective measure meant to analyze inhibitory control. However, this measure was intended for individual use and had not previously been used with a group (Kochanska et al., 1996). Although interrater reliability was high and counselors only recorded scores for 1-3 children, the recording of these scores was frequently inconsistent. Specifically, counselors often did not utilize the correct scoring template and often missed cards or scores. Specifically, counselors often did not utilize the correct scoring template and often missed cards or scores. The tasks required of counselors during STPs are immense and often incredibly time consuming; it is possible that the addition of the measure during camp was beyond the counselors' capacity. Future research could utilize either an alternative inhibitory control measure, or use the whisper task within a less demanding context. Another limitation related to inhibitory control was that the IC behaviors were not eliminated from the overall behavior outcomes. This could have impacted the results.

Although previous literature has utilized small sample sizes when collecting ActiGraph data (Kushida et al., 2001), it is possible the limited results were related to the small sample size. It is possible that significant findings were missed, and future research should examine these links with more participants. Similarly, the target period used to manipulate level of physical activity was relatively short and often interrupted. Additional research should examine the links with a longer period.

Finally, when comparing the relationship between variables for each diagnosis, no significance was found. This is likely due to small sample size, but future studies should seek to clarify the distinct differences between diagnoses within this model.

Future Research

Although there are many limitations to the current study, interesting findings were discovered that may lend to research on the impact of physical activity as a component of treatment for children with either ADHD or ASD. Specific research recommendations based on the limitations to the current study are listed above. Additionally, research should continue to investigate the impact of specific physical activities on other variables including sleep, inhibitory control and behavior. Details surrounding the duration and intensity of physical activity should continued to be examined in order to identify treatment targets to improve outcomes. The scientific and clinical community would benefit greatly from continued research in this field.

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Appendices

Appendix A. Recruitment Flier

UW AUTISM CENTER
UNIVERSITY of WASHINGTON

206-221-CAMP (2267)
apex@uw.edu

SEA-STAR PROGRAM

An Apex Summer Camp Program for Children with Attention Deficit Hyperactivity Disorder and their Peers and Siblings

A UW Autism Center Program

in collaboration with

Seattle Children's PEARL Clinic

Our summer day camp program focuses on providing advanced peer experiences to children with ADHD, ASD, and related disorders. It aims to build social skills and self-esteem in the context of typical summer day camp activities. The program offers 150 hours of treatment in 5 weeks, roughly the equivalent of 2 years of clinic or school-based social skills training. It is run in collaboration with Dr. Mark Stein and the Seattle Children's PEARL Clinic.

Goals for campers include:

- Improved peer interactions
- Increased self-efficacy and confidence
- Experience with common playground games
- Enhanced self-regulation of emotions and behavior

Kids: Ages 6-12 with ASD, ADHD, siblings and peers

Dates: July 5th - August 5th, 2016
5-week Program
Monday through Friday
9am-3pm

Cost: $3500
$200 discount applied to applications received by 3/15/2016

www.apexsummercamp.org

Apex Summer Camp • UW Autism Center • Box 357920 • Seattle, WA 98195 • apex@uw.edu
Phone: 206.221.CAMP (2267) • Fax: 206.685.8490

Appendix B. Parent Treatment Consent

Below is a copy of the treatment consent provided to parents upon registration for Apex Summer Camp. This consent is distributed electronically via REDCap; the basic formatting is slightly different online. The spaces for signatures allow parents to provide electronic signatures.

This consent form describes the treatment components of Apex Summer Camp Program. Please read each page carefully, and initial each page at the bottom on the line provided.

1. I agree to have my child, XXX, participate in the Apex Summer Camp Program at the University of Washington Autism Center (APEX), and I agree to cooperate as fully as possible with the APEX staff during the program.

2. I agree to allow my child's physician, XXX, my child's school, XXX, my child's therapist, XXX, to release relevant information (including medical and psychological history, intellectual and achievement testing, school records and teacher reports, etc.) to the program staff as it gathers information on my child.

3. I understand that the program will run from Tuesday, July 5th, through Friday, August 5th, 2016. It will meet at Seattle Hebrew Aacademy, Monday through Friday, from 9:00 AM until 3:00 PM. I understand that some parts of the program are held at various University of Washington facilities, and at off-site field trip locations.

4. I understand that my child will receive treatment focused on five goals:

(a) teaching my child to develop the social skills, problem-solving skills, and social awareness necessary to enable him or her to get along better with other children;

(b) teaching my child appropriate behaviors for success in classroom situations so as to enhance academic performance and productivity;

(c) teaching my child to follow through with instructions, to comply with adult requests, and to complete tasks that he/she may commonly fail to finish;

(d) improving my child's self-esteem by teaching him or her competencies in recreational and other task-related areas;

(e) teaching parents how to develop, reinforce, and maintain these positive changes

Please Initial Here: _____

5. I understand that my child will receive points for appropriate behavior and lose points for inappropriate behavior and that the points may be exchanged for daily prizes. Point totals may be rewarded with social honors, such as High Point Kid. I understand that my child's counselors will monitor his or her behavior and award or remove points continually throughout the day, informing my child of point gains and losses as they occur. The behaviors for which my child may earn points include: (1) following rules; (2) paying attention during activities; (3) behaving

appropriately for a specified period of time; (4) good sportsmanship; (5) complying with commands; (6) helping another person; (7) sharing; (8) contributing positively to group discussions; and (9) ignoring provocations and insults. The behaviors for which my child will lose points include (1) breaking rules; (2) being a poor sport; (3) physical aggression; (4) destruction of property; (5) noncompliance with adult commands; (6) stealing; (7) teasing other children; (8) talking back to staff members; (9) swearing; (10) lying; (11) leaving his or her group without permission; (12) interrupting others; and (13) whining and complaining. I understand that this type of program is a token reinforcement or point system, and that this type of treatment is generally called behavior modification or behavior therapy.

6. I understand that my child's treatment will also include instruction in social skills. That instruction will include direct instruction, modeling, role-playing, and practice in concepts that may include communication, participation, cooperation, validation, and anger management. The skills and strategies taught will be monitored and reinforced during group activities.

7. I understand that my child will also be taught group problem solving skills. This will involve teaching my child the following four-step procedure: (1) identification of problems that interfere with their group functioning; (2) discussion and negotiation skills through which a resolution to the problem can be reached; (3) development of written contracts that specify the problem, its resolution, and the consequences that are to be applied if the contract is kept or broken; and (4) evaluation and modification of the contracts. I understand that many of the contingencies, both positive and negative, that are specified in the contracts are group contingencies; that is, they apply to the entire group of children who wrote the contract rather than solely to individuals within the group. I understand, however, that individual contracts may be developed with my child should that be deemed appropriate by APEX treatment staff (See point 14 below).

8. I understand that my child may be asked to take a break from an ongoing activity, meaning that my child will sit by the side of the activity in which his or her group is engaged for a period of time until they can rejoin. I further understand that if my child exhibits aggressive, self-injurious behavior or dangerous behavior (e.g. running away), he or she may be physically restrained by his or her counselor in order to prevent injury to the child or others.

9. I understand that if I participate in the parent training groups (see point 17 below), my child will receive a Daily Report Card that will describe the kind of day my child has had in the program. I understand that I will be expected to provide a positive consequence of some kind for my child's reaching his or her goals on the Daily Report Card, and I agree to do this.

10. I understand that my child will spend around 60 minutes each day in a classroom focusing on small group skills. This may include playing board games and completing projects both individually and in small groups. I understand that the purpose of my child's participation in these activities is to develop and practice age-appropriate games and social skills, and to develop successful classroom behaviors such as following classroom rules, following directions, and staying on task.

Please Initial Here: _____

11. I understand that during other parts of the day my child will participate in other age-appropriate activities, including group sports such as kickball, soccer, basketball, and that these activities will occur in a group with 12 other children and 4-5 counselors. Treatment will be implemented continuously during these activities.

12. I understand that on Fridays my child may take field trips to other sites and that my child must earn the privilege to take such trips. I give permission for my child to take these field trips if he or she has earned them.

13. I understand that the APEX staff members may develop individualized programs for my child under some circumstances. I understand that individualized programs that differ substantially from the treatment described herein will be discussed with me in advance of their implementation.

14. I understand that the various components of the treatments may be implemented in varying degrees during the summer program. Thus, there may be times or situations in which my child does not receive points or feedback regarding his or her behavior. For example, at recess a simple set of rules are enforced and children sit out for violating the rules. Similarly, the point system is typically not employed during field trips. I understand that the purpose of these periods is to assess the degree to which my child is responding to the treatment program.

15. I understand that I will be invited to periodic parent group meetings. I understand that the purpose of these meetings is to teach me strategies for how to approach common behavioral challenges.

16. I understand that throughout the day my child will be observed by trained observers, who will code different aspects of my child's behavior, and will be rated by program staff on a number of rating scales. These observations may occur across a variety of settings, including small group, individual, dyadic, structured or unstructured settings, free play, the classroom, or individual testing sessions. Further, my child may be involved in individual task sessions designed to assess my child's cognitive and social skills and his or her responses to treatment, and about his or her social relationships. I understand that the purpose of these observations and ratings is to monitor my child's progress in the program and his or her response to treatment, as well as to gather information about the behavior of children with behavior and learning problems across various program settings. Finally, I understand that I will be asked to complete questionnaires regarding a number of aspects of my behavior and my family. I understand the purpose of these is to gather baseline information that might help understand my family and child so as to facilitate both treatment planning and evaluation and the acquisition of knowledge regarding ASD and ADHD.

17. I understand that all of the information gathered regarding my family and my child will be treated confidentially, and information with identifying characteristics will be shared only within the APEX staff, and with my permission, with my child's physician, school, and therapist.

Please Initial Here: _____

18. I understand that I am responsible for providing transportation for my child to the APEX site, and I agree to have my child at Seattle Hebrew Aacademy by 9:00 AM and to pick him or her up at 3:00 PM daily. I understand that I will receive brief feedback from the APEX staff regarding my child's behavior. I understand that my child needs to bring his or her lunch, snacks, in a backpack each day, and that my child should be dressed appropriately for active, outdoor activities. I understand that all other equipment and expenses will be provided by APEX.

19. I understand that I am financially responsible for any damages that my child causes to the facilities used during the summer program. This includes the buildings and their contents, vehicles, program materials, and equipment. I understand that I am also financially responsible for any damages that my child causes to someone else's personal property during the summer program. I understand that APEX will not assume financial responsibility for damages done to property or possessions by any child enrolled in the summer program.

20. I understand that I am free to terminate my involvement and my child's involvement in the program at any time and for any reason. However, I further understand that termination of my and/or my child's involvement in the program does not release me from my financial obligation. I understand that once I have signed this agreement I am responsible for payment of the amount agreed upon, unless other arrangements are made with the camp director.

21. I understand that my child may be terminated from involvement in Apex Summer Camp for any one of a number of reasons that include but are not limited to the following: repeated tardiness, unexcused absences, my failure to follow staff treatment recommendations, and my own disruptive or otherwise inappropriate behavior. I understand that my child may also be terminated from treatment if his or her behavior is judged by the Camp Director and clinical staff to require unavailable resources, or be too disruptive to be adequately managed in a group setting and thus interferes with the delivery of treatment to other children.

22. I understand that Apex Summer Camp does not represent a cure for most of the children who attend it. Rather it represents a good start for what usually needs to be a long-term, intensive treatment. I understand that whether the effects of Apex Summer Camp maintain after the program has ended will depend on how hard my child's school and I work to continue treatment.

Guardian 1 Name:

Guardian 1 Signature:

Guardian 2 Name:

Guardian 2 Signature:

Appendix C. Parent Research Consent

UNIVERSITY OF WASHINGTON
CONSENT FORM
Summer Treatment Program: Impact of Physical Activity

Principal Investigators:

Ben Aaronson, Ed. S	Apex Camp Director, Department of Psychiatry and Behavioral Health University of Washington ba1@uw.edu	(206) 543-3339

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David Stewart, Ph.D.	Chair and Associate Professor of Clinical Psychology, Seattle Pacific University davidste@spu.edu	(206) 281-2660

Researchers' Statement

We are asking you to be in a research study. The purpose of this consent form is to give you the information you will need to help you decide whether to be in the study or not. Please read the form carefully. You may ask questions about the purpose of the research, what we would ask you to do, the possible risks and benefits, your rights as a volunteer, and anything else about the research or this form that is not clear. When we have answered all your questions, you can

decide if you want to be in the study or not. This process is called "informed consent." We will give you a copy of this form for your records.

PURPOSE OF THE STUDY

This study is designed to investigate the impact of physical activity on sleep, inhibitory control, and behavior. Specifically, this study will examine the influence of physical activity on treatment outcomes for children. We hope to gain a better understanding of the best combination of treatment for children with Autism Spectrum Disorder, Attention Deficit Hyperactivity Disorder, or related symptoms.

STUDY PROCEDURES

You have been invited to take part in a study because you are involved in a treatment intervention through Apex Summer Camp and the SeaStar Program. If you agree to participate in this research, we will use information we are collecting during the Summer Treatment Program. During camp this year, we will be looking at differences in behavior following a physical activity, such as soccer or playground play, versus a calmer activity such as arts and crafts or board games. These activities are already in the schedule of camp. If you consent to the current research study, information collected within camp will be used for research. There are two segments of research you may choose to take part in. You may choose to participate in one, both, or neither segment of research. Both are explained below.

Segment 1: For this phase of research, you will be asked to complete questionnaires of your child's overall behavior, functioning, symptoms and sleep. These are questionnaires very similar to those you would complete at a standard office visit. You will complete these questionnaires before and after camp. Additionally, you will be asked to complete a brief daily sleep questionnaire about your child's sleep for six specific weeknights during camp. Similarly, the Summer Treatment Program includes a token point system that has been explained in the camp consent form. If you agree to participate in this research study, daily points and behavior information from the token system will be used as research data. For example, the amount of tokens earned and lost, and specific types of behaviors that occurred will be recorded. These questionnaires and participation in the token system are standard to Apex Camp protocol; participation in research indicates agreement for your responses to be used in research. In addition to token system information, counselors will be tracking participation and performance on a brief game that measures impulsivity. This is similar to other games played at camp, such as Simon Says or Red Light Green Light. Children will be asked to name cartoon characters in a whisper. If you agree to participate in research, your child's responses will be used as data. These questionnaires are all brief; before and after camp questionnaire completion should take no more than 20 minutes. The sleep log should take a maximum of 5 minutes per log.

The responses to each of these questionnaires will be collected using a study participant number and will not include any identifying information. Research data will be kept separate from any identifying information (child's name, doctor name, etc.). Information from the token system will also be immediately coded by study participant number and will not be identifiable.

Segment 2: In addition to completing the above questionnaires, your child would be sent home with an Actiwatch, which looks like a regular watch and measures activity or motion. Your child

will need to wear the ActiWatch on their wrist all the time (24 hours a day) for three week nights and days before camp, with the exception of bathing and swimming, six specific week nights and days during camp, and three week nights and days after camp. During camp, your child will wear the Actiwatch three week nights and days one week, and three week nights and days another week. The Actiwatch will help us learn about your child's sleep and activity during the day and night. The ActiWatch only assesses movement and does not collect any information about your child's location. After the designated period, you will return the Actiwatch to us by bringing it to camp. All your child is required to do is wear the Actiwatch. There are are no additional requirements from you for this portion.

Once you consent to participate in this segment of the research study, your child will be randomly assigned to specific dates to wear the Actiwatch. These will be consecutive to make this as easy as possible for your family. There is a possibility that you might consent to this segment and not be chosen to wear an Actiwatch. There are a limited number of Actiwatches and participants will be randomly chosen to wear them.

Activity and sleep data collected by the Actiwatch will be recorded via the study participant number and will not be related to your child's identifying information in any way. It will be kept separate from any identifying information. This data will be used to further examine the level of physical activity and sleep before, during, and after camp. Parents may also have the opportunity to receive feedback on their child's Actiwatch data following camp.

RISKS, STRESS, OR DISCOMFORT

There are no known physical risks associated with any of these procedures. The risk of invasion of privacy or embarrassment from completing questionnaires and sleep logs are minimal. Precautions are taken to ensure all information collected for research is coded and de-identified so privacy will not be lost. The questions on these questionnaires are very standard and sensitive subjects are generally not included; they focus on things like social attention, impulsivity, and activity level. There is a possibility of slight discomfort in wearing the ActiWatches similar to those of wearing a regular watch. If your child becomes distressed at any time as a result of discomfort associated with wearing the ActiWatch, he/she may remove the watch and discontinue.

There is also a possibility of increased stress in completing sleep logs during camp and/or your child wearing the ActiWatch. If you consent to the ActiWatch portion, you will be asked to obtain and return the watches before and after camp either in person or via mail. Primary investigators will be present to help with this process. During camp, you will simply pick up and return the watches in person. Although these are minimal, you are free to discontinue participation at any time.

There is also the potential risk of loss of confidentiality if your child agrees to wear an ActiWatch; other individuals will see the ActiWatch. Beyond the physical presence of the ActiWatch, participation in this research study will not be public knowledge, thus minimizing additional risk of loss of confidentiality. Similarly, there are many safeguards in place, including the use of a study participant number, to ensure minimal risk of loss of confidentiality. In addition to the minimal risk of loss of confidentiality with research data, there are also situations where we would be required to break confidentiality. In any situation where we feel you or your child was in danger of hurting yourself or another person, or that your child or another child or vulnerable adult was in danger of being hurt, we are obligated by law to report this information to the appropriate state agency. Also, if the records were subpoenaed, we would have to break confidentiality.

ALTERNATIVES TO TAKING PART IN THIS STUDY

The alternative to taking part in this study is to choose not to participate in the research portion and participate in camp as usual. In this case, none of your responses or child's behavior will be used.

BENEFITS OF THE STUDY

Although there are no direct benefits to your child although information gained from this research has the potential to help others. In addition, obtaining objective and reliable information on their child's behavior and sleep, over time is often found to be valuable to participants and their caretakers. This research study will provide valuable information about social and behavioral outcomes related to this summer intervention program. The program utilizes a series of evidence-based intervention practices, and this study will help clarify the impact of using this constellation of practices in a naturalistic summer day camp setting. The families involved in this clinical program over the past few years have noted significant behavioral and social gains. We would like to scientifically investigate the effectiveness of this program, and share the methodology so that other children may benefit from similar programs beyond our community.

CONFIDENTIALITY OF RESEARCH INFORMATION

As stated above, all information will be recorded according to a deidentified study participant number. Your identifying information (i.e., name, phone number) will remain confidential and separate from your study participant number. Identifiable data will be kept by camp director Ben Aaronson in a locked cabinet. The link between participant identifying information and study participant number will be accessible only by the primary investigators. Data kept by study participant number will be accessible by the research team within a locked online secure system requiring a username and password. This data may be used to help us in future studies.

We will utilize every safeguard possible to keep your information confidential. However, it is not possible for any system of protecting your confidentiality to be completely secure. It is possible that unauthorized persons might discover you are participating in research, or might obtain information about you. University and government offices sometimes review studies such as this one to make sure they are being done safely and legally, including institutional oversight review offices at the research site, the UW, or state; and federal regulators. If a review of this study takes place, your records may be examined. The reviewers will protect your privacy. The study records will not be used to put you at legal risk of harm

ADDITIONAL INFORMATION

You may consent to participate in either segment of this research study, both segments, or neither. It is possible that you may consent to participate in the Actigraphy section and not be chosen to wear an ActiWatch. You may also choose not to consent to participate in research, or to withdraw from the study at any time. In either instance, you will not be penalized in any way. Your child will be able to participate in camp treatment regardless of whether you consent to participate in research. Your participation in this research will in no way impact your child's treatment in camp. You may refuse to answer questions or participate in any portion of the activities described above.

If you have questions or concerns or need to report a problem associated with your participation in the study, please contact the Project Coordinator for the study at (206) 543-3339. If you have questions about your rights as a subject, call the Human Subjects Division at (206) 543-0098.

Thank you very much for your time and participation in this study.

Printed name of study staff obtaining consent* Signature* Date*

Subject's statement

Segment 1: Questionnaire Research Consent

I volunteer to take part in the research components involved in segment 1 of this consent. I consent to allow data collected from myself or my child within the duration of this treatment to be used as research data. This study has been explained to me and I have had a chance to ask questions. If I have questions later about the research, or if I have been harmed by participating in this study, I can contact one of the researchers listed on the first page of this consent form. If I have questions about my rights as a research subject, I can call the Human Subjects Division at (206) 543-0098. I will receive a copy of this consent form.

Printed name of subject Signature of subject Date

When subject is a minor:

Printed name of parent Signature of parent Date

When subject is not able to provide informed consent:

Printed name of representative Signature of representative Date

---

Relationship of representative to subject

Segment 2: Actigraphy

I volunteer to take part in the research components involved in segment 2 of this consent. I consent to allow my child to wear an ActiWatch for the designated time. This study has been explained to me and I have had a chance to ask questions. If I have questions later about the research, or if I have been harmed by participating in this study, I can contact one of the researchers listed on the first page of this consent form. If I have questions about my rights as a

research subject, I can call the Human Subjects Division at (206) 543-0098. I will receive a copy of this consent form.

Printed name of subject	Signature of subject	Date

When subject is a minor:

Printed name of parent	Signature of parent	Date

When subject is not able to provide informed consent:

Printed name of representative	Signature of representative	Date

Relationship of representative to subject

Copies to: Researcher
Subject
Subject's Medical Record (if applicable)

Appendix D. Counselor Behavior Tracking Sheet: Original Camp Behavior Tracking

Appendix E. Intervention Specific Counselor Tracking Sheet

Activity Intervention: PA vs. CAU

Counselors: During the after lunch target period, please lead your bunk through one of the below designated activities! On this sheet, please log the following:

Bunk Group: RED or BLUE

Date: _____

Intervention Week: PA or CAU

Chosen Activity_____

Duration of Activity: _____

Campers Details:

Camper Name	Participation?	Alternate Activity	Other Notes:

Appendix F. Example of Counselor List of Activities: A or B

A: Volcanos and Craters

Materials: Plastic disc cones
Set Up: Counselors (and kids if possible) scatter cones, half face up and half upside down
Players:

- Split kids in two teams:
  - Team Volcano
  - Team Crater

Rules:

- When counselors say go
  - Volcanos try to flip all cones right side up
  - Craters try to flip all cones upside down

Tips: place cones with enough distance between that kids aren't running into each other while they try to flip

A: SHARKS AND MINNOWS

Materials: Nothing!!
Set Up: Designate a play area (field, court, etc.)
Players:

- Select Sharks: a few players or team leaders
- All other kids: Minnows

Rules:

- Sharks say: "Shark Attack!" and Minnows try to run from one side to the other
- Use safe 'butterfly hands tags'
- If a Minnow is tagged they become a Shark!

When there are only a few Minnows left, they become the first sharks for the next round!

Appendix F Continued. Example of Counselor List of Activities: A or B

B: Ice Painting

Materials:

- Liquid Tempera Paint
- Ice cube trays
- Popsicle sticks
- Paper
- Plastic Wrap

Directions

- Pour paint into ice cube trays and cover with plastic wrap, then stick popsicle stick into each section
- When cubes are frozen, use them to paint!

B: Charades

Materials:

- Charades box, either use pre-made cards have kids come up with ideas of things to act out and write them on cards (Make sure you check before you put them in the box!)

Directions:

- Kids will come up on their own or in pairs
- Have them draw a card from the charades box and act it out
    - Try not to talk!!
- Set a time limit (e.g., 2-4 minutes depending on your group)

Tips: split up into teams and compete between teams or compete as a bunk against another bunk; compete as a bunk against yourselves (keep track of how many you can guess and try to beat your record!)

Appendix G. Whisper Task

** Note: the characters below will appear on cards of equal size and proportion. The card set will be distributed to the counselors during training.

Sample Scoring Sheet:

Whisper Task Scoring						
Camper	Card 1	Card 2	Card 3	Card 4	Card 5	Card 6
Name 1						
Name 2						
Name 3						
* W- whisper, N- normal or talking voice, S- shout						

Appendix I. Whisper Task Continued

Appendix H. Daily Sleep Diary

DAILY SLEEP RECORD: Please complete this survey before the end of the day

1. Person completing this form today:
    - Mom
    - Dad
    - Other

Below are a set of questions for Parent and Child to complete together:

What time did you go to bed last night? (Hour: Minute, e.g., 8:30)

How many minutes did it take you to fall asleep last night?

When did you wake up today? (Hour: Minute, e.g., 6:30)

How well would you say you slept last night?

- Very Poorly
- Poorly
- Average
- Well
- Very Well

How many times did you get out of bed after falling asleep?

How tired did you feel when you woke up?

- Very tired
- Slightly tired
- Not very tired
- Not at all tired

Did you nap yesterday?

- No
- Yes; if yes, how many minutes?

Did you consume caffeine yesterday?

- No
- Yes; if yes, what did you have and how much?

_____

Below are a set of questions for the Parent to complete independently.

How much time did your child spend *playing video games* last night? (in minutes)

_____

How much time did your child spend *watching TV/movies* last night? (in minutes)

_____

How hard was it for your child to wake up today?

- Very easy
- Easy
- Neutral
- Difficult
- Very Difficult

Did your child take a stimulant medication yesterday?

- No
- Yes; if yes, please list medication type and dose (e.g., Concerta, Adderall, Vyvanse, Quillivant, Focalin, etc.; 10mg)

_____

Below is a list of words that describe different feelings and emotions. Read each item carefully and then circle the answer indicating the extent to which your child seemed to feel most of the day yesterday:

Joyful

- Very slightly of Not at all
- A little
- Moderately
- Quite a bit
- Extremely

Miserable

- Very slightly of Not at all

- A little
- Moderately
- Quite a bit
- Extremely

Cheerful
- Very slightly of Not at all
- A little
- Moderately
- Quite a bit
- Extremely

Mad
- Very slightly of Not at all
- A little
- Moderately
- Quite a bit
- Extremely

Happy
- Very slightly of Not at all
- A little
- Moderately
- Quite a bit
- Extremely

Afraid
- Very slightly of Not at all
- A little
- Moderately
- Quite a bit
- Extremely

Lively
- Very slightly of Not at all
- A little
- Moderately
- Quite a bit
- Extremely

Scared
- Very slightly of Not at all
- A little
- Moderately
- Quite a bit
- Extremely

Proud

- Very slightly of Not at all
- A little
- Moderately
- Quite a bit
- Extremely

Sad

- Very slightly of Not at all
- A little
- Moderately
- Quite a bit
- Extremely

Thank you!