Investigating the Effectiveness of a Fundamental Motor Skill Intervention for 4 Year Old Children with Autism Spectrum Disorder

By

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Investigating the Effectiveness of a Fundamental Motor Skill Intervention for 4 Year Old Children with Autism Spectrum Disorder

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Abstract

Young children with Autism Spectrum Disorder (ASD) experience significant delays in their fundamental motor skills (FMS) yet, FMS are virtually ignored in the intervention literature as traditional therapies focus on the core challenges in the social, communicative, and behavioural domains. This study sought to examine the effectiveness of a FMS intervention at improving the motor skills, adaptive behaviour, and social skills of 4 year old children with ASD. **Motor Outcomes (Manuscript 1):** Results demonstrated significant improvements in motor skills following the intervention; these improvements were retained at the 6-week follow-up. **Adaptive Behaviour and Social Skill Outcomes (Manuscript 2):** Results demonstrated individual gains in adaptive behaviour and social skills; although no significant group improvements were found. **Conclusion:** The results of this study suggest that a FMS intervention can be effective at improving motor skills, and may result in individual behavioural improvements. These findings warrant further research with a larger sample.

Keywords: autism spectrum disorder, fundamental motor skills, adaptive behaviour, children, motor intervention, active play

Emily E. Bremer (2014)

Statement of Originality

I, Emily E. Bremer, hereby declare that this thesis is, to the best of my knowledge, original, except as acknowledged in the text. I further declare that the material contained in this thesis has not been previously submitted, either in whole or in part, for a degree at this or any other university.

Emily E. Bremer (2014)

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List of Abbreviations Used

ABA	Applied Behaviour Analysis
ASD	Autism Spectrum Disorder
BDI-2	Battelle Developmental Inventory-2
BOTMP	Bruininks-Oseretsky Test of Motor Proficiency
BSID-2	Bayley Scales of Infant Development-2
BSID-3	Bayley Scales of Infant Development-3
CAAL	Child/Adolescent Activity Log
CTC	Children's Treatment Centre
DSM-5	Diagnostic and Statistical Manual of Mental Disorders-5
DST	Dynamic Systems Theory
EIBI	Early Intensive Behavioural Interventions
ESDM	Early Start Denver Model
FMS	Fundamental Motor Skills
IQ	Intelligence Quotient
MABC-2	Movement Assessment Battery for Children-2
M-CHAT	Modified Checklist for Autism in Toddlers
MSEL	Mullen Scales of Early Learning
MVPA	Moderate-to-Vigorous Physical Activity
PDD	Pervasive Developmental Disorder
PDD-NOS	Pervasive Developmental Disorder - Not Otherwise Specified
PDMS-2	Peabody Developmental Motor Scales-2

SD	Standard Deviation
SOFIT	System for Observing Fitness Instruction Time
SSIS	Social Skills Improvement System
TD	Typical Development
TGMD	Test of Gross Motor Development
TGMD-2	Test of Gross Motor Development-2
VABS	Vineland Adaptive Behavior Scales
VABS-2	Vineland Adaptive Behavior Scales-2

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Overview

This thesis is divided into seven sections:

1. Introduction
2. Literature Review
3. Manuscript 1
4. Manuscript 2
5. Pilot Study
6. Thesis Conclusions
7. Appendices that include ethics approval, consent forms, recruitment flyer, questionnaires, and raw data

Section 1: Introduction

Introduction to Thesis

Autism Spectrum Disorder

Autism Spectrum Disorder (ASD) is characterized by challenges in social communication, social interactions, and a restricted pattern of behaviour or interests (American Psychiatric Association, 2013) and it occurs in approximately 1 in 150 (Fombonne, 2009) to 1 in 88 children (Kogan et al., 2009). The challenges that children with ASD experience in the communication and social domains often result in difficult behaviours, such as aggression and non-compliance (Fox, Vaughn, Dunlap, & Wyatte, 2002; Singh et al., 2006). However, children with ASD often exhibit strengths in their visual skills, and have a higher nonverbal than verbal intelligence quotient (IQ) (Mayes & Calhoun, 2003; Quill, 1997). Given the challenges that children with ASD experience and the high prevalence of the disorder, the need for early intervention is a high priority.

Early interventions for children with ASD typically target the social, communicative, and behavioural domains through speech-language therapy, sensory-integration therapy, and intensive behavioural interventions (Matson & Smith, 2008; Myers & Johnson, 2007; Simpson et al., 2005). However, there is great variability in the level of functioning across the spectrum of children with ASD and as such, there is also variability in the children's response to various treatments (Lord et al., 2005; Matson & Smith, 2008). Although the primary concern for parents of young children with ASD and clinicians is often social, communicative, and behavioural skills, children with ASD also experience challenges in other areas of development.

Benefits of Play and Play Skills in ASD

Play is a voluntary, flexible, and pleasurable activity that is an important part of the overall development of all children (Boucher & Wolfberg, 2003; Ginsburg, 2007). Play provides a platform for children to develop and practice their cognitive, social, and motor skills (Boucher & Wolfberg, 2003; Gallo-Lopez & Rubin, 2012; Ginsburg, 2007; Pellegrini & Smith, 1998b). For example, play allows children to use and manipulate toys which is important for executive functioning and problem solving (Burdette & Whitaker, 2005; Gallo-Lopez & Rubin, 2012). During play children can engage with peers, which helps to develop a sense of understanding, self-regulation, cooperation, and fosters friendships (Burdette & Whitaker, 2005; Gallo-Lopez & Rubin, 2012). Lastly, play provides an opportunity for children to be physically active and improve their motor skills (Pellegrini & Smith, 1998b). Therefore, there are a number of positive outcomes associated with play, making it an integral part of children's overall development.

The play of young children with ASD has been described as repetitive, uninventive, and rigid (Boucher & Wolfberg, 2003; Gallo-Lopez & Rubin, 2012) as children with ASD tend to have difficulties with functional and spontaneous play, as well as imitating others during play (Charman et al., 1997; Williams, Reddy, & Costall, 2001). As a result, children with ASD are likely missing out on the many developmental benefits that play can provide. Given the challenges that children with ASD experience in the social, communicative, behavioural, and motor domains (American Psychiatric Association, 2013; Lloyd, MacDonald, & Lord, 2011), children with ASD arguably have much to gain from participating in play. However, in order to benefit from play, a child must have the necessary skills to participate. We propose that underdeveloped motor skills may be one of the critical factors that is inhibiting children with ASD from participating in play.

Fundamental Motor skills and ASD

Fundamental motor skills (FMS) are the basic movements necessary to participate in games, sport, recreational physical activities, and active play (Lubans, Morgan, Cliff, Barnett, & Okely, 2010; Payne & Isaacs, 2002). It is essential that young children develop proficient motor skills since motor proficiency enables participation in active play (Pellegrini & Smith, 1998b) and may contribute to one's social, communicative, and overall development (Bhat, Galloway, & Landa, 2012; Jasmin et al., 2009; Larkin & Summers, 2004a; MacDonald, Lord, & Ulrich, 2013).

Although research is limited, the literature indicates that young children with ASD have motor skills that are significantly delayed and of poor quality (Jasmin et al., 2009; Liu & Breslin, 2013; Lloyd et al., 2011; Ozonoff et al., 2008). It has also been suggested that the motor skills of young children with ASD become significantly worse with increasing age (Landa & Garrett Mayer, 2006; Lloyd et al., 2011). This 'falling behind' may be due to children with ASD not learning new motor skills at the same rate as their peers with typical development (TD); thus, creating a significant gap between their actual skill level and the level at which their skills should be for their age. Given the importance of motor skill proficiency for optimal development in children with ASD (Bhat et al., 2012; Jasmin et al., 2009; Larkin & Summers, 2004a; MacDonald et al., 2013), it is important that interventions begin to target motor skill proficiency, particularly at a young age.

Fundamental Motor Skill Interventions for Young Children with Delays

There are currently no known studies examining the effectiveness of FMS interventions for young children with ASD. However, previous research has demonstrated that FMS interventions can be effective at improving the motor skills of preschool age children with a developmental delay (Kirk & Rhodes, 2011). Given the importance of FMS proficiency to the overall development of young children with ASD (Bhat et al., 2012; Jasmin et al., 2009; Larkin & Summers, 2004a; MacDonald et al., 2013), it is important that future research examine the effectiveness of FMS interventions in this population. Furthermore, given the significant challenges that children with ASD experience in the social, communicative, and behavioural domains (American Psychiatric Association, 2013) it may be beneficial to further explore the relationship between FMS and these areas, as well as whether these developmental areas can be improved through a motor skill intervention.

Summary

Children with ASD experience challenges with their social, communicative, and behavioural skills (American Psychiatric Association, 2013). They also have motor skills that are significantly delayed and of poor quality (Liu & Breslin, 2013; Lloyd et al., 2011; Ozonoff et al., 2008). Proficient motor skills are essential for engagement in active play (Lubans et al., 2010; Pellegrini & Smith, 1998b) and in turn, play provides an ideal platform to improve social, cognitive, behavioural, and overall functioning (Boucher & Wolfberg, 2003; Gallo-Lopez & Rubin, 2012; Ginsburg, 2007; Pellegrini & Smith, 1998b). Therefore, it is important that young children with ASD are provided with an opportunity to gain proficiency in the motor skills required to engage in play.

This study will be the first to measure the effectiveness of a FMS intervention at improving the motor skills, adaptive behaviour, and social skills of 4 year old children with ASD. This study will also examine whether the intensity of intervention that is provided has any bearing on the intervention outcomes. Results from this study will be divided into the two main components of this thesis: the motor skill outcomes following the intervention (refer to Section 3); and the adaptive behaviour and social outcomes following the intervention (refer to Section 4). Since the intervention literature for young children with ASD virtually ignores motor skills, a small pilot study was conducted prior to this thesis in order to determine the feasibility of conducting a FMS intervention with this population. Results from the pilot study can be found in Section 5 of this thesis.

Proposed Research Framework: Dynamic Systems Theory

Motor Development and Active Play

Motor development is characterized by the changes in motor behaviour that occur across an individual's life, as well as in the processes that underlie these changes (Clark & Whitall, 1989; Payne & Isaacs, 2002). Motor development is both product and process oriented as it focuses not only on the motor output, but also on the factors that contribute to the occurrence of any given motor behaviour (Clark & Whitall, 1989). Fundamental motor skills (FMS) are the basic movement skills, such as running, jumping and throwing, that are essential to the future acquisition of the more complex skills required in games, dance, sports, gymnastics, recreational physical activities, and active play (Burton & Miller, 1998; Payne & Isaacs, 2002). FMS are important for engagement in physical activity (Lubans et al., 2010) and in young children, they are required to engage in active play (Pellegrini & Smith, 1998b). Active play is important for young children as it provides them with an opportunity to engage with their peers, learn social cues, and be physically active (Gallo-Lopez & Rubin, 2012; Ginsburg, 2007). Therefore, delayed FMS may negatively impact the development of other areas, such as social and communicative skills.

Children with Autism Spectrum Disorder (ASD) have motor skills that are delayed and of poor quality (Liu & Breslin, 2013; Lloyd et al., 2011; Ozonoff et al., 2008); they also experience significant challenges in the social and communicative domains (American Psychiatric Association, 2013). The play of children with ASD has been described as solitary, repetitive, inflexible, and developmentally inappropriate (Boucher & Wolfberg, 2003; Gallo-Lopez & Rubin, 2012; Williams, 2003; Williams et al., 2001; Wolfberg & Schuler, 1993). We propose that the inefficient motor skills of children with ASD may be one of the most influential factors that inhibit their engagement in active play, and that this relationship may be best explained by dynamic systems theory (DST).

Application of Dynamic Systems Theory

Given the vast benefits of active play (Gallo-Lopez & Rubin, 2012; Pellegrini & Smith, 1998b) and the notion that children with ASD typically do not engage in developmentally appropriate play (Boucher & Wolfberg, 2003; Gallo-Lopez & Rubin, 2012; Williams, 2003; Williams et al., 2001; Wolfberg & Schuler, 1993), our target behaviour for children with ASD is engagement in active play. The inhibition and promotion of active play in children with ASD can be viewed through the lens of DST. DST is an ecological approach commonly applied to biological processes, and more recently used to explain motor development (Clark & Whitall, 1989; Kugler, Kelso, & Turvey, 1980; Thelen, 1995). There are three main aspects of DST that work together to influence how one moves: self-organization, attractors, and control parameters (Thelen, 1995).

Self-organization refers to the coordination of many subsystems and the spontaneous nature in which systems organize to produce a specific behaviour (Thelen, Ulrich, & Wolff, 1991). In order for a given behaviour, such as active play, to occur all of the individual subsystems, or inputs, need to align. For example, children with ASD will need the neural connections involved in the movement of limbs, sufficient motivation to explore their surroundings, and the motor skills to actually engage in play, among other things, before active play will occur. If any of these individual subsystems is lacking (i.e.

motor skills are delayed), the system will not self-organize to produce the desired output (i.e. active play).

Attractors are the pattern of behaviour to which an individual is most drawn (Thelen, 1995). For instance, one could choose to walk, crawl, jump, or roll as their preferred means of locomotion; however, most adults choose to walk from place-to-place as walking is their most efficient, and attractive, state of motor behaviour. Children with ASD tend to engage in abnormal play that is solitary, repetitive, and inflexible (Boucher & Wolfberg, 2003; Gallo-Lopez & Rubin, 2012). For example, children with ASD may engage in solitary and repetitive tasks such as sitting and lining up or counting toys. They may also have difficulties engaging in imaginative play or using toys or objects in ways other than their functional use (e.g. using a spoon as an imaginary sword). Children with ASD are most likely to engage in this abnormal type of play; thus, it is their attractor state. However, given the importance of active play for one's overall development (Gallo-Lopez & Rubin, 2012; Ginsburg, 2007), one should consider active play (e.g. engaging with peers, exploring playground equipment, participating in imaginative play) as the desired output for a child with ASD. In order to shift this solitary, repetitive, play into active play, there needs to be a change in their system. We propose that improving FMS may be one of the critical factors, or control parameters, needed for a child with ASD to start engaging in active play.

Control parameters are variables that promote or inhibit a certain behaviour in that when a particular control parameter reaches its critical point, a change in the preferred pattern of behaviour will result (Thelen et al., 1991). Although control parameters do not literally control the system, they are constantly shaping one's behaviour at any given time as they can involve any aspect of the individual, environment, or task (Thelen et al., 1991). Individual control parameters can include the various systems of the human body such as the muscular, skeletal, nervous and perceptual systems. Whereas, contextual factors are those factors that are external to the individual such as the surface of the floor and the presence of people or objects. Both individual and contextual factors can encourage or inhibit a particular behaviour from occurring. Therefore, it is probable that the lack of meaningful, active play exhibited by young children with ASD can be partially attributed to many individual and contextual factors that act as control parameters on their system; one of the most important of which, we hypothesize, is FMS. If a young child with ASD does not have proficient FMS they will not be able to effectively move about their environment and engage in the type of active games that are typical of young children (i.e. chasing one another around; playing with balls and toys; and exploring obstacles by climbing, jumping, and sliding). This lack of engagement in active play may further hinder the ability of a child with ASD to engage in social situations and communicate with one's peers; thus, potentially falling further behind in overall development.

Further Analysis of Motor Skills as a Control Parameter to Active Play

By understanding the role of control parameters in relation to young children with ASD, researchers and practitioners can focus interventions on developing the individual domains that are inhibiting active play. Within the context of DST, in order to promote active play in young children with ASD, one would need to manipulate a particular control parameter in order to cause a shift in the system. This could include teaching children with ASD how to communicate their needs more effectively with their peers; it could include teaching the functional use of different toys and play objects; or it could teach children with ASD to engage in joint attention, among other things. However, play in the preschool years is supposed to be spontaneous, child-driven, and predominately physically active (Pellegrini & Smith, 1998a, 1998b). This means that in order for a child to actually engage in play, they have to have the physical ability or the skills to do so. We hypothesize that one of the essential control parameters for active play is proficiency in FMS, as these are the skills that will enable a child with ASD to physically engage in play; which in turn can provide opportunities to improve in all other developmental areas associated with play. Therefore, intervening on FMS may cause the shift in the system that is needed for children with ASD to participate in active play.

Summary

Children with ASD do not play in the same manner as children with typical development (TD) (Gallo-Lopez & Rubin, 2012), and these differences may be due to the delays in social, communicative, and motor skills that they experience (American Psychiatric Association, 2013; Lloyd et al., 2011). Active play provides an excellent platform for the development of social, communicative, and motor skills (Gallo-Lopez & Rubin, 2012; Ginsburg, 2007); however, these skill are also required to engage in active play in the first place. DST provides a useful framework for trying to understand the lack of active play in young children with ASD. We propose that motor skills may be one of the control parameters for active play in young children with ASD. If motor skills can be improved through intervention, it may increase engagement in active play and provide an opportunity for the development of social and communicative skills.

Significance of the Research

This study will add to the early intervention literature regarding young children with Autism Spectrum Disorder (ASD); it will also address the gaps in the literature in regard to the fundamental motor skills (FMS) of this population. Previous research has found that motor skill interventions can be effective at improving motor skills in preschool age children with developmental delays; however, children with ASD have been excluded from most of this research (Kirk & Rhodes, 2011). Motor skills have typically been neglected in the early intervention literature for young children with ASD as research and clinical priorities tend to lay with the core challenges of ASD. Children with ASD also present challenges to researchers due to behavioural issues and the large variability in functioning across the spectrum of children with ASD. This study will attempt to improve the overall development of young children with ASD by intervening on FMS and investigating its impact on adaptive behaviour and social skills.

Justification of Methodology

This study included participants that were 4 years of age with a diagnosis of ASD. There are currently no known FMS interventions in the literature for preschool age (3-5 year old) children with ASD. Very strict age criteria were chosen for this study in order to limit any potential behavioural difficulties that could result from having a wider age range. The intensity and duration of motor skill interventions are highly variable in the literature pertaining to preschool age children with developmental delays (excluding children with ASD); with an average intervention length of 13.7 weeks and total instruction time ranging from 9-28 hours (Kirk & Rhodes, 2011). However, since there is no motor skill intervention literature specifically for young children with ASD, we chose a duration (12 sessions) that we thought would be manageable for parents and decided to investigate the differences between two different intensities (1 session/week vs. 2 sessions/week). Additionally, most early intervention services for young children with ASD are clinically-based sessions that target the core challenges of ASD (i.e. social and communication skills). In contrast, the present study addressed an area of need for children with ASD that is virtually ignored in the intervention literature and also provided peer interactions through the group setting. Teaching FMS in a community-based group intervention provided an opportunity for participants to improve motor skills, as well as engage socially with peers and instructors.

Purpose and Overall Contribution

The purpose of this study is to determine the effectiveness of a FMS intervention at improving the motor skills, adaptive behaviour, and social skills of 4 year old children with ASD. A secondary purpose is to determine whether a higher intensity of the same intervention is more or less effective at improving these domains. There is currently no research supporting the effectiveness of a FMS intervention for preschool age children with ASD; thus, results from this study will fill a critical gap in the scientific literature, and may help to shape future interventions for young children with ASD.

Current interventions for young children with ASD typically focus on social and communication skills, and the reduction of maladaptive behaviours (Matson, Matson, & Rivet, 2007; Matson & Smith, 2008; Simpson et al., 2005; Virués-Ortega, 2010). However, the National Research Council’s (2001) committee on educating children with autism recommends the development of social skills that enhance participation in family and community activities, developmentally appropriate tasks and play, and gross and fine motor skills, among other things. Proficiency in FMS is essential to participation in these other domains. Therefore, interventions are needed that address multiple areas of development simultaneously. This study will help to fill that need and address these essential areas of development by providing a play-based FMS intervention and measuring its effectiveness at improving the motor skills, adaptive behaviour, and social skills of 4 year old children with ASD.

Hypotheses and Objectives

Objectives of the Research

1. To investigate the effect of a community-based FMS intervention on the motor skills of 4 year old children with a diagnosis of ASD.
2. To investigate the effect of a community-based FMS intervention on the adaptive behaviour and social skills of 4 year old children with a diagnosis of ASD.
3. To investigate the differences between two intensities (1x/week for 12 weeks vs. 2x/week for 6 weeks) of a FMS intervention at improving the motor skills, adaptive behaviour, and social skills of 4 year old children with a diagnosis of ASD.

Specific Hypotheses of the Research

1. The FMS intervention will result in improvements to the motor skills of 4 year old children with ASD.
2. The FMS intervention will result in improvements to the adaptive behaviour and social skills of 4 year old children with ASD.
3. The lower intensity FMS intervention (1x/week for 12 weeks) will result in greater improvements in motor skills, adaptive behaviour, and social skills at the post-test when compared to the higher intensity intervention (2x/week for 6 weeks).

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Section 2: Literature Review

Literature Review

Autism Spectrum Disorder

Autism Spectrum Disorder (ASD) is a complex developmental disorder that was first described by Leo Kanner in 1943 (Kanner, 1943) in his report entitled, "Autistic Disturbances of Affective Contact" in which he provided case studies of 11 children. Kanner (1971) further categorized these same children as all having an inability to "relate themselves to people and situations in the ordinary way, and an anxiously obsessive desire for the preservation of sameness" (p. 140). Despite these characteristics, the 11 children were otherwise physically healthy; however, several of the children were reported as being somewhat clumsy in their gross motor performance (Kanner, 1943, 1971). Kanner (1943) emphasized the uniqueness of these children in his first report and since that time, thousands of studies have looked to further describe the characteristics, diagnostic criteria, and treatment for children with autism (Volkmar, Lord, Bailey, Schultz, & Klin, 2004).

The diagnostic criteria for autism have been refined since Kanner's original description of the disorder as the Diagnostic and Statistical Manual for Mental Disorders has been updated throughout the decades (American Psychiatric Association, 2000, 2013; Kanner, 1943). Autism was previously considered one of five pervasive developmental disorders (PDD), along with Asperger's Disorder, Pervasive Developmental Disorder – Not Otherwise Specified (PDD-NOS), Rett's Disorder, and Childhood Disintegrative Disorder; all of which were characterized by impairments in reciprocal social interactions, communication, and stereotyped behaviour or interests (American Psychiatric Association, 2000). Current diagnostic criteria for children with autism uses the term ASD to include all children with deficits in social communication and social interactions; as well as restricted patterns of behaviour or interests, including stereotyped or repetitive movements, use of objects, or speech (American Psychiatric Association, 2013). These symptoms must be present in the early developmental period, cause clinically significant impairments in functioning, and not be better explained by intellectual disability (American Psychiatric Association, 2013). Individuals who are diagnosed with ASD will now also be given a severity rating of levels 1-3; where level 1 designates those individuals who require the least support and level 3 is for those requiring very substantial support (American Psychiatric Association, 2013). Given the deficits these children experience in their social, communicative, and behavioural skills, and the high number of children with a diagnosis of ASD, it is important that the necessary supports are in place to help guide these children throughout their lifespan.

The reported prevalence of autism has shifted from approximately 4.4 cases per 10,000 in the late 1960's to early 1990's (Gillberg, 1990; Volkmar et al., 2004), to its current estimate of 1 in 150 (Fombonne, 2009) to 1 in 88 children (Kogan et al., 2009) being affected; boys are consistently more affected than girls at rate of 4 to 1 (Kanner, 1943; Kogan et al., 2009). Few studies have examined the incidence of autism (i.e. the rate of new cases); thus, it is difficult to tell whether the increased prevalence is due to an actual increase in the disorder, or rather increased awareness, earlier diagnosis, and changes in practice (Volkmar et al., 2004). Regardless of the reason for an increased prevalence, it is apparent that there are more children being diagnosed with autism now than in the past.

Children with ASD typically have higher nonverbal IQs than verbal IQs, high levels of rote learning, and have relative strengths in their visual skills such as matching, spatial relations, and short-term memory (Mayes & Calhoun, 2003; Quill, 1997). Despite these strengths, the combination of challenges that children with ASD experience in regards to their social, communicative, and behavioural skills can result in the presence of difficult behaviours such as self-harm, aggression, and non-compliance (Fox et al., 2002; Singh et al., 2006). There is no cure for ASD; however, these behaviours and deficits are often dealt with through multiple interventions including speech-language therapy, occupational therapy, physical therapy, and behavioural interventions (e.g. Applied Behavioural Analysis) (Myers & Johnson, 2007; Simpson et al., 2005). Many studies and clinical reports have demonstrated the effectiveness of these interventions in improving the outcomes for children with ASD, particularly if the interventions are intensive and introduced early on in the child's life (Corsello, 2005; McConachie & Diggle, 2007; Virués-Ortega, 2010). Despite the evidence supporting these programs, early intervention can be extremely cost prohibitive for the families of children with ASD (Chasson, Harris, & Neely, 2007). For example, Early Intensive Behavioural Interventions can cost an average of $40,000 a year (Chasson et al., 2007); thus, placing a significant financial burden on the health care system, social services, and individual families. Furthermore, many families experience long wait times for their child's services, which can negatively impact both the child's level of functioning and the family's quality of life (Brown, MacAdam–Crisp, Wang, & Iarocci, 2006). The families of children with ASD can experience a number of stressors associated with raising a child with ASD, including the child's difficult behavioural profile, their need for additional attention and services, and the financial burden of accessing additional services, all of which can be detrimental to the family's overall quality of life (Brown et al., 2006).

Children with ASD experience deficits in their communication and social skills, as well as demonstrating repetitive behaviours and interests (American Psychiatric Association, 2013). It is important that children with ASD receive a significant amount of early intervention in order for them to have the most optimal outcomes and reduce family stress (Brown et al., 2006; Corsello, 2005). Thus, children with ASD must have access to accessible, cost-effective, early interventions that will address all of the behavioural and functional needs of each individual child.

Motor Skills of Young Children with ASD

Leo Kanner, in his early descriptions of autism, noted a 'clumsiness' in the gross motor performance of the children whom he observed (Kanner, 1943). Since this initial description, research has consistently demonstrated that children with ASD experience challenges in the motor domain (Bhat, Landa, & Galloway, 2011; Landa & Garrett Mayer, 2006; Liu & Breslin, 2013; Lloyd et al., 2011; Ozonoff et al., 2008). Although these challenges are consistent, there is large variability in the measures and age ranges used in the research, leaving significant gaps in the literature. For example, Landa and Garrett Mayer (2006) investigated the gross and fine motor skills of 24 infants with ASD at 6, 14, and 24 months of age in comparison to children with a language delay (n=11) and children with typical development (TD; n=52). Using the Mullen Scales of Early Learning (MSEL) to assess motor skills, they found that at 6 months of age there were no statistically significant differences between the three groups. However, at 14 months of age the children with ASD were significantly below the children with TD in both their fine and gross motor skills. Furthermore, at 24 months of age the children with ASD were significantly behind both the group with the language delay and with TD in both fine and gross motor skills (Landa & Garrett Mayer, 2006). One limitation to this study is the use of the MSEL to assess motor development. The MSEL is commonly used in the psychology domain; however, there are more robust motor assessments that are commonly used in the motor domain which would provide a stronger measure of motor skills. Despite its limitations, this study makes a significant contribution to the literature as it provides a longitudinal analysis of the motor development of infants and toddlers with ASD. Results indicate that the motor skills of children with ASD fall significantly behind their peers throughout their toddler years; thus, indicating a need for an early motor intervention for these children.

More recently, Lloyd and colleagues (2011) investigated the motor skills of 162 toddlers aged 12-36 months with ASD while controlling for non-verbal IQ. Motor skills were assessed with the gross and fine motor subscales of the MSEL and the motor domain of the Vineland Adaptive Behavior Scales (VABS), which is a parent questionnaire. Results indicated that the gross and fine motor skills of the sample were significantly delayed and became worse with each 6 month period of chronological age (Lloyd et al., 2011). This finding suggests that young children with ASD fall further behind in the motor domain as they get older even when non-verbal IQ is controlled for. However, as this was a cross-sectional study, it is also possible that the older children in the sample simply had poorer motor skills than the average child with ASD. In order to account for this possibility, a subset of 58 children from the sample were measured twice approximately 12 months apart; providing the ability to examine the longitudinal trajectory of motor skills in the same group of children (Lloyd et al., 2011). Results from the longitudinal sample found that these children had motor skills that were below where they should be for their age and became significantly more delayed with increasing age; thus, confirming the results of the cross-sectional study (Lloyd et al., 2011). Additionally, in both the cross-sectional and longitudinal study, scores from the MSEL and VABS were positively related, which helped to confirm the presence of a motor delay through the parents' perception of their toddler's motor abilities. Although this study used the MSEL as its measure of motor development, which is not as commonly used in the motor domain, it is the largest study of directly measured motor skills of toddlers with ASD and the only study to control for IQ; thus, making a significant contribution to the literature.

Ozonoff and colleagues (2008) also used the MSEL and VABS to investigate the motor development of 54 children aged 26-61 months with autism in comparison to 25 children with a developmental delay and 24 children with TD. They also used home videos to look for movement abnormalities in the children. The video analysis indicated that no elevated rates of movement abnormalities were found in the home videos for any of the children (Ozonoff et al., 2008). However, the children with autism had significantly lower motor scores on the MSEL and VABS than the children with TD; there were no significant differences between the children with autism and those with a developmental delay (Ozonoff et al., 2008). This study is limited by its use of the MSEL; however, the scores from the VABS strengthen the study by adding an additional measure of motor development. This is one of the few studies to include children in the 4-5 year old age range; thus making it relevant to the current study.

Another study that examined the motor skills of 3-4 year old children with ASD, as part of a larger study, included 35 participants who were assessed with the second edition of the Peabody Developmental Motor Scales (PDMS-2) (Jasmin et al., 2009). The researchers found that 63% of the children had a significant gross motor delay, 53% had a fine motor delay, and 57% had an overall motor delay (Jasmin et al., 2009). These findings indicate the significant motor delays that children with ASD experience. Although this study had a relatively small sample and did not control for IQ, it is strengthened by its direct measure of motor skills and that it is one of the few studies to include 3-4 year old children.

Provost and colleagues (2006) compared the motor delays of young children 21-41 months of age with ASD (n=19), a developmental delay (n=19), and those with no motor delays (n=18). They used the Bayley Scales of Infant Development-2 (BSID-2) and the PDMS-2 to directly measure the children's motor skills. Results indicated that 84% of the children with ASD were significantly delayed on the BSID-2 and the remaining 16% were mildly delayed (Provost et al., 2006). Additionally, all children except one scored below average or lower on the PDMS-2 and the children with ASD scored significantly lower than the children in the group without motor delays on all measures (Provost et al., 2006). This study is limited by its small sample size; however, the BSID-2 and PDMS-2 are both commonly used motor assessments in the motor domain, which is a definite strength of this study.

Another study using a robust measure of motor development was conducted by Lane and colleagues (2012) who investigated the motor characteristics of 30 children ranging in age from 19-41 months who were referred to a clinic for a possible diagnosis of ASD. A chart review indicated that 22 of these children had a final diagnosis of ASD, 7 had a non-ASD diagnosis and one was developing typically (Lane et al., 2012). The fine and gross motor domains of the Bayley Scales of Infant Development-3 (BSID-3) was used to assess motor development. Results indicated that the children with ASD were on average 8.59 months behind their chronological age in regard to their fine motor developmental and 6.36 months behind in their gross motor development; indicating a significant motor delay, especially given their young age (Lane et al., 2012). Although this study had a relatively small sample, it used a very strong measure of motor skills, resulting in an accurate depiction of the motor abilities of the children in this sample. Therefore, this study indicates that motor delays may be a key characteristic of young children with ASD.

Matson and colleagues (2010) examined the motor abilities of a large sample of 397 children with a diagnosis of autism, pervasive developmental disorder-not otherwise specified (PDD-NOS), or atypical development ranging in age from 17-36 months. Motor skills were assessed using the gross and fine motor subdomains of the Battelle Developmental Inventory-2 (BDI-2) which uses a combination of direct observation and parent reports. Results indicated that 16.2% and 25.6% of the children with autism had gross and fine motor impairments, respectively; this was significantly more than the children in the atypical group (Matson et al., 2010). These findings are relevant as a large sample was used and significant delays in motor development were evident.

More recently, Liu and Breslin (2013) compared the motor skills of 30 children with ASD (aged 3-16 years) with 30 age-matched children with TD using the Movement Assessment Battery for Children-2 (MABC-2); 10 children in each group were between

3-6 years of age. The researchers found that the children with ASD scored significantly lower in all three domains of the MABC-2 (manual dexterity, ball skills, and static and dynamic balance), as well as in their overall percentile score when compared to the children with TD (Liu & Breslin, 2013). Furthermore, 77% of the children with ASD scored below the 5th percentile on the MABC-2 indicating a significant motor delay; no children with TD were found to have, or be at risk for, motor delays (Liu & Breslin, 2013). The results of this study further indicate that children with ASD have motor delays that are present in early childhood and persist through adolescence.

Lastly, a study of the predictors of optimal outcomes for toddlers with ASD could be indicative of the need for motor skill interventions at an early age (Sutera et al., 2007). This study assessed 90 children who screened positively on the Modified Checklist for Autism in Toddlers (M-CHAT) at the age of 2 years (73 of whom had a diagnosis of ASD), and re-evaluated their diagnosis at the age of 4 years (Sutera et al., 2007). At the re-evaluation, 13 of the original 73 children with ASD no longer met the diagnostic criteria for ASD. The researchers found that the most distinguishing factor between those children at age 2 who subsequently no longer met the diagnostic criteria for ASD and those who still met diagnostic criteria, were their motor skills at age 2 as reported by their parents on the VABS and through direct measurement using the MSEL (Sutera et al., 2007). Children who no longer met ASD diagnostic criteria at 4 years of age were more likely at 2 years of age to have been able to run smoothly with changes in speed and direction, open doors by turning and pulling the doorknob, and pedal a tricycle, when compared to their peers who still met the diagnostic criteria for ASD (Sutera et al., 2007). The results of this study support the notion that motor skill proficiency is important for the optimal outcomes of young children with ASD; thus, it may be beneficial to intervene on motor skills at a young age in children who have, or who are at risk for, ASD.

The literature clearly indicates that young children with ASD have motor skills that are significantly delayed and of poor quality (Landa & Garrett Mayer, 2006; Lane et al., 2012; Lloyd et al., 2011; Matson et al., 2010; Ozonoff et al., 2008; Provost et al., 2006). It is also possible that the motor skills of children with ASD get significantly worse, or fall significantly behind their peers with TD, with increasing age (Landa & Garrett Mayer, 2006; Lloyd et al., 2011). Furthermore, early motor skill proficiency may be related to optimal outcomes in young children with ASD (Sutera et al., 2007). Despite these findings, the research is still limited and only one study (Lloyd et al., 2011) controlled for IQ when measuring motor skills. It is possible that the studies that did not control for IQ only included higher functioning children with ASD due to potential issues with compliance and maladaptive behaviours in lower functioning children. Future research should continue to investigate motor proficiency across the entire spectrum of functioning in children with ASD, as well as examine the causes behind these motor delays.

Possible Causes of Motor Impairments in Children with ASD

The exact cause of the motor delays exhibited by children with ASD is unknown; however, it is hypothesized that it could be attributed to many factors including neurological deficits, genetics, difficulties with sensory-motor integration, and the impact of a comorbid diagnosis of intellectual disability. Research has indicated that children with ASD may exhibit a vast array of neurological impairments affecting the cerebellum, basal ganglia, mirror neurons, and sensorimotor cortices (Dowd, Rinehart, & McGinley, 2010; Esposito & Paşca, 2013; Jones & Prior, 1985). This neurological dysfunction may contribute to the impaired motor abilities of children with ASD, including difficulties with imitating gestures and dynamic movements (Dowd et al., 2010; Esposito & Paşca, 2013; Jones & Prior, 1985). Another indicator of early neurodevelopmental disruption in children with ASD has been suggested by Flanagan and colleagues (2012) who have demonstrated that head lag during pull-to-sit in infants is significantly associated with ASD at 36 months of age. Thus, the motor delays experienced by children with ASD can be partially attributed to neurological deficits or abnormalities.

It has also been hypothesized that these motor delays are partly attributed to genetic causes, as a large amount of the genetic variance in ASD is shared with developmental coordination disorder (Lichtenstein, Carlström, Råstam, Gillberg, & Anckarsäter, 2010), which is a childhood neurodevelopmental disorder that negatively impacts gross and fine motor coordination (American Psychiatric Association, 2013). Moreover, motor delays are common among non-ASD siblings of children with ASD, further indicating a possible genetic link to these motor delays (Bhat, Galloway, & Landa, 2012). Children with ASD also experience difficulties with sensory processing, particularly in regard to integrating multiple sensory inputs, and they exhibit both hypo- and hyper-sensitivities to sensory stimuli (Dowd et al., 2010; Watling, Deitz, & White, 2001). These sensory issues can have adverse effects on the perceptual abilities of children with ASD, as well as their ability to integrate sensory and motor information, resulting in motor dysfunction (Dowd, McGinley, Taffe, & Rinehart, 2012; Dowd et al., 2010). Therefore, genetics and impaired sensory-motor integration may also play a role in the motor functioning of children with ASD.

Lastly, many children with ASD also have a diagnosis of intellectual disability (American Psychiatric Association, 2013; Matson & Shoemaker, 2009). Research has demonstrated that intellectual disability is associated with delays in motor skills (Lahtinen, Rintala, & Malin, 2007; Vuijk, Hartman, Scherder, & Visscher, 2010; Wuang, Wang, Huang, & Su, 2008) and that these delays may be related to impairments in executive functioning (Hartman, Houwen, Scherder, & Visscher, 2010). Therefore, IQ or a comorbid diagnosis of intellectual disability, can also contribute to the motor delays experienced by children with ASD. Although the exact cause of the motor delays exhibited by children with ASD is unclear, evidence suggests that a number of factors (e.g. neurological, genetic, and intellectual ability) may contribute to these delays. Future research should further investigate the relative contribution of these factors, as well as look for additional factors that may contribute to the motor delays in children with ASD. However, regardless of the reason for these motor delays, it is imperative that we understand the implications of poor motor skills for young children with ASD, as well as ways in which we can improve motor skills.

Benefits of Play

Play is an important aspect of the overall development of all children as it provides an opportunity to develop skills in the cognitive, social, and physical domains; it has also been described as a pleasurable, voluntary, flexible, and symbolic activity (Boucher & Wolfberg, 2003; Gallo-Lopez & Rubin, 2012; Ginsburg, 2007; Pellegrini & Smith, 1998b). For example, play provides children with an opportunity to improve their executive functioning and problem solving skills by creating imaginary games, following the rules of games, and exploring novel equipment and toys (Burdette & Whitaker, 2005).

It has also been suggested that play may improve cognitive performance either through heightened arousal of the nervous system during play, or simply by allowing children to have a break from cognitive tasks, which results in better cognitive performance following play (Pellegrini & Smith, 1998b). Play also provides children with an opportunity to use objects to represent places, people, or things in their real or imaginary world and the manipulation of toys and objects provides an opportunity for problem-solving and understanding how parts fit together (Gallo-Lopez & Rubin, 2012). Thus, there are a number of cognitive benefits that stem from engaging in play.

Engagement in play can also provide a number of positive benefits for a child's social functioning (Burdette & Whitaker, 2005; Gallo-Lopez & Rubin, 2012). For example, play provides the opportunity to develop friendships, learn how to cooperate with peers, lead and follow others in games, and learn how to be flexible in their activities, as well as in their use of toys and objects (Burdette & Whitaker, 2005). Furthermore, through play children can learn how to develop empathy for their peers, become more self-aware, and acquire the ability to self-regulate their behaviours (Burdette & Whitaker, 2005). The emotional well-being of children may also be positively influenced through play as it has been suggested that free play can minimize anxiety, depression, aggression, and sleep problems in children (Burdette & Whitaker, 2005). Lastly, play helps children connect with others through joint attention and sharing, and also provides an opportunity to explore and express both positive and negative feelings (Gallo-Lopez & Rubin, 2012). Therefore, it is critical that children engage in play in order to reap some of the social benefits that play can provide.

In addition to the social and cognitive benefits of play, there may also be a number of physical benefits. The play of preschool age children has been described as being predominately physically active, and encompassing gross motor activities (Pellegrini & Smith, 1998b). This engagement in physically active play may provide an opportunity for children to develop endurance and strength, both of which are important for physical fitness throughout the lifespan (Pellegrini & Smith, 1998b). Furthermore, active play allows children to further develop their motor skills and acquire the ability to move effectively and efficiently through their environment (Pellegrini & Smith, 1998b). However, it is likely that the physical benefits, such as improved motor skills, that are promoted through active play are also essential for a child's ability to actually engage in play in the first place.

Play Skills in Young Children with ASD

Given the vast benefits of play (Boucher & Wolfberg, 2003; Burdette & Whitaker, 2005; Gallo-Lopez & Rubin, 2012; Ginsburg, 2007), it is imperative that all children have the opportunity and ability to participate, yet children with ASD do not play in the same way as children with TD (Gallo-Lopez & Rubin, 2012). Kanner's (1943) first description of children with autism described their pretend play as 'impoverished' and since that time, the play of young children with ASD has been further described as repetitive, rigid, uninventive, and solitary (Gallo-Lopez & Rubin, 2012). Moreover, it has been suggested that a lack of varied, spontaneous play may be one of the most reliable early signs of autism (Charman et al., 1997); thus, there may be significant developmental consequences for children with ASD who do not learn how to engage in play.

Williams and colleagues (2001) examined the functional play of 15 children with autism in comparison to 15 children with Down syndrome and 15 children with TD all between 11 and 65 months of age. Each child with autism was matched to a child with Down syndrome and with TD based on their developmental age. The functional play of all children was recorded at home on multiple occasions and examined for functional differences (Williams et al., 2001). The results indicated that the children with autism spent significantly less time in elaborate functional play, new types of play (in contrast to repetitive play), and integrated play than the children with Down syndrome and TD (Williams et al., 2001). These findings indicate some of the challenges that young children with ASD have in playing; however, it is unclear whether these challenges are inherent to ASD or a cascade effect from not having the actual skills needed to engage in play.

A study of the functional play skills of 20-month old children at risk for autism in comparison to children with a developmental delay found that very few of the children in either group produced spontaneous pretend play, although they did engage in functional play (Charman et al., 1997). However, the children with a developmental delay engaged in pretend play after prompting, whereas the children at risk for autism did not. Furthermore, the children in the autism group had significant challenges with empathy, joint attention, and imitation (Charman et al., 1997). Children with ASD are delayed in many of the areas that are critical for a child's optimal development, yet these areas can all be promoted through play (Burdette & Whitaker, 2005; Gallo-Lopez & Rubin, 2012). Thus, it may be important to examine ways in which to promote play in young children with ASD.

The play of young children with ASD has been described as stereotypical, uninventive, and rigid (Boucher & Wolfberg, 2003; Gallo-Lopez & Rubin, 2012; Williams et al., 2001). As a result, children with ASD may be at risk of missing out on the many developmental benefits that play provides (Burdette & Whitaker, 2005; Ginsburg, 2007; Pellegrini & Smith, 1998b). Thus, it is important that researchers, clinicians, and parents promote engagement in play for young children with ASD. However, it is likely that in order to participate in play, some basic developmental (e.g. social, communication, motor) skills are required. We propose that a critical skill needed for engagement in play is fundamental motor skills.

Active Play: Physical Activity for Young Children

Fundamental motor skills (FMS) are the foundation movements necessary to participate in games, sports, dance, gymnastics, recreational physical activities, and active play (Burton & Miller, 1998; Payne & Isaacs, 2002). Children who are not proficient in skills such as running, jumping, balancing, kicking, catching, and throwing are less likely to access the range of physical activity options available to establish an active lifestyle (Bouffard, Watkinson, & Thompson, 1996). Recent research has demonstrated positive relationships between FMS and physical activity in children with TD (Butcher & Eaton, 1989; Fisher et al., 2005; Hume et al., 2008; Lubans et al., 2010; Okely, Booth, & Patterson, 2001; Williams et al., 2008; Wrotniak, Epstein, Dorn, Jones, & Kondilis, 2006). Although this link has not been established in children with ASD, it is plausible that motor skills are related to physical activity in this population as well. Recent research has found that school-age children with ASD are less active than their peers with TD (Pan, 2008; Pan & Frey, 2006; Pan et al., 2011b) and that physical activity and social engagement can be interdependent (Pan, 2009; Pan, Tsai, & Hsieh, 2011a). However, the physical activity of young children with ASD, and how it relates to social behaviour at a young age, is unclear. In young children, physical activity usually manifests itself in the form of active play (Burdette & Whitaker, 2005; Pellegrini & Smith, 1998b). Active play is beneficial for children as it helps them to develop their motor skills, social skills, and an overall understanding of the world (Byers & Walker, 1995b; Jobling & Virji-Babul, 2004; Ridgers, Stratton, & Fairclough, 2006b). Children with ASD experience delays in many of the developmental areas that are promoted through play. As such, the National Research Council (2001) has listed the development of play skills as one of six priority areas of intervention for children with ASD, as play may be even more important for children with ASD as it will provide them with an opportunity to develop the skills in which they are delayed.

Central to a child's need and desire to play is their physical ability to engage in play and motor skills have a significant influence on the ability of a child to participate in active play (Menear, 2007; Pellegrini & Smith, 1998b; Williams et al., 2008). For instance, Williams and colleagues (2008) examined the relationship between FMS proficiency and physical activity in a large sample of 3-4 year old children. They found that the children with the most proficient motor skills also spent the greatest amount of time in moderate and vigorous physical activity compared to those children with lower levels of motor proficiency (Williams et al., 2008). As physical activity in young children is most often observed in the form of active play (Burdette & Whitaker, 2005), it is important that children develop motor skill proficiency at a young age in order to participate, and take advantage, of the associated benefits of play. However, if a child does not possess the appropriate skills to engage in an activity, he or she will likely withdraw due to one's inability to participate and the potential for failure (Bouffard et al., 1996; Wall, 2004). Movement is one of the primary components of play; therefore, it is important that children have the necessary skills and confidence to explore their environment, and engage in play opportunities with their self and peers. Children with ASD experience delays in their motor skills (Landa & Garrett Mayer, 2006; Lane et al., 2012; Lloyd et al., 2011; Ozonoff et al., 2008; Sipes, Matson, & Horovitz, 2011), which may greatly inhibit their ability to engage in play; thus, limiting the development of social and communicative skills.

Physical Activity in Individuals with ASD

Physical activity is important for overall health including weight management, reducing the risk of developing diabetes, cardiovascular disease, and other chronic conditions, among other things in children and adults with TD (Warburton, Nicol, & Bredin, 2006); however there is limited literature on physical activity, and its benefits, in young children with ASD. Studies have found that school-age children with ASD are less physically active than their peers with TD (Pan, 2008; Pan & Frey, 2006; Pan et al., 2011b). For example, Pan and Frey (2006) examined the physical activity patterns of 30 youth, aged 10-19 years, with ASD (males, n=27). Participants were divided into three groups based on school level: Early School, Middle School, and High School and physical activity was measured for 7 consecutive days by accelerometer. Participants also completed the Child/Adolescent Activity Log (CAAL) on each day they wore their accelerometer. The results indicated that the majority of participants in Early School and Middle School met the recommended guidelines for Moderate-to-Vigorous Physical

Activity (MVPA) each day; while, those in High School did not (Pan & Frey, 2006). However, none of the groups met the recommendation to engage in bouts of 20 minute, continuous MVPA at least three times a week (Pan & Frey, 2006). Results from the CAAL indicated that the daily average time spent in non-school physical activity on weekdays was 30, 43, and 17 minutes in the Early School, Middle School, and High School groups, respectively. Furthermore, the most frequently reported type of physical activity between all three groups was walking, which averaged 7.93 minutes per day (Pan & Frey, 2006). These results indicate that youth with ASD get less active as they get older, and do not engage in large amounts of physical activity outside of school.

Another study compared the time children with and without ASD spent in MVPA during inclusive recess (Pan, 2008). The physical activity of 48 children (n=24 with ASD), 7-12 years of age, were accessed by accelerometer for 5 days at school. Results indicated that the children with ASD engaged in significantly less MVPA during recess than those children without ASD (Pan, 2008). It is possible that children with ASD are not as active during recess because they do not have the skills, motor and social, to do so; however, this link has not been established. Regardless of the reason, it is important that children with ASD are provided with the opportunities to be as active as their peers with TD. Lastly, Pan and colleagues (2011b) examined the physical activity levels of 35 boys, aged 7-12 years, with ASD. Participants were divided into three groups based on their grade level: lower grade (grades 1-2), middle grade (grades 3-4), and upper grade (grades 5-6). Physical activity was measured by accelerometer for 7 consecutive days. The results indicate that children in the lower grade group were significantly more active than children in middle and upper grades (Pan et al., 2011b). Children in the lower grades did not differ on physical activity levels between weekdays and weekend days; however, middle grade children were more active on weekend days and upper grade children were more active on weekdays. Although all children accumulated 60 minutes of MVPA on weekdays, this was not true of the weekends in any age group (Pan et al., 2011b). It is possible that children with ASD do not have the motor and social skills required to be physically active on the weekends, which is a time where physical activity is often a spontaneous, unsupervised activity undertaken as a social endeavour with peers. Furthermore, children with ASD may not be given the choice to be physically active in their free time due to behavioural and/or safety concerns of their parents.

Physical activity provides an important avenue for both skill development, and lifelong health benefits (Janssen & LeBlanc, 2010; Lubans et al., 2010). Research has also indicated that childhood motor proficiency is positively related to physical activity in adulthood (Lloyd, Saunders, Bremer, & Tremblay, 2014). The majority of individuals with developmental disabilities, including those with ASD, are physically inactive beginning in childhood and continuing through adulthood (Draheim, Williams, & McCubbin, 2002; Hilgenkamp, Reis, van Wijck, & Evenhuis, 2012; Temple, 2010). Thus, there is the potential for lifelong benefits to the overall health and quality of life of individuals with ASD by providing them with the tools to be physically active from a young age.Future research should further examine physical activity patterns in children with ASD, particularly in younger children, as well as examine whether their current physical activity is from purposeful activity or simply excess movement commonly found in children with ASD in the form of repetitive behaviours.

Relationship Between Physical Activity and Social Behaviour in ASD

Engagement in physical activity may be an important moderator for social behaviour. For example, the relationship between physical activity and social behaviour in 19 males with ASD was examined in inclusive middle school physical education classes (Pan et al., 2011a). Physical activity was assessed by accelerometer during two physical education lessons in one week of their regular school schedules. Social engagement was assessed by a trained observer of the physical education classes. Social engagement was divided into engagement with adults or peers, as well as social interactions and social initiations (Pan et al., 2011a). Correlations between physical activity and social engagement indicated that social initiations with peers were positively correlated with steps per minute and MVPA. Furthermore, social interactions with peers were positively correlated with moderate physical activity, vigorous physical activity, and MVPA. However, social initiations and interactions with adults were not correlated with physical activity (Pan et al., 2011a). Although this study focused on children with ASD in middle school, the results support the idea that physical activity is important for social engagement, particularly with peers.

Another study examined the physical activity levels and social engagement of 25 males, 7-12 years of age, with ASD to determine whether a relationship exists between these two variables (Pan, 2009). Physical activity was assessed for 5 consecutive school days by accelerometer and social engagement was measured using an observation tool during physical education and recess each day for 5 consecutive school days. Social engagement was categorized as being with adults or peers, and interactive or non-interactive (Pan, 2009). The results indicated that overall physical activity levels were not related to social engagement during physical education or recess. However, non-interactive engagement with adults, such as looking, orienting, and listening, was positively correlated with vigorous physical activity during physical education (Pan, 2009). Although these results are limited, they suggest that social engagement with adults may help to facilitate physical activity for children with ASD. Future research should examine this relationship in younger children, as well as outside of the school setting.

Relationship Between Motor Skills and Social Behaviour in ASD

It is proposed that there is a reciprocal relationship to the development of motor skills and social skills in young children (Larkin & Summers, 2004b); and this relationship may further relate to the severity of delays experienced by children with ASD. For instance, MacDonald, Lord, and Ulrich (2013) examined whether FMS were predictive of standardized social communicative skills in 35 children between 6-15 years of age with ASD. Motor skills were assessed with the Test of Gross Motor Development-2 (TGMD-2), a validated and reliable measure of motor proficiency. The participants' teachers completed the Social Skills Improvement System (SSIS) Rating Scales in order to assess each child's social behaviour. A calibrated ASD severity score was also used as a measure of social communicative skills (MacDonald et al., 2013). Results indicated that locomotor subscale raw scores and total raw scores on the TGMD-2 did not predict the children's calibrated ASD severity. However, object control raw scores were a significant predictor of calibrated ASD severity; indicating the children with less proficient object control scores were more likely to have more severe symptoms of ASD. Neither subscale nor total raw motor skill scores were predictive of standardized social skills, as measured by the SSIS (MacDonald et al., 2013). Although only object control raw scores were predictive of calibrated ASD severity, this may be due to the fact that object control skills often require social interaction (i.e. playing catch with a partner). Future research should further examine the relationship between motor skills and social skills in young children with ASD, as well as whether improved motor skills result in improved social skills.

It has also been suggested that there is relationship between motor skills and language development in young children with ASD (Bhat et al., 2012). For example, Bhat and colleagues (2012) examined the motor development of 24 infant siblings of children with ASD (i.e. high-risk infants) in comparison to 24 infants with TD at 3 and 6 months of age, as well as the impact of early motor development on language at 18 months of age. They found that a greater number of infants in the high risk group had delayed motor development at 3 and 6 months of age (Bhat et al., 2012). Furthermore, all high risk infants with a language delay at 18 months had exhibited a motor delay at 3 months of age, and a significant number of the high risk infants that had a motor delay at 6 months of age also had a language delay at 18 months of age (Bhat et al., 2012). These results help to demonstrate the importance of early motor development for the development of communication skills in children with, and at risk for, ASD.

Similarly, LeBarton and Iverson (2013) investigate the relationship between fine motor skills and expressive language skills between 12 and 36 months of age in 34 infants at high risk for developing ASD. They found that these infants exhibited fine motor delays between 12 and 24 months of age, as well as expressive language delays at 36 months of age (LeBarton & Iverson, 2013). Moreover, the results indicated that fine motor skills significantly predicted expressive language at 36 months of age (LeBarton & Iverson, 2013). Thus, it is important that the motor skills of children with ASD are prioritized in research and early interventions, particularly given the potential cascading effect that may occur if motor skills are not fully developed.

Impairments in social interactions and communication is a hallmark characteristic of ASD (American Psychiatric Association, 2000, 2013). As such, traditional therapies for children with ASD, such as early intensive behavioural interventions (EIBI), often focus on developing communication and social skills in isolation from motor development (Matson & Smith, 2008). Although EIBI is considered the most effective treatment for the social and communicative delays children with ASD experience (Eldevik et al., 2009; Matson & Smith, 2008), there is no evidence that it has any benefit for motor skill development, which is essential for engagement in active play (Dawson et al., 2010). Thus, it is imperative that researchers and practitioners begin to examine new ways to intervene on social and communicative skills, which could also be beneficial to other developmental areas. Given the vast benefits of play, it is important that children with ASD have the opportunity and ability to participate. Therefore, providing a motor skill intervention for children with ASD may be beneficial in improving their motor skills and providing them with the tools necessary to engage in play; engagement in active play can then provide opportunities to improve in other key developmental areas, such as communicative and social skills through play-based interactions with peers and adults.

Effectiveness of Motor Skill Interventions for Young Children with Delays

To the best of our knowledge, there are no published research studies on the effectiveness of FMS interventions for preschool age children with ASD. However, there are a handful of studies that have demonstrated that motor skill interventions can be effective in preschool age children with a developmental delay. Goodway and Branta

(2003) used a quasi-experimental design to assign intact preschool classes of 4 and 5 year old children to motor skill intervention and control groups. Children in the intervention classroom received 24 instructional sessions over a 12-week period, whereas children in the control group received their typical preschool curriculum which did not include organized physical activity (Goodway & Branta, 2003). The children's FMS were assessed pre- and post- intervention using the Test of Gross Motor Development (TGMD) (Goodway & Branta, 2003; Ulrich, 1985). In comparison to the control group, the group receiving the motor skill intervention demonstrated significantly higher object control and locomotor skills following the intervention (Goodway & Branta, 2003). This study indicates that motor skill interventions can be effective for young children with developmental delays.

A similar study investigated the effect of a 9-week motor skill intervention on children in preschool classrooms at risk for a developmental delay (Goodway, Crowe, & Ward, 2003). The intervention group received 18, 35-minute lessons while the control group received their regular classroom curriculum. The TGMD was used pre- and post-intervention to assess the FMS of all children (Goodway et al., 2003; Ulrich, 1985). Results indicated that the intervention group improved significantly more than the control group from pre- to post-test on both their locomotor and object control skills; they also had significantly higher post-test scores than the control group (Goodway et al., 2003). This study is significant as it demonstrates the effectiveness of motor skill interventions for preschool age children with developmental delays.

Lastly, Hamilton, Goodway, and Haubenstricker (1999) examined the effectiveness of an 8-week motor skill intervention for preschool age children at risk for developmental delay delivered by the children's parents. The intervention group participated in two 45-minute lessons per week, whereas the control group was engaged by their parents in movement songs, but no direct motor skill instruction (Hamilton et al., 1999). Both groups were pre- and post-tested on the object control subscale of the TGMD (Ulrich, 1985). The results showed that the intervention group significantly improved their object control skills following the intervention; the control group did not change (Hamilton et al., 1999). This study adds to the intervention literature pertaining to the effectiveness of FMS interventions for preschool age children with developmental challenges.

It is evident that FMS interventions can be effective at improving the motor skills of young children with developmental delays (Kirk & Rhodes, 2011); however, the effectiveness of FMS interventions for young children with ASD is yet to be determined. Young children with ASD experience significant delays in the motor domain (Landa & Garrett Mayer, 2006; Liu & Breslin, 2013; Lloyd et al., 2011; Ozonoff et al., 2008), and these delays may be related to the development of social behaviour, communication skills, and optimal outcomes (Bhat et al., 2012; LeBarton & Iverson, 2013; MacDonald et al., 2013; Sutera et al., 2007). Therefore, young children with ASD may benefit significantly from motor skill interventions, not just in the motor domain but, for their overall development. Accordingly, future research should investigate the impact of motor skill interventions on the motor skills, social skills, and overall wellbeing of young children with ASD.

Conclusion

Children with ASD experience challenges in their social and communication skills, and have restrictive interests and behaviours (American Psychiatric Association, 2013). Children with ASD also experience significant delays in their motor skills (Landa & Garrett Mayer, 2006; Lane et al., 2012; Lloyd et al., 2011; Matson et al., 2010; Ozonoff et al., 2008); these delays likely act as a control parameter inhibiting them from engaging in active play. Play is important for young children, particularly those with ASD, as it provides them with an opportunity to develop their motor, social, and communication skills (Gallo-Lopez & Rubin, 2012; Pellegrini & Smith, 1998a). FMS interventions have been effective at improving the motor skills of preschool age children with developmental delays (Goodway & Branta, 2003; Hamilton et al., 1999; Kirk & Rhodes, 2011); however, no published research has examined the effectiveness of a motor skill intervention for preschool age children with ASD. This study will fill a critical gap in the literature by intervening on the motor skills of preschool age children with ASD and measuring the impact on motor skills, adaptive behaviour, and social skills.

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Section 3: Manuscript 1
Effectiveness of a Fundamental Motor Skill Intervention at Improving the Motor Skills of 4 year Old Children with Autism Spectrum Disorder

Emily E. Bremer (2014)

Abstract

Children with Autism Spectrum Disorder (ASD) have motor skills that are delayed and of poor quality, which may inhibit their engagement in active play; yet, motor skills are often neglected in the intervention literature. The purpose of this study was to examine the effectiveness of a fundamental motor skill (FMS) intervention at improving the motor skills of 4 year old children with ASD; participants were divided into an experimental and control group for this part of the study. A secondary purpose was to investigate the impact of intervention intensity on motor skills; Group 1 (the former experimental group; intervention for 1 hour/week for 12 weeks) was compared to Group 2 (the former control group; intervention for 2 hours/week for 6 weeks) for this section of the study. The Peabody Developmental Motor Scales-2 (PDMS-2) and Movement Assessment Battery for Children-2 (MABC-2) were used to assess motor skills at baseline, post-intervention, and at a 6-week follow-up for each group. Results from the first section of the study indicated that the experimental group improved significantly on the PDMS-2 object manipulation raw score ($p=0.029$), and PDMS-2 total motor quotient ($p=0.044$) following the intervention. Findings from the second part of the study demonstrated a significant time effect for all PDMS-2 variables, indicating improvements following the intervention and skill retention at the 6-week follow-up; there were no significant findings related to the MABC-2. Furthermore, no significant group by time interactions were present, indicating that both intensities of the intervention were effective. The results of this study indicate that a FMS intervention can be effective at improving the motor skills of 4 year old children with ASD; however, future research with larger samples is necessary.

Emily E. Bremer (2014)

Introduction

Autism Spectrum Disorder

Autism Spectrum Disorder (ASD) is a very common developmental disability that affects approximately 1 in 150 (Fombonne, 2009) to 1 in 88 children (Kogan et al., 2009). Children with ASD experience deficits in their social communication skills and social interactions; they also have restricted patterns of behaviour or interests (American Psychiatric Association, 2000, 2013). Children who are now diagnosed with ASD under the fifth edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) will be given a severity rating of levels 1-3, with level 3 indicating that the child requires the largest amount of support (American Psychiatric Association, 2013). Given the significant challenges that children with ASD experience, early intervention is of the utmost importance. There are numerous intervention options for parents; some are grounded in evidence, some are not, some are extremely expensive, and government-funded programs often have very long wait times (Chasson, Harris, & Neely, 2007; Eldevik et al., 2009; Lord et al., 2005; Matson, Matson, & Rivet, 2007; Matson & Smith, 2008). Therefore, it is important to implement evidence-based interventions for children with ASD that are not only beneficial to the child's overall well-being but, also cost-effective for both the social system and individual families.

The core challenges that children with ASD experience are often addressed with early interventions including speech-language pathology, behavioural interventions, and occupational therapy (Myers & Johnson, 2007; Simpson et al., 2005). These interventions are often effective in improving the outcomes for children with ASD, especially if they are introduced at an early age and are highly intensive (Corsello, 2005; McConachie &

Diggle, 2007; Virués-Ortega, 2010). One area that is often overlooked in the development of children with ASD is their fundamental motor skills (FMS), because the primary focus of early intervention is traditionally their core challenges in social, communicative, and behavioural skills. However, one study of the optimal outcomes for toddlers with ASD suggests that motor skill proficiency is one of the most predictive factors for children with ASD at the age of 2 to have the best possible outcomes at 4 years of age (Sutera et al., 2007). Motor skills are virtually ignored in early intervention literature of children with ASD; yet, they are important to the overall development of all children (Rosenbaum, 2005). Therefore, it is important to further understand the developmental trajectory of motor skills in young children with ASD, as well as whether motor skills can be improved through intervention.

Fundamental Motor Skills

FMS are the basic movement skills that are crucial for the future development of the more complex skills needed in games, dance, sports, gymnastics, and recreational physical activities (Burton & Miller, 1998; Payne & Isaacs, 2002). Research has demonstrated that proficiency in FMS is positively associated with physical activity in children with typical development (TD) (Fisher et al., 2005; Lubans et al., 2010; Okely et al., 2001); however, this relationship has not been established in children with ASD. In young children, physical activity is manifested in the form of active play (Active Healthy Kids Canada, 2010; Burdette & Whitaker, 2005; Pellegrini & Smith, 1998b). Active play is of paramount importance for preschool-age children as it provides them with an opportunity to develop their motor skills, social skills, and an overall understanding of the world (Byers & Walker, 1995a; Jobling & Virji-Babul, 2004; Ridgers, Stratton, &

Fairclough, 2006a). However, in order to reap the benefits of active play, children may need to have the motor skills required to participate; thus, there could be negative implications for a child's overall development when they do not have proficient motor skills.

A child's development may be described best as a dynamic system as it involves the interaction of multiple sub-systems and contextual factors in order to reach a steady state, or equilibrium (Kugler et al., 1980; Thelen, 1995). One component of dynamic systems theory is control parameters; these are variables that can promote or inhibit particular behaviours depending on when they reach their critical point to allow a behaviour to emerge (Thelen et al., 1991). When examining the overall development of young children, motor skills could be considered a control parameter to development in other domains. For example, if a child cannot move efficiently or confidently they likely will not be able to keep up with their peers during active games and as a result, may be excluded from many activities. This exclusion may limit their social interactions, opportunities for communication, their ability to play appropriately, and the further development of proficient motor skills. Therefore, there can be many negative implications for overall development stemming from the inability to move efficiently and effectively at a young age.

The research investigating the motor skills of young children with ASD is consistent in finding that they are significantly delayed in regards to their FMS (Landa & Garrett Mayer, 2006; Lane et al., 2012; Liu & Breslin, 2013; Lloyd et al., 2011; Matson et al., 2010; Ozonoff et al., 2008; Provost et al., 2006). For example, a large study investigating the motor skills of children with ASD included 162 toddlers aged 12-36 months of age and used the gross and fine motor subscales of the Mullen Scales of Early Learning (MSEL), as well as the motor domain of the Vineland Adaptive Behavior Scales (VABS) in order to assess motor development (Lloyd et al., 2011). The results indicated that the gross and fine motor skills of the sample were significantly delayed for their age, and became worse with increasing chronological age (Lloyd et al., 2011). This finding suggests that children with ASD fall further behind their peers with TD in the motor domain as they get older. Furthermore, a subset of 58 children from this sample were measured twice over 12 months, in order to examine the longitudinal trajectory of their motor skills (Lloyd et al., 2011). The results from this longitudinal sample further confirmed that the children had motor skills that were delayed for their age, and became significantly more delayed as they got older (Lloyd et al., 2011). Thus, children with ASD may greatly benefit from early motor interventions in order to minimize these motor delays and prevent children with ASD from falling further behind their peers with TD throughout childhood and adolescence.

Most of the studies of the motor skills of children with ASD focus on toddlers under the age of 3 years (Landa & Garrett Mayer, 2006; Lane et al., 2012; Lloyd et al., 2011; Matson et al., 2010; Provost et al., 2006) and school-age children (Pan, Tsai, & Chu, 2009; Staples & Reid, 2010), which leaves a significant gap in the literature pertaining to the motor skills of preschool aged children with ASD. One of the few studies of motor development to include children in the 4-5 year old age range examined the motor skills of 54 children aged 26-61 months with autism in comparison to 25 children with a developmental delay and 24 children with TD (Ozonoff et al., 2008). Results indicated that the children with autism had significantly lower motor scores on the MSEL and VABS than the children with typical development; however, there were no significant differences between the children with autism and those with a developmental delay (Ozonoff et al., 2008). Although there is variability in the measures and ages ranges of these studies, the conclusions all support a need for early motor interventions for young children with ASD.

Furthermore, Liu and Breslin (2013) compared the motor skills of 30 children with ASD (aged 3-16 years) with 30 age-matched children with TD using the Movement Assessment Battery for Children-2 (MABC-2); 10 of the 30 children in each group were between 3-6 years of age. They found that 77% of the children with ASD scored below the 5th percentile on the MABC-2 indicating a significant motor delay; no children with TD were found to have, or be at risk for, motor delays (Liu & Breslin, 2013). The children with ASD also scored significantly lower in all three domains of the MABC-2 (manual dexterity, balance, and aiming and catching), as well as in their overall percentile score when compared to the children with TD (Liu & Breslin, 2013). The results of this study further indicate that children with ASD have motor delays that are present in early childhood and persist through adolescence.

FMS interventions have previously been effective in preschool age children with developmental delays (Goodway & Branta, 2003; Goodway et al., 2003; Hamilton et al., 1999; Kirk & Rhodes, 2011). A recent systematic review found that there were 11 known studies investigating the effectiveness of motor skill interventions for 3-5 year old children with developmental delays, and 9 of these studies significantly improved FMS (Kirk & Rhodes, 2011). However, all of these studies excluded children with ASD; thus, leaving a critical gap in the literature pertaining to the effectiveness of FMS interventions for preschool age children with ASD.

We hypothesize that underdeveloped motor skills are a control parameter that prevent young children with ASD from engaging in active play. Without proficient motor skills, children with ASD may not be able to effectively play with their peers and without active play opportunities for social interactions and communication are greatly limited. Therefore, in order to counteract the negative consequences of not engaging in active play, it is important to examine whether motor skills can be improved through intervention in young children with ASD.

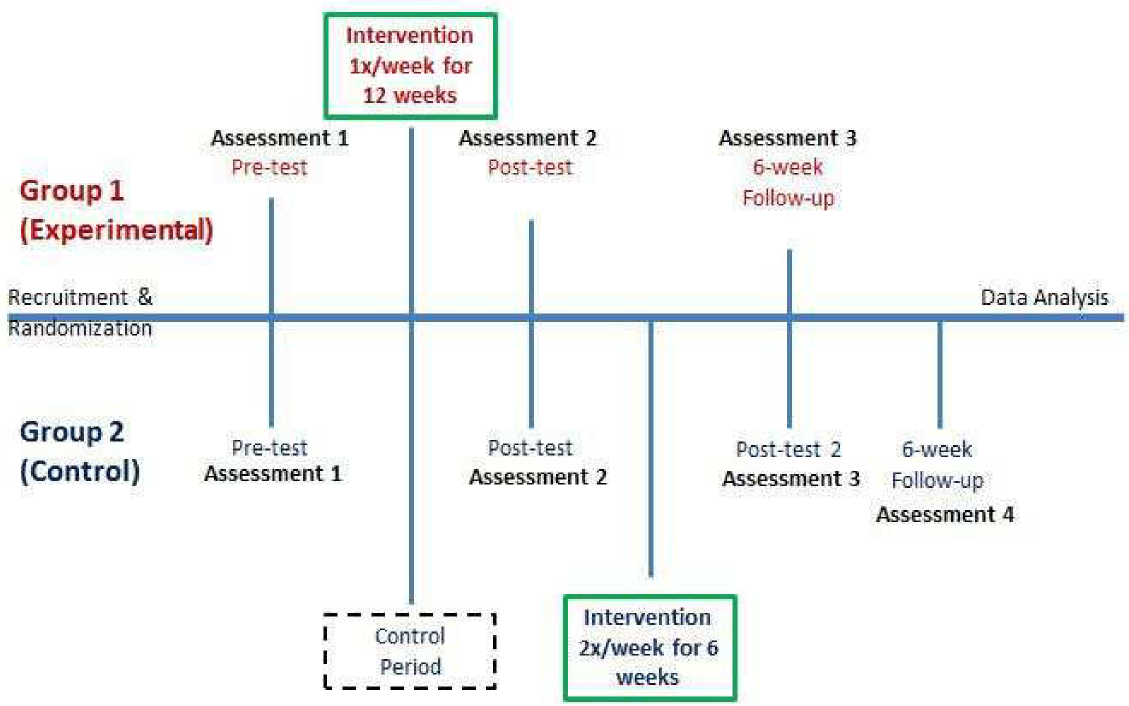
The purpose of this study was to examine the effectiveness of a FMS intervention at improving the motor skills of 4 year old children with ASD. A secondary objective was to determine whether an increased intensity of the motor skill intervention was more or less effective at improving the motor skills of children with ASD compared to an intervention of the same duration but, lower intensity.

Method

Study Design

Ethical approval was received from a University Research Ethics Board and a local Children's Treatment Centre's (CTC) Research Committee and Quality Leadership Council (Appendices 1 and 2, respectively) and all parents provided informed consent prior to the beginning of the study (Appendix 3). This study employed a counter-balanced design. This design enabled the effectiveness of the motor skill intervention to be tested (children receiving the intervention in Group 1 while Group 2 acted as the control); as well as compare the effectiveness of two different intensities of the intervention (1 hour/week for 12 weeks vs. 2 hours/week for 6 weeks). Regardless of group assignment, all children recieved the intervention for the exact same number of sessions and hours. Each group also attended three or four assessments, depending on group assignment, where motor skills and social behaviour were assessed. Assessments 1 and 2 provided the pre- and post-assessment, respectively, of the experimental (Group 1) and control (Group 2) groups. Assessment 3 acted as the 6-week follow-up for Group 1 and the post-test for Group 2 following their intervention. Group 2 then attended a fourth assessment for their 6-week follow-up (Figure 1).

Figure 1. Overview of study design.



Recruitment

A recruitment flyer (Appendix 4) that advertised the motor skill intervention was posted on bulletin boards and social media websites at the local CTC in order to publicize the study to the parents of 4 year old children with a diagnosis of ASD who received services at the CTC. All of the families of 4 year old children with ASD that were on the waitlist for Applied Behaviour Analysis (ABA)-Based Services for Children and Youth in Durham Region with ASD offered through the local CTC were also targeted for participation in this motor skill intervention and were mailed a copy of the recruitment flyer along with an accompanying letter of support from the Developmental Pediatrician at the CTC (Appendix 5).

Participants

Inclusion criteria for the study required that participants have a diagnosis of ASD and be 4 years of age. Children were excluded from participating if their parents could not commit to bringing them to the assessments and intervention sessions. A total of 9 children were signed up for the study by their parents and were randomly assigned to one of two groups. Group assignment was generated using an online random assignment tool, group assignment was not concealed, and participants and the primary investigator were not blind to group assigment. Group 1 consisted of 5 children, all of whom were male. Group 2 consisted of 4 children, one of whom was female.

Procedures

All measurements were conducted in the researcher's office with the child and his or her parent or caregiver present. At the initial assessment, all parents completed a supplemental information form (Appendix 6) in order to provide demographic data and a brief medical history of their child. The remaining measurements were conducted with the child at each of the assessment sessions:

Anthropometric Measurements

Height was measured to the nearest 0.1 cm using a wall-mounted stadiometer (SECA 222) and weight was measured to the nearest 0.1 kg using a digital scale (Tanita Digital HD351).

Motor Proficiency

The Peabody Developmental Motor Scales-2 (PDMS-2) (Folio & Fewell, 2000) is a standardized motor skill assessment that is validated from birth to 6 years of age. It was used to provide raw scores in stationary skills, locomotion, object manipulaiton, grasping, and visual-motor integration, as well as composite scores in gross motor, fine motor, and a total motor quotient (Folio & Fewell, 2000). The PDMS-2 was ideally suited for this study as it is normed down to infancy and therefore can more accurately capture the motor skills of children with ASD without a floor effect. The total motor quotient score provided by the results of the PDMS-2 was considered the primary outcome for this study.

The Movement ABC-2 (Henderson, Sugden, & Barnett, 2007) was also used to assess the participant's motor skills in order to address the potential scope of motor impairment in these children. The Movement ABC-2 is a standardardized motor skill assessment for children aged 3-16 years and is commonly used to identify children who experience significant delays in their motor development, such as children with Developmental Coordination Disorder (Henderson et al., 2007). The test required the child to perform a series of eight motor tasks that are grouped into three domains: manual dexterity, aiming and catching, and balance (Henderson et al., 2007). Results from the MABC-2 provided objective, quantitative data on each participant's level of motor impairment. All motor assessments were conducted by the principal investigator in an office setting with the participant's parent(s) present.

Adaptive Behaviour and Social Skills

Adaptive behaviour and social skills were assessed at each of the time points using the Vineland Adaptive Behavior Scales-2 (VABS-2) (Sparrow, Cicchetti, & Balla, 2005), the Social Skills Improvement System (SSIS) (Gresham & Elliott, 2008), and behavioural video coding during the first and last intervention sessions. Please refer to Manuscript 2 for more information on this part of the study.

Motor Skill Intervention

Group 1 attended a 12 week FMS intervention for 1 hour per week while Group 2 acted as a control. Group 2 then attended a 6 week FMS intervention for 2 hours each week (1 hour per day on two separate days; Figure 1). Despite differences in intervention intensity, all sessions were the exact same between the two groups (i.e. the same instruction, content, and number of hours). Each intervention session consisted of a warm-up, skill instruction, active games, and free play time (Table 1). Skills that were taught included both locomotor (running, hopping, leaping, etc.) and object control (throwing, catching, kicking, etc.) skills and they progressed in difficulty over the intervention period (Table 2). The instructor-to-child ratio for both groups ranged from 1-to-2 to 1-to-1, depending on attendance. Examples of the typical room set-up for the intervention can be found in Appendix 7.

Table 1. Format of each intervention session.

Activity	Time
Warm-up	5 minutes
Review of previous week's activity	10 minutes
Activity 1 (Direct instruction)	10 minutes
Activity 2 (Direct Instruction)	10 minutes
Activity 3 (Active Game/Obstacle Course)	10 minutes
Free play	10 minutes

Table 2. Skills taught over the course of the intervention.

Session	Skill
1	Balance
2	Running
3	Underhand Roll
4	Galloping & Leaping
5	Underhand Throwing
6	Jumping
7	Dribbling/Bouncing
8	Overhand Throwing
9	Catching
10	Hopping
11	Kicking
12	Striking

Intervention sessions were run by the primary investigator with assistance from trained undergraduate research assistants and each session was consistent in providing structured instruction and practice, the opportunity to practice the newly learned skills in a game, and an opportunity for unstructured free play. Transitions between activities were guided through a large Picture Exchange Communication System that was created for this study by the principal investigator using task appropriate images for a motor skill intervention (Figure 2).

Figure 2. Picture Exchange Communication System used for all sessions.

At the end of each session parents/guardians were provided with a handout that outlined 3-4 activities that could be played at home during the week in order to practice the skills taught during the session (Appendix 8). The lesson plans for the intervention were established from two currently availble resources: Active Start (Special Olympics Canada, 2010), and Healthy Opportunities for Preschoolers (Temple & Preece, 2010).

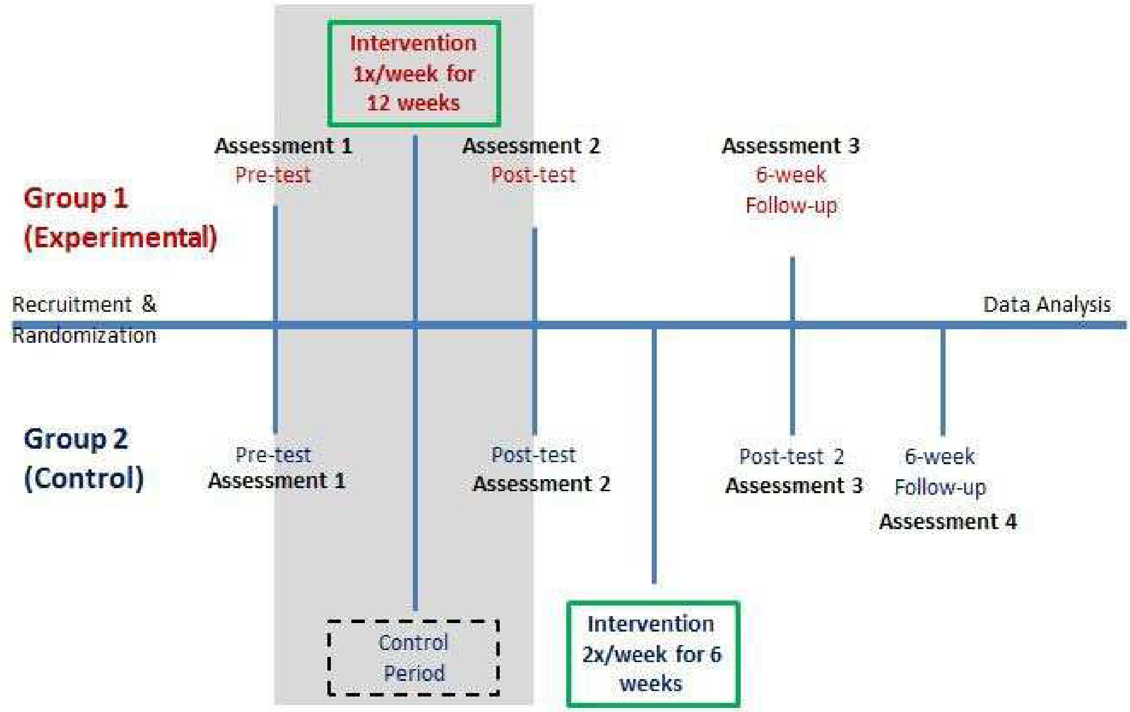
This series of lesson plans were successfully used in a pilot for this study (Section 6) and minor changes were then made based on the success of the activities and the children's activity preferences.

Statistical Analyses

Part 1. Intervention Effectiveness: Experimental versus Control Group

Descriptive characteristics were calcualated on all variables at the baseline assessment for the experimental and control goups. An independent samples t-test was used to assess differences between the experimental and control groups at baseline on all continuous variables; a Fisher's exact test was used to assess differences in the sex distribution between the two groups. The magnitude of change from pre- to post-intervention for each participant in the experimental and control groups was calculated by subtracting their pre-intervention score from their post-intervention score on the raw subscale scores and quotient scores of the PDMS-2, as well as the raw subscale scores and total test standard scores of the MABC-2. The average magnitude of change was then calculated for both the experimental and control groups. A t-test was used to test for significant differences between the experimental and control groups on their magnitude of change from pre- to post-intervention for all motor variables. Effect sizes were also calculated on the average magnitude of change scores in the experimental and control groups for all motor variables. These analyses were used to determine the effectiveness of the motor skill intervention at improving motor skills in the experimental group in comparison to the control group who did not receive the intervention (Highlighted in the shaded box in Figure 3).

Figure 3. Section of study analyzed for 'Part 1. Intervention Effectiveness: Experimental versus Control Group'

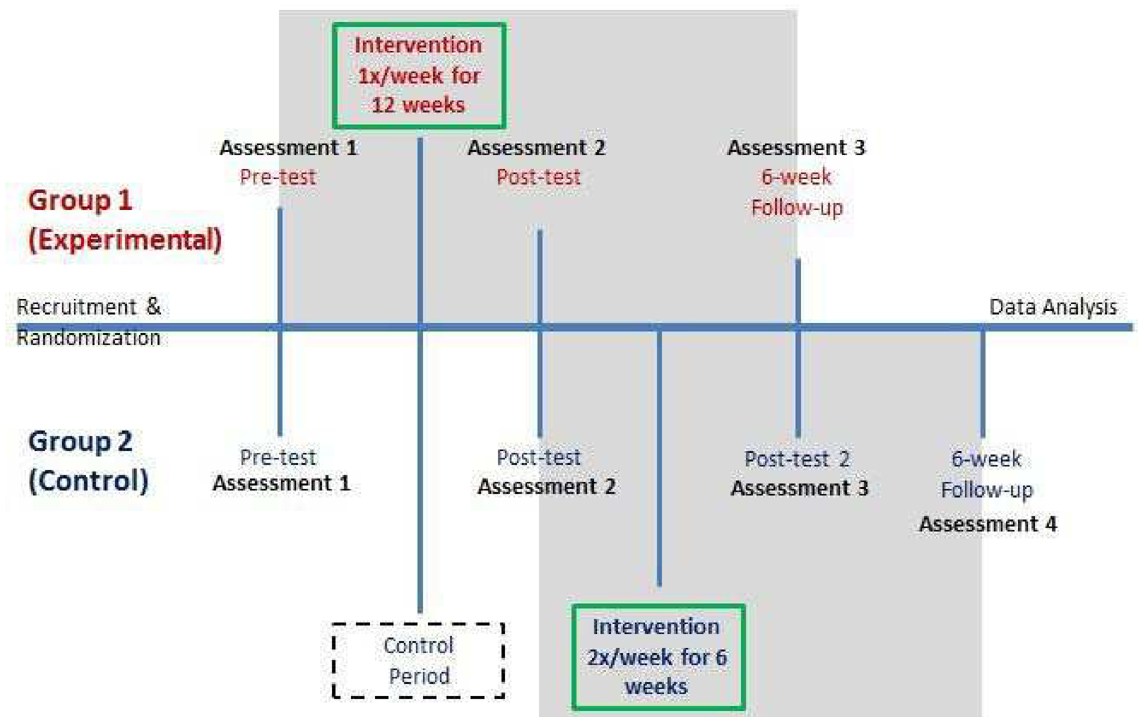


Part 2. Analysis of Intervention Intensity: Group 1 versus Group 2

In order to assess whether the effects of randomization had been maintained during the initial control period, descriptive characteristics were calculated for Group 1 and Group 2 at their respective pre-test prior to conducting analyses of the effectiveness of the two different intensities of the intervention. An independent samples t-test was used to asseess whether there were any differences between Group 1 and Group 2 at their pre-test on all continuous variables; a Fisher's exact test was used to assess differences in the sex distribution between the two groups. Assumptions of skewness and kurtosis were met to conduct a two-way analysis of variance with repeated measures on all motor skill variables at the pre-, post-, and 6-week follow-up assessments by group to assess the effect of the intervention, as well as group interactions (Group 1 = 1x/week for 12 weeks;

Group 2 = 2x/week for 6 weeks), and group by time interactions. This analysis was run to determine whether intervention intensity had an impact on the outcome of the intervention. As two separate motor skill assessments were used in this study, a pearson product correlation was conducted between the PDMS-2 total motor quotient score and MABC-2 total test score at the pre-, post-, and 6-week follow-up for the complete sample to ensure there was agreement between the two measures at each time point. The highlighted sections in Figure 4 indicate the sections of the overall study that were used from each group in order to run these analyses.

Figure 4. Sections of study analyzed for 'Part 2. Analysis of Intervention Intensity: Group 1 versus Group 2'



Part 3. Predictors of Optimal Treatment Response

An attendance score was calculated for each participant based on the percentage of motor skill sessions they attended. Pearson product correlations were conducted between the attendance score and magnitude of change score from pre- to post-intervention for the complete sample on the PDMS-2 motor quotients and MABC-2 standard scores to assess whether attendance had an impact on the intervention outcome and would need to be controlled for. As attendance did not have a significant impact on intervention outcomes, no further steps were taken to control for attendance in subsequent analyses.

Pearson product correlations were also conducted between the VABS-2 adaptive behavior composite standard score at the pre-test and the average magnitude of change from pre- to post-intervention for the complete sample on the PDMS-2 total motor quotient in order to explore whether adaptive behaviour is related to our primary intervention outcome, which may be important for inclusion criteria and group assignment in future interventions.

Part 4. Power Calculation

Given our current sample size of 9 participants, we have 59% power to detect statistical differences at an alpha level of 0.05 on our primary outcome measure, the PDMS-2 total motor quotient. However, we would require at least 14 participants to detect differences with a similar alpha level and 80% power.

Results

Part 1. Intervention Effectiveness: Experimental versus control Group

Descriptive statistics of the participants at baseline are presented in Table 3. No statistical differences were found between the groups in regards to their age, BMI, motor proficiency, and level of social functioning at baseline (Table 3). One participant in Group 2 was absent for the baseline assessment resulting in a sample size of three. However, he was present for the pre-, post-, and follow-up assessments so is included in the analyses of intervention intensity and skill retention resulting in a total sample size of nine for those analyses (n=9; Group 1: n=5, Group 2: n=4). Although there was only one female in the study she was included in all analyses due to the already small sample size and the heterogeneity of symptoms that all children with ASD experience.

Table 3. Baseline descriptive characteristics, motor proficiency, and social functioning by group

	Experimental (mean ± SD, *count*)	**Control** (mean ± SD, *count*)	**p- value**
Sex (male, female)	*5 M*	*2 M, 1 F*	0.375
Age (months)	51.60 ± 3.05	52.00 ± 2.65	0.857
Height (cm)	102.12 ± 4.89	103.1 ± 6.3	0.805
Weight (kg)	18.30 ± 3.29	17.5 ± 2.0	0.731
BMI (kg/m^2)	17.44 ± 1.67	16.5 ± 0.7	0.385
Age of Onset of Walking (months)	14.60 ± 2.41	12.33 ± 0.58	0.171
PDMS-2 Gross Motor Quotient	70.00 ± 11.42	62.33 ± 6.35	0.335
PDMS-2 Fine Motor Quotient	69.40 ± 10.04	67.00 ± 5.20	0.720
PDMS-2 Total Motor Quotient	66.80 ± 11.48	60.33 ± 6.35	0.413
MABC-2 Manual Dexterity Standard Score	2.20 ± 0.84	2.67 ± 2.89	0.808
MABC-2 Balance Standard Score	2.60 ± 1.34	2.67 ± 0.58	0.939
MABC-2 Aiming & Catching Standard Score	6.80 ± 4.87	3.67 ± 2.89	0.358
MABC-2 Total Test Standard Score	2.00 ± 1.00	2.00 ± 1.73	1.000
Vineland Adaptive Behavior Composite Standard Score	72.40 ± 6.43	67.00 ± 7.00	0.307
Vineland Maladaptive Behavior v-Scale Score	19.00 ± 1.87	20.33 ± 1.53	0.341

Significant motor delays were found throughout the sample at baseline. All participants had motor skills that were very poor, poor, or below average on the gross, fine, and total motor quotients of the PDMS-2 (Figure 5). All but one participant had, or was at risk for, significant movement difficulties as measured by the MABC-2 subdomain standard scores at baseline (Figure 6). All participants had a MABC-2 total test standard score below 5 at baseline, indicating significant movement difficulties (Figure 6).

Figure 5. *Baseline PDMS-2 quotient scores and descriptive categories by participant.*

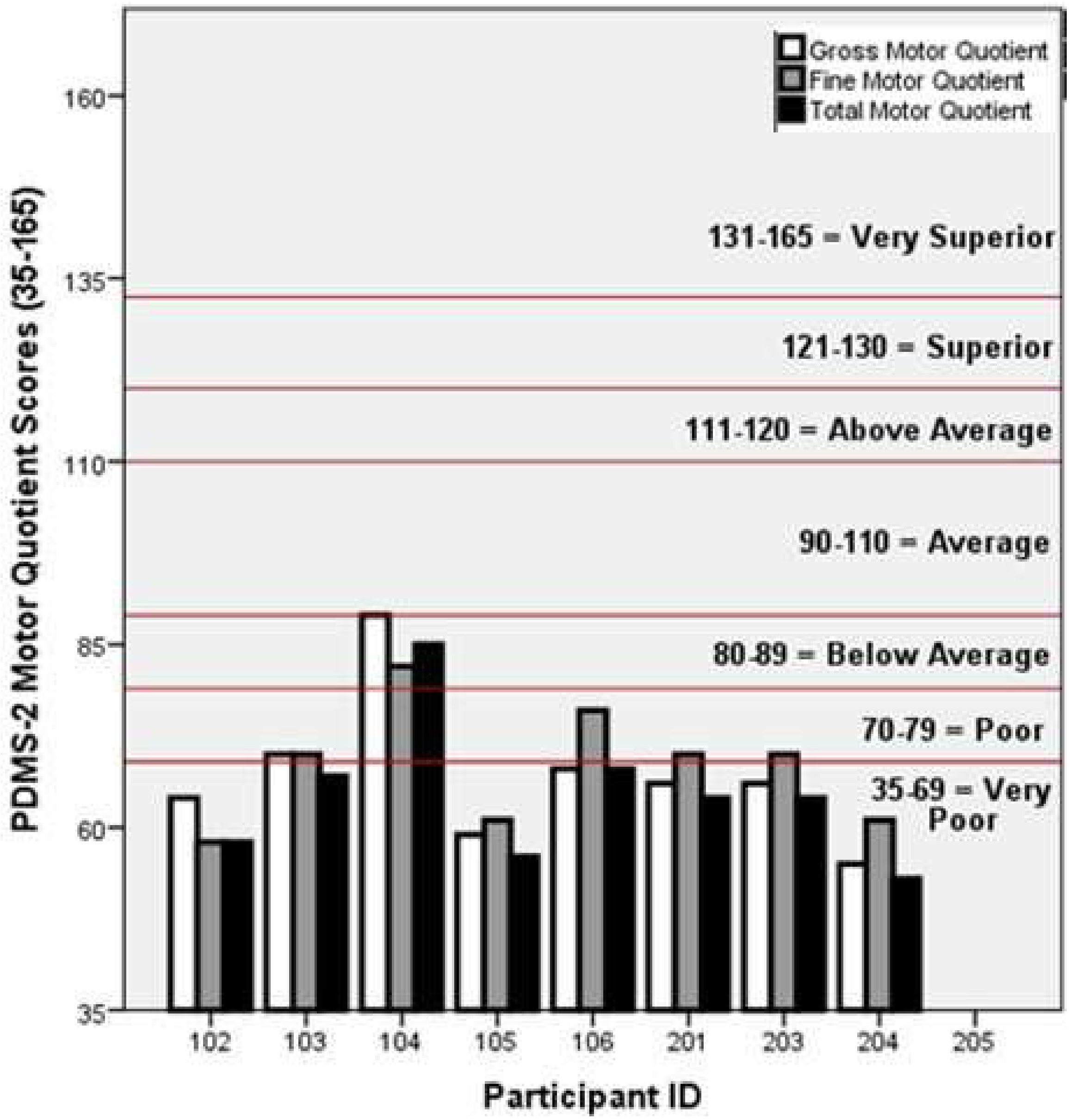
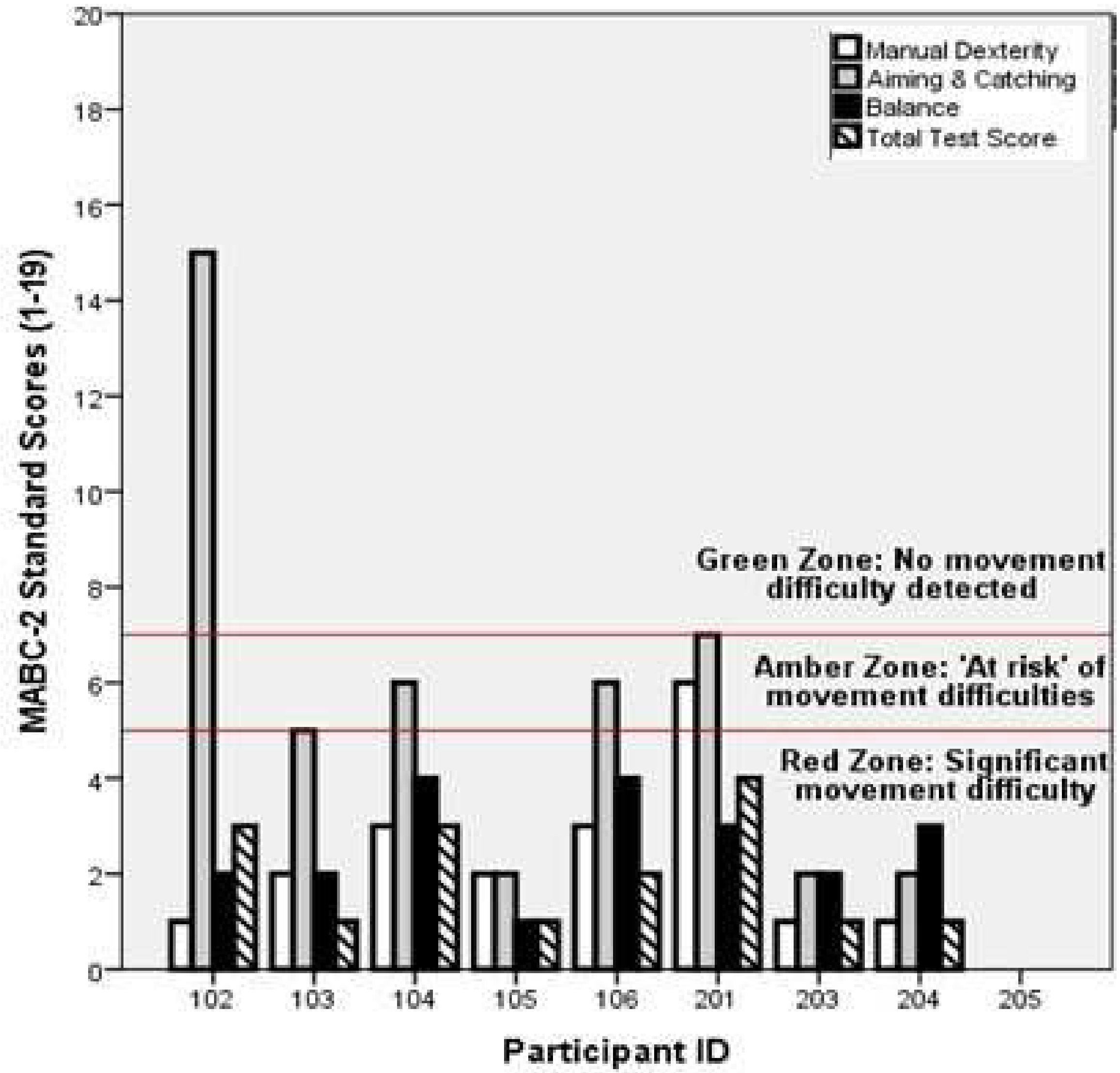


Figure 6. *Baseline MABC-2 standard scores and descriptive categories by participant.*



The average magnitude of change from pre- to post-intervention was calculated for all PDMS-2 subscale raw scores and motor quotients (Table 4), as well as the MABC-2 subdomain standard scores and total test standard score in the experimental and control groups (Table 5). Improvements were seen in the experimental group from pre- to post-intervention on all motor skill variables. Significant differences in motor scores from pre-to post- intervention were found between the experimental and control group on the PDMS-2 object manipulation raw score and the PDMS-2 total motor quotient (Table 4).

Table 4. Magnitude of change scores from pre- to post-intervention on the PDMS-2 in the experimental and control group.

PDMS-2 Variable	**Group**	**Pre-Test Score** (mean ± SD)	**Post-Test Score** (mean ± SD)	**Magnitude of Change** (mean ± SD)	**p-value**	**Effect Size**
Stationary Raw Score	Experimental	41.40 ± 4.39	43.00 ± 5.39	1.60 ± 2.41	0.212	0.42
	Control	39.00 ± 1.73	39.00 ± 1.73	0.00 ± 0.00		
Locomotor Raw Score	Experimental	131.40 ± 15.04	142.80 ± 18.65	11.40 ± 5.60	0.100	0.58
	Control	111.67 ± 7.77	115.33 ± 12.42	3.67 ± 5.13		
Object Manipulation Raw Score	Experimental	21.40 ± 7.57	28.60 ± 3.33	7.20 ± 2.59	0.029	0.70
	Control	17.33 ± 8.33	18.33 ± 7.37	1.00 ± 3.61		
Grasping Raw Score	Experimental	43.60 ± 2.70	46.20 ± 3.42	2.60 ± 1.67	0.109	0.61
	Control	44.00 ± 2.00	44.67 ± 1.53	0.67 ± 0.58		
Visual-Motor Integration Raw Score	Experimental	103.20 ± 14.38	111.80 ± 14.38	8.60 ± 3.85	0.395	0.28
	Control	98.67 ± 6.66	103.00 ± 14.42	4.33 ± 9.61		
Gross Motor Quotient	Experimental	70.00 ± 11.42	74.60 ± 13.45	4.60 ± 4.72	0.095	0.57
	Control	62.33 ± 6.35	62.33 ± 6.35	0.00 ± 0.00		
Fine Motor Quotient	Experimental	69.40 ± 10.04	75.40 ± 12.97	6.00 ± 3.67	0.055	0.67
	Control	67.00 ± 5.20	67.00 ± 6.00	0.00 ± 3.00		
Total Motor Quotient	Experimental	66.80 ± 11.48	72.20 ± 14.20	5.40 ± 3.91	0.044	0.65
	Control	60.33 ± 6.35	60.67 ± 6.81	0.33 ± 1.53		

Table 5. Magnitude of change scores from pre- to post-intervention on the MABC-2 in the experimental and control group.

MABC-2 Variable	**Group**	**Pre-Test Score** (mean ± SD)	**Post-Test Score** (mean ± SD)	**Magnitude of Change** (mean ± SD)	**p-value**	**Effect Size**
Manual Dexterity Standard Score	Experimental	2.20 ± 0.84	4.20 ± 2.78	2.00 ± 2.24	0.184	0.53
	Control	2.67 ± 2.89	2.67 ± 2.89	0.00 ± 0.00		
Aiming & Catching Standard Score	Experimental	6.80 ± 4.87	7.20 ± 3.27	0.40 ± 4.51	0.710	0.16
	Control	3.67 ± 2.89	3.00 ± 1.73	-0.67 ± 1.16		
Balance Standard Score	Experimental	2.60 ± 1.34	4.80 ± 4.44	2.20 ± 3.42	0.349	0.38
	Control	2.67 ± 0.58	2.67 ± 2.08	0.00 ± 1.73		
Total Test Standard Score	Experimental	2.00 ± 1.00	4.00 ± 4.24	2.00 ± 3.81	0.412	0.35
	Control	2.00 ± 1.73	2.00 ± 1.73	0.00 ± 0.00		

Part 2. Analysis of Intervention Intensity: Group 1 versus Group 2

Descriptive characteristics of the participants at their respective pre-test are presented in Table 6. No significant differences were found between the groups in regards to their sex, age, overall motor proficiency, and adaptive behaviour, indicating that the effect of randomization was maintained following Part 1 of the study.

Table 6. Descriptive characteristics, motor proficiency, and social functioning by group at their respective pre-test for Part 2 of the analyses.

	Group 1 (mean ± SD, *count*)	**Group 2** (mean ± SD, *count*)	**p- value**
Sex (male, female)	*5 M*	*3 M, 1 F*	0.444
Age (months)	51.60 ± 3.05	54.25 ± 2.22	0.190
Height (cm)	102.12 ± 4.89	106.80 ± 7.10	0.278
Weight (kg)	18.30 ± 3.29	18.10 ± 1.92	0.918
BMI (kg/m^2)	17.44 ± 1.67	15.88 ± 1.09	0.151
Age of Onset of Walking (months)	14.60 ± 2.41	12.00 ± 0.82	0.080
PDMS-2 Gross Motor Quotient	70.00 ± 11.42	65.25 ± 7.81	0.503
PDMS-2 Fine Motor Quotient	69.40 ± 10.04	71.50 ± 10.25	0.766
PDMS-2 Total Motor Quotient	66.80 ± 11.48	64.75 ± 9.88	0.786
MABC-2 Manual Dexterity Standard Score	2.20 ± 0.84	3.25 ± 2.63	0.491
MABC-2 Balance Standard Score	2.60 ± 1.34	4.00 ± 3.16	0.395
MABC-2 Aiming & Catching Standard Score	6.80 ± 4.87	4.00 ± 2.45	0.333
MABC-2 Total Test Standard Score	2.00 ± 1.00	2.75 ± 2.06	0.540
Vineland Adaptive Behavior Composite Standard Score	72.40 ± 6.43	80.00 ± 17.21	0.386
Vineland Maladaptive Behavior v-Scale Score	19.00 ± 1.87	20.25 ± 2.75	0.443

The results of the two-way analysis of variance with repeated measures on the PDMS-2 variables from pre- to post- to 6-week follow-up by group are presented in Table 7; results from the MABC-2 are presented in Table 8. There were no significant group differences for any of the motor variables and no group by time interactions were present, indicating that intervention intensity (1x/week for 12 weeks vs. 2x/week for 6 weeks) did not have an effect on motor outcomes (Tables 7-8).

The results indicate that with the groups combined, time had a significant effect on all PDMS-2 variables (Table 7) but, not on the MABC-2 scores (Table 8), demonstrating improvements on the PDMS-2 following the intervention and skill retention at the 6-week follow-up. Post-hoc analyses with Bonferroni corrections revealed that the PDMS-2 stationary raw score improved significantly between the pre-test and 6-week follow-up ($p=0.017$). The PDMS-2 locomotor and object manipulation raw scores improved significantly from the pre- to post-test ($p=0.003$ and $p=0.001$, respectively), and form the pre-test to 6-week follow-up ($p=0.001$ and $p=0.003$, respectively). Furthermore, the PDMS-2 grasping and visual-motor integration raw scores significantly improved pre- to post-intervention ($p=0.043$ and $p=0.000$, respectively) and retained that improvement from the post-test to the 6-week follow-up ($p=1.000$ and $p=1.000$, respectively). The PDMS-2 fine motor quotient improved significantly from the pre- to post-test ($p=0.016$) and did not decline at the 6-week follow-up ($p=1.000$). Lastly, the PDMS-2 gross and total motor quotients improved significantly from the pre- to post-test ($p=0.018$ and $p=0.005$, respectively), and from the pre-test to 6-week follow-up ($p=0.003$ and $p=0.017$, respectively; Figure 7).

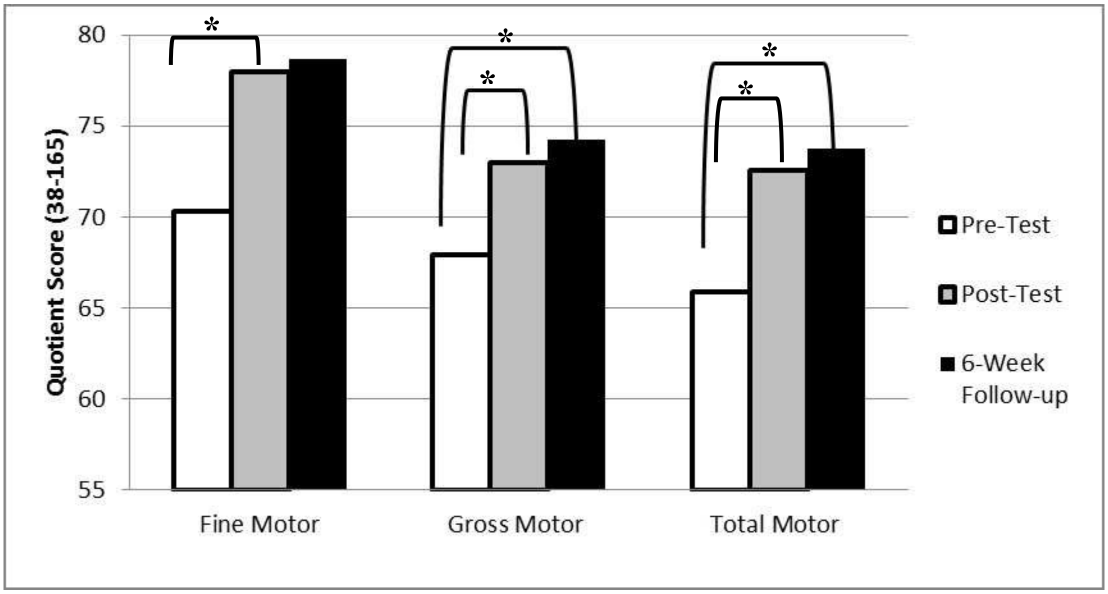
Table 7. Pre-, post-, and 6-week follow-up PDMS-2 scores by group.

	Group	**Pre-Test** (mean ± SD)	**Post-Test** (mean ± SD)	**6- Week Follow-up** (mean ± SD)	**Group**	**Time**	**Group x Time**
Stationary Raw Score	Group 1 Group 2	41.40 ± 4.39 40.00 ± 2.5	43.00 ± 5.39 42.75 ± 3.30	45.80 ± 5.36 42.50 ± 3.70	F = 0.356, p = 0.569	F = 8.759, p = 0.003	F = 1.707, p = 0.217
Locomotor Raw Score	Group 1 Group 2	131.40 ± 15.04 121.50 ± 15.97	142.80 ± 18.65 133.00 ± 19.43	152.00 ± 13.73 132.75 ± 24.58	F = 1.225, p = 0.305	F = 24.892, p = 0.000	F = 2.717, p = 0.101
Object Manipulation Raw Score	Group 1 Group 2	21.40 ± 7.57 21.00 ± 8.04	28.60 ± 7.44 27.25 ± 9.43	30.00 ± 5.48 25.75 ± 9.29	F = 0.157, p = 0.704	F = 18.640, p = 0.000	F = 1.253, p = 0.316
Grasping Raw Score	Group 1 Group 2	43.60 ± 2.70 45.00 ± 1.41	46.20 ± 3.42 46.25 ± 2.50	46.80 ± 4.09 46.00 ± 2.94	F = 0.013, p = 0.914	F = 8.351, p = 0.004	F = 1.893, p = 0.187
Visual-Motor Integration Raw Score	Group 1 Group 2	103.20 ± 14.38 109.25 ± 17.17	111.80 ± 14.38 119.00 ± 17.94	113.40 ± 21.89 113.50 ± 20.81	F = 0.145, p = 0.715	F = 8.813, p = 0.015	F = 1.370, p = 0.284
Gross Motor Quotient	Group 1 Group 2	70.00 ± 11.42 65.25 ± 7.81	74.60 ± 13.45 71.00 ± 8.52	78.40 ± 13.52 69.00 ± 9.63	F = 0.636, p = 0.451	F = 15.161, p = 0.000	F = 3.325, p = 0.066
Fine Motor Quotient	Group 1 Group 2	69.40 ± 10.04 71.50 ± 10.25	75.40 ± 12.97 81.25 ± 17.73	79.60 ± 20.28 77.50 ± 15.97	F = 0.042, p = 0.844	F = 5.386, p = 0.018	F = 1.001, p = 0.392
Total Motor Quotient	Group 1 Group 2	66.80 ± 11.48 64.75 ± 9.88	72.20 ± 14.20 73.00 ± 13.24	77.00 ± 15.38 69.75 ± 13.00	F = 0.108, p = 0.752	F = 16.394, p = 0.003	F = 62.346, p = 0.078

Table 8. Pre-, post-, and 6-week follow-up MABC-2 scores by group.

	Group	**Pre-Test** (mean ± SD)	**Post-Test** (mean ± SD)	**6- Week Follow-up** (mean ± SD)	**Group**	**Time**	**Group x Time**
Manual Dexterity Standard Score	Group 1	2.20 ± 0.84	4.20 ± 2.78	5.60 ± 4.51	F = 0.041,	F = 3.262,	F = 1.719,
	Group 2	3.25 ± 2.63	4.00 ± 2.31	3.75 ± 2.22	p = 0.846	p = 0.069	p = 0.215
Aiming & Catching Standard Score	Group 1	6.80 ± 4.87	7.20 ± 3.27	6.80 ± 3.96	F = 0.956,	F = 1.136,	F = 0.535,
	Group 2	4.00 ± 2.45	6.25 ± 3.40	4.25 ± 2.63	p = 0.361	p = 0.349	p = 0.597
Balance Standard Score	Group 1	2.60 ± 1.34	4.80 ± 4.44	5.40 ± 4.10	F = 0.025,	F = 3.312,	F = 1.814,
	Group 2	4.00 ± 3.16	5.75 ± 2.06	4.00 ± 3.16	p = 0.879	p = 0.066	p = 0.199
Total Test Standard Score	Group 1	2.00 ± 1.00	4.00 ± 4.24	4.80 ± 4.66	F = 0.033,	F = 2.292,	F = 1.187,
	Group 2	2.75 ± 2.06	4.00 ± 2.94	3.00 ± 2.31	p = 0.861	p = 0.170	p = 0.316

Figure 7. PDMS-2 motor quotients of the complete sample at pre-, post-, and 6-week follow-up.



* Significantly different at p<0.05

Results of the Pearson product correlations between the PDMS-2 total motor quotient and MABC-2 total test score are presented in Table 9. There was significant agreement between the two measures at the post-test and 6-week follow-up; however, the relationship was not significant at the pre-test (Table 9).

Table 9. Correlations between PDMS-2 and MABC-2 at pre-, post-, and follow-up assessments for the complete sample.

Assessment	Variable 1	Variable 2	R	p-value
Pre	PDMS-2 Total Motor Quotient	MABC-2 Total Test Score	0.600	0.087
Post	PDMS-2 Total Motor Quotient	MABC-2 Total Test Score	0.941	<0.0001
6-week	PDMS-2 Total Motor Quotient	MABC-2 Total Test Score	0.970	<0.0001

Part 3. Predictors of Optimal Treatment Response

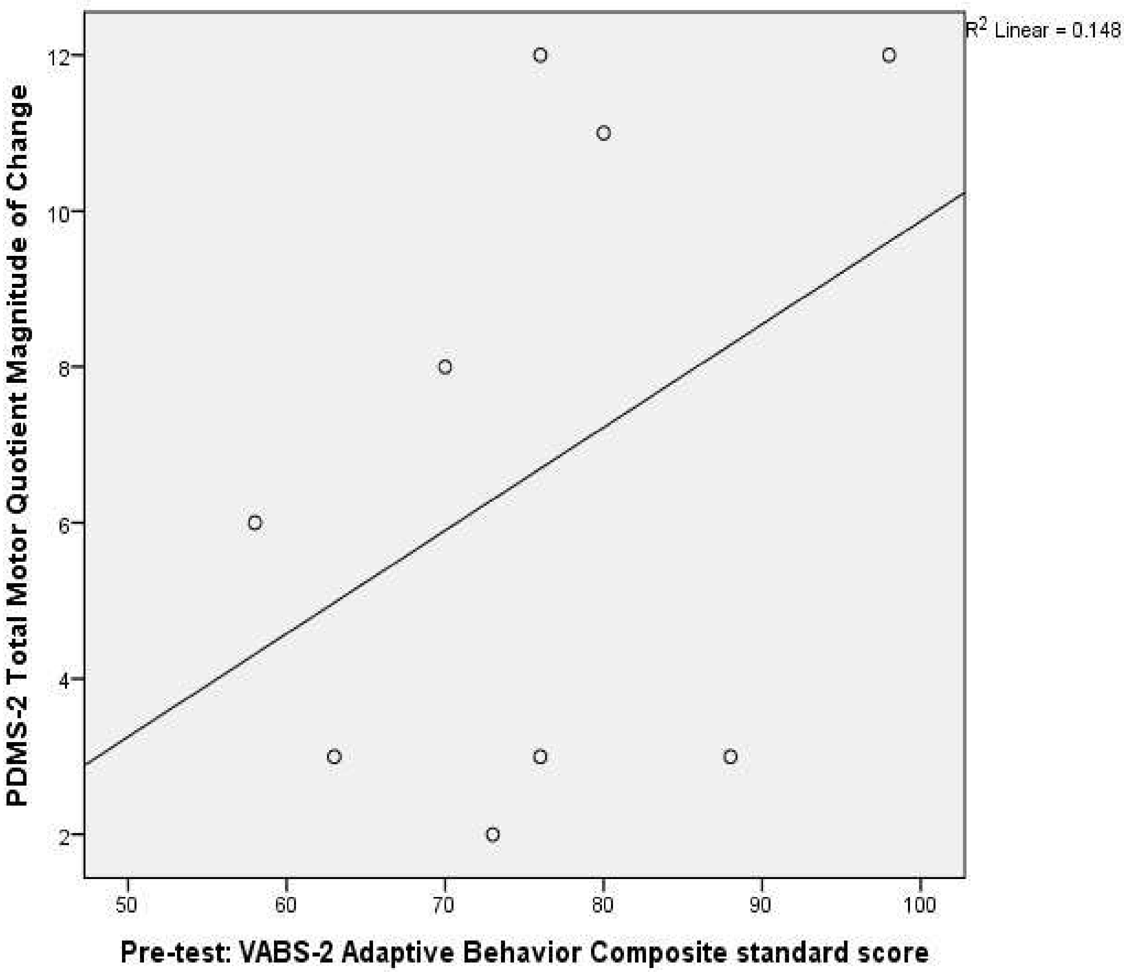
The average attendance at the intervention sessions was 71.6% and 66.6% for Groups 1 and 2, respectively (*t(7)=0.541, p=0.605*). Attendance rates were not significantly correlated with the magnitude of change from pre- to post-intervention on the PDMS-2 motor quotients or MABC-2 standard scores for the complete sample (Table 10).

Table 10. Correlations of attendance and magnitude of change from pre- to post-intervention on all motor variables for the complete sample.

Variable 1	Variable 2 - Magnitude of Change	R	p-value
Attendance	PDMS-2 Gross Motor Quotient	-0.029	0.940
Attendance	PDMS-2 Fine Motor Quotient	0.310	0.417
Attendance	PDMS-2 Total Motor Quotient	0.138	0.722
Attendance	MABC-2 Manual Dexterity Standard Score	0.374	0.321
Attendance	MABC-2 Balance Standard Score	0.142	0.716
Attendance	MABC-2 Aiming & Catching Standard Score	0.116	0.767
Attendance	MABC-2 Total Test Standard Score	0.394	0.294

The VABS-2 adaptive behavior composite standard score at the pre-test was not significantly associated with improvements in the PDMS-2 total motor quotient (r=0.384, p=0.307; Figure 8) at the post-test.

Figure 8. Scatter plot of VABS-2 adaptive behavior composite standard score at the pre-test and PDMS-2 total motor quotient magnitude of change from pre- to post-intervention.



Discussion

The purpose of this study was to investigate the effectiveness of a FMS intervention at improving the motor skills of 4 year old children with ASD. Our results indicate that the motor skills of the experimental group significantly improved following the FMS intervention, in comparison to the control group who did not receive the intervention. The secondary purpose of this study was to investigate whether a higher intensity of the same intervention was more or less effective at improving motor skills in this population. Our results indicate that although both intensities of the intervention significantly improved the motor skills of the 4 year old children with ASD, there were no significant differences between the two intensities in regard to an improvement in motor skills or in skill retention.

The first part of this study examined the effectiveness of a FMS intervention at improving the motor skills of 4 year old children with ASD in comparison to children who did not receive the intervention. Previous studies have found that FMS interventions can be effective at improving the FMS of 3-5 year old children with developmental delays, excluding children with ASD (Kirk & Rhodes, 2011). However, no studies have examined the effectiveness of FMS interventions for young children with ASD; thus, our study helped to fill a significant gap in the literature. We found that the children in the experimental group improved in all areas of the PDMS-2 and MABC-2 following the intervention, whereas the control group remained the same, slightly declined, or only slightly improved following the 12-week control period. The improvements in the experimental group were only statistically significant on the PDMS-2 object manipulation raw score and the total motor quotient, which was our primary outcome measure. The lack of statistical significance on the other test variables may be due to our small sample size. This explanation is confirmed with the moderate to large effect sizes on the PDMS-2 variables, which indicate the positive effect of the intervention and justify further study with a larger sample.

The significant improvement of object manipulation skills following the intervention may be relevant for the overall functioning of a child with ASD. MacDonald and colleagues (2013) found that the object control skills of 6-15 year old children with

ASD significantly predicted their social communicative skills, meaning that those individuals with better object control skills were more likely to have better social communicative skills. The relationship between object control and social communicative skills is likely due to the social aspect of many object control skills, such as playing catch with a peer. The significant improvement in object control skills in this study may be partly attributed to the low ratio of instructors to participants in the intervention, which provided very intensive, and supportive, opportunities for skill practice. We hypothesize that if we can improve the object control skills of young children with ASD through early intervention, they may be more likely to succeed in the social communicative domain throughout childhood. Furthermore, any functional improvements in motor skills can be significant for an individual child with ASD as it may provide them with the skills required to engage in active play and activities of daily living.

Our baseline motor skill assessments on the PDMS-2 indicated that all children were below average on their gross, fine, and total motor quotients. Furthermore, all children had a MABC-2 total test score that indicated a significant movement difficulty was present. One participant scored in the 'green zone' of the MABC-2 for aiming and catching at baseline; however, his overall test score still indicated a significant movement difficulty was present. Since the MABC-2 is a product-oriented assessment, the higher score in the aiming and catching domain simply indicates that the participant was able to hit the target by throwing a beanbag and catching the beanbag thrown at him or her without dropping it; however, it does not necessarily indicate that these skills were performed in a proficient manner (Henderson, Sugden, & Barnett, 2007; Staples, 2013). All participants were significantly delayed in regard to their motor skills at the onset of this study, which is consistent with previous literature that has demonstrated that young children with ASD have significant delays in their motor skills and consistently score below their peers with TD on motor assessments (Liu & Breslin, 2013; Lloyd et al., 2011; Matson et al., 2010; Ozonoff et al., 2008).

As movement is a primary element of active play, the motor delays that children with ASD experience may have many negative consequences (Gallo-Lopez & Rubin, 2012; Jobling & Virji-Babul, 2004). For instance, active play provides an opportunity for children to improve their executive functioning and problem-solving skills through the manipulation and use of objects and toys (Burdette & Whitaker, 2005; Gallo-Lopez & Rubin, 2012). Play is also essential for the development of joint attention, sharing, empathy, cooperation, and emotional regulation through the peer interactions that play can provide (Burdette & Whitaker, 2005; Gallo-Lopez & Rubin, 2012). Furthermore, functional play skills in early childhood are a significant predictor of language skills in adolescents with ASD (Sigman & McGovern, 2005). Thus, engagement in play is essential for the optimal development of any child. However, in order to play one needs to be able to move effectively and efficiently throughout one's environment (Pellegrini & Smith, 1998b). Children with ASD, by definition, experience significant delays in their social and communication skills (American Psychiatric Association, 2000, 2013) and they have motor skills that are delayed and of poor quality (Liu & Breslin, 2013; Lloyd et al., 2011; Ozonoff et al., 2008). These skills are all required to engage in active play; however, participation in active play also promotes the development of these skills. Therefore, developing proficient FMS may be even more important for children with ASD as it will provide them with an opportunity to engage in active play. If children with

ASD do not have the FMS required to participate in active play, they may be less likely to engage in play, and may not benefit from the developmental experience that play provides.

The secondary purpose of this study was to investigate whether a higher intensity of the FMS intervention was more or less effective at improving the motor skills of 4 year old children with ASD. Our results from the two-way ANOVA with repeated measures indicated that there were no group by time interactions for any of the motor skill variables. This finding demonstrates that there was no difference between the two intensities of the intervention (1x/week for 12 weeks and 2x/week for 6 weeks) at improving the motor skills of the 4 year old children with ASD in this study. This finding is relatively consistent with previous literature that has found large variability in both the intensity (i.e. the frequency of sessions) and dosage (i.e. number of sessions) of motor skill interventions for preschool age children with TD and developmental delays; all of which seem to be moderately effective (Kirk & Rhodes, 2011; Riethmuller, Jones, & Okely, 2009). As intervention intensity was not significant in this study, we recommend that future research investigate the role of intervention dosage on study outcomes. We did find time to be a significant factor for all PDMS-2 variables, indicating that the complete sample significantly improved in all subdomains of the PDMS-2, regardless of the intensity. Furthermore, all improvements at the post-test were retained at the 6-week follow-up. Skill retention is an essential element of program effectiveness and we interpret this outcome as an indication of the success of the intervention.

Unlike the results from the PDMS-2, there were no significant improvements on the MABC-2 test scores following the intervention for either group. However, the

MABC-2 is designed to assess whether a movement difficulty is present and is more concerned with the product (i.e. whether a child catches the ball) than the process (i.e. how the ball is actually caught) (Henderson et al., 2007; Staples, 2013). Although the participant's motor skills improved following the intervention, as evident in the PDMS-2 results, movement difficulties were still present; consequently, we would be unlikely to see a change in MABC-2 scores. Future research should further examine the outcomes between various intervention intensities, and skill retention at follow-up, with randomized controlled trials and increased time before follow-up assessments.

Since the goal of early interventions for children with ASD is to provide them with the best possible outcomes, it may be valuable to determine who will benefit the most from particular forms of treatment in order to individualize the treatment approach. Our results from Part 3 of the analysis suggest that adaptive behaviour at baseline may be related to an overall improvement in motor skills following the intervention, with better adaptive behaviour resulting in a larger increase in motor skill proficiency. Similar relationships have been demonstrated with social and behavioural interventions for children with ASD (Magiati, Moss, Charman, & Howlin, 2011; McGovern & Sigman, 2005; Zachor & Ben Itzchak, 2010); however, to the best of our knowledge this relationship has not been demonstrated for a motor skill intervention for children with ASD. We recommend that future research examine the ability of adaptive behaviour to predict increases in motor skills following an intervention as this information may be beneficial for inclusion criteria and treatment course in the clinical setting. We also found that attendance was not significantly related to an improvement in motor skills following the intervention. This may be due to the fact that although overall attendance rates were consistent with previous intervention literature (Barry et al., 2003; Cliff, Wilson, Okely, Mickle, & Steele, 2007), there was little variability between individual participant's attendance and attendance was quite good. We hypothesize that a larger sample may result in more variability in attendance and as a consequence, attendance may impact intervention outcomes. It is recommended that future motor skill interventions continue to record and analyse the effect of attendance on the intervention outcomes.

Early intervention is of utmost importance for children with ASD and there are a wide range of services available to these children including early intensive behavioural interventions, speech-language pathology, and occupational therapy (Myers & Johnson, 2007; Simpson et al., 2005). However, these services can be cost prohibitive (Chasson et al., 2007) and typically only focus on the core deficits of ASD including, social and communication skills, and the reduction of maladaptive behaviours (Matson & Smith, 2008). In contrast, this motor skill intervention was implemented with minimal funding at no cost to the families, and in a community setting; it likely could also be implemented through recreation programs and integrated into physical education classes. It is well documented that children with ASD experience challenges in the motor domain (Liu & Breslin, 2013; Lloyd et al., 2011; Ozonoff et al., 2008); however, motor skills are often neglected in the intervention literature. Therefore, this study helped to fill a significant gap in the literature. Furthermore, the positive gains that were made in motor skill proficiency can have very important implications for the ability of participants to become more engaged with their peers, family, and community throughout their life. For instance, Titus and Watkinson (1987) noted that providing a brief period of segregated motor skill instruction to a small group of 5-10 year old children with moderate intellectual disabilities may have contributed to the children's ability to keep up, physically and socially, with their peers with TD in an integrated free play setting; which can have positive implications for playground inclusion throughout childhood. Similarly, being able to move efficiently can help a child participate during family outings and activities, such as going to the park or for a bike ride. Motor skills are also essential for community participation such as attending a camp, playing on a sports team, or participating in individual physical activities within a community organization. These increased opportunities that stem from motor skill proficiency can in turn provide a platform for the development of social and communicative skills; thus, positively impacting the overall development of an individual with ASD.

Strengths and Limitations

To the best of our knowledge, this is the first study to investigate the effectiveness of a FMS intervention at improving the motor skills of preschool age children with ASD. Therefore, this study helps to fill a significant gap in the early intervention literature. A second strength of this study is that it was a community-based intervention that was run with minimal funding. Therefore, it would be feasible for future practitioners and community organizers to implement similar motor skill interventions for young children with ASD.

As with all studies, there are limitations to our findings. Our biggest limitation is the small sample size, which resulted in a small amount of statistical power. This small sample makes our findings less generalizable to all 4 year old children with ASD. However, it is important to note that our small sample likely would have biased our findings toward the null hypothesis; thus, the fact that we still found significant results is promising in regard to the effectiveness of motor skill interventions for young children with ASD. Another limitation stemming from our small sample size is that we would ideally have had a third group that was a true control throughout the entire study and been able to run the two different intensities of intervention simultaneously. This would give us an even better indication of the effectiveness of the intervention as well as the differences in intervention intensity on the study outcomes. Unfortunately, including a third group was not plausible for this study as it would require a much larger sample size, more research assistants, and more physical space to conduct the interventions simultaneously. Furthermore, there are ethical questions of not providing control participants with a presumably effective treatment, and as such we would likely still need to offer this control group some type of comparable intervention following the study.

A third limitation is the group imbalance and that there was only one female in the study. Ideally, there would be equal numbers of participants in each group and the proportion of males and females would be the same in each group. However, as we used a sample of convenience and parents had to be able to commit to bringing their child to the intervention sessions, this was not possible. Furthermore, the small group seemed to work well in terms of group dynamics, and it limited potential distractions from having too many children, while still providing opportunities for social interactions. A fourth limitation to our study is that the researchers were not blind to group allocation, which may have biased our findings toward the alternative hypothesis. Given our limited resources we were unable to blind individuals involved in this study to the randomization; however, we recommend that future studies blind those individuals who are measuring the study outcomes to the group allocation in order to ensure study transparency and prevent potential bias.

The final limitation is that baseline IQ was not measured in this study. As IQ is associated with motor skill proficiency (Lahtinen, Rintala, & Malin, 2007b; Vuijk et al., 2010; Wuang et al., 2008) it is possible that it may have been a confounding factor to the participant's motor skills, and their ability to learn and retain new skills. Furthermore, IQ may also have had an influence on a child's ability to understand the instructions that were given to them in the sessions; thus, further impacting intervention outcomes. We did not have the resources to measure IQ in this study but, recommend that future studies measure IQ in order to control for its potential influence.

Despite these limitations, we still found significant improvements in motor skills following the intervention, as well as moderate to large effect sizes. These findings are promising, particularly as this is the first study to investigate the effectiveness of a FMS intervention at improving the motor skills of 4 year old children with ASD; more research is warranted in this area.

Future Research

Future studies should continue to examine the effectiveness of FMS interventions for 4 year old children with ASD. We also recommend that future studies include larger age bands (e.g. 3-5 years), as well as younger and older children. It is important that future studies use a larger sample that is representative of the entire spectrum of children with ASD. However, as the small groups that were used in our study appeared to be successful, it may be beneficial to maintain the low instructor-to-child ratio by employing a study design that allows multiple groups, each containing 4-6 children, to receive the motor skill intervention. Based on our preliminary findings, it may be beneficial to base group assignment on adaptive behaviour levels in order for the children to have the most success in the intervention. It is also recommended that future studies employ a randomized controlled trial, with a true control group, and a longer follow-up period in order to further examine the effectiveness of motor skill interventions, as well as skill retention at follow-up. In order to address ethical concerns of not providing the FMS intervention to the control group, they could be offered a free play or fine motor group (another area in which they are delayed) during the study; or they could receive the FMS intervention following study completion. Our results indicated that intervention intensity did not have any bearing on the intervention outcomes; however, we recommend that future studies further examine this relationship. We also suggest that future research look at the potential impact of dosage on intervention outcomes by designing interventions with or more or less than 12, one hour, sessions.

We found that the use of take-home sheets following each intervention session was a relatively easy way to keep parents informed of the skills their child was learning, as well as games and activities that could be implemented at home in order to further practice the new motor skills. The parents of our participants were typically very pleased with these take-home sheets and implied that they implemented the activities at home with their child. In the future, we would recommend that practitioners continue to use similar information sheets to keep parents involved and increase their ability to work with their child at home. However, we would recommend that future research should assess the extent to which take-home or information sheets are used, and whether intervention outcomes differ between those children who were engaged at home by activities recommended on the take home sheets.

This intervention was community-based as it was held at a local CTC. We found that this venue was an ideal setting to conduct the motor skill intervention as all participants had previously attended the CTC for other services and were familiar with the environment. We recommend that future motor skill interventions employ similar community-based designs; however, it would also be beneficial to run early motor skill interventions in other setting such as day cares, or integrate them into the physical education curriculum in elementary schools in order to reach more children with ASD that may not be able to attend a community program outside of school hours.

Conclusion

The aim of this study was to implement a motor skill intervention for 4 year old children with ASD and examine its effectiveness between two different intensities of the intervention. Our results indicate that the 4 year old children with ASD in our study had motor skills that were of poor quality at the beginning of the intervention, which is consistent with previous literature (Liu & Breslin, 2013; Lloyd et al., 2011; Ozonoff et al., 2008). We found that the FMS intervention was effective at improving the motor skills of the children in our experimental group, when compared to the control group. Furthermore, all children on average had improvements in motor skills from the pre- to post-test, and retained their improvements at the 6-week follow-up, with no differences in the group that received a higher intensity intervention. These findings suggest that a FMS intervention can be effective at improving the motor skills of 4 year old children with ASD. However, more research is required with larger, well-controlled, samples.

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Section 4: Manuscript 2
Investigating the Impact of a Fundamental Motor Skill Intervention on the Adaptive Behaviour and Social Skills of 4 Year Old Children with Autism Spectrum Disorder

Abstract

Children with Autism Spectrum Disorder (ASD) experience challenges with social skills, communication, and behaviour. They also have motor skills that are significantly delayed. We hypothesize that poor motor skills may be the critical factor needed to engage in active play, which in turn contributes to overall development. The purpose of this study was to examine the effectiveness of a fundamental motor skill (FMS) intervention at improving the adaptive behaviour and social skills of 4 year old children with ASD; participants were divided into an experimental and control group for this part of the study. A secondary purpose was to investigate the impact of intervention intensity on the primary outcomes; Group 1 (the former experimental group; intervention for 1 hour/week for 12 weeks) was compared to Group 2 (the former control group; intervention for 2 hours/week for 6 weeks) for this section of the study. The Vineland Adaptive Behaviour Scales-2 (VABS-2), Social Skills Improvement System (SSIS), and behavioural video coding were used to assess adaptive behaviour and social skills at baseline, post-intervention, and at a 6-week follow-up for each group. Results from the first section of the study indicated that the experimental group declined on the VABS-2 and SSIS variables, although not significantly, following the intervention. The second part of the study indicated that there were no significant differences between the study outcomes following the two intensities of intervention. We did find many individual improvements on both the VABS-2 and SSIS, as well as increased instances of appropriate play following the intervention. The results of this study indicate that a FMS intervention may provide functional gains in adaptive behaviour and social skills of 4 year old children with ASD; however, more research with a larger sample is required.

Emily E. Bremer (2014)

Introduction

Autism Spectrum Disorder

Autism Spectrum Disorder (ASD) is a developmental disability that is characterized by challenges in the areas of social communication, social interactions, and restricted patterns of behaviour or interests (American Psychiatric Association, 2013). Current estimates put the reported prevalence of ASD at approximately 1 in 150 (Fombonne, 2009) to 1 in 88 children (Kogan et al., 2009). The challenges that children with ASD experience persist across multiple settings (i.e. at home, at school, in the community) and are not better explained by intellectual disability (American Psychiatric Association, 2013). There is great variability in the level of functioning in children with ASD and as such, children who are diagnosed with ASD under the Fifth Edition of the Diagnostic and Statistical Manual for Mental Disorders will be given a severity rating of levels 1-3 (American Psychiatric Association, 2013). Level 1 indicates the child needs limited support, level 2 indicates a need for moderate support, and level 3 indicates a need for very substantial support (American Psychiatric Association, 2013). In addition to social and communication delays, children with ASD have motor skills that are delayed and of poor quality (Liu & Breslin, 2013; Lloyd et al., 2011; Ozonoff et al., 2008). However, motor skills are traditionally overlooked in the treatment of ASD.

Early interventions for children with ASD have customarily focused on the core deficits of ASD (i.e. social and communication skills, and the reduction of maladaptive behaviours) in isolation from other domains (Matson & Smith, 2008). However, according to dynamic systems theory the development of young children involves the organization of multiple domains or systems (i.e. cognitive, social, motor) simultaneously, in the presence of a supportive external environment (Thelen, Fisher, & Ridley-Johnson, 1984; Thelen et al., 1991). Children with ASD experience delayed motor skills (Landa & Garrett Mayer, 2006; Liu & Breslin, 2013; Lloyd et al., 2011), as well as challenges with social and communication skills (American Psychiatric Association, 2013). By intervening only on the core deficits of ASD (i.e. social and communication skills) we may be able to improve these areas; however, it may be at the expense of other critical systems, such as motor development, which we know must improve simultaneously for optimal child development. Therefore, there is a critical need to develop interventions that are effective at improving multiple domains or systems concurrently, rather than just the core deficits, in order to provide the best possible outcome for children with ASD.

Social and Behavioural Interventions for Children with ASD

Early interventions for children with ASD typically target the core deficits in the social communicative and behavioural domains (Matson & Smith, 2008). Social skill and behavioural interventions are widely available for children with ASD; however, there is great variability in the types of interventions employed, as well as their effectiveness (Bellini et al., 2007; Eikeseth, Smith, Jahr, & Eldevik, 2007; Eldevik et al., 2009; Matson et al., 2007). For instance, Bellini and colleagues (2007) conducted a meta-analysis of 55 single-subject design studies of school-based social skill interventions for children and adolescents with ASD and found that there was great variability in these interventions in regard to the skills targeted, intensity, and the duration of the interventions. The researchers also noted that although there were moderate maintenance effects in terms of the gains that were made, results indicated that these interventions had a low treatment effect and low generalization effects across participants, settings, and play stimuli (Bellini et al., 2007). Thus, there is still a need for interventions that are more generalizable for children with ASD, while still being beneficial in terms of social and behavioural gains.

Another common therapy for young children with ASD is Early Intensive Behavioural Intervention (EIBI), which is regarded as the most effective treatment (Matson & Smith, 2008). EIBI involves an individualized, comprehensive intervention that addresses all skill domains and is directed by individuals with advanced training in applied behaviour analysis (Green, Brennan, & Fein, 2002). EIBI is often effective at improving the intelligence scores and overall adaptive behavior composites of children with ASD (Dawson et al., 2010; Eldevik et al., 2009; Matson & Smith, 2008). For instance, a recent meta-analysis of nine controlled studies examining the effectiveness of EIBI found a large effect size for improving intelligence scores and a moderate effect size in regard to the adaptive behavior composite (Eldevik et al., 2009). However, there is some controversy among researchers over whether intelligence is a viable outcome measure to use for early intervention in children with ASD as improvements may be due to increased compliance at post-tests, rather than actual improvements (Charman & Howlin, 2003; Matson & Smith, 2008). Regardless, the consistent positive outcomes seen with EIBI are promising for the social and behavioural well-being of children with ASD. Unfortunately, intensive interventions can be cost prohibitive for individual families, and the social system, with EIBI costing an average of $40,000 a year (Chasson et al., 2007). Furthermore, early childhood interventions often have long wait times that result in children not receiving interventions right away, which may hinder early development

(Miller et al., 2008; Postl, 2006). Thus, there is a need to create additional interventions that can augment current treatments, such as EIBI, in order to lessen the burden on the social system and provide families with additional services to improve their child's overall development.

Children with ASD are significantly delayed in regard to their motor skills (Lloyd et al., 2011), and motor skills are essential for participation in active play (Pellegrini & Smith, 1998). Therefore, it is hypothesized that there can be negative implications in other developmental areas, such as social and communicative skills, for children with ASD who do not have proficient motor skills. Although many early behavioural interventions, such as EIBI, are comprehensive programs, there is limited evidence that motor skills are targeted through this type of intervention; or how the developmental gains made in programs like EIBI transfer to activities such as active play. One of the few studies that actually reports on motor outcomes of EIBI show that participants are still falling behind in the motor domain following the intervention (Dawson et al., 2010). Dawson and colleagues (2010) conducted a randomized, controlled trial to investigate the efficacy of the Early Start Denver Model (ESDM; a type of EIBI) for children with ASD between 18 and 30 months of age. They found that the children who received ESDM showed significant improvements in IQ, adaptive behaviour, and autism diagnosis two years after entering the program (Dawson et al., 2010). However, the motor skills of the children with ASD actually declined over the two year program, rather than improved (Dawson et al., 2010). This delay in motor skills can have negative consequences for a child's ability to engage in active play, which in turn could hinder further development of social and behavioural skills. Therefore, there is a critical need to create interventions that not only improve social and behavioural skills but, also work on motor skill acquisition in order to augment traditional therapies and ensure that children with ASD do not fall further behind in the motor domain.

Active Play, Motor Skills, and Social Behaviour

Active play is one of the primary avenues to promote the overall development of children (Ginsburg, 2007). Active play provides opportunities for children to develop their motor skills, social skills, and an overall understanding of the world (Byers & Walker, 1995a; Jobling & Virji-Babul, 2004; Ridgers et al., 2006a). For instance, play enables children to develop their cognitive and problem solving skills through the organization and use of objects (Gallo-Lopez & Rubin, 2012). Active play gives children an opportunity to engage with peers through joint attention and imitation, and it provides a platform for the development of verbal and non-verbal communication (Burriss & Tsao, 2002; Gallo-Lopez & Rubin, 2012). Finally, active play promotes movement and the development of motor skills through the exploration of one's environment and the manipulation of toys and objects (Burriss & Tsao, 2002; Gallo-Lopez & Rubin, 2012). Children with ASD experience delays in most of the developmental areas that are promoted and practiced through active play, including motor, social, and communication skills. If a child is missing any one of these developmental skills it can have detrimental effects on to their ability to actually engage in active play and further hinder their overall development. For example, without proficient motor skills a child may not be able to keep up with one's peers during play. As a result, opportunities for social interactions may be limited which can take away from the opportunity that active play provides to improve delays in the social domain.

Given the core deficits that children with ASD experience, it is important that they are able to access evidence-based early interventions that target their deficits in social communication and social interactions. One potential way to improve these skills in young children is through FMS interventions that promote engagement in active play. We know that active play is essential to a child's overall development (Ginsburg, 2007) and that movement is a primary component of active play (Jobling & Virji-Babul, 2004). Active play is also important for the development and practice of social and communication skills (Gallo-Lopez & Rubin, 2012), two areas in which children with ASD experience delays (American Psychiatric Association, 2013). Improving FMS through intervention has the potential to help children with ASD move more effectively and efficiently. This improvement may provide them with the movement skills necessary to engage in active play, and increased participation in play can provide a platform for the development and practice of social and communication skills.

There is a paucity of research examining the relationship between FMS and social behaviour in children with ASD. However, MacDonald, Lord, and Ulrich (2013) recently demonstrated that the object control skills (e.g. throwing, catching, kicking, etc.) of 6-15 year old children with ASD significantly predicted the severity of their social communicative deficits. They found that participants with less proficient object control skills were likely to have more severe social communicative deficits (MacDonald et al., 2013). Improving object control skills may result in a simultaneous improvement in social communicative skills for children with ASD, likely due to the social aspects of many object control skills (e.g. playing catch with a peer). Another study examined the impact of low and high, gross and fine motor skills on socialization in children under 3 years of age with autism, pervasive developmental disorder-not otherwise specified (PDD-NOS) and atypical development (non-ASD) (Sipes et al., 2011). The authors found that participants with more proficient gross motor skills exhibited significantly less impairment in socialization, regardless of diagnosis. This effect was not significant in regard to fine motor skills and socialization. However, the researchers found that proficiency in fine motor skills had a greater effect on socialization for children with autism than those with PDD-NOS and atypical development (Sipes et al., 2011). These findings demonstrate the importance of both gross and fine motor skills on socialization in children with ASD. However, interventions that target gross motor skills for children with ASD may have a greater impact on their social skills.

Children with ASD experience delays in their social, communicative, and motor abilities. Gross motor skills may be important predictors to the development of social skills (MacDonald et al., 2013; Sipes et al., 2011). They provide opportunities for one to move about his or her environment toward new people and objects, interact with others through the exchange and manipulation of toys, and engage in play-based activities. Children with ASD who lack proficiency in gross motor skills may have difficulties engaging in active play; thus, further stalling their social development. Intervening on motor skills may be an effective way in which to promote the development of social behaviour in children with ASD, and would serve the dual purpose of improving motor skills, along with social and behavioural skills.

Purpose

Early intervention is of utmost importance for the optimal outcome of children with ASD (Eldevik et al., 2009; Matson & Smith, 2008). Motor skills are an extremely important element of the development of young children as they provide children with the foundation skills needed to engage in active play (Pellegrini & Smith, 1998b; Williams et al., 2008); and through active play, the opportunities to develop social and behavioural skills are plentiful (Gallo-Lopez & Rubin, 2012). As such, there is a need to create cost-effective interventions that focus on the development of FMS, and to investigate the impact this has on the development of social and behavioural skills in children with ASD. Therefore, the purpose of this study was to explore the impact of a small, community-based FMS intervention on the adaptive behaviour and social skills of 4 year old children with ASD.

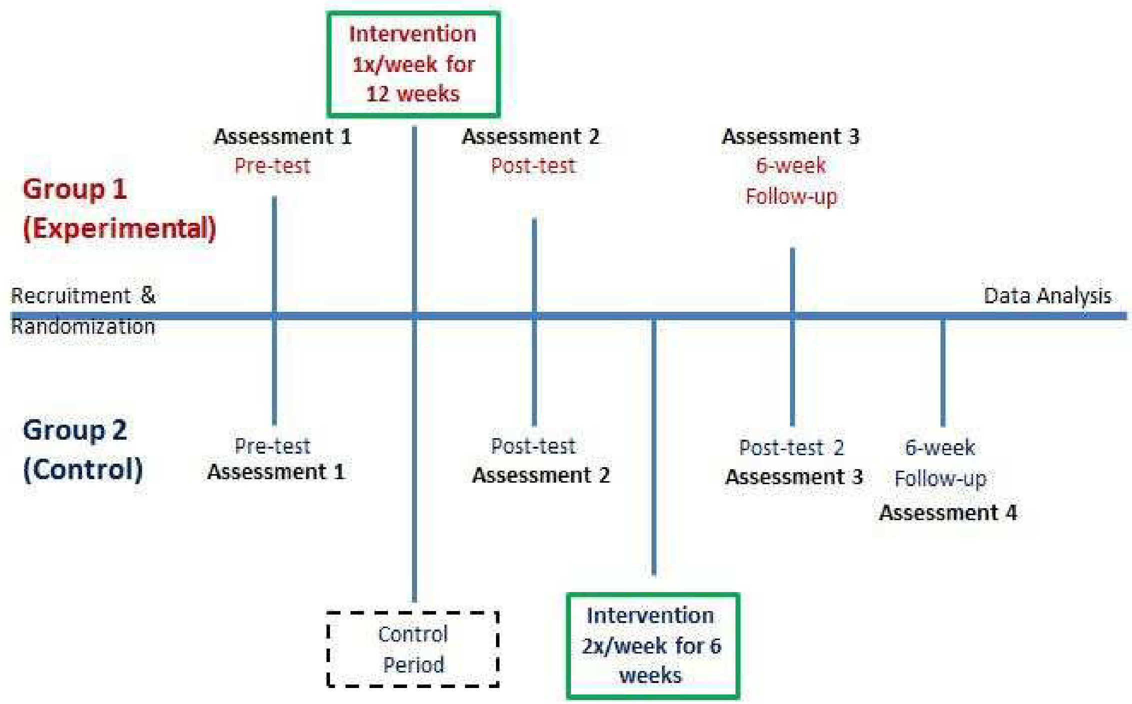
Method

Study Design

Ethical approval was received from a University Research Ethics Board (Appendix 1) and a local Children's Treatment Centre's (CTC) Research Committee and Quality Leadership Council (Appendix 2) and all parents provided informed consent prior to the beginning of the study (Appendix 3). This study was designed with a counter-balanced, experimental design. This design enabled us to test the effectiveness of the FMS intervention at improving adaptive behaviour and social skills while Group 1 was the experimental group and Group 2 acted as the control; as well as compare the effectiveness of two different intensities of the intervention (1 hour/week for 12 weeks vs. 2 hours/week for 6 weeks) at improving adaptive behaviour and social skills. Regardless of group assignment, all children recieved the intervention for the exact same number of sessions. Each group also attended three to four assessments, depending on the group, where their adaptive behaviour, social skills, and motor skills were assessed.

Assessments 1 and 2 provided a pre- and post-assessment respectively of the experimental (Group 1) and control (Group 2) groups. Assessment 3 acted as the 6-week follow-up for Group 1 and the post-test for Group 2 following their intervention. Group 2 then attended a fourth assessment for their 6-week follow-up (Figure 9).

Figure 9. Overview of study design.



Recruitment

A recruitment flyer (Appendix 4) advertising the study was posted on bulletin boards and social media websites at the local CTC in order to advertise the study to the parents of 4 year old children with a diagnosis of ASD. The families of 4 year old children with ASD that were on the waitlist for Applied Behaviour Analysis (ABA)-Based Services for Children and Youth with ASD offered through the local CTC were also targeted for participation in this study and mailed a copy of the recruitment flyer along with an accompanying letter of support from the Developmental Pediatrician at the CTC (Appendix 5).

Participants

Inclusion criteria for the study required that participants have a diagnosis of ASD and be 4 years of age. Participants were excluded from participating if their parents could not commit to bringing them to the assessments and intervention sessions. A total of 9 children were signed up for the study by their parents and were randomly assigned to one of two groups. Group assignment was generated using an online randomn assignment tool, group assignment was not concealed, and participants and the primary investigator were not blind to group assigment. Group 1 consisted of 5 children, all of whom were male. Group 2 consisted of 4 children, one of whom was female.

Procedures

All measurements were conducted in the researcher's office with the child and his or her parent or caregiver present. At the initial assessment, all parents completed a supplemental information form (Appendix 6) in order to provide demographic data and a brief medical history of their child. The remaining measurements were conducted with the child at each of the assessment sessions:

Adaptive Behaviour

Adaptive behaviour is the degree to which an individual typically perfroms daily activities required for personal and social sufficiency; it is age-related and for young children includes activities such as dressing and getting along with peers (Sparrow et al., 2005). To assess adaptive behaviour, the Vineland Adaptive Behavior Scales-2 (VABS-2) (Sparrow et al., 2005) was completed by the child's parents at each of the assessments. The VABS-2 assesses adaptive behaviour in the following domains: communication, daily living skills, socialization, motor skills, and maladaptive behaviour. The VABS-2 helped to provide a broad overview of each participant's level of functioning and helped to highlight participants' strengths and weaknesses. It is a commonly used tool to identify any deficits in adaptive behaviour and is widely used in an overall comprehensive evaluation of children with developmental disabilities, including those with ASD (Eldevik et al., 2009; Perry & Factor, 1989). The VABS-2 asked parents to rate their child's behaviour on a three-point scale in response to specific statements corresponding to the various domains (Sparrow et al., 2005). The primary outcome measure for this study is the overall adaptive behaviour composite score that is generated from this questionnaire.

Social Skills

The Social Skills Improvement System (SSIS) (Gresham & Elliott, 2008) is a standardized assessment used to measure a child's social skills and competing problem behaviours. The SSIS requires parents to rate their child's behaviour across a range of 15 subscales in order to provide a comprehensive social skills assessment (Gresham & Elliott, 2008). The SSIS was completed by the children's parents at each of the assessment periods.

Behavioural Video Coding

Each intervention session was concluded with a 10-minute free play period that allowed the participants to explore the equipment, practice newly learned skills, and engage in activities of their choosing. This free play period was videotaped using a Sony Handycam HDR-CX110 during the first and last intervention sessions (i.e. sessions #1 and #12). These videos were coded by the principal investigator using Social Behaviour Codes (Table 11, Appendix 9) that were adapted from Hauck et al.'s (1995) Behavior Coding Scheme. None of the codes were removed from Hauck et al.'s (1995) original scheme; however, eight additional categories were added to better account for the nature of the group free play session: Appropriate Play, Inapprpriate Play, Verbal Response, Non-verbal Response, Target of Initiation/Response – Adult, Target of Initiation/Response – Child, and Out of Frame (Table 11, Appendix 9). Behaviours were recorded at 15-second intervals for each child, and the target of their behaviour (i.e. adult or child) was also recorded when appropriate. Interrater reliability was established with a research assistant trained by the principal investigator on 27% of the videos (Table 19). This behavioural coding provided an additional measure of social skills to be analyzed. The free play videos were also coded by the principal investigator using the System for Observing Fitness Instruction Time (SOFIT; Appendix 10) (McKenzie, Sallis, & Nader, 1991) in order to examine the children's engagement in different intensities (i.e. lying, sitting, standing, walking, and vigorous) of physical activity. Activity levels were coded at 20-second intervals for each child with the predominant activity for that time frame. Inter-rater reliability for the SOFIT videos was also established on 27% of the videos with a research assistant who was trained by the principal investigator (Table 19).

Table 11. Social Behaviour codes adapted from Hauck et al.'s (1995) Behavior Coding Scheme.

Type of Behaviour	**Code Number**	**Behavioural Code**	**Description**
Positive Initiations	1	Give affection	Initiating a physical or verbal expression of affection
	2	Give information	Child informs other about something the other may not know; may include an expression of need
	3	Greet	Child uses language/action customarily used when meeting another
	4	Initiate play	Child initiates play activity with another person
	5	Joint attention	Child calls attention of another to an object or activity
	6	Seek aid/information verbally	Child verbally requests assistance or information from another
	7	Seek aid/information nonverbally	Child requests assistance or information from another with nonverbal means
	8	Appropriate play	Child is actively playing, in a meaningful way, by themselves or with a peer
Negative Initiations	9	Aggression	Physical violence or aggression directed toward another's person or destruction of another's property
	10	Provocation	Testing or other negative verbal or gestural behaviour, or physical but nonviolent actions such as stealing another child's toy or seat

Table 11. Continued

Low-level Initiations	11	Imitate	Child repeats another's actions
	12	Echolalia	Child echoes something recently heard
	13	Looks	Child looks at other's face, body, or actions
	14	Move into proximity	Child moves to within 3 feet of another
	15	Neutral physical contact	Child makes physical contact with another which is not overtly aggressive, affectionate, ritualistic, or provocative
	16	Ritualized behaviour	Child performs a ritualized or self-stimulating behaviour
	17	Inappropriate play	Child engages in sedentary play and/or does not use equipment in a purposeful way
Attention-seeking Behaviour	18	Seek attention verbally	Child engages in verbal direction of another's attention to self
	19	Seek attention nonverbally	Child engages in nonverbal behaviours to direct the other's attention to self
Avoidance	20	Move out of proximity	Child moves 3 feet or more away from another
Social Response	21	Verbal response	Child responds verbally to social stimuli directed toward him/her by peers

Table 11. Continued

	22	Non-verbal response	Child responds non-verbally to social stimuli directed toward him/her by peers
Target of Initiation/ Response	23	Adult	Social initiation or response was directed to/from an adult
	24	Child	Social initiation or response was directed to/from another child
Out of Frame	25	Out of frame	Child cannot be seen in the video

Motor Proficiency

Motor proficiency was assessed at each time point using the Peabody Developmental Motor Scales-2 (PDMS-2) (Folio & Fewell, 2000) and the Movement ABC-2 (Henderson et al., 2007). Please refer to Manuscript 1 for more information on this part of the study.

Motor Skill Intervention

Group 1 attended a 12 week FMS intervention for 1 hour per week while Group 2 acted as a control. Group 2 then attended a 6 week FMS intervention for 2 hours each week (1 hour per day on two separate days; Figure 9). Despite differences in intervention intensity, all sessions were the same between the two groups (i.e. the same instruction, content, and number of hours). Each intervention session consisted of a warm-up, skill instruction, active games, and free play (Table 12). Skills that were taught included both locomotor (running, hopping, leaping, etc.) and object control (throwing, catching, kicking, etc.) skills that progressed in difficulty over the intervention period (Table 13). The instructor-to-child ratio for both groups ranged from 1-to-2 to 1-to-1, depending on attendance. Examples of the typical room set-up for the intervention can be found in Appendix 7.

Table 12. Format of each intervention session.

Activity	Time
Warm-up	5 minutes
Review of previous week's activity	10 minutes
Activity 1 (Direct instruction)	10 minutes
Activity 2 (Direct Instruction)	10 minutes
Activity 3 (Active Game/Obstacle Course)	10 minutes
Free play	10 minutes

Table 13. Skills taught over the course of the intervention.

Session	Skill
1	Balance
2	Running
3	Underhand Roll
4	Galloping & Leaping
5	Underhand Throwing
6	Jumping
7	Dribbling/Bouncing
8	Overhand Throwing
9	Catching
10	Hopping
11	Kicking
12	Striking

Intervention sessions were run by the principal investigator with assistance from trained undergraduate research assistants and each session was consistent in providing structured instruction and practice, the opportunity to practice the newly learned skills in a game, and an opportunity for unstructured free play. Transitions between activities were guided through a large Picture Exchange Communication System that was created for this study by the principal investigator (Figure 10). Activity schedules have been very effective for young children with ASD in previous social skill interventions (Matson et al., 2007).

Figure 10. Picture Exchange Communication System used for all sessions.

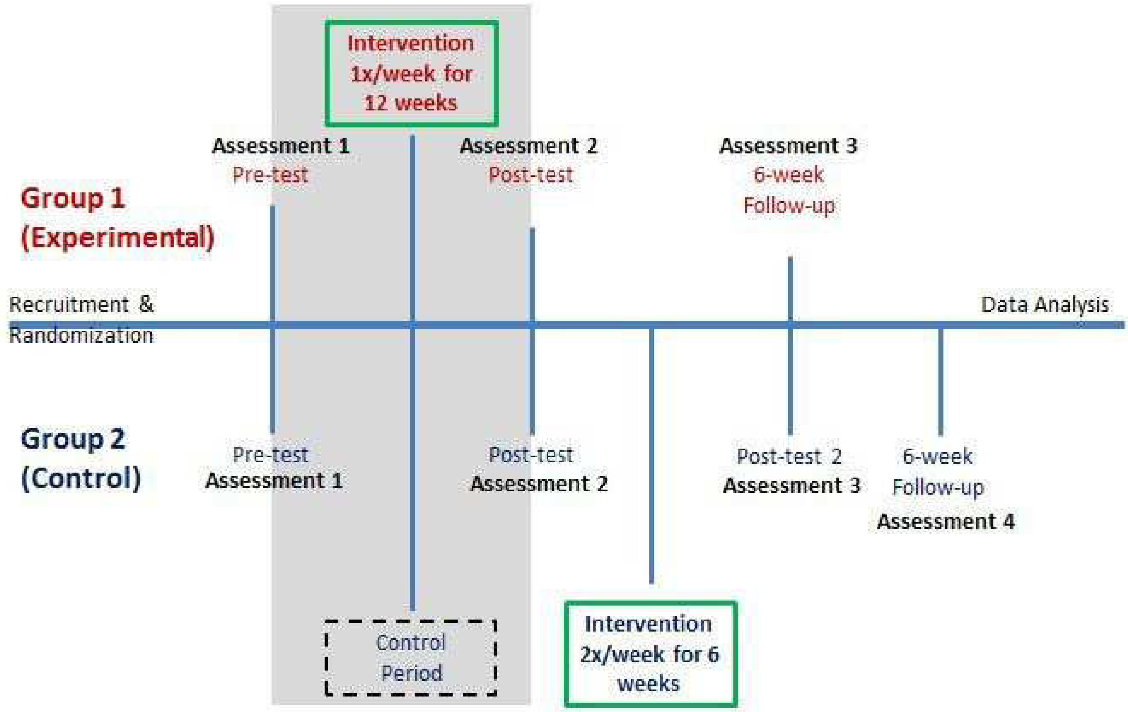
At the end of each session parents and/or guardians were provided with a handout that outlined 3-4 activities that could be played at home during the week in order to practice the skills taught during the session (Appendix 8). The lesson plans for the intervention were established from two currently availble resources: Active Start (Special Olympics Canada, 2010), and Healthy Opportunities for Preschoolers (Temple & Preece, 2010). These lesson plans were successfully used in a pilot for this study (Section 5) and minor changes were then made based on the success of the activities and the children's activity preferences.

Statistical Analyses

Part 1. Intervention Effectiveness: Experimental versus Control Group

Descriptive characteristics were calcualated on all variables at baseline for the experimental and control groups. An independent samples t-test was used to assess differences between the experimental and control groups at baseline on all continuous variables; a Fisher's exact test was used to assess differences in the sex distribution between the two groups. The magnitude of change from pre- to post-intervention for each participant in the experimental and control groups was calculated by subtracting their pre-intervention score from their post-intervention score on the raw subscale scores and domain scores of the VABS-2, as well as the raw subscale scores and domain scores of the SSIS. The average magnitude of change was then calculated for both the experimental and control groups. A t-test was used to test for significant differences between the experimental and control groups on their magnitude of change from pre- to post-intervention for all adaptive and social variables. Effect sizes were also calculated between the magnitude of change scores for the experimental and control groups. These analyses were used to determine the effectiveness of the motor skill intervention at improving adaptive behaviour and social skills in the experimental group in comparison to the control group who did not receive the intervention (Highlighted in the shaded box in Figure 11).

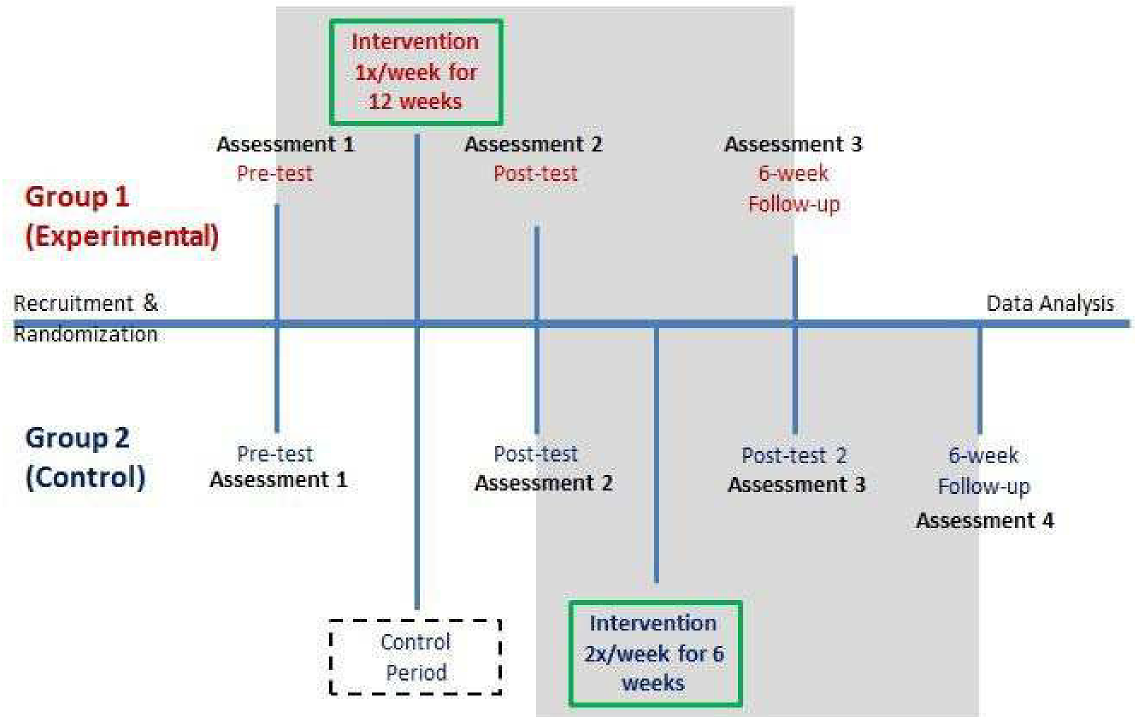
Figure 11. Section of study analyzed for 'Part 1. Intervention Effectiveness: Experimental versus Control Group'.



Part 2. Analysis of Intervention Intensity: Group 1 versus Group 2

Prior to conducting analyses of the effectivness of the two different intervention intensities, an independent samples t-test was run on all continuous variables and a Fisher's exact test was run on the discrete variables for Group 1 and Group 2 at their respective pre-test. These analyses were conducted to ensure that the effects of randomization had been maintained during the initial control period. Assumptions of skewness were met to conduct a two-way analysis of variance with repeated measures on all adaptive behaviour and social skill variables at the pre-, post-, and 6-week follow-up assessments by group (Group 1 = 1x/week for 12 weeks; Group 2 = 2x/week for 6 weeks) to assess the effect of the intervention, as well as group effects, and group by time interactions. This analysis was run to determine whether intervention intensity had an impact on the outcome of the intervention. The highlighted sections in Figure 12 demonstrate the sections of the overall study that were used from each group in order to run these analyses.

Figure 12. Sections of study analyzed for 'Part 2. Analysis of Intervention Intensity: Group 1 versus Group 2'.



Part 3. Individual Changes in Adaptive Behaviour and Social Skills

Due to the variability in social behaviour of the complete sample, all adaptive behaviour and social skill variables were examined for individual changes from pre- to post-intervention and to the 6-week follow-up. An increase in adaptive behaviours on the VABS-2 and social skills on the SSIS was seen as an improvement. In contrast, a decrease in maladaptive behaviours on the VABS-2 and a decrease in problem behaviours on the SSIS was recognized as an individual improvement.

Part 4. Behavioural Video Coding

In order to ensure interrater reliabilty was maintained on the coding of the behavioural videos, intraclass correlation coefficients were calculated between the principal investigator and a trained research assistant on 27% of the videos (Table 19). Frequency of social behaviours and physical activity levels from the free play videos were examined for individual changes from the first to last intervention sessions. A paired t-test was employed to examine group differences on the social behaviours that occurred most frequently, as well as between frequencies of physical activity levels from the free play sessions of the first to last intervention session.

Part 5. Predictors of Optimal Treatment Response

An attendance score was calculated for each participant based on the percentage of motor skill sessions they attended. Pearson product correlations were conducted between the attendance score and the average maganitude of change from pre- to post-intervention for the complete sample on the VABS-2 adaptive beahavior composite standard score and the SSIS social skills standard score to assess whether attendance had an impact on the intervention outcomes. If a significant relationship was found, further steps would be taken to control for attendance in all analyses of the intervention outcomes.

Pearson product correlations were also conducted between the baseline VABS-2 adaptive behavior composite standard score and the average magnitude of change from pre- to post-intervention for the complete sample on the VABS-2 adaptive behaviour composite standard score and the SSIS social skills and problem behaviours standard scores in order to explore whether adaptive behaviour is important for intervention outcomes, which could have an impact on inclusion criteria and group assignment in future interventions

Part 6. Power Calculation

Given our current sample size of 9 participants, we have 35% power to detect statistical differences at an alpha level of 0.05 on our primary outcome measure, the VABS-2 adaptive behaviour composite. However, we would require at least 24 participants to detect differences with a similar alpha level and 80% power.

Results

Part 1. Intervention Effectiveness: Experimental versus Control Group

Descriptive characteristics of the participants at baseline are presented in Table 14. No significant differences were found between the groups in regard to their sex, age, overall social functioning, and motor proficiency. One participant in Group 2 was absent for the baseline assessment resulting in a sample size of three. Although there was only one female in the study she was included in all analyses due to the already small sample size and the heterogeneity of symptoms that are exhibited by children with ASD.

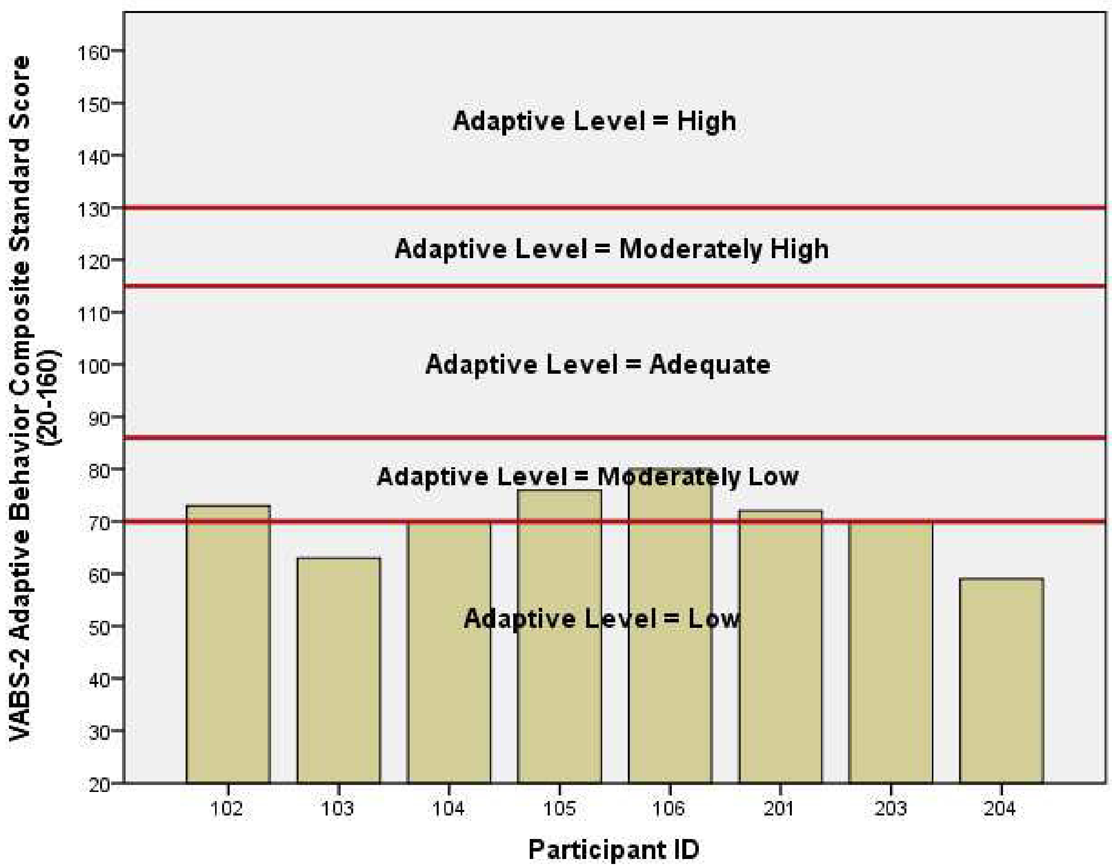
Table 14. Baseline descriptive characteristics, adaptive behaviour, social functioning, and motor proficiency by group.

	Experimental (mean ± SD, *count*)	**Control** (mean ± SD, *count*)	**p- value**
Sex (male, female)	*5 M*	*2M, 1 F*	0.375
Age (months)	51.60 ± 3.05	52.00 ± 2.65	0.857
Age of Diagnosis (months)	30.50 ± 5.00*	38.33 ± 3.22	0.066
VABS-2 Adaptive Behavior Composite Standard Score	72.40 ± 6.43	67.00 ± 7.00	0.307
VABS-2 Maladaptive Behavior v-Scale Score	19.00 ± 1.87	20.33 ± 1.53	0.341
SSIS Social Skills Scale Standard Score	75.60 ± 13.81	68.00 ± 19.16	0.534
SSIS Problem Behaviors Scale Standard Score	110.60 ± 13.22	126.33 ± 18.88	0.210
PDMS-2 Total Motor Quotient	66.80 ± 11.48	60.33 ± 6.35	0.413

* n = 4 as one participant's age of diagnosis was not provided

Significant deficits in social functioning were evident in the sample at baseline. All participants had a standard score of 80 or below on the VABS-2 Adaptive Behavior Composite, which indicates that their adaptive levels are in the low (standard score of ≤70) and moderately low (standard score of 71-85) categories (Figure 13).

Figure 13. Baseline VABS-2 Adaptive Behavior Composite standard score and adaptive levels by participant.



The average magnitude of change from pre- to post-intervention was calculated for all VABS-2 subdomain standard scores, the Adaptive Behavior Composite standard score, and the Maladaptive Behavior subdomain v-scale score in the experimental and control groups (Table 15). The average magnitude of change was also calculated on the SSIS social skills and problem behaviours standard scores from pre- to post-intervention in the experimental and control groups (Table 15). No significant differences were found on any of the VABS-2 or SSIS variables from pre- to post-intervention between the experimental and control groups. One participant in the experimental group did not have a complete motor skills section on the VABS-2 at the post-test; therefore, the motor skills standard score and adaptive behaviour composite score at the post-test could not be calculated. As such, the magnitude of change score for motor skills and adaptive behaviour could also not be calculated for this participant, resulting in a sample size of 4 in the experimental group on the VABS-2 motor skills standard score and adaptive behaviour composite score.

Table 15. Magnitude of change scores for VABS-2 and SSIS variables from pre- to post-intervention by group.

Variable	Group	Pre-Test Score (mean ± SD)	Post-Test Score (mean ± SD)	Magnitude of Change (mean ± SD)	p-value	Effect Size
VABS-2 Communication standard score	Experimental	77.40 ± 14.50	76.40 ± 11.39	-1.00 ± 3.74	0.433	-0.25
	Control	76.67 ± 10.02	83.33 ± 21.55	3.33 ± 11.02		
VABS-2 Daily Living Skills standard score	Experimental	76.40 ± 9.94	71.40 ± 8.44	-5.00 ± 7.00	0.105	-0.61
	Control	78.67 ± 14.57	82.00 ± 17.35	3.33 ± 3.06		
VABS-2 Socialization standard score	Experimental	73.20 ± 10.52	67.40 ± 9.07	-2.20 ± 7.60	0.182	-0.53
	Control	66.00 ± 10.15	70.67 ± 10.41	4.67 ± 1.16		
VABS-2 Motor skills standard score	Experimental*	78.75 ± 4.50	85.25 ± 12.82	6.50 ± 11.09	0.793	-0.10
	Control	60.67 ± 2.89	70.33 ± 17.93	9.67 ± 19.40		
VABS-2 Adaptive Behavior Composite standard score	Experimental*	74.75 ± 4.27	72.75 ± 5.85	-2.00 ± 2.94	0.136	-0.53
	Control	67.00 ± 7.00	74.00 ± 15.10	7.00 ± 9.85		
VABS-2 Maladaptive Behavior Index v-scale score	Experimental	19.00 ± 1.87	19.60 ± 3.05	0.60 ± 2.41	0.798	-0.11
	Control	20.33 ± 1.53	21.33 ± 2.08	1.00 ± 1.00		
SSIS Parent Social Skills Scale standard score	Experimental	75.60 ± 13.81	70.60 ± 11.57	-5.00 ± 4.64	0.783	0.10
	Control	68.00 ± 19.16	62.00 ± 20.30	-6.00 ± 5.00		
SSIS Parent Problem Behavior Scale standard score	Experimental	110.60 ± 13.22	116.80 ± 18.46	6.60 ± 16.50	0.855	0.08
	Control	126.33 ± 18.87	131.00 ± 20.81	4.67 ± 5.77		

* n=4

Part 2. Analysis of Intervention Intensity: Group 1 versus Group 2

Baseline characteristics of the participants at their group's pre-test are presented in Table 16. No significant differences were found between the groups in regards to their sex, age, overall social functioning, and motor proficiency, indicating that the effects of randomization were maintained following Part 1 of the study. Only 7 of the participants completed and returned their VABS-2 and SSIS parent questionnaires at the pre-, post-, and 6-week follow-up assessments. Therefore, these 7 participants were included in the two-way analysis of variance with repeated measures (Table 17) to compare the effect of the two different intervention intensities (Group 1 = 1x/week for 12 weeks; Group 2 = 2x/week for 6 weeks). However, one participant in Group 1 did not complete the VABS-2 Motor Skills domain at the post-test; therefore, repeated measures analyses of the VABS-2 motor skills domain and the VABS-2 Adaptive Behavior Composite (which accounts for all sub-domains) only includes 6 participants (n=3 from each group). Group assignment was only significant for the VABS-2 Daily Living Skills standard score, with Group 2 scoring significantly higher than Group 1 (Table 17). Time was not a significant factor and no group by time interactions were present on any of the VABS-2 and SSIS variables (Table 17).

Table 16. Descriptive characteristics, adaptive behaviour, social functioning, and motor proficiency by group at their respective pre-test.

	Group 1 (mean ± SD, *count*)	**Group 2** (mean ± SD, *count*)	**p- value**
Sex (male, female)	*4 M*	*3 M*	-
Age (months)	52.50 ± 2.65	54.00 ± 2.65	0.491
Age of Diagnosis (months)	32.67 ± 3.06*	40.00 ± 6.08	0.135
VABS-2 Adaptive Behavior Composite Standard Score	73.00 ± 7.26	87.33 ± 11.02	0.090
VABS-2 Maladaptive Behavior v-Scale Score	18.50 ± 1.73	19.33 ± 2.52	0.623
SSIS Social Skills Scale Standard Score	75.75 ± 15.95	76.00 ± 8.72	0.982
SSIS Problem Behaviors Scale Standard Score	108.50 ± 14.27	115.67 ± 5.86	0.457
PDMS-2 Total Motor Quotient	62.25 ± 6.13	68.67 ± 7.37	0.262

* n = 4 as one participant’s age of diagnosis was not provided

Table 17. Pre-, post-, and 6-week follow-up of adaptive behaviour and social skill scores by group.

	Group*	Pre-Test	Post-Test	6- Week Follow-up	Group	Time	Group x Time
VABS-2 Communication Standard Score	1 2	79.67 ± 17.77 101.00 ± 10.54	78.00 ± 15.00 97.33 ± 13.65	84.33 ± 7.57 96.00 ± 11.53	F = 2.838, p = 0.167	F = 0.536, p = 0.605	F = 1.564, p = 0.267
VABS-2 Daily Living Skills Standard Score	1 2	81.00 ± 5.29 91.67 ± 1.16	77.00 ± 4.00 99.00 ± 7.21	83.67 ± 4.16 98.33 ± 9.87	F = 24.590, p = 0.008	F = 1.110, p = 0.375	F = 1.640, p = 0.253
VABS-2 Socialization Standard Score	1 2	77.33 ± 7.57 82.67 ± 10.97	71.33 ± 8.02 84.67 ± 8.62	74.33 ± 13.50 83.67 ± 14.22	F = 1.255, p = 0.325	F = 0.314, p = 0.739	F = 1.258, p = 0.335
VABS-2 Motor Skills Standard Score	1** 2	81.00 ± 0.00 82.33 ± 20.43	88.67 ± 13.28 99.67 ± 7.51	87.33 ± 8.51 100.67 ± 9.07	F = 1.674, p = 0.265	F = 3.000, p = 0.156	F = 0.591, p = 0.490
VABS-2 Adaptive Behavior Composite Standard Score	1** 2	76.33 ± 3.51 87.33 ± 11.02	75.00 ± 4.58 93.67 ± 9.87	79.33 ± 3.79 93.33 ± 11.37	F = 5.230, p = 0.084	F = 3.921, p = 0.065	F = 2.879, p = 0.114
VABS-2 Maladaptive Behavior Index v-scale score	1 2	18.50 ± 1.73 19.33 ± 2.52	18.75 ± 2.75 19.67 ± 3.51	18.75 ± 3.20 18.33 ± 3.79	F = 0.046, p = 0.838	F = 0.404, p = 0.678	F = 0.505, p = 0.618
SSIS Parent Social Skills Scale standard Score	1 2	75.75 ± 15.95 76.00 ± 8.72	70.25 ± 13.33 84.33 ± 6.81	71.25 ± 9.29 91.00 ± 9.54	F = 2.086, p = 0.208	F = 1.298, p = 0.308	F = 4.425, p = 0.084
SSIS Parent Problem Behaviors Scales standard score	1 2	108.50 ± 14.27 115.67 ± 5.86	113.00 ± 18.92 118.00 ± 16.64	111.50 ± 20.22 104.00 ± 10.15	F = 0.023, p = 0.886	F = 1.018, p = 0.396	F = 1.058, p = 0.383

* Group 1: n = 4, unless otherwise specified; Group 2: n = 3
** Group 1: n = 3

Part 3. Individual Changes in Adaptive Behaviour and Social Skills

Individual participant scores on the VABS-2 subdomain and Adaptive Behavior Composite standard scores, as well as the VABS-2 Maladaptive Behavior Index v-scale score, and the SSIS domain standard scores are presented in Table 18 for the pre-, post-, and 6-week follow-up assessments. Four of the seven participants (participants 102, 105, 201, and 205) with complete data for both the pre-test and 6-week follow-up improved in at least 75% (6/8) of the subdomains examined on the VABS-2 and the SSIS from the pre-test to the 6-week follow-up (Table 18). Furthermore, 100% of the participants with complete data for the VABS-2 Adaptive Behavior Composite standard score improved from the pre-test to the 6-week follow-up (Figure 14). The VABS-2 individual item raw scores were examined and it was found that 86% of participants (6/7) improved from the pre- to follow-up assessments in regard to ‘caring for self’ and ‘relating to others’. Additionally, 71% of participants (5/7) improved in regard to ‘caring for home’, ‘playing and using leisure time’, ‘using large muscles’, and ‘using small muscles’ as measured by the VABS-2 individual item raw scores from pre-intervention to the 6-week follow-up. In regard to the SSIS, 71% of participants (5/7) improved from the pre-test to the 6-week follow-up on their ‘assertion’ and ‘engagement’ raw scores, as well as decreasing their number of ‘externalizing’ and ‘internalizing’ problem behaviours.

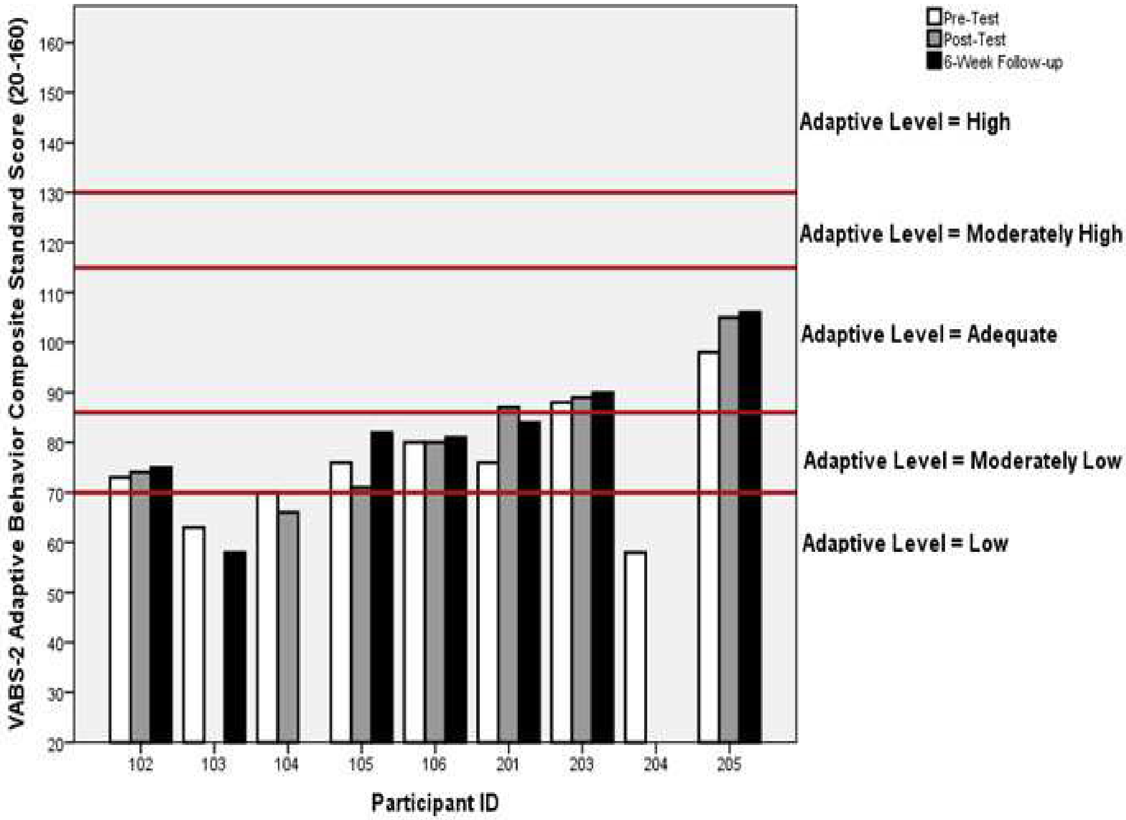
Table 18. Adaptive behaviour and social skill scores at pre-, post-, and 6-week follow-up assessments by individual participant.

Variable	Assessment	Participant 102	103	104	105	106	201	203	204	205
VABS-2 Communication standard score	Pre	76	81	67	63	100	91	100	59	112
	Post	78	79	69	63	93	85	95	-	112
	6-week	79	74	-	81	93	85	95	-	108
VABS-2 Daily Living Skills standard score	Pre	77	60	79	87	79	93	91	62	91
	Post	81	60	66	77	73	93	97	-	107
	6-week	79	53	-	87	85	87	105	-	103
VABS-2 Socialization standard score	Pre	72	57	77	86	74	74	79	59	95
	Post	72	55	68	79	63	77	83	-	94
	6-week	74	53	-	88	61	77	74	-	100
VABS-2 Motor Skills standard score	Pre	81	64	72	81	81	59	91	61	97
	Post	81	-	75	81	104	104	91	-	104
	6-week	81	64	-	84	97	97	94	-	111
VABS-2 Adaptive Behavior Composite standard score	Pre	73	63	70	76	80	76	88	58	98
	Post	74	-	66	71	80	87	89	-	105
	6-week	75	58	-	82	81	84	90	-	106
VABS-2 Maladaptive Behavior Index v-scale score	Pre	17	21	21	18	18	22	19	23	17
	Post	17	20	23	16	22	23	20	-	16
	6-week	16	21	-	16	22	21	20	-	14

Table 18. Continued

Variable	Assessment	Participant 102	103	104	105	106	201	203	204	205
SSIS Parent Social Skills Scale standard score	Pre	72	55	75	91	85	66	80	40	82
	Post	72	52	72	84	73	79	82	-	92
	6-week	76	58	-	79	72	97	80	-	96
SSIS Parent Problem Behaviors Scale standard score	Pre	93	125	119	115	101	120	118	155	109
	Post	101	132	132	93	126	130	125	-	99
	6-week	93	129	-	95	129	102	115	-	95

Figure 14. VABS-2 Adaptive Behavior Composite standard score and adaptive levels by participant at pre-, post-, and 6-week follow-up assessments.



Part 4. Behavioural Video Coding

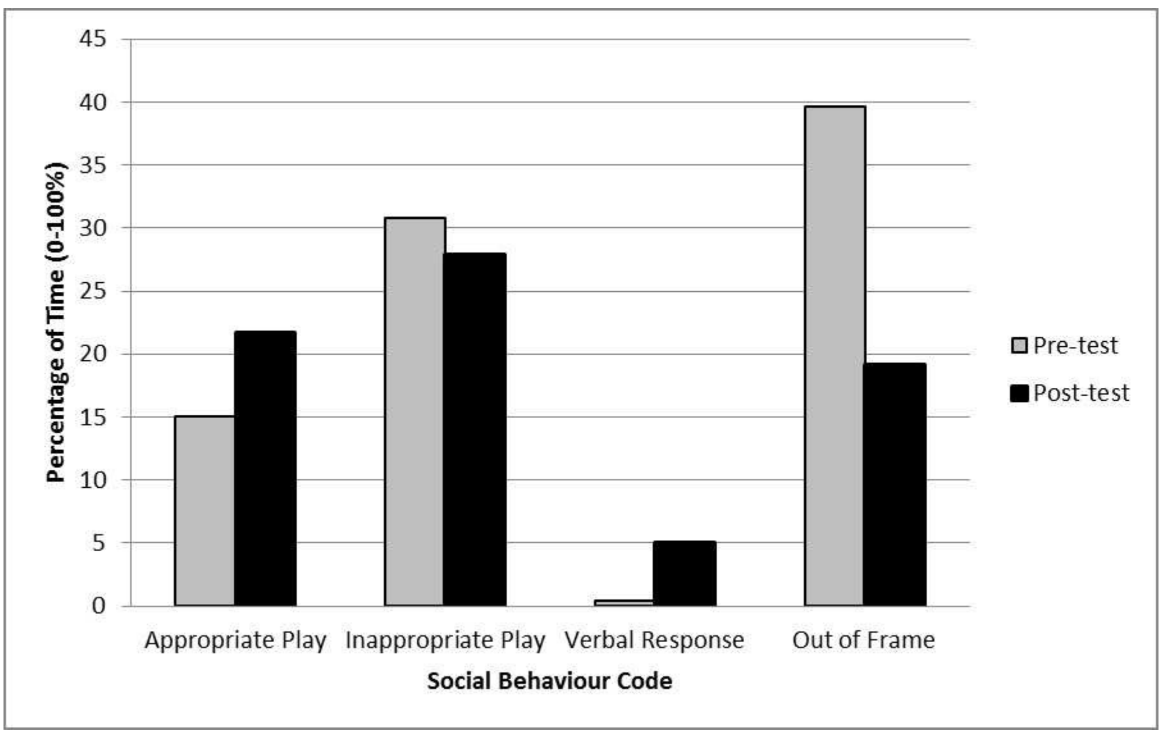
Behavioural video coding was conducted by the principal investigator on the 10-minute free play period during the first and last intervention sessions for each group. Inter-rater reliability was established with a trained research assistant on 27% of the videos; the intraclass correlation coefficients are presented separately in Table 19 for the social behaviour and physical activity coding.

Table 19. Summary of intraclass correlation coefficients for a sample of free play videos coded for interrater reliability.

Video Rated	Intraclass Correlation Coefficient
Participant 106 – Social pre-test	0.893
Participant 203 – Social post-test	0.904
Participant 204 – Social post-test	0.919
Participant 205 – Social post-test	0.972
Participant 103 – Activity pre-test	0.928
Participant 104 – Activity pre-test	0.996
Participant 201 – Activity pre-test	0.993
Participant 203 – Activity post-test	0.832

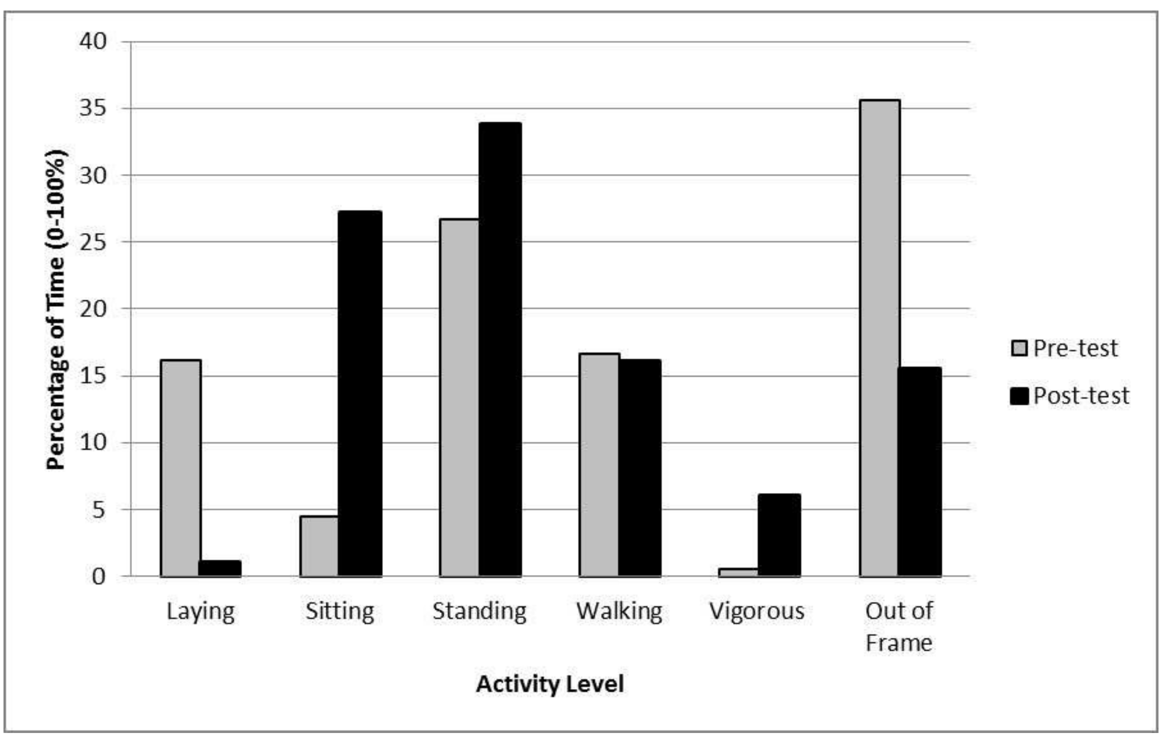
Three of the participants (102, 103, and 106) in Group 1 were absent for their final intervention session; thus, did not have complete pre- and post- behavioural videos for the free play sessions. Therefore, six of the participants were included in the analyses of behavioural changes. In regard to positive social initiations, 50% of participants (104, 204, and 205) increased their number of instances of joint attention from zero to one from pre- to post-intervention. The remaining three participants had no instances of joint attention at either time point. All participants in Group 2 increased the time they spent in appropriate play from pre- to post-intervention; whereas, the two participants in Group 1 decreased their time spent in appropriate play. Three of the participants (201, 203, and 205) increased the number of times they moved into proximity of another individual from pre- to post-intervention; participant 204 stayed the same, and participants 104 and 105 slightly decreased in this category. A decrease in the number of instances of inappropriate play was seen as an improvement for the child. As such, 50% of the participants (201, 203, and 204) improved in this area; the remaining three participants increased their time spent in inappropriate play from pre- to post-intervention. Similarly, a decrease in the number of instances a child moved out of proximity of another individual was seen as an improvement. As such, 50% of the participants (104, 105, and 204) improved in this area; the remaining three participants did not exhibit this behaviour at either time point. Lastly, in regard to social responses, four of the participants (104, 201, 203, and 205) increased their number of verbal responses from pre- to post-intervention, and three of the participants (105, 204, and 205) increased their number of non-verbal responses. None of the improvements from pre- to post- intervention were statistically significant for the group. The average percentage of time that the group spent engaging in appropriate play, inappropriate play, and responding verbally, as well as the time they were out of frame are presented in Figure 15.

Figure 15. Average percentage of time spent in select behavioural activities pre- to post-intervention for the complete sample (n=6).



Physical activity levels were examined for individual changes between the first and last free play sessions in the six participants with complete behavioural video data. It was found that all participants in Group 2 increased the amount of time they spent standing, while the participants in Group 1 decreased their standing from pre- to post-intervention. Furthermore, 50% of the participants (203, 204, and 205) increased the amount of time they spent walking, and 50% of participants (104, 203, and 205) increased the amount of time they spent in vigorous activity form pre-to post-intervention. None of these improvements were statistically significant for the group. The average percentage of time that the group spent in all levels of physical activity, as well as the time they were out of frame is presented in Figure 16.

Figure 16. Percentage of time spent in levels of activity pre- to post-intervention for the complete sample (n=6).



Part 5. Predictors of Optimal Treatment Response

The average attendance rate for the intervention sessions were 71.6% and 66.8% for Groups 1 and 2, respectively (t(7)=0.530, p=0.613). Attendance was not associated with improvement from pre- to post-intervention on the VABS-2 adaptive behavior composite standard score (r=0.076, p=0.872) or the SSIS social skills standard score (r=0.062, p=0.883).

The VABS-2 adaptive behavior composite standard score at the pre-test was not significantly associated with improvements in the adaptive behavior composite (r=0.424, p=0.343; Figure 17) or the SSIS social skills standard score (r=0.400, p=0.326; Figure 18) at the post-test; it was also not significantly associated with a decrease in problem behaviours from pre-to post-intervention as measured by the SSIS problem behaviours standard score (r=-0.278, p=0.505; Figure 19).

Figure 17. Scatter plot of VABS-2 adaptive behavior composite standard score at baseline and magnitude of change from pre- to post-intervention.

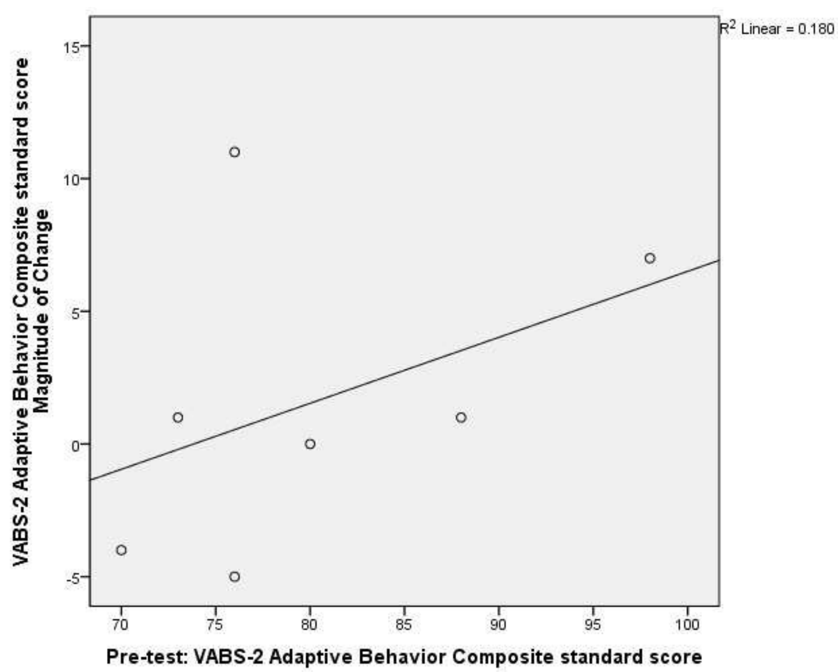


Figure 18. Scatter plot of VABS-2 adaptive behavior composite standard score at baseline and SSIS social skills standard score magnitude of change from pre- to post-intervention.

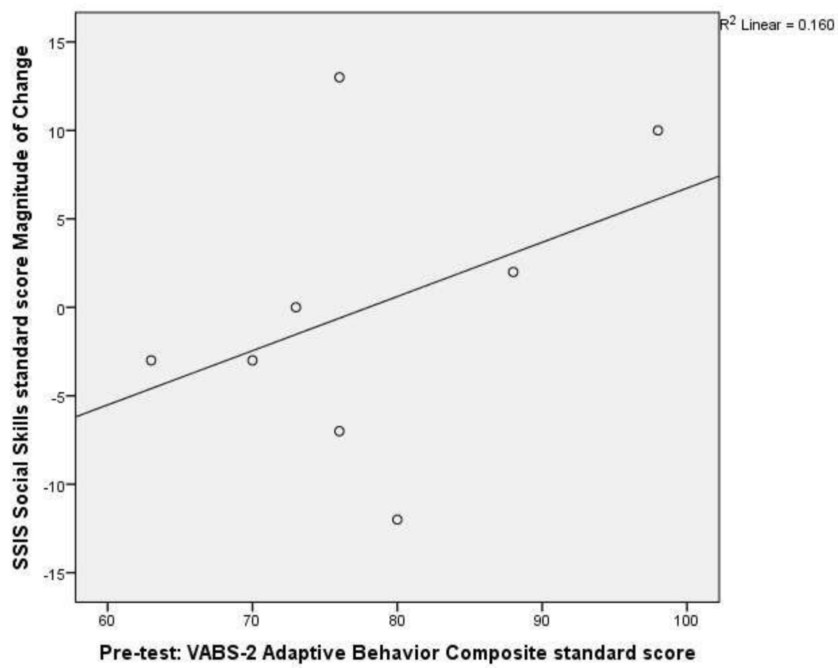
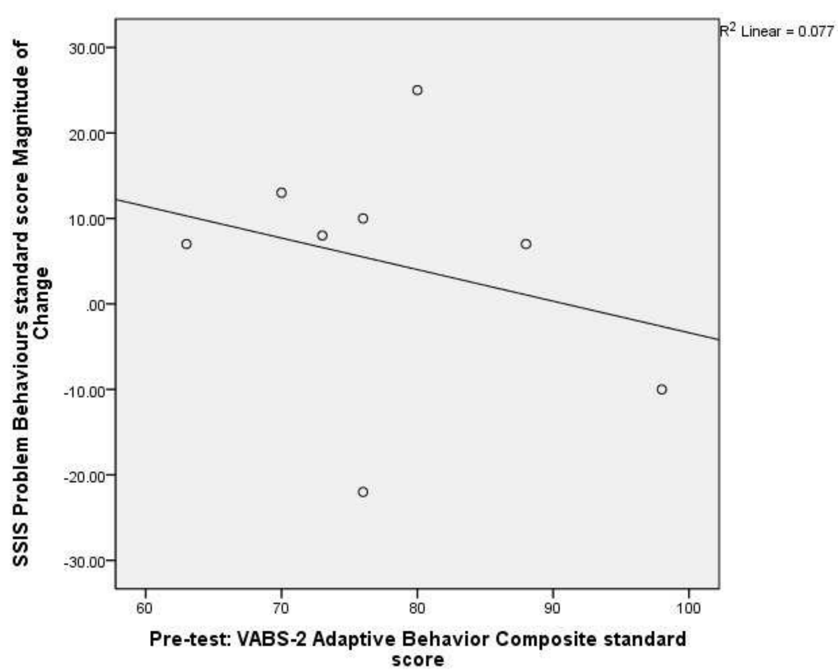


Figure 19. Scatter plot of VABS-2 adaptive behavior composite standard score at baseline and SSIS problem behaviours standard score magnitude of change from pre- to post-intervention.



Discussion

The purpose of this study was to investigate the effectiveness of a FMS intervention at improving the adaptive behaviour and social skills of 4 year old children with ASD. Our results indicate that the FMS intervention did not improve the adaptive behaviour and social skills of the experimental group. The secondary purpose of this study was to examine whether a higher intensity of the intervention was more or less effective at improving adaptive behaviour and social skills. We found that no significant changes in adaptive behaviour and social skills were evident following either intensity of the intervention, for the complete sample. However, numerous gains were made in both adaptive behaviour and social skills for individual participants.

The results of our baseline assessments demonstrated that all children had adaptive behaviour levels and social skills that were delayed for their age at the onset of the study; however, this is to be expected given that all children had a diagnosis of ASD. To the best of our knowledge, no previous studies have examined the impact of a FMS intervention on the adaptive behaviour and social skills of young children with ASD. When participants in the experimental group who received the FMS intervention were compared to those in the control group we found that there were no statistically significant differences between the changes in the groups from the pre-test to the post-test. In fact, we actually saw that the experimental group slightly declined in their adaptive behaviour and social skills following the intervention; whereas, the control group slightly improved over this time. This finding indicates that for the group as a whole, the intervention was not effective at improving adaptive behaviour and social skills. It is possible that the FMS intervention was disruptive to the participant's routine, or changed their home behaviour in a way that resulted in this decline in adaptive behaviour and social skills following the intervention. However, we propose that there may be a few other plausible factors that contributed to this finding. For example, children in the control group may have received additional services specifically targeting their social skills and adaptive behaviour while they were waiting to receive the motor skill intervention. We did not restrict participants from receiving additional services while in the study and it is likely that services specifically targeting adaptive behaviours and social skills may have resulted in improvement for the control group. However, as we did not ask participants in the control group to notify us if they received other services we can only speculate that this was a potential cause. Another potential reason for our findings may be the heterogeneity of our sample and our small sample size, which make it difficult to detect group changes following the intervention. Part of this difficulty is evident in the large standard deviations seen in the magnitude of change scores of the outcome measures. These large standard deviations demonstrate the individual variability within the sample in terms of how much change occurred following the intervention. Previous research has also demonstrated large differences and variability in the individual responses of children with ASD to various interventions (Lord et al., 2005; Magiati et al., 2011; National Research Council, 2001). Furthermore, social and behavioural skills are very complex to measure in children with ASD and there are no measures that are universally recognized as being the gold-standard for assessment of these skills (Dowd, Rinehart, & McGinley, 2010), which can make it difficult to measure and detect group changes in a research or clinical setting. Therefore, these findings justify a need not only for further investigation with a larger sample but, to examine our results on an individual basis to look for functional changes in each participant.

In order to address our secondary research question in Part 2 of the analyses, we examined changes in the sample from the pre- to post-test to the 6-week follow-up, including examining group by time interactions to determine if a higher intensity intervention was more or less effective. We found that Group 2 had significantly better daily living skills than Group 1 *(p=0.008)*; however, group assignment was not a significant factor for any other variable. Time was also not a significant factor and no group by time interactions were evident on any of the adaptive behaviour and social skill variables. Previous research has found that the motor skills of 3-4 year old children with ASD are significantly related to daily living skills (Jasmin et al., 2009). This relationship is likely due to the fact that at a young age daily living skills predominately include activities such as dressing, feeding, and basic chores like cleaning one's room; all of which require motor skills and coordination. However, since daily living skills did not significantly change over the course of this intervention, we attribute the group difference to factors outside of our control such as home environment or additional treatment services. Overall, we can conclude that there was no difference between the two intensities of the intervention in regard to its effect on adaptive behaviour and social skills as no significant group by time interactions were present. Although this finding also indicates that no significant group improvements were made in adaptive behaviour or social skills following the intervention, it also suggests that no significant declines were made over the course of the intervention or at the 6-week follow-up. This finding is important as previous research has found that children with ASD often have adaptive behaviour scores that appear to decline with age, likely due to the fact that children with ASD do not develop adaptive behaviour skills at the same rate as their peers with typical development (TD) (Klin et al., 2007; Perry, Flanagan, Geier, & Freeman, 2009). Furthermore, preschool-age children have relatively unstable behaviour profiles that are likely to change in short periods of time (Campbell, 1995). Therefore, although group gains in adaptive behaviour were not evident following the intervention, it may be just as important that we did not find significant declines in the group. Further research is warranted into the trajectory of adaptive behaviour and social skills and the rate at which new skills can be learned, which may be beneficial in designing the length of future interventions as well as when follow-up assessments should be conducted.

No significant group improvements in adaptive behaviour and social skills were found following the intervention; however, there were many individual improvements made in adaptive behaviour and social skills, as well as individual reductions in maladaptive behaviour. These individual improvements can be interpreted as functional gains for the individual child, which are important for overall functioning. For example, gains in communication may help a child engage with their peers or relay their needs to their parents and teachers. Reductions in maladaptive behaviour may make it easier for a child to engage in play and be included by peers and siblings. These functional improvements can have a positive impact on a child's overall development and well-being. For instance, a study of the developmental progression of adolescents with autism who had been assessed in preschool and middle school found that language skills in adolescence could be predicted by functional play skills, responsiveness to others', and the frequency of requesting behaviours in early childhood (Sigman & McGovern, 2005).

As such, the individual gains in adaptive behaviour and social skills made through this motor skill intervention may provide a platform for future engagement in play and social interactions, possibly having positive implications for overall development.

The results of the behavioural video coding did not find any statistically significant improvements; however, they help to demonstrate the functional improvements in behaviour that were made by the participants following the intervention. For example, we saw a decrease in the number of instances that participants were out of frame from the first to last intervention session, indicating a reduction in off-task behaviour. Given the size of the room and the camera placement, out of frame activities were typically off-task behaviours such as sitting alone in a corner or attempting to leave the room. As such, a decrease in the amount of time spent out of frame can be seen as an improvement in the children's functional behaviour. Similarly, there was an increase in the time spent participating in appropriate play and a decrease in the time spent in inappropriate play for the complete sample. The improvements seen in the behavioural video coding are considered to be positive outcomes from the intervention as appropriate play skills may be essential for the ability of a child to engage in social activities with peers. This ability to engage with peers may be important for further development in adaptive behaviour as a child with ASD gets older. For example, one study has found that elementary school children with autism who were more socially engaged with their peers on the school playground were more likely to have later improvements in adaptive behaviour, even when IQ was controlled for (McGovern & Sigman, 2005). However, in order for this initial peer engagement to occur one must have the skills, both physical and social, to do so. Therefore, the increases in appropriate play and the individual improvements in adaptive behaviour that were evident following our intervention are promising and their impact on further development and inclusion with peers should be further explored in future research.

In terms of activity levels, we saw an increase in the amount of time that was spent sitting down form the first to last intervention session. This increased time spent sitting was predominately a result of participants engaging in purposeful, yet sedentary, pursuits such as putting together the numbered pieces of a foam hop-scotch puzzle. However, we also saw increases in the time spent in vigorous activity, which is important for the overall physical activity levels of children with ASD, which is typically lower than their peers with TD (Pan, 2009; Pan et al., 2011b). However, further research is required to differentiate whether increased vigorous activity in a free play setting truly represents on-task behaviours such as purposeful running for a game or if it is more indicative of off-task behaviours such as running for self-stimulation.

In order to provide the best possible outcomes for social skills and adaptive behaviour in children with ASD, it may be beneficial to only enroll the children in FMS interventions that are most likely to benefit in the social and adaptive domains from this course of treatment. In Part 5 of the analyses we found that the VABS-2 adaptive behavior composite at the pre-test was positively correlated with the magnitude of change on the adaptive behavior composite and the SSIS social skills standard score. In other words, better adaptive behaviour at the start of the intervention was related to an increased gain in adaptive behaviour and social skills following the intervention. The VABS-2 adaptive behavior composite at the pre-test was negatively correlated with the magnitude of change on the SSIS problem behaviors standard score following the intervention. This indicates that better adaptive behaviour at the pre-test was related to a reduction in problem behaviours following the intervention. Similar relationships have been documented in previous intervention literature for children with ASD. For instance, Zachor and Itzchak (2010) found that young toddlers 15-35 months of age with less severe autism symptoms at baseline had better outcomes in adaptive behaviour and cognitive skills one year following community-based autism interventions. Similarly, Ozonoff and Cathcart (1998) found that children 2-6 years of age participating in a home-based intervention for children with autism were more likely to make larger improvements if they had good language skills and less severe autistic symptoms at baseline. Although the relationships between adaptive behaviour and response to treatment were not statistically significant in our study, they demonstrate a trend that should be further explored in order to determine which children could benefit the most from a motor skill intervention in terms of adaptive behaviour and social skills.

We found that attendance rates were consistent with previous intervention literature (Barry et al., 2003; Cliff et al., 2007) and attendance did not have a significant impact on the intervention outcomes. However, this may be due in part to the fact that attendance was relatively consistent among all participants in our small sample. We hypothesize that with a larger sample there may be more individual variability in attendance and as such, this may have an impact on the intervention outcomes. It is suggested that future research continue to examine the impact of attendance on intervention outcomes.

Strengths and Limitations

As with all studies, there are strengths and limitations to these findings. The first strength is that this is the first study to examine the impact of a FMS intervention on the adaptive behaviour and social skills of 4 year old children with ASD. No previous studies have implemented similar interventions for young children with ASD; therefore, this study starts to fill a significant gap in the literature and helps to lay the foundation for future research in this area. A second strength of this study is that this was a community-based program that was relatively easy to implement and was run with minimal funding. Therefore, this program could be run by other practitioners and researchers looking to implement a community-based intervention for young children with ASD.

There are a number of limitations to our current study. The first limitation is our small sample size as it reduces our statistical power to detect changes following the intervention. Furthermore, we had a group imbalance in terms of group size and the sex distribution; ideally we would have equal sized groups, with equal numbers of males and females in each group. A second limitation stemming from our small sample size is that we would ideally have had a third group that was a true control throughout the entire study. With a third group we could have run the two different intensities of the intervention over the same time period and had a third group that was assessed but, never received the motor skill intervention. This would give us an even better indication of the effectiveness of the intervention as well as the differences in intervention intensity on the intervention outcomes. However, including a third group would require a much larger sample size, as well as more research assistants and physical space to conduct the interventions simultaneously; we were not equipped to do this given the size and time constraints of this thesis. Furthermore, having a true control group raises ethical questions of not providing the participants with anything, and as such we would likely still need to offer this control group some type of comparable intervention following the study.

A third limitation to our study is that the participants and researchers were not blind to the randomization, which could potentially introduce bias into the findings. Given our limited resources we were unable to conduct blind randomization; however, it is recommended that future studies blind the participants and assessors to their group assignment to ensure no bias occurs. A final limitation is that we did not measure IQ in our study in order to use it as a covariate in our analyses. We know that IQ is related to overall functioning in children with ASD and it likely had an impact on the intervention outcomes (Klin et al., 2007; McGovern & Sigman, 2005; Perry et al., 2009; Sigman & McGovern, 2005). Given our limited resources we were not able to measure IQ but, suggest that it is assessed and controlled for in future studies. Despite these limitations, the fact that we saw individual gains in adaptive behaviour and social skills following the intervention are positive findings that suggest the need for further research.

Future Research

We suggest that future research should further study the effectiveness of a FMS intervention at improving the adaptive behaviour and social skills of young children with ASD. It is recommended that a larger sample is used; however, it may be beneficial to continue running the intervention in a small group (e.g. 4-6 children) setting. Future studies should continue to focus on children in the preschool age range (i.e. 3-5 years); however, it may also be beneficial to study both younger and older age bands to assess the impact of a FMS intervention on adaptive behaviour and social skills at various ages.

Future studies should try to employ a randomized controlled trial where participants and researchers are blind to the randomization in order to truly understand the impact of the motor skill intervention on adaptive behaviour and social skills. It is also recommended that longer follow-up periods are employed to assess the impact of the intervention on further development throughout childhood. A longer follow-up may also help to further address the impact of intensity on intervention outcomes. However, as intensity had no bearing on this study, we also recommend that future research examine the impact of dosage (i.e. the total number of sessions) on intervention outcomes. In order to better assess the impact of the intervention it is also recommended that researchers include a true control group that does not receive the FMS intervention. However, in order to address any ethical concerns of withholding treatment, the control group could receive an unstructured free play session rather than the motor skill intervention. This would provide the participants with an activity that could be beneficial to their development but, would not provide any direct instruction. Another option would be to provide the control group with a fine motor skill intervention, rather than the fundamental/gross motor skill intervention that the experimental group would be receiving.

Based on our findings, children with better adaptive behaviour may benefit the most in terms of adaptive behaviour and social skill improvements made during the motor skill intervention. Thus, it may be beneficial to base group assignment or inclusion criteria on baseline adaptive behaviour in order to help ensure optimal outcomes are reached for the participants. However, as this research is very preliminary we also recommend that future research continue to include the whole spectrum of children with ASD in order to help determine the effectiveness of a motor skill intervention at improving adaptive behaviour and social skills for all children with ASD; as well as which additional factors may predict the optimal outcomes from this type of intervention. Furthermore, it may be beneficial to embed some specific social skills training within the motor skill curriculum in order to optimize the outcomes for the participants.

Conclusion

The purpose of this study was to examine the effectiveness of a FMS intervention at improving the adaptive behaviour and social skills of 4 year old children with ASD. When compared to the control group, we found that adaptive behaviour and social skills slightly declined in our experimental group; however, these declines were not significant, which may be just as important for young children with ASD. The secondary purpose of this study was to examine whether intervention intensity had an impact on the adaptive behaviour and social skill outcomes and our results indicate that there were no significant differences in outcomes between the two intensities of intervention. Upon analyses of individual participants' results we found many individual improvements in adaptive behaviour and social skills, as well as individual reductions in maladaptive behaviour. These functional gains may have important implications for the overall functioning of a young child with ASD, including their ability to engage in play and social situations with their peers. These preliminary findings suggest that a FMS intervention may be effective at making individual improvements in the adaptive behaviour and social skills of 4 year old children with ASD. However, additional research is required to further examine these outcomes in larger, controlled, samples of children with ASD.

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Section 5: Pilot Study

Abstract

Children with Autism Spectrum Disorder (ASD) experience difficulties with social interactions, communication, behaviour, and exhibit significant motor delays. However, traditional therapies focus on the core challenges of ASD, while virtually ignoring motor skills. The primary objective of this pilot study was to determine the feasibility of delivering a 1 hour/week fundamental motor skill (FMS) intervention to 4 year old children with ASD. A secondary objective was to determine the impact of the intervention on motor skills, adaptive behaviour, and physical activity pre- and post-intervention. Motor skills were assessed with the Peabody Developmental Motor Scales-2 (PDMS-2) and Movement Assessment Battery for Children-2 (MABC-2), adaptive behaviour was assessed with the Vineland Adaptive Behavior Scales-2 (VABS-2), and physical activity was assessed for 7 consecutive days using a time-stamped pedometer. Results indicated that parents were willing to bring their child to a FMS intervention, and that the children were able to remain engaged during a 1 hour session. Individual improvements were evident on the PDMS-2 and VABS-2 following the intervention. Parent feedback revealed difficulties (behavioural and sensory) with having their child wear the pedometer. Findings from this pilot study indicated that running a motor skill intervention for 4 year old children with ASD is possible and suggested that there may be benefits to both motor skills and adaptive behaviour following the intervention; thus, warranting further research with a larger, controlled sample.

Emily E. Bremer (2014)

Introduction

Children with Autism Spectrum Disorder (ASD) experience significant delays in social communication and social interactions, and also exhibit restricted patterns of behaviour or interests (American Psychiatric Association, 2013). ASD is a prevalent developmental disability that affects anywhere from 1 in 150 (Fombonne, 2009) to 1 in 88 children (Kogan et al., 2009). As the implications of ASD are far-reaching, and the prevalence is high, it is of utmost importance for researchers and clinicians to understand the best way in which to support and provide early intervention for children with ASD.

Interventions for children with ASD typically address their core deficits in social, communication, and behavioural skills (Matson & Smith, 2008). However, one area that is often overlooked is the development of fundamental motor skills (FMS). FMS are the basic movement skills that are essential for the future development of the more complex skills needed in games, sport, dance, recreational physical activities, and active play (Burton & Miller, 1998; Payne & Isaacs, 2002). Proficient FMS are particularly important for young children as they enable them to engage in active play, which in turn provides opportunities for development in all domains of child development including cognitive, social, and communicative skills, as well as further physical development (Gallo-Lopez & Rubin, 2012). Unfortunately, the literature is consistent in finding that young children with ASD have significant motor delays (Liu & Breslin, 2013; Lloyd et al., 2011; Matson et al., 2010; Ozonoff et al., 2008). We hypothesize that improving the FMS of children with ASD will result in improvements in social behaviour and physical activity levels.

The primary objective of this pilot study was to determine whether a 12 week, 1 hour/week FMS intervention could be feasibly delivered to 4 year old children with ASD. For instance, whether parents would be able to bring their child to a weekly intervention session, whether the multi-purpose space donated by a local Children's Treatment Centre (CTC) would provide enough room to run the program, and whether we would be able to maintain the children's attention for a one hour session. A secondary research objective was to determine whether the motor skill intervention would improve the motor proficiency of study participants. A third objective was to examine whether the motor skill intervention would result in subsequent gains in adaptive behaviour and physical activity.

Method

Study Design

Ethical approval was received from a University Research Ethics Board (Appendix 11) and the Research Committee and Quality Leadership Council at a local CTC (Appendix 12) and all parents provided informed consent prior to the onset of the study (Appendix 13). This pilot study employed a pre-post experimental design. All participants were assessed on their motor skills, social behaviour, and physical activity levels prior to the onset of the study. Participants then attended a FMS intervention for 1 hour per week for 12 consecutive weeks were subsequently assessed again on all measures.

Recruitment

Parents of 4 year old children with a diagnosis of ASD were targeted for recruitment through the use of a recruitment flyer (Appendix 14). This flyer was posted on bulletin boards and social media websites of the local CTC.

Participants

Six participants were signed up for the study by their parents. Inclusion criteria for the pilot study required that participants be 4 years of age and have a diagnosis of ASD. Children were excluded from participating if their parents could not commit to bringing them to the assessments and intervention sessions.

Procedures

All measurements were conducted in the researcher's office with the child and their parent or caregiver present. At the pre-test, all parents completed a supplemental information form in order to provide demographic data and a brief medical history of their child (Appendix 15). At the post-test, parents were asked to complete a program evaluation survey in order to provide qualitative feedback on the effectiveness of the intervention for their child and for further program development (Appendix 16). The remaining measurements were conducted with the child at both the pre- and post-test.

Anthropometric Measurements

Height was measured to the nearest 0.1 cm using a wall-mounted stadiometer (SECA 222) and weight was measured to the nearest 0.1 kg using a digital scale (Tanita Digital HD351).

Motor Proficiency

The Peabody Developmental Motor Scales-2 (PDMS-2) (Folio & Fewell, 2000) is a standardized motor skill assessment that is validated from birth to 6 years of age. It was used to measure raw scores in stationary skills, locomotion, object manipulaiton, grasping, and visual-motor integration, as well as composite scores in gross motor, fine motor, and a total motor quotient. The PDMS-2 was ideally suited for this study as it is normed down to infancy and therefore can more accurately capture the motor skills of children with ASD without a floor effect.

The Movement ABC-2 (MABC-2) (Henderson et al., 2007) was also used to assess the participant's motor skills in order to address the potential scope of motor impairment in these children. The MABC-2 is a standardardized motor skill assessment for children aged 3-16 years and is used to identify children who experience significant delays in their motor development (Henderson et al., 2007). The test required the child to perform a series of eight motor tasks that are grouped into three domains: manual dexterity, aiming and catching, and balance (Henderson et al., 2007). Results from the MABC-2 provided objective, quantitative data on each participant's movement competence. All motor assessments were conducted by the principal investigator in an office setting with the participant's parent(s) present.

Adaptive Behaviour

Adaptive behaviour was assessed pre- and post-intervention using the Vineland Adaptive Behavior Scales-2 (VABS-2) (Sparrow et al., 2005). Adaptive behaviour is age-related and describes the degree to which an individual typically perfroms daily activities required for personal and social sufficiency (Sparrow et al., 2005). The VABS-

2 is a parent questionnaire used to assess adaptive behaviour in the following domains: communication, daily living skills, socialization, motor skills, and maladaptive behaviour (Sparrow et al., 2005). The VABS-2 helped to provide a broad overview of the child's level of functioning, particularly in regard to their social skills, and helped to highlight the child's strengths and weaknesses. It is a commonly used tool to identify any deficits in adaptive behaviour and is widely used in an overall comprehensive evaluation of children with developmental disabilities including those with ASD. The questionnaire asked parents to rate their child's behaviour on a three-point scale in response to specific statements corresponding to the various domains (Sparrow et al., 2005).

Physical Activity

Physical activity was measured for 7 days immediately following the pre- and post-assessments using a time-stamped pedometer (Omron Pocket Pedometer Model Number HJ-720ITCCAN). The Omron HJ-720ITC pedometer has demonstrated accuracy and reliability under various conditions with adults and has been successfully used in a childhood population (Holbrook, Barreira, & Kang, 2009; Pabayo et al., 2012). Having the time-stamped pedometer gave a more accurate measure of physical activity and intensity than a regular pedometer. Parents were instructed to have their child wear the pedometer on their right hip from the time they got up in the morning until they went to bed at night, with the excpetion of water activities (i.e. bathing and swimming). All participants were given a postage paid envelope to return the pedometer after 7 days.

Motor Skill Intervention

Participants attended a FMS intervention for 1 hour per week for 12 consecutive weeks that was held at the CTC and run by the primary investigator with assistance from trained undergraduate research assistants. Each intervention session consisted of a warm-up, skill instruction, active games, and free play time (Table 20). Skills that were taught included both locomotor (running, hopping, leaping, etc.) and object control (throwing, catching, kicking, etc.) skills that progressed in difficulty over the intervention period (Table 21). Intervention sessions were consistent in providing structured skill instruction and practice, the opportunity to practice the newly learned skills in a game, and an opportunity for unstructured free play. Transitions between activities were guided through a large Picture Exchange Communication System that was created for this pilot study by the principal investigator (Figure 20). At the end of each session parents/guardians were provided with a handout that outlined 3-4 activities that could be played at home during the week in order to practice the skills taught during the session (Appendix 8). The lesson plans for the intervention were established from two currently availble resources: Active Start (Special Olympics Canada, 2010), and Healthy Opportunities for Preschoolers (Temple & Preece, 2010). Examples of the typical room set-up for the intervention can be found in Appendix 7. The instructor-to-child ratio for the intervention was typically 1-to-1, depending on group attendance.

Table 20. Format of each intervention session.

Activity	Time
Warm-up	5 minutes
Review of previous week's activity	10 minutes
Activity 1 (Direct instruction)	10 minutes
Activity 2 (Direct Instruction)	10 minutes
Activity 3 (Active Game/Obstacle Course)	10 minutes
Free play	10 minutes

Table 21. Skills taught over the course of the intervention.

Session	Skill
1	Balance
2	Running
3	Underhand Roll
4	Galloping & Leaping
5	Underhand Throwing
6	Jumping
7	Dribbling/Bouncing
8	Overhand Throwing
9	Catching
10	Hopping
11	Kicking
12	Striking

Figure 20. Picture Exchange Communication System used for all sessions.

Statistical Analyses

Descriptive characteristics were calculated on all variables. An attendance score was calculated for each participant based on the number of motor skill sessions they attended. PDMS-2 subscale raw scores and motor quotitent scores were examined for individual changes from pre- to post-intervention. MABC-2 subdomain and test total standard scores were also examined for individual changes. Results from the VABS-2 subdomain and Adaptive Behavior Composite standard scores, as well as the Maladaptive Behavior Index v-sclae score were observed for indiviudal improvements (a decrease in the Maladaptive Behavior Index is seen as a positive outcome or improvement for the child). An average daily step count and average daily wear time (in hours) was calculated for each participant from their 7 days of pedometer data pre- and post-intervention. An average hourly step count was also calculated by dividing the average daily steps by the average wear time for each participant pre- and post-intervention. These activity counts were then examined for individual changes. Parent program evaluation surveys were read by the principal investigator for qualitative feedback on the intervention.

Results

Baseline Characteristcs

Six children were enrolled in this study and completed the pre-test. One child was withdrawn from the study by his parents after two sessions due to behavioural difficulties; two more children were withdrawn by their parents after two and six sessions respectively, as their parents could no longer bring them to the sessions. Therefore, there is complete pre- and post-data for three of the participants; all of whom are male. Two of the three participants attended all 12 of the intervention sessions and one particpant attended 8 of the intervention sessions; the average attendance for the three participants was 89%. Descriptive characteristics of the three participants at baseline are presented in Table 22.

Table 22. Descriptive characteristics of the participants at baseline.

	Participant 1	**Participant 2**	**Participant 3**
Age (months)	56	51	55
Age of Diagnosis (months)	24	36	48
Height (cm)	112.2	105.2	111.4
Weight (kg)	22.2	17.3	19.7
BMI (kg/m^2)	17.6	15.6	15.9
Onset of Walking (months)	18	11	12

Motor Skills

The PDMS-2 subscale raw scores and motor quotient scores, as well as the MABC-2 subdomain and total test standard scores for pre- and post-intervention are presented in Table 23. All participants improved or remained the same on all PDMS-2 variables (Table 23). Participant 1 slightly declined on all MABC-2 variables; Participant 2 slightly declined on all MABC-2 variables other than balance; and Participant 3 improved on all MABC-2 variables (Table 23).

Table 23. Pre- and post-intervention scores on all PDMS-2 and MABC-2 motor variables by participant.

	Participant	**1**	**2**	**3**
PDMS-2 Stationary Raw Score	Pre-test	41	41	48
	Post-test	44	48	52
PDMS-2 Locomotor Raw Score	Pre-test	127	135	148
	Post-test	142	153	158
PDMS-2 Object Manipulation Raw Score	Pre-test	16	20	31
	Post-test	18	26	30
PDMS-2 Grasping Raw Score	Pre-test	43	43	43
	Post-test	49	43	46
PDMS-2 Visual-Motor Integration Raw Score	Pre-test	116	130	128
	Post-test	136	134	133
PDMS-2 Gross Motor Quotient	Pre-test	66	70	76
	Post-test	68	76	85
PDMS-2 Fine Motor Quotient	Pre-test	64	76	73
	Post-test	91	79	85
PDMS-2 Total Motor Quotient	Pre-test	62	70	73
	Post-test	75	75	83
MABC-2 Manual Dexterity Standard Score	Pre-test	7	6	2
	Post-test	5	2	7
MABC-2 Aiming & Catching Standard Score	Pre-test	2	9	8
	Post-test	1	4	12
MABC-2 Balance Standard Score	Pre-test	3	6	5
	Post-test	2	8	9
MABC-2 Total Test Standard Score	Pre-test	3	6	3
	Post-test	2	3	9

Adaptive Behaviour

The VABS-2 subdomain and Adaptive Behavior Composite standard scores and maladaptive behavior index v-scale score are presented in Table 24 for each participant pre- and post-intervention. Participant 1 remained the same or improved in half of the VABS-2 domains; Participant 2 slightly declined in all domains other than their maladaptive behavior index; and Participant 3 improved in all domains other than their daily living skills (Table 24).

Table 24. Pre- and post-intervention scores on VABS-2 variables by participant.

	Participant	**1**	**2**	**3**
Communication Standard Score	Pre-test	100	108	100
	Post-test	97	100	104
Daily Living Skills Standard Score	Pre-test	79	105	109
	Post-test	79	103	107
Socialization Standard Score	Pre-test	70	88	94
	Post-test	57	68	97
Motor Skills Standard Score	Pre-test	84	111	97
	Post-test	91	100	111
Adaptive Behavior Composite Standard Score	Pre-test	80	103	100
	Post-test	78	91	105
Maladaptive Behavior Index v-scale score	Pre-test	20	20	18
	Post-test	19	20	17

Physical Activity

The daily average step counts, daily average wear time, and average hourly steps for each participant pre- and post-intervention are presented in Table 25. In regard to their average steps per hour, Participants 1 and 3 declined from pre- to post-intervention; whereas, Participant 2 slightly improved.

Table 25. Pre- and post-intervention pedometer step counts by participant.

	Participant	**1**	**2**	**3**
Daily Average Pedometer	Pre-test	13	13.9	10.3
Wear Time (Hours)	Post-test	13.3	13.4	10.6*
Daily Average Steps	Pre-test	13495.3	12383.6	14698.9
	Post-test	9393.7	12248.4	8462.3*
Average Steps/Hour	Pre-test	1038.1	890.9	1427.1
	Post-test	706.3	914.1	798.3*

* Based on 6 days of pedometer data.

Parent Feedback

Overall, parents were satisfied with the motor skill intervention. When asked to provide general comments about the program the parents had the following to say:

> Parent of participant 1: *"We loved that there were other kids there, unlike most therapy sessions we do. I think it was great and wish there were more programs like this to sign up for."*
>
> Parent of participant 2: *"Thank you for your patience and continual effort to engage him."*
>
> Parent of participant 3: *"Seen definite improvement. Overall, a great experience for all of us!"*

Discussion

The primary objective of this study was to determine the feasibility of implementing a FMS intervention for 4 year old children with ASD. Since there is no empirical evidence on motor skill interventions for this population, we wanted to ensure that parents would be willing to bring their child to the program, that the dosage and intensity of the intervention would be suitable for the parents and children, and that the curriculum would be beneficial in teaching FMS to the participants. Our results indicated that a motor skill intervention is feasible for this population. Although three of our participants withdrew from the study it was due to reasons outside of our control, which is indicative of one of the potential issues with conducting longitudinal interventions in this population The three participants that remained in the study had attendance rates that were high and consistent with intervention literature (Barry et al., 2003; Cliff et al., 2007), indicating that parents were willing and able to bring their child to the intervention. It is important that researchers take attrition rates into account when planning similar studies in the future.

We found that the length of the intervention sessions (i.e. 1 hour) was manageable for the children's attention-span as the children's level of participation at the beginning and end of the sessions was relatively constant. Furthermore, the hour enabled us to provide ample opportunities for skill practice and active play. The curriculum that we used provided many active games that were effective at teaching the motor skills addressed in our intervention plan (Table 21). We found that the participants enjoyed completing an obstacle course near the end of the session that incorporated multiple skills and provided a natural progression from one skill to the next; thus, we recommend that this be included in all lesson plans going forward. The multipurpose room in which we conducted the intervention was an adequate size for our group and the activities we had planned. We were able to minimize many of the distractions in this room by keeping non-essential equipment in one corner and having any toys that would not be used out of sight. The children were also familiar with this multipurpose space as they had received prior services at the CTC; thus, knew they were there for treatment purposes and were typically eager to enter the child-friendly centre. Lastly, the feedback provided by the parents indicated that this intervention was meaningful for the family and was desired by the parents for their child with ASD. As it is important that community-based interventions align with the family's capacity to attend the program, the positive feedback from the parents indicated we had created a program that was within the family's capacity to attend. All of these positive findings regarding the feasibility of running a motor skill intervention for 4 year old children with ASD provided us with the confidence to go ahead with the larger motor skill intervention employed for this thesis.

We found that all participants in this study had very low levels of motor proficiency at the onset of the study (Table 23). This finding is consistent with previous literature that children with ASD have poor motor skills (Liu & Breslin, 2013; Lloyd et al., 2011; Ozonoff et al., 2008) and demonstrates the substantial need for FMS interventions for children with ASD. The motor skill intervention was effective in making functional improvements in motor skills for the three participants that completed the study as their gross, fine, and total motor quotients of the PDMS-2 increased from pre- to post-intervention. Only one participant improved on their MABC-2 total test score and the other two participants slightly declined. However, this may be due more to the nature of the MABC-2 as it is designed to detect movement difficulties but, may not be as sensitive to individual changes over short periods of time (Venetsanou et al., 2011). The improvements seen on the PDMS-2 may have practical implications for the ability of these children to engage in active play and activities of daily living that require gross and fine motor skills. For example, an improvement in gross motor skills can enable a child to run around and play with their peers, as well as move efficiently throughout one's home (i.e. up and down stairs, around furniture, etc.). Improvements in fine motor skills can enable a child to care for oneself (i.e. do up buttons, hold cutlery, etc.), as well as engage in play by manipulating toys and small objects. Individual gains in adaptive behaviour on the various domains of the VABS-2 were evident in the three participants in this study (Table 24). Some individual declines were also evident; however, they may be due to factors outside of the intervention and without a control group it is difficult to determine the actual impact on adaptive behaviour. Regardless, individual improvements in adaptive behaviour can be beneficial to children as it may allow them to better interact with their peers, parents, and other adults. Furthermore, improved adaptive behaviour may help to reduce family stress as the child is able to become more independent and reduce their maladaptive behaviours. These findings provide very preliminary evidence that a FMS intervention may be effective at improving the motor skills and adaptive behaviour of young children with ASD.

In regard to physical activity we found that two of the participants actually decreased their average number of steps from pre- to post-intervention (Table 25). However, this may be due to seasonal changes as the pre-test was conducted at the end of the summer when children are typically more active and the post-test was in December when inclement weather often results in decreased activity levels (Tucker & Gilliland, 2007). However, the participants averaged a relatively adequate number of steps each day considering that the Canadian guidelines for children over 6 years of age recommends 12,000 steps per day to meet the physical activity requirements (Colley, Janssen, & Tremblay, 2012); there are no step targets for children under the age of 6. The step counts seen in this study therefore pose the question of whether the children were actually participating in appropriate physical activity or whether it was excess movement produced by repetitive behaviours often seen in children with ASD, which cannot be differentiated by pedometry. Moreover, the participant's parents indicated significant difficulties in their children's adherence to wearing the pedometer due to sensory difficulties and the distraction that it caused. Therefore, the feasibility of using pedometers to measure physical activity in this young population of children with ASD should be further explored.

The findings from this pilot study indicate that it is feasible to implement a FMS intervention for 4 year old children with ASD. Our results also indicate that functional improvements may be made in motor skills and adaptive behaviour through a FMS intervention. However, the ability to capture changes in physical activity using pedometers in this population may be limited. This pilot study warrants further investigation into the effectiveness of a FMS intervention at improving motor skills and adaptive behaviour in 4 year old children with ASD.

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Section 6: Thesis Conclusions

Thesis Conclusions

Summary

Autism Spectrum Disorder (ASD) is an increasingly prevalent, complex developmental disorder (American Psychiatric Association, 2013; Fombonne, 2009; Kogan et al., 2009). Children with ASD experience significant challenges with social communication, social interactions, and demonstrate a restricted pattern of behaviour or interests (American Psychiatric Association, 2013). Much of the intervention literature on young children with ASD focuses on their core challenges in the social, communicative, and behavioural domains (Matson & Smith, 2008), yet children with ASD also exhibit significant delays in their motor skills (Jasmin et al., 2009; Lloyd, MacDonald, & Lord, 2011; Ozonoff et al., 2008). Proficient fundamental motor skills (FMS) are essential for young children to participate in active play (Lubans, Morgan, Cliff, Barnett, & Okely, 2010; Pellegrini & Smith, 1998); thus, children with ASD may be limited in their ability to play due to their inability to move effectively and efficiently. Engagement in active play provides a number of developmental benefits including opportunities for cognitive, social, language, and physical development (Boucher & Wolfberg, 2003; Gallo-Lopez & Rubin, 2012; Pellegrini & Smith, 1998; Williams, Reddy, & Costall, 2001). Therefore, it is critical that children with ASD have the FMS needed to engage in play, in order to gain the developmental benefits of play. The primary objective of the current study was to investigate the effectiveness of a FMS intervention at improving the motor skills, adaptive behaviour, and social skills of 4 year old children with ASD. The secondary objective was to determine whether a higher intensity of the same intervention was more or less effective at improving the primary outcomes of the study following the intervention.

The results from this study demonstrated that a FMS intervention for 4 year old children with ASD was able to produce significant improvements in the motor skills of the experimental group, in comparison to the control group who did not receive the intervention. Upon both study groups receiving the intervention, we found significant improvements in motor skills in both groups at the post-test and these improvements were maintained at the 6-week follow-up, with no significant group differences due to intervention intensity. These findings demonstrated that the FMS intervention was effective at improving motor skills, and that intervention intensity had no bearing on the motor outcomes.

In regard to adaptive behaviour and social skills, the experimental group slightly declined, although not significantly, following the intervention in comparison to the control group. After both groups received the intervention, we did not find any significant group differences. However, we did find a number of individual improvements in adaptive behaviour and social skills, as well as an increase in the amount of time participants engaged in appropriate play from the first to last intervention session. We also found that adaptive behaviour at baseline may be positively related to improvements in adaptive behaviour and social skills, and negatively related to increases in maladaptive behaviours following the intervention. These results indicate that individual improvements in adaptive behaviour and social skills can be made following a FMS intervention for 4 year old children with ASD and that children with better adaptive behaviour at baseline may benefit the most, in terms of adaptive behaviour and social skills, from a FMS intervention.

Recommendations

The findings from the current study warrant future research investigating the effectiveness of a FMS intervention at improving the motor skills, adaptive behaviour, and social skills of young children with ASD. Future studies should ideally employ a randomized controlled trial design; include larger sample sizes; older and younger age bands; and the entire spectrum of children with ASD, while controlling for IQ. Future studies should also be implemented in the community setting, as well as within schools and clinical practices in order to potentially benefit the greatest number of children.

We recommend FMS interventions similar to this be implemented as a primary form of treatment for children with ASD. Most publically funded services for children with ASD currently have long-wait times since children typically enter the programs one at a time, rather than in groups, and they are cost-prohibitive to the social system and individual families. In contrast, this group motor skill intervention was implemented in a community setting with minimal funding, and provided services to more than one child at a time; thus, could be easily replicated with minimal funding. One way to decrease the burden on the social system that is caused by families waiting for intensive behavioural interventions for their child with ASD could be to implement group motor skill interventions in the community recreation and leisure sector, as well as within the clinical sector. This could have the positive outcomes of improving motor skills, as well as providing a group setting for children to practice and improve their social and communicative skills. A program such as this could potentially augment other social and communicative therapies for higher functioning children (who may benefit the most in terms of adaptive behaviour and social skills following a motor skill intervention). For lower functioning children with ASD who may require more intensive services and additional support, a motor skill intervention could be provided to them while they are on the waitlist for additional services. Receiving a motor skill intervention while waiting for more intensive services could be of particular importance to young children with ASD who should be attaining developmental milestones more quickly; thus, potentially falling further behind if they are left without any form of early intervention for prolonged periods of time. Therefore, we recommend that FMS interventions should be implemented through community recreation programs and government funded autism services in order to provide children with ASD with an opportunity to improve their motor skills and potentially augment their other early intervention services that target the social, communicative, and behavioural domains.

Another way to ensure that all children with ASD attain proficient motor skills is to implement FMS interventions into all day care and primary school curriculums. A FMS intervention, such as ours, could be easily implemented in a school setting during physical education classes and we hypothesize that it should help not only the children with ASD but, all children in the class. Adapted physical education and adapted physical educator training programs are essentially non-existent in Canadian schools. As a result, many physical education teachers do not know how to accommodate a child with ASD in their classroom. This means that if a child with ASD does not have the motor skills needed to participate in class, they will likely be increasingly left out of activities as they advance through elementary school and fall progressively further behind their peers. This may lead to frustration and an increase of maladaptive behaviours on the part of the child with ASD, as well as frustration for the teacher who may not have the training to adapt games to the child's skill level. We propose that one way to counteract this entire issue is to teach FMS to children with ASD at an early age, before the developmental gap with their peers becomes too large. If children with ASD have the skills required to participate in games and physical education class, then they will ideally be included in these situations. This inclusion is beneficial for overall confidence and self-esteem, increased opportunities for social engagement and communication with peers, as well as the reduction of any frustrations that physical educators may face with a child with ASD who does not have proficient motor skills. Therefore, we recommend that all primary school curriculums include a comprehensive FMS intervention, particularly for younger children, and inclusive of children with ASD.

Lastly, participating in physical activity at a young age can provide an avenue for lifelong engagement in recreational physical activities; which may result in improved health, opportunities for social interactions, and an overall high quality of life. Yet, in order to engage in physical activity, one needs to have proficient motor skills. We found that intervening on FMS at young age in children with ASD can result in improved motor skills, as well as individual benefits to adaptive behaviour and social skills. These improvements may enable children with ASD to participate in family outings, engage in physically active play with peers, participate in day care or physical education activities, and join sports teams. Thus, an early FMS intervention has the potential for lifelong benefits for children with ASD and should be a priority for all parents and clinicians working with children with ASD.

Conclusion

In conclusion, we found that a community-based FMS intervention can be effective at improving the motor skills of 4 year old children with ASD, and may also produce individual gains in adaptive behaviour and social skills in this population. These improvements may lead to better overall functioning for a child with ASD, including providing them with the skills needed to engage in active play. To the best of our knowledge, this is the first study to examine the effectiveness of a FMS intervention in this population; therefore, these findings make a significant contribution to the early intervention literature for young children with ASD. We recommend the development of proficient motor skills become a priority for all future research and therapy for young children with ASD.

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Section 7: Appendices

Appendix 1: Certificate of Approval from the University of Ontario Institute of Technology Research Ethics Board

UNIVERSITY OF ONTARIO INSTITUTE OF TECHNOLOGY

RESEARCH ETHICS BOARD
OFFICE OF RESEARCH SERVICES

Date: December 11th, 2012

To: Emily Bremer (PI), Meghann Lloyd (Supervisor)

From: Amy Leach, REB Chair

REB File #: 12-040

Project Title: Investigating a motor skill intervention for 4 year old children with autism spectrum disorder

DECISION: APPROVED

START DATE: December 11th, 2012 **EXPIRY: December 11th, 2013**

The University Of Ontario Institute Of Technology Research Ethics Board has reviewed and approved the above research proposal. The application in support of the above research project has been reviewed by the Research Ethics Board to ensure compliance with the Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans (TCPS2) and the UOIT Research Ethics Policy and Procedures.

Please note that the Research Ethics Board (REB) requires that you adhere to the protocol as last reviewed and approved by the REB.

Always quote your REB file number on all future correspondence.

Please familiarize yourself with the following forms as they may become of use to you.

- **Change Request Form:** any changes or modifications (i.e. adding a Co-PI or a change in methodology) must be approved by the REB through the completion of a change request form before implemented.
- **Adverse or unexpected Events Form:** events must be reported to the REB within 72 hours after the event occurred with an indication of how these events affect (in the view of the Principal Investigator) the safety of the participants and the continuation of the protocol. (I.e. un-anticipated or un-mitigated physical, social or psychological harm to a participant).
- **Research Project Completion Form:** must be completed when the research study has completed.
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All Forms can be found at http://research.uoit.ca/EN/main/231307/Research_Forms.html.

REB Chair Dr. Amy Leach, SSH amy.leach@uoit.ca	Ethics and Compliance Officer compliance@uoit.ca

University of Ontario, Institute of Technology
2000 Simcoe Street North, Oshawa ON, L1H 7K4
PHONE: (905) 721-8668, ext. 3693

Appendix 2: Certificate of Ethical Approval from the Grandview Children's Centre Research Committee and Quality Leadership Council

GRANDVIEW
CHILDREN'S
CENTRE

November 5, 2012

UOIT Research Ethics Board
2000 Simcoe Street North
Oshawa, Ontario
L1H 7K4

Dear UOIT Research Ethics Board:

I am pleased to provide a letter confirming our participation in the Master's Thesis research project of Ms. Emily Bremer, under the supervision of Dr. Meghann Lloyd, on a motor skill intervention for 4 year old children with Autism Spectrum Disorder.

We are pleased to be hosting and collaborating with these researchers.

Sincerely,

Lorraine Sunstrum-Mann, ECEDH, RN, BA, MBA
Executive Director

... leading the way to excellence in services for children and youth with special needs and their families
600 Townline Road South, Oshawa, ON L1H 7K6 • 905.728.1673 • 1.800.304.6180 • Fax 905.728.2961
www.grandviewcc.ca
Registered Charitable Organization

Appendix 3: Parent/Guardian Informed Consent Form for Study Participation

UOIT
CHALLENGE INNOVATE CONNECT

UNIVERSITY OF ONTARIO INSTITUTE OF TECHNOLOGY
2000 SIMCOE STREET NORTH OSHAWA, ON, CANADA L1H 7K4
PH 905.721.8668 www.uoit.ca

Informed Consent:
Investigating a Motor Skill Intervention for 4 year old Children with Autism Spectrum Disorder

Investigators:

Emily Bremer	Faculty of Health Sciences University of Ontario Institute of Technology 905-721-8668, ext. 2953 emily.bremer@uoit.ca
Dr. Meghann Lloyd	Faculty of Health Sciences University of Ontario Institute of Technology 905-721-8668, ext. 5308 meghann.lloyd@uoit.ca

Background and Rationale:

You and your child are invited to participate in a voluntary motor skill intervention. The purpose of this project is to investigate whether an early motor skill intervention is effective in improving the motor skills, social behaviour and physical activity of 4 year old children with Autism Spectrum Disorder (ASD). We will measure their motor skills, social skills and physical activity levels.

Why is this work important?

Children with ASD often experience impairments in their social and motor skills. These delays can make it challenging for them to interact with their peers and meaningfully engage in active play. The development of social and motor skills work together – motor skills help children to participate in active play and this engagement in play helps to develop social skills. Motor skill interventions can help to improve children's motor proficiency, social skills, and physical activity levels by providing them with instruction and the opportunity to engage in active play. The results from this study will be used to inform larger motor skill interventions for children with and without ASD.

Study Procedures:

All children who participate in this study will receive the intervention; children will be randomly assigned to 2 groups. One group will receive the intervention first, and the other group will receive it second. To participate in this study we will ask you and your child to visit The University of Ontario Institute of Technology (UOIT) for four separate 1 hour sessions as well as participate in a small group motor skill intervention run by a UOIT graduate student at Grandview Children's Centre; complimentary parking will be provided. This study includes assessment of fundamental motor skills, physical activity, and social behaviour, as well as anthropometric measurements of height and weight. During your visits to UOIT we will ask you to complete three questionnaires to provide demographic information as well as details of your child's social behaviour; these questionnaires will take approximately 45 minutes to complete. We will measure your child's motor skills (i.e. throwing, hopping, jumping), how tall they are and how much they weigh. We will also ask them to wear a small device called a pedometer (which looks like a pager or a small cell phone) for seven consecutive days. These assessments will be repeated 4 times over the course of the study.

Your child will be randomly assigned to either Group A or Group B; all children will receive the motor skill intervention regardless of group and both interventions will consist of 12 hours of instruction. The following table outlines the order of assessments and intervention for each group:

Group A	Group B
Pre-test - motor skills - physical activity - social behaviour	Pre-test - motor skills - physical activity - social behaviour
Intervention - 1 hour/week for 12 weeks - 12 hours total instruction time	Control Period
Post-test - motor skills - physical activity - social behaviour	Post-test - motor skills - physical activity - social behaviour
Control Period	Intervention - 2 hours/week for 6 weeks - 12 hours total instruction time
6 week follow-up - motor skills - physical activity - social behaviour	Post-test 2 - motor skills - physical activity - social behaviour
12 week follow-up - motor skills - physical activity - social behaviour	6 week follow-up - motor skills - physical activity - social behaviour

More details about each part of the study are included below:

- Physical activity will be measured using a pedometer, which is a small device that looks like a beeper worn on the waistband of your child's pants for 7 consecutive days, after which point you will mail the pedometer back to us in a pre-paid envelope. The pedometer will be worn at all 4 assessment periods. The pedometer records the amount of physical activity (i.e. how many steps your child takes during the day), but does not record what activity your child is engaged in or where your child is. We will ask you/your child to complete a daily log sheet outlining the activity they engaged in while wearing the pedometer (e.g. soccer practice, school, reading, play). We encourage your child to wear the monitor for all activities except while sleeping or participating in activities that involve water (such as bathing or swimming).

- Motor skill proficiency will be measured using two standardized assessment tools called the "Peabody Developmental Motor Scales-2 (PDMS-2)" and the "Movement Assessment Battery for Children-2 (Movement ABC-2)". The PDMS-2 examines your child's reflexes, posture, locomotion, object manipulation, grasping, and visual-motor integration skills. Both of these tools help to provide us with a better understanding of where your child's motor skills are. Motor skill proficiency will be measured at all 4 assessments.

- Social behaviour will be assessed with two standardized questionnaires called the "Vineland Adaptive Behaviour Scale-2" and the "Social Skills Improvement Scale (SSIS)". These questionnaires will ask you to rate your child's social behaviour and level of adaptive functioning. These questionnaires will be completed at all 4 assessments. We will also videotape the first and last free play sessions of the motor skill intervention (i.e. the final 10 minutes of the first and last session). These videotapes will be coded for social interactions. The videotapes are completely confidential and will not be shared with anyone other than the researchers.

- The motor skill intervention is an instructional play-based program that will take place at Grandview Children's Centre and will be run by a graduate student and undergraduate volunteers in Kinesiology at UOIT. Each intervention session will consist of a warm-up activity, specific skill instruction (e.g. catching, skipping, hopping), active games incorporating the skills that were taught, and free time for self-initiated play. Skill instruction will focus on both locomotor (running, hopping, leaping, etc.) and object control (throwing, catching, kicking, etc.) skills.

Risks and Benefits:

Your child's participation in this study does not pose any risk that differs from what they would normally encounter in daily life. All physical activities are similar to standard physical education and sport/recreation activities. As with any physical activity, there is a risk of falling, however all the equipment is standard physical education equipment and safety is our first priority. All study personnel are trained in First Aid and CPR, and in the event of an injury, the facility's standard emergency procedures will be followed. In the event that your child suffers injury as a direct result of participating in this study, normal legal rules for compensation will apply. By signing this consent form you are in no way waiving your legal rights or releasing the investigator and the sponsor from their legal and professional responsibilities.

Your child will potentially benefit from this study by receiving valuable motor skill instruction which may help to improve their motor skill proficiency, social interactions and physical activity levels. The research findings will also help to shape future motor skill interventions that will potentially help other children to become healthier. You can withdraw your child from the study at any time, and you are not required to provide a reason for doing so. Withdrawing your child will in no way affect the services that they receive from Grandview Children's Centre and/or any other agency; however, withdrawing from the study prior to the end of the intervention will mean that your child will not receive the motor skill instruction being offered. We will also provide you with a report on your child as to their own personal results.

Confidentiality:

The data collected in this study for current and potentially future research will be secured safely. Although participation in this study is not anonymous, all information that you and your child provide will remain confidential. Participant information will be numbered and will not contain names. One file which connects your child's name with their study identification number will be stored separately on a secured server that can only be accessed by researchers directly involved in the study and the University of Ontario Institute of Technology Research Ethics Board who has access to records for auditing purposes. Overall results may be published for scientific purposes, but participant identity will remain confidential as all data will be de-identified. Limits of this confidentiality include situations of suspected child abuse, concerns of harm to self or others, or any request for information by court order.

Questions about the study:

If you have questions about this study, please contact Emily Bremer or Dr. Meghann Lloyd at 905-721-8668, ext. 2953. This study has been reviewed and approved by the University of Ontario Institute of Technology Research Ethics Board (REB #__), which is a committee of the university. Its goal is to ensure the protection of the rights and welfare of people participating in research. The Board's work is not intended to replace a parent/guardian or child's judgment about what decisions and choices are best for you. If you have any questions about your child's rights as a research participant you may contact the University of Ontario Institute of Technology Research Ethics Board at 2000 Simcoe St. N., Oshawa, ON, L1H 7K4, 905-721-8668 ext. 3693 or compliance@uoit.ca

Informed Consent to Participate: Investigating a motor skill intervention for 4 year old children with Autism Spectrum Disorder

I, ...,
(Your Name)

the parent/guardian of .... :
(Your Child's Name)

☐ **Give consent** to my child's participation in the above study.

☐ **Give consent** for my child to be videotaped as part of the study.

☐ Give consent for data from this study to be used in future studies (e.g. physical activity and motor skills) to help children with ASD.

☐ I am willing to receive further information regarding future research studies that my child may be eligible for.
Email: ______________________________
Phone: ______________________________

I have read and understood the attached information sheet or had the attached information sheet verbally explained to me, and have received a copy of this consent form. I have been fully informed of the details of the study and have had the opportunity to discuss my concerns. I understand that I am free to withdraw my child at any time or not answer questions.

____
Name of child

______________________________ ______________________
Name of Parent/Guardian Contact phone number

______________________________ ______________________
Signature of Parent/Guardian Date

______________________________ ______________________
Investigator's signature Date

Appendix 4: Recruitment Flyer for Study Participation

Appendix 5: Grandview Children's Centre Letter of Support to Accompany Recruitment Flyer

January 21, 2013

Dear parent/caregiver,

Grandview Children's Centre has been given an opportunity to participate in a research project that assesses fundamental motor skills in children with Autism Spectrum Disorder. You are being sent this letter because our database shows that you have a 4 year old child previously diagnosed with Autism Spectrum Disorder. The study, entitled "A Motor Skill Intervention for 4 Year Old Children with Autism Spectrum Disorder" gives children an opportunity to participate in a group intervention designed to improve fundamental motor skills. Please refer to the enclosed recruitment flyer for further information.

This research project has been reviewed and approved by our Research Committee. The research committee consists of our senior leaders, and front line staff, with our Medical Director, Dr. Carolyn Hunt as the chair. The decision to participate in research is completely yours, it will in no way affect the care that your family or your child receives at Grandview. We simply wish to provide you with any opportunities possible to help us understand Autism and what works in the treatment of Autism. If you do not wish to participate you can simply disregard this package.

If you have any questions about this letter, or how Grandview approves research, please contact the Medical Director at 905-728-1673 x2340, and leave us a message regarding your concerns and we will get back to you. We welcome your feedback on this topic.

If you have any questions about this specific research project, please contact the researchers directly, at 905-721-8668 x2953.

Sincerely,

Dr. Carolyn Hunt

Appendix 6: Supplemental Information Form for Parents/Guardians

ID#:

Supplemental Information Form

This form includes questions about your child that will help to describe the information we learn through this study and identify factors that may relate to children's rate of progress and development. Please feel free to ask questions if you would like further clarification.

1. Child's name: ______________________________
2. Birth date: ______________ (day, month, and year)
3. How old was your child when they started walking (5 steps in a row)?
   __________ months
4. What is your child's diagnosis (i.e. autism, Asperger's syndrome, Pervasive Developmental Disorder (PDD), Pervasive Developmental Disorder-Not Otherwise Specified (PDD-NOS)?
   ____
5. At what age did your child receive their diagnosis? ______________
6. Has your child also been diagnosed with any of the following?
   - ☐ Anxiety
   - ☐ Attention Deficit Disorder
   - ☐ Attention Deficit Hyperactivity Disorder
   - ☐ Development Delay
   - ☐ Epilepsy
   - ☐ Intellectual Disability
   - ☐ Learning Disability
   - ☐ Operational Defiant Disorder
   - ☐ Seizures
   - ☐ Sensory Integration Disorder
   - ☐ Visual Problems
   - ☐ Other: ______________
7. Has your child ever received any motor interventions (i.e. physical therapy, occupational therapy)? If yes, please specify from what age and the duration.
   ____
   ____
   ____
8. Is your child currently receiving any other form of therapy (i.e. speech-language, Applied Behaviour Analysis (ABA)-based services, etc.)? If yes, please specify the type and duration.
   ____

1 of 2

____

____

9. Please list any medications your child is currently taking:

   ____

   ____

10. Please self-declare your child's ethnicity using the options below:
    (consistent with Statistics Canada, 2011)

    - ☐ Aboriginal
    - ☐ Arab/West Asian
    - ☐ Black
    - ☐ Chinese
    - ☐ Filipino
    - ☐ Japanese
    - ☐ Korean
    - ☐ Latin American
    - ☐ South Asian
    - ☐ Southeast Asian
    - ☐ White
    - ☐ Undeclared
    - ☐ Other: ____________________

11. Please indicate your child's birth order and the number of siblings they have:

    birth order:_______________ # of siblings:______________

12. Do any of your other children have Autism Spectrum Disorder (ASD)? If yes, please indicate their age.

    ____

13. Please indicate the age of parents at your child's birth:

    Mother: _________________ Father: _______________

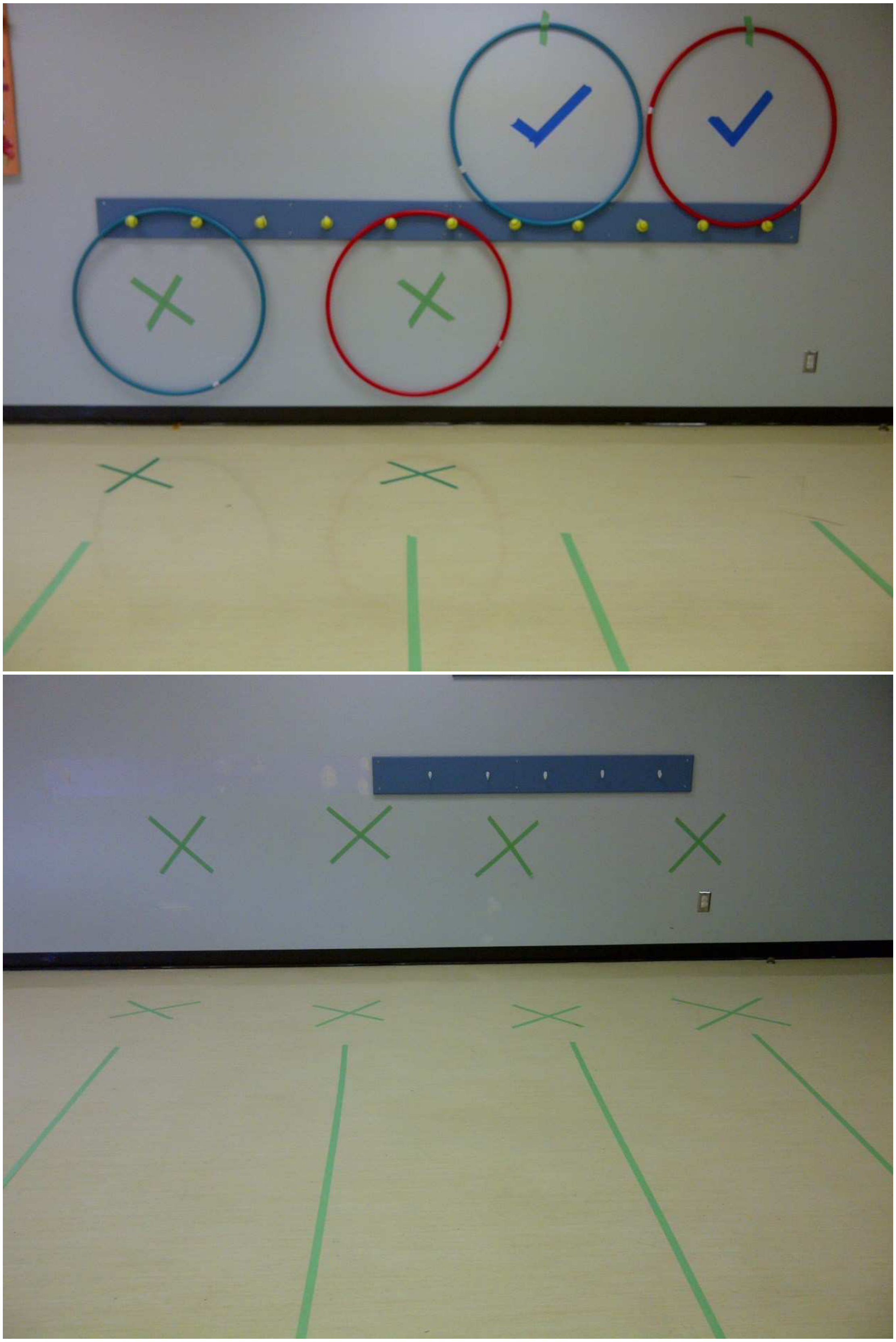
14. Please indicate the highest level of education completed by each parent:

    Mother: _________________ Father: _______________

15. Please estimate the annual household income (optional):

    - ☐ Under $20,000
    - ☐ $20,000 - $39,000
    - ☐ $40,000 - $59,000
    - ☐ $60,000 - $79,000
    - ☐ $80,000 - $99,000
    - ☐ Over $100,000

Appendix 7: Examples of the Room Set-Up for the Intervention Sessions



Emily E. Bremer (2014)

Appendix 8: Sample Instructional Take-Home Sheet for Parents/Guardians

Week 1 – Balance

Good balance is important for both stationary and active tasks.

Practice balancing can be incorporated into everyday activities.

For example, while your child is watching tv, helping to make food, or brushing their teeth have them try these balance activities:

- standing on one foot
- standing on their tiptoes

To work on dynamic balance, have your child try these activities while walking around the house or to/from school or the park:

- Practice walking in a straight line (as if on a balance beam) by following lines on the floor or sidewalk
- Have them walk on their tiptoes – challenge them to follow a straight line or take as many steps in a row on their tiptoes as they can

TIPS

✓ Let them start by holding on to an object to establish balance and then gradually have them let go and balance on their own.

✓ Have them focus on a spot on the floor or wall to help maintain their balance.

Try interactive games to practice balancing:

- Encourage balancing in different ways such as on one leg, on tiptoes, two knees and one hand, bottom and two hands, knees and one elbow, etc.
- Call out a number for how many body parts can touch the floor (ie. 3 – you could then balance on 2 hands and 1 foot)
- Have your child practice balancing a beanbag or stuffed animal on different body parts (ie. Balance it on their foot, on their head, on their shoulder) – join in or have a sibling participate to see who can balance the longest or take turns coming up with new ways to balance

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Appendix 9: Social Behaviour Codes Adapted from Hauck et al.'s (1995) Behavior Coding Scheme

Social Behaviour Codes

Positive Initiations

1. **Give affection**: initiating a physical or verbal expression of affection
2. **Give information**: child informs other about something the other may not know; may include an expression of need
3. **Greet**: child uses language/action customarily used when meeting another
4. **Initiate play**: child initiates play activity with another person
5. **Joint attention**: child calls attention of another to an object or activity
6. **Seek aid/information verbally**: child verbally requests assistance or information from another
7. **Seek aid/information nonverbally**: child requests assistance or information from another with nonverbal means
8. **Appropriate play**: child is actively playing, in a meaningful way, by themselves or with a peer

Negative Initiations

9. **Aggression**: physical violence or aggression directed toward another's person or destruction of another's property
10. **Provocation**: testing or other negative verbal or gestural behaviour, or physical but nonviolent actions such as stealing another child's toy or seat

Low-level Initiations

11. **Imitate:** child repeat's another's actions
12. **Echolalia**: child echoes something recently heard
13. **Looks:** child looks at other's face, body, or actions
14. **Move into proximity**: child moves to within 3 feet of another
15. **Neutral physical contact**: child makes physical contact with another which is not overtly aggressive, affectionate, ritualistic, or provocative
16. **Ritualized behaviour**: child performs a ritualized or self-stimulating behaviour
17. **Inappropriate play**: child engages in sedentary play and/or does not use equipment in a purposeful way

Attention-seeking Initiation

18. **Seek attention verbally**: child engages in verbal direction of another's attention to self
19. **Seek attention nonverbally**: child engages in nonverbal behaviours to direct the other's attention to self

Avoidance

20. **Move out of proximity**: child moves 3 feet or more away from another

Social Response

21. **Verbal response**: child responds verbally to social stimuli directed toward him/her by peers
22. **Non-verbal response**: child responds non-verbally to social stimuli directed toward him/her by peers

Target of Initiation/Response:

23. **Adult**: Social initiation or response was directed to/from an adult
24. **Child**: Social initiation or response was directed to/from another child

Out of Frame

25. **Out of frame**: child cannot be seen in the video

Appendix 10: System for Observing Fitness Instruction Time (SOFIT) Coding Scheme

8. SOFIT DEFINITIONS AND CODING CONVENTIONS

8.1. Student activity levels

Code the activity level/ body position of a target student into one of the five following categories using momentary time sampling (i.e., code a number to indicate what the student is doing at the "record" prompt):

1. lying
2. sitting
3. standing
4. walking
5. vigorous

Code levels 1-4 (lying, sitting, standing, walking), unless the student is expending more energy than that required for an ordinary walk.

Code level 5 (vigorous) if the activity the student is doing at that moment requires expending more energy than he/she would during ordinary walking (do not consider body position only). For example, code 5 (vigorous) when the student is running, jogging, skipping, hopping, wrestling with a peer (even though lying on her back), and pedaling on a moving or stationary bike (even though sitting).

MCKENZIE 9.14.12 SOFIT PROTOCOL Page 8

When the student is in transition from one category to another, enter the code for the higher category. For example, code level 2 (sitting) if at the record signal the student is partially lying down and partially sitting up; code level 3 (standing) when the student is kneeling.

Appendix 11: Certificate of Approval from the University of Ontario Institute of Technology Research Ethics Board for the Pilot Study

UOIT
CHALLENGE INNOVATE CONNECT

RESEARCH ETHICS BOARD
OFFICE OF RESEARCH SERVICES

Date: July 4th, 2012

To: Emily Bremer (PI), Meghann Lloyd (Faculty Supervisor)

From: Amy Leach, REB Chair

REB File #: 11-111

Project Title: A motor skill intervention for 4 year old children with Autism Spectrum Disorder: A pilot study

DECISION: APPROVED

START DATE: July 4th, 2012 EXPIRY: July 4th, 2013

The University Of Ontario Institute Of Technology Research Ethics Board has reviewed and approved the above research proposal. The application in support of the above research project has been reviewed by the Research Ethics Board to ensure compliance with the Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans (TCPS2) and the UOIT Research Ethics Policy and Procedures.

Please note that the Research Ethics Board (REB) requires that you adhere to the protocol as last reviewed and approved by the REB.

Always quote your REB file number on all future correspondence.

Please familiarize yourself with the following forms as they may become of use to you.

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All Forms can be found at http://research.uoit.ca/EN/main/231307/Research_Forms.html.

REB Chair Dr. Amy Leach, SSH amy.leach@uoit.ca	Amy Leach	Ethics and Compliance Officer compliance@uoit.ca

UNIVERSITY OF ONTARIO INSTITUTE OF TECHNOLOGY
2000 SIMCOE STREET NORTH OSHAWA, ON, CANADA L1H 7K4
PH (905) 721-8668, ext. 3693 FX (905) 721-3119

Appendix 12: Certificate of Ethical Approval from the Grandview Children's Centre Research Committee and Quality Leadership Council for the Pilot Study

GRANDVIEW CHILDREN'S CENTRE

June 4, 2012

UOIT Research Ethics Board
2000 Simcoe Street North
Oshawa, Ontario
L1H 7K4

Dear UOIT Research Ethics Board:

I am pleased to provide a letter confirming our participation in the research project of Ms. Emily Bremer, under the supervision of Dr. Meghann Lloyd, on a motor skill intervention for 4 year old children with Autism Spectrum Disorder.

We are pleased to be hosting and collaborating with these researchers.

Yours sincerely,

LSMann

Lorraine Sunstrum-Mann, ECEDH, RN, BA, MBA
Executive Director

... leading the way to excellence in services for children and youth with special needs and their families in Durham Region.
600 Townline Road South, Oshawa, ON L1H 7K6 • 905.728.1673 • 1.800.304.6180 • Fax 905.728.2961
www.grandviewcc.ca
A Registered Charitable Organization

Appendix 13: Parent/Guardian Informed Consent Form for Study Participation in the Pilot Study

UNIVERSITY OF ONTARIO INSTITUTE OF TECHNOLOGY
2000 SIMCOE STREET NORTH OSHAWA, ON, CANADA L1H 7K4
PH 905.721.8668 www.uoit.ca

Informed Consent:
A Motor Skill Intervention for 4 year old Children with Autism Spectrum Disorder

Investigators:

Emily Bremer — Faculty of Health Sciences
University of Ontario Institute of Technology
905-721-8668, ext. 2953
emily.bremer@uoit.ca

Dr. Meghann Lloyd — Faculty of Health Sciences
University of Ontario Institute of Technology
905-721-8668, ext. 5308
meghann.lloyd@uoit.ca

Background and Rationale:

You and your child are invited to participate in a voluntary motor skill intervention. The purpose of this project is to investigate whether an early motor skill intervention is effective in improving the motor skills, social behaviour and physical activity of 4 year old children with Autism Spectrum Disorder (ASD). We are also interested in measuring their motor skills, social skills and physical activity levels.

Why is this work important?

Children with ASD experience impairments in their social and motor skills. These delays can make it challenging for them to interact with their peers and meaningfully engage in active play. The development of social and motor skills work together – motor skills help children to participate in active play and this engagement in play helps to develop social skills. Motor skill interventions can help to improve children's motor proficiency, social skills, and physical activity levels by providing them with instruction and the opportunity to engage in active play. The results from this pilot study will be used to implement a larger motor skill intervention for children with and without ASD.

Study Procedures:

To participate in this study we will ask you and your child to visit The University of Ontario Institute of Technology (UOIT) for two separate 1 hour sessions as well as participate in a small group motor skill intervention for 12 consecutive weeks run by UOIT graduate students at Grandview Children's Centre; complimentary parking will be provided. This study includes assessment of physical activity, fundamental motor skills, and social behaviour, as well as anthropometric measurements of height and weight. During your visits to UOIT we will ask you to complete two questionnaires to provide demographic information as well as details of your child's social behaviour. We will measure your child's motor skills (for example, throwing, hopping, jumping), how tall they are and how much they weigh. We will also ask them to wear a small device called a pedometer (which looks like a pager or a small cell phone) for seven consecutive days. Your child will then participate in a 12 week motor skill intervention where you will be asked to bring your child to Grandview Children's Centre for 1 hour a week on a specified day and time. At the end of the 12 weeks, you and your child will be asked to return to UOIT to have their motor skills, physical activity, and social behaviour measured. You will also be asked to complete a one-page program feedback questionnaire in order to help us better run future interventions.

More details about each part of the study are included below:

- Physical activity will be measured using a pedometer, which is a small device that looks like a beeper worn on the waistband of your child's pants for 7 consecutive days, after which point you will mail the pedometer back to us in a pre-paid envelope. The pedometer will be worn both before and after the 12 week intervention. The pedometer records the amount of physical activity (i.e. how many steps your child takes during the day), but does not record what activity your child is engaged in or where your child is. We will ask you/your child to complete a daily log sheet outlining the activity they engaged in while wearing the pedometer (e.g. soccer practice, school, reading, play). We encourage your child to wear the monitor for all activities except while sleeping or participating in activities that involve water (such as bathing or swimming).

- Motor skill proficiency will be measured using two standardized assessment tools called the "Peabody Developmental Motor Scales-2 (PDMS-2)" and the "Movement Assessment Battery for Children-2 (Movement ABC-2)". The PDMS-2 examines your child's reflexes, posture, locomotion, object manipulation, grasping, and visual-motor integration skills. Both of these tools help to provide us with a better understanding of where your child's motor skills are.

- The motor skill intervention is an instructional play-based program that will take place once a week for 12 consecutive weeks at Grandview Children's Centre and will be run by graduate students in the Kinesiology department at UOIT. Each intervention session will consist of a warm-up activity, specific skill instruction (e.g. catching, skipping, hopping), active games incorporating the skills that were taught, and free time for self-initiated play. Skill instruction will focus on both locomotor (running, hopping, leaping, etc.) and object control (throwing, catching, kicking, etc.) skills.

Risks and Benefits:

Your child's participation in this study does not pose any risk that differs from what they would normally encounter in daily life. All physical activities are similar to standard physical education and sport/recreation activities. As with any physical activity, there is a risk of falling, however all the equipment is standard physical education equipment and safety is our first priority. All study personnel are trained in First Aid and CPR, and in the event of an injury, the facility's standard emergency procedures will be followed. In the event that your child suffers injury as a direct result of participating in this study, normal legal rules for compensation will apply. By signing this consent form you are in no way waiving your legal rights or releasing the investigator and the sponsor from their legal and professional responsibilities.

Your child will potentially benefit from this study by receiving valuable motor skill instruction which may help to improve their motor skill proficiency, social interactions and physical activity levels. The research findings will also help to shape future motor skill interventions that will potentially help other children to become healthier. You can withdraw your child from the study at any time, and you are not required to provide a reason for doing so. We will also provide you with a report on your child as to their own personal results.

Confidentiality:

The data collected in this study for current and potentially future research will be secured safely. All information that you and your child provide will be numbered and will not contain names. One file which connects your child's name with their study identification number will be stored separately on a secured server that can only be accessed by researchers directly involved in the study and the University of Ontario Institute of Technology Research Ethics Board who has access to records for auditing purposes. Overall results may be published for scientific purposes, but participant identity will remain confidential as all data will be de-identified. Limits of this confidentiality include situations of suspected child abuse, concerns of harm to self or others, or any request for information by court order.

Questions about the study:

If you have questions about this study, please contact Emily Bremer or Dr. Meghann Lloyd at 905-721-8668, ext. 2953. This study has been reviewed and approved by the University of Ontario Institute of Technology Research Ethics Board (REB #___), which is a committee of the university. Its goal is to ensure the protection of the rights and welfare of people participating in research. The Board's work is not intended to replace a parent/guardian or child's judgment about what decisions and choices are best for you. If you have any questions about your child's rights as a research participant you may contact the University of Ontario Institute of Technology Research Ethics Board at 2000 Simcoe St. N., Oshawa, ON, L1H 7K4, 905-721-8668 ext. 3693 or compliance@uoit.ca

Informed Consent to Participate: A motor skill intervention for 4 year old children with Autism Spectrum Disorder

I, ...,
(Your Name)

the parent/guardian of .... :
(Your Child's Name)

☐ **Give consent** to my child's participation in the above study.

☐ Give consent for data from this study to be used in future studies (e.g. physical activity and motor skills) to help children with ASD.

☐ I am willing to provide program feedback upon completion of the intervention.

☐ I am willing to receive further information regarding future research studies that my child may be eligible for.
Email: ______________________________
Phone: ______________________________

I have read and understood the attached information sheet or had the attached information sheet verbally explained to me, and have received a copy of this consent form. I have been fully informed of the details of the study and have had the opportunity to discuss my concerns. I understand that I am free to withdraw my child at any time or not answer questions.

____
Name of child

______________________________________ ________________________
Name of Parent/Guardian Contact phone number

______________________________________ ________________________
Signature of Parent/Guardian Date

______________________________________ ________________________
Investigator's signature Date

Appendix 14: Recruitment Flyer for Study Participation in the Pilot Study

Appendix 15: Supplemental Information Form for Parents/Guardians for the Pilot Study

ID#:

Supplemental Information Form

This form includes questions about your child that will help to describe the information we learn through this study and identify factors that may relate to children's rate of progress and development. Please feel free to ask questions if you would like further clarification.

1. Child's name: ______________________________________
2. Birth date: ____________________ (day, month, and year)
3. How old was your child when they started walking (5 steps in a row)?
   ____________ months
4. What is your child's diagnosis (i.e. autism, Asperger's syndrome, PDD, PDD-NOS)? ______________________________________
5. At what age did your child receive their diagnosis? ____________________
6. Has your child been diagnosed with any of the following?
   - ☐ Anxiety
   - ☐ Attention Deficit Disorder
   - ☐ Attention Deficit Hyperactivity Disorder
   - ☐ Development Delay
   - ☐ Epilepsy
   - ☐ Intellectual Disability
   - ☐ Learning Disability
   - ☐ Operational Defiant Disorder
   - ☐ Seizures
   - ☐ Sensory Integration Disorder
   - ☐ Visual Problems
   - ☐ Other:________________
7. Has your child ever received any motor interventions (i.e. physical therapy, occupational therapy)? If yes, please specify from what age and the duration.
   ____
   ____
   ____

1 of 2

8. Please list any medications your child is currently taking:

____

____

9. Please self-declare your child's ethnicity using the options below:
(consistent with Statistics Canada, 2011)

☐ Aboriginal	☐ Arab/West Asian	☐ Black
☐ Chinese	☐ Filipino	☐ Japanese
☐ Korean	☐ Latin American	☐ South Asian
☐ Southeast Asian	☐ White	☐ Undeclared
☐ Other: ____________________		

10. Please indicate your child's birth order and the number of siblings they have:
birth order:________________ # of siblings:______________

11. Do any of your other children have ASD? If yes, please indicate their age.

____

12. Please indicate the age of parents at your child's birth:
Mother: __________________ Father: ________________

13. Please indicate the highest level of education completed by each parent:
Mother: __________________ Father: ________________

14. Please estimate the annual household income (optional):
- ☐ Under $20,000
- ☐ $20,000 - $39,000
- ☐ $40,000 - $59,000
- ☐ $60,000 - $79,000
- ☐ $80,000 - $99,000
- ☐ Over $100,000

2 of 2

Appendix 16: Program Evaluation Form for Parents/Guardians for the Pilot Study

UOIT
CHALLENGE INNOVATE CONNECT
UNIVERSITY OF ONTARIO INSTITUTE OF TECHNOLOGY
2000 SIMCOE STREET NORTH OSHAWA, ON, CANADA L1H 7K4
PH 905.721.8668 www.uoit.ca

Program Evaluation:
A Motor Skill Intervention for 4 year old Children with Autism Spectrum Disorder

1. Do you think this intervention had a positive impact on your child?

____

____

2. Was the frequency (1x/week for 12 weeks) of this intervention manageable?

____

3. Would it be manageable to bring your child to a similar intervention more often (i.e. 2x/week for 12 weeks)?

____

4. Were there any aspects of this intervention that you and/or your child particularly liked?

____

____

5. Were there any aspects of this intervention that you and/or your child did not like?

____

____

6. Do you think that the sessions were run in an organized manner?

____

7. Comments:

____

____

____

Appendix 17: Raw Data in Tables

PDMS-2 data by participant at Assessment 1

	Participant								
Variable	**102**	**103**	**104**	**105**	**106**	**201**	**203**	**204**	**205**
Age (Months)	52	49	48	54	55	49	54	53	
Stationary raw score	41	40	49	38	39	38	41	38	
Stationary age equivalent (months)	33	28	48	18	21	18	33	18	
Stationary percentile	5	5	50	2	2	2	5	2	
Stationary standard score	5	5	10	4	4	4	5	4	
Locomotor raw score	112	127	153	128	137	118	114	103	
Locomotor age equivalent (months)	25	31	46	32	36	28	26	23	
Locomotor percentile	2	9	37	5	5	5	2	2	
Locomotor standard score	4	6	9	5	5	5	4	4	
Object Manipulation raw score	16	25	26	11	29	20	24	8	
Object Manipulation age equivalent (months)	22	29	30	17	34	24	28	15	
Object Manipulation percentile	2	5	9	0	9	5	5	0	
Object Manipulation standard score	4	5	6	2	6	5	5	1	
Grasping raw score	40	44	47	42	45	44	46	42	
Grasping age equivalent (months)	14	34	43	20	37	34	40	20	
Grasping percentile	0	5	25	1	5	5	9	1	
Grasping standard score	2	5	8	3	5	5	6	3	
Visual-Motor Integration raw score	88	99	111	94	124	106	97	93	
Visual-Motor Integration age equivalent (months)	21	27	34	23	43	31	25	23	
Visual-Motor Integration percentile	2	5	9	2	16	5	2	2	
Visual-Motor Integration standard score	4	5	6	4	7	5	4	4	
Gross Motor Quotient sum of standard scores	13	16	25	11	15	14	14	9	
Gross Motor Quotient quotient score	64	70	89	59	68	66	66	55	

PDMS-2 data by participant at Assessment 1 continued

	Participant								
Variable	**102**	**103**	**104**	**105**	**106**	**201**	**203**	**204**	**205**
Gross Motor Quotient percentile	0	2	23	0	1	1	1	0	
Fine Motor Quotient sum of standard scores	6	10	14	7	12	10	10	7	
Fine Motor Quotient quotient score	58	70	82	61	76	70	70	61	
Fine Motor Quotient percentile	0	2	12	0	5	2	2	0	
Total Motor Quotient sum of standard scores	19	26	39	18	27	24	24	16	
Total Motor Quotient quotient score	58	67	85	56	68	64	64	53	
Total Motor Quotient percentile	0	1	16	0	1	0	0	0	

PDMS-2 data by participant at Assessment 2

	Participant								
Variable	**102**	**103**	**104**	**105**	**106**	**201**	**203**	**204**	**205**
Age (Months)	56	53	51	57	58	52	57	55	53
Stationary raw score	40	40	52	39	44	38	41	38	43
Stationary age equivalent (months)	28	28	53	21	38	18	33	18	37
Stationary percentile	2	5	50	2	9	2	5	2	9
Stationary standard score	4	5	10	4	6	4	5	4	6
Locomotor raw score	123	130	169	138	154	123	122	101	140
Locomotor age equivalent (months)	30	33	57	36	46	30	29	22	37
Locomotor percentile	2	5	63	5	16	5	2	1	9
Locomotor standard score	4	5	11	5	7	5	4	3	6
Object Manipulation raw score	27	29	34	17	36	24	21	10	29
Object Manipulation age equivalent (months)	32	34	40	22	43	28	25	16	34
Object Manipulation percentile	5	9	16	2	16	5	5	0	9
Object Manipulation standard score	5	6	7	4	7	5	5	2	6
Grasping raw score	44	47	51	42	47	45	46	43	46
Grasping age equivalent (months)	34	43	63	20	43	37	40	28	40
Grasping percentile	2	16	63	1	16	5	9	1	9
Grasping standard score	4	7	11	3	7	5	6	3	6
Visual-Motor Integration raw score	97	113	121	98	130	119	91	99	128
Visual-Motor Integration age equivalent (months)	25	36	41	26	50	40	23	27	48
Visual-Motor Integration percentile	2	5	9	2	25	9	1	2	37
Visual-Motor Integration standard score	4	5	6	4	8	6	3	4	9
Gross Motor Quotient sum of standard scores	13	16	28	13	20	14	14	9	18
Gross Motor Quotient quotient score	64	70	96	64	79	66	66	55	74

PDMS-2 data by participant at Assessment 2 continued

	Participant								
Variable	**102**	**103**	**104**	**105**	**106**	**201**	**203**	**204**	**205**
Gross Motor Quotient percentile	0	2	39	0	8	1	1	0	4
Fine Motor Quotient sum of standard scores	8	12	17	7	15	11	9	7	15
Fine Motor Quotient quotient score	64	76	91	61	85	73	67	61	85
Fine Motor Quotient percentile	0	5	27	0	16	3	1	0	16
Total Motor Quotient sum of standard scores	21	28	45	20	35	25	23	16	33
Total Motor Quotient quotient score	60	70	93	59	79	66	63	53	77
Total Motor Quotient percentile	0	2	32	0	8	1	0	0	6

PDMS-2 data by participant at Assessment 3

	Participant								
Variable	**102**	**103**	**104**	**105**	**106**	**201**	**203**	**204**	**205**
Age (Months)	58	55	53	59	60	55	59	57	55
Stationary raw score	46	45	54	39	45	45	43	38	45
Stationary age equivalent (months)	41	40	58	21	40	40	37	18	40
Stationary percentile	16	9	63	2	9	9	5	2	9
Stationary standard score	7	6	11	4	6	6	5	4	6
Locomotor raw score	137	150	171	142	160	144	128	108	152
Locomotor age equivalent (months)	36	44	61	38	50	39	32	24	45
Locomotor percentile	5	9	75	9	16	9	5	2	16
Locomotor standard score	5	6	12	6	7	6	5	4	7
Object Manipulation raw score	25	31	37	24	33	28	23	18	40
Object Manipulation age equivalent (months)	29	37	44	28	39	33	27	23	48
Object Manipulation percentile	5	9	25	5	9	9	5	2	25
Object Manipulation standard score	5	6	8	5	6	6	5	4	8
Grasping raw score	43	48	51	42	50	49	46	43	47
Grasping age equivalent (months)	28	46	63	20	55	49	40	28	43
Grasping percentile	1	25	63	1	37	37	9	1	16
Grasping standard score	3	8	11	3	9	9	6	3	7
Visual-Motor Integration raw score	90	123	121	92	141	126	102	107	141
Visual-Motor Integration age equivalent (months)	22	42	41	23	72	46	28	31	72
Visual-Motor Integration percentile	1	9	9	2	84	16	2	5	91
Visual-Motor Integration standard score	3	6	6	4	13	7	4	5	14
Gross Motor Quotient sum of standard scores	17	18	31	15	19	18	15	12	21
Gross Motor Quotient quotient score	72	74	102	68	76	74	68	61	81
Gross Motor Quotient percentile	3	4	55	1	5	4	1	0	10

PDMS-2 data by participant at Assessment 3 continued

	Participant								
Variable	**102**	**103**	**104**	**105**	**106**	**201**	**203**	**204**	**205**
Fine Motor Quotient sum of standard scores	6	14	17	7	22	16	10	8	21
Fine Motor Quotient quotient score	58	82	91	61	106	88	70	64	103
Fine Motor Quotient percentile	0	12	27	0	65	21	2	0	58
Total Motor Quotient sum of standard scores	23	32	48	22	41	34	25	20	42
Total Motor Quotient quotient score	63	75	97	62	88	78	66	59	89
Total Motor Quotient percentile	0	5	42	0	21	7	1	0	23

PDMS-2 data by participant at Assessment 4

Participant									
Variable	**102**	**103**	**104**	**105**	**106**	**201**	**203**	**204**	**205**
Age (Months)						56	61	59	56
Stationary raw score						45	41	38	46
Stationary age equivalent (months)						40	33	18	41
Stationary percentile						9	2	2	16
Stationary standard score						6	4	4	7
Locomotor raw score						146	131	99	155
Locomotor age equivalent (months)						40	33	22	47
Locomotor percentile						9	5	1	16
Locomotor standard score						6	5	3	7
Object Manipulation raw score						33	21	15	34
Object Manipulation age equivalent (months)						39	25	21	40
Object Manipulation percentile						9	5	1	9
Object Manipulation standard score						6	5	3	6
Grasping raw score						49	46	42	47
Grasping age equivalent (months)						49	40	20	43
Grasping percentile						37	5	1	16
Grasping standard score						9	5	3	7
Visual-Motor Integration raw score						125	97	95	137
Visual-Motor Integration age equivalent (months)						44	25	24	62
Visual-Motor Integration percentile						16	2	2	63
Visual-Motor Integration standard score						7	4	4	11
Gross Motor Quotient sum of standard scores						18	14	10	20
Gross Motor Quotient quotient score						74	66	57	79
Gross Motor Quotient percentile						4	1	0	8

PDMS-2 data by participant at Assessment 4 continued

	Participant								
Variable	**102**	**103**	**104**	**105**	**106**	**201**	**203**	**204**	**205**
Fine Motor Quotient sum of standard scores						16	9	7	18
Fine Motor Quotient quotient score						88	67	61	94
Fine Motor Quotient percentile						21	1	0	35
Total Motor Quotient sum of standard scores						34	23	17	38
Total Motor Quotient quotient score						78	63	55	83
Total Motor Quotient percentile						7	0	0	13

MABC-2 data by participant at Assessment 1

Variable	Participant								
	102	103	104	105	106	201	203	204	205
Manual Dexterity Task 1 standard score	1	2	4	2	6	7	1	1	
Manual Dexterity Task 2 standard score	1	1	7	1	4	8	1	1	
Manual Dexterity Task 3 standard score	1	4	1	1	1	5	1	1	
Manual Dexterity total component score	3	7	12	4	11	20	3	3	
Manual Dexterity total standard score	1	2	3	2	3	6	1	1	
Manual Dexterity total percentile score	0.1	0.5	1	0.5	1	9	0.1	0.1	
Aiming & Catching Task 1 standard score	17	5	8	3	7	6	3	3	
Aiming & Catching Task 2 standard score	11	6	5	4	6	8	4	5	
Aiming & Catching total component score	28	11	13	7	13	14	7	8	
Aiming & Catching total standard score	15	5	6	2	6	7	2	2	
Aiming & Catching total percentile score	95	5	9	0.5	9	16	0.5	0.5	
Balance Task 1 standard score	5	5	7	3	3	6	3	5	
Balance Task 2 standard score	3	3	4	3	4	3	3	3	
Balance Task 3 standard score	2	2	3	1	6	2	3	3	
Balance total component score	10	10	14	7	13	11	9	11	
Balance total standard score	2	2	4	1	4	3	2	3	
Balance total percentile score	0.5	0.5	2	0.1	2	1	0.5	1	
Test Total component Score	41	28	39	18	37	45	19	22	
Test Total standard Score	3	1	3	1	2	4	1	1	
Test Total percentile Score	1	0.1	1	0.1	0.5	2	0.1	0.1	

MABC-2 data by participant at Assessment 2

Variable	Participant								
	102	103	104	105	106	201	203	204	205
Manual Dexterity Task 1 standard score	3	3	11	7	9	7	1	1	6
Manual Dexterity Task 2 standard score	1	1	9	1	4	8	1	1	6
Manual Dexterity Task 3 standard score	1	5	7	1	1	6	1	1	5
Manual Dexterity total component score	5	9	27	9	14	21	3	3	17
Manual Dexterity total standard score	2	3	9	3	4	6	1	1	5
Manual Dexterity total percentile score	0.5	1	37	1	2	9	0.1	0.1	5
Aiming & Catching Task 1 standard score	9	6	12	3	9	5	3	3	5
Aiming & Catching Task 2 standard score	6	8	9	4	6	7	4	4	9
Aiming & Catching total component score	15	14	21	7	15	12	7	7	14
Aiming & Catching total standard score	8	7	11	2	8	5	2	2	7
Aiming & Catching total percentile score	25	16	63	0.5	25	5	0.5	0.5	16
Balance Task 1 standard score	3	5	14	3	6	5	4	3	6
Balance Task 2 standard score	3	3	9	3	3	7	3	3	7
Balance Task 3 standard score	1	4	12	3	12	4	1	3	12
Balance total component score	7	12	35	9	21	16	8	9	25
Balance total standard score	1	3	12	2	6	5	1	2	8
Balance total percentile score	0.1	1	75	0.5	9	5	0.1	0.5	25
Test Total component Score	27	35	83	25	50	49	18	19	56
Test Total standard Score	1	2	11	1	5	4	1	1	5
Test Total percentile Score	0.1	0.5	63	0.1	5	2	0.1	0.1	5

MABC-2 data by participant at Assessment 3

Variable	Participant								
	102	**103**	**104**	**105**	**106**	**201**	**203**	**204**	**205**
Manual Dexterity Task 1 standard score	2	4	13	9	17	9	6	3	8
Manual Dexterity Task 2 standard score	1	1	11	1	11	9	1	1	10
Manual Dexterity Task 3 standard score	1	1	7	1	1	1	1	1	1
Manual Dexterity total component score	4	6	31	11	29	19	8	5	19
Manual Dexterity total standard score	2	2	11	3	10	6	2	2	6
Manual Dexterity total percentile score	0.5	0.5	63	1	50	9	0.5	0.5	9
Aiming & Catching Task 1 standard score	10	3	11	3	10	8	3	3	8
Aiming & Catching Task 2 standard score	10	6	9	4	8	10	4	8	10
Aiming & Catching total component score	20	9	20	7	18	18	7	11	18
Aiming & Catching total standard score	10	3	10	2	9	9	2	5	9
Aiming & Catching total percentile score	50	1	50	0.5	37	37	0.5	5	37
Balance Task 1 standard score	5	5	14	3	4	6	4	5	6
Balance Task 2 standard score	4	4	9	3	1	4	7	3	9
Balance Task 3 standard score	1	12	12	4	12	12	1	12	12
Balance total component score	10	21	35	10	17	22	12	20	27
Balance total standard score	2	6	12	2	5	6	3	6	8
Balance total percentile score	0.5	9	75	0.5	5	9	1	9	25
Test Total component Score	34	36	86	28	64	59	27	36	64
Test Total standard Score	2	2	12	1	7	6	1	2	7
Test Total percentile Score	0.5	0.5	75	0.1	16	9	0.1	0.5	16

MABC-2 data by participant at Assessment 4

Variable	Participant								
	102	103	104	105	106	201	203	204	205
Manual Dexterity Task 1 standard score						9	6	1	8
Manual Dexterity Task 2 standard score						10	5	1	8
Manual Dexterity Task 3 standard score						1	1	1	1
Manual Dexterity total component score						20	12	3	17
Manual Dexterity total standard score						6	3	1	5
Manual Dexterity total percentile score						9	1	0.1	5
Aiming & Catching Task 1 standard score						8	7	3	5
Aiming & Catching Task 2 standard score						6	1	4	8
Aiming & Catching total component score						14	8	7	13
Aiming & Catching total standard score						7	2	2	6
Aiming & Catching total percentile score						16	0.5	0.5	9
Balance Task 1 standard score						6	3	3	5
Balance Task 2 standard score						4	1	3	8
Balance Task 3 standard score						6	4	4	12
Balance total component score						16	8	10	25
Balance total standard score						5	1	2	8
Balance total percentile score						5	0.1	0.5	25
Test Total component Score						50	28	20	55
Test Total standard Score						5	1	1	5
Test Total percentile Score						5	0.1	0.1	5

VABS-2 data by participant at Assessment 1

Variable	Participant								
	102	103	104	105	106	201	203	204	205
Receptive raw score	22	18	20	21	31	28	10	20	
Receptive v-Scale score	10	8	9	9	14	13	5	9	
Receptive Adaptive Level	2	1	1	1	3	3	1	1	
Receptive Age Equivalent (Years-Months)	1-10	1-6	1-7	1-9	3-11	2-11	0-11	1-7	
Expressive raw score	59	52	59	33	69	55	44	31	
Expressive v-Scale score	10	10	11	7	12	11	8	7	
Expressive Adaptive Level	2	2	2	1	2	2	1	1	
Expressive Age Equivalent (Years-Months)	2-7	2-4	2-7	1-10	3-2	2-6	2-1	1-8	
Written raw score	5	12	0	3	17	7	17	6	
Written v-Scale score	13	18	9	11	20	15	20	13	
Written Adaptive Level	3	4	1	2	4	3	4	3	
Written Age Equivalent (Years-Months)	3-5	4-11	1-10	2-9	5-8	4-2	5-8	3-10	
Communication	33	36	29	27	46	39	33	29	
Communication standard score	76	81	67	63	100	87	76	67	
Communication percentile score	5	10	1	1	50	19	5	1	
Communication Adaptive Level	2	2	1	1	3	3	2	1	
Personal raw score	16	33	45	39	49	36	42	30	
Personal v-Scale score	7	9	13	10	13	10	11	8	
Personal Adaptive Level	1	1	3	2	3	2	2	1	
Personal Age Equivalent (Years-Months)	1-6	2-6	3-3	2-10	3-7	2-9	3-1	2-4	
Domestic raw score	8	0	8	13	5	11	8	4	
Domestic v-Scale score	13	8	13	16	11	15	13	10	
Domestic Adaptive Level	3	1	3	3	2	3	3	2	
Domestic Age Equivalent (Years-Months)	2-11	0-7	2-11	4-11	2-2	4-6	2-11	1-10	

VABS-2 data by participant at Assessment 1 Continued

Variable	Participant								
	102	**103**	**104**	**105**	**106**	**201**	**203**	**204**	**205**
Community raw score	16	4	4	14	11	16	16	7	
Community v-Scale score	14	9	9	13	11	15	14	9	
Community Adaptive Level	3	1	1	3	2	3	3	1	
Community Age Equivalent (Years-Months)	3-10	1-6	1-6	3-6	3-1	3-10	3-10	2-3	
Daily Living Skills v-scale score	34	26	35	39	35	40	38	27	
Daily Living Skills standard score	77	60	79	87	79	89	85	62	
Daily Living Skills percentile score	6	0	8	19	8	23	16	1	
Daily Living Skills Adaptive Level	2	1	2	3	2	3	2	1	
Interpersonal raw score	31	9	34	39	31	20	18	23	
Interpersonal v-Scale score	9	5	11	12	9	7	7	8	
Interpersonal Adaptive Level	1	1	2	2	1	1	1	1	
Interpersonal Age Equivalent (Years-Months)	1-9	0-1	2-2	2-7	1-9	0-7	0-6	0-9	
Play and Leisure Time raw score	20	6	16	32	14	6	12	6	
Play and Leisure Time v-Scale score	10	7	9	13	8	7	8	6	
Play and Leisure Time Adaptive Level	2	1	1	3	1	1	1	1	
Play and Leisure Time Age Equivalent (Years-Months)	1-11	0-7	1-5	3-6	1-3	0-7	1-1	0-7	
Coping raw score	13	8	16	20	21	20	31	2	
Coping v-Scale score	11	10	13	13	14	14	17	7	
Coping Adaptive Level	2	2	3	3	3	3	3	1	
Coping Age Equivalent (Years-Months)	2-5	1-10	2-10	3-5	3-7	3-5	5-7	0-4	
Socialization V-scale score	30	22	33	38	31	28	32	21	

VABS-2 data by participant at Assessment 1 Continued

Variable	Participant								
	102	**103**	**104**	**105**	**106**	**201**	**203**	**204**	**205**
Socialization standard score	72	57	77	86	74	68	75	55	
Socialization percentile score	3	0	6	18	4	2	5	0	
Socialization Adaptive Level	2	1	2	3	2	1	2	1	
Gross Motor raw score	71	54	55	73	72	50	52	58	
Gross Motor v-Scale score	13	10	10	14	13	9	9	10	
Gross Motor Adaptive Level	3	2	2	3	3	1	1	2	
Gross Motor Age Equivalent (Years-Months)	3-9	2-1	2-2	3-11	3-10	1-10	2-0	2-4	
Fine Motor raw score	36	22	30	32	36	20	20	25	
Fine Motor v-Scale score	11	8	11	10	11	7	7	8	
Fine Motor Adaptive Level	2	1	2	2	2	1	1	1	
Fine Motor Age Equivalent (Years-Months)	3-2	1-11	2-8	2-10	3-2	1-8	1-8	2-2	
Motor Skills V-scale score	24	18	21	24	24	16	16	18	
Motor Skills standard score	81	64	72	81	81	59	59	64	
Motor Skills percentile score	10	1	3	10	10	0	0	1	
Motor Skills Adaptive Level	2	1	2	2	2	1	1	1	
Adaptive Behavior Composite sum of raw scores	306	262	295	317	334	303	295	248	
Adaptive Behavior Composite standard score	73	63	70	76	80	72	70	59	
Adaptive Behavior Composite percentile score	4	1	2	5	9	3	2	0	
Adaptive Behavior Composite Adaptive Level	2	1	1	2	2	2	1	1	

VABS-2 data by participant at Assessment 1 Continued

Variable	Participant							
	102	**103**	**104**	**105**	**106**	**201**	**203**	**204**	**205**
Internalizing raw score	1	7	5	6	6	10	7	6	
Internalizing v-Scale score	15	20	19	19	19	21	20	19	
Internalizing Adaptive Level	1	2	2	2	2	3	2	2	
Externalizing raw score	3	10	15	4	4	7	5	13	
Externalizing v-Scale score	15	19	22	16	16	18	17	21	
Externalizing Adaptive Level	1	2	3	1	1	2	1	3	
Other raw score	7	11	10	4	5	7	9	13	
Maladaptive Behavior raw score	11	28	30	14	15	24	21	32	
Maladaptive Behavior v-Scale score	17	21	21	18	18	20	19	22	
Maladaptive Behavior Adaptive Level	1	3	3	2	2	2	2	3	

VABS-2 data by participant at Assessment 2

Variable	Participant								
	102	103	104	105	106	201	203	204	205
Receptive raw score	26	19	21	21	27	25	28	12	33
Receptive v-Scale score	11	8	9	9	12	11	13	6	16
Receptive Adaptive Level	2	1	1	1	2	2	3	1	3
Receptive Age Equivalent (Years-Months)	2-6	1-6	1-9	1-9	2-10	2-5	2-11	1-1	4-11
Expressive raw score	57	54	67	32	62	65	69	23	69
Expressive v-Scale score	10	10	12	7	10	11	11	6	12
Expressive Adaptive Level	2	2	2	1	2	2	2	1	2
Expressive Age Equivalent (Years-Months)	2-6	2-6	2-11	1-9	2-10	2-10	3-2	1-4	3-2
Written raw score	8	12	0	4	20	16	22	6	24
Written v-Scale score	13	17	9	11	20	19	22	13	24
Written Adaptive Level	3	3	1	2	4	4	5	3	5
Written Age Equivalent (Years-Months)	4-3	4-11	1-10	3-1	6-0	5-6	6-5	3-10	6-9
Communication	34	35	30	27	42	41	46	25	52
Communication standard score	78	79	69	63	93	91	100	59	112
Communication percentile score	7	8	2	1	32	27	50	0	79
Communication Adaptive Level	2	2	1	1	3	3	3	1	3
Personal raw score	30	25	33	40	56	45	51	30	48
Personal v-Scale score	8	8	9	10	14	12	12	8	12
Personal Adaptive Level	1	1	1	2	3	2	2	1	2
Personal Age Equivalent (Years-Months)	2-4	2-1	2-6	2-11	4-5	3-3	3-10	2-4	3-6
Domestic raw score	13	0	5	9	4	17	13	4	10
Domestic v-Scale score	15	8	11	13	10	17	15	10	14
Domestic Adaptive Level	3	1	2	3	2	3	3	2	3
Domestic Age Equivalent (Years-Months)	4-11	0-7	2-2	3-5	1-10	6-5	4-11	1-10	3-11

VABS-2 data by participant at Assessment 2 Continued

Variable	Participant								
	102	103	104	105	106	201	203	204	205
Community raw score	15	9	6	12	7	15	18	5	20
Community v-Scale score	13	10	9	11	8	13	14	9	15
Community Adaptive Level	3	2	1	2	1	3	3	1	3
Community Age Equivalent (Years-Months)	3-7	2-6	2-2	3-2	2-3	3-7	4-2	1-10	4-6
Daily Living Skills v-scale score	36	26	29	34	32	42	41	27	41
Daily Living Skills standard score	81	60	66	77	73	93	91	62	91
Daily Living Skills percentile score	10	0	1	6	4	32	27	1	27
Daily Living Skills Adaptive Level	2	1	1	2	2	3	3	1	3
Interpersonal raw score	34	21	28	36	25	33	34	23	52
Interpersonal v-Scale score	10	7	8	11	8	10	10	8	15
Interpersonal Adaptive Level	2	1	1	2	1	2	2	1	3
Interpersonal Age Equivalent (Years-Months)	2-2	0-7	1-5	2-4	1-1	2-0	2-2	0-9	4-8
Play and Leisure Time raw score	19	5	13	24	17	7	5	11	33
Play and Leisure Time v-Scale score	9	6	8	10	8	7	6	7	13
Play and Leisure Time Adaptive Level	1	1	1	2	1	1	1	1	3
Play and Leisure Time Age Equivalent (Years-Months)	1-10	0-6	1-2	2-6	1-6	0-8	0-6	1-0	3-7
Coping raw score	11	5	16	17	6	21	37	3	25
Coping v-Scale score	11	8	12	13	9	14	18	8	15
Coping Adaptive Level	2	1	2	3	1	3	4	1	3
Coping Age Equivalent (Years-Months)	2-2	1-1	2-10	2-11	1-6	3-7	7-5	0-7	4-7
Socialization V-scale score	30	21	28	34	25	31	34	23	43

VABS-2 data by participant at Assessment 2 Continued

Variable	Participant								
	102	103	104	105	106	201	203	204	205
Socialization standard score	72	55	68	79	63	74	79	59	95
Socialization percentile score	3	0	2	8	1	4	8	0	37
Socialization Adaptive Level	2	1	1	2	1	2	2	1	3
Gross Motor raw score	70	45	70	76	78	50	65	61	72
Gross Motor v-Scale score	12	8	13	15	18	9	11	10	13
Gross Motor Adaptive Level	2	1	3	3	4	1	2	2	3
Gross Motor Age Equivalent (Years-Months)	3-6	1-6	3-6	4-11	5-11	1-10	2-11	2-6	3-10
Fine Motor raw score	41		26	29	48	20	57	22	53
Fine Motor v-Scale score	12		9	9	13	7	16	7	16
Fine Motor Adaptive Level	2		1	1	3	1	3	1	3
Fine Motor Age Equivalent (Years-Months)	3-9		2-3	2-6	4-3	1-8	5-1	1-11	4-9
Motor Skills V-scale score	24		22	24	31	16	27	17	29
Motor Skills standard score	81		75	81	104	59	91	61	97
Motor Skills percentile score	10		5	10	61	0	27	0	42
Motor Skills Adaptive Level	2		2	2	3	1	3	1	3
Adaptive Behavior Composite sum of raw scores	312		278	300	333	317	361	241	395
Adaptive Behavior Composite standard score	74		66	71	80	76	88	58	98
Adaptive Behavior Composite percentile score	4		1	3	9	5	21	0	45
Adaptive Behavior Composite Adaptive Level	2		1	2	2	2	3	1	3

VABS-2 data by participant at Assessment 2 Continued

Variable	**Participant**								
	102	**103**	**104**	**105**	**106**	**201**	**203**	**204**	**205**
Internalizing raw score	1	7	12	4	18	10	7	10	4
Internalizing v-Scale score	15	20	22	18	24	21	20	21	18
Internalizing Adaptive Level	1	2	3	2	3	3	2	3	2
Externalizing raw score	2	4	17	3	10	10	5	15	2
Externalizing v-Scale score	14	16	24	15	19	19	17	22	14
Externalizing Adaptive Level	1	1	3	1	2	2	1	3	1
Other raw score	9	12	7	2	6	13	9	14	5
Maladaptive Behavior raw score	12	23	36	9	34	33	21	39	11
Maladaptive Behavior v-Scale score	17	20	23	16	22	22	19	23	17
Maladaptive Behavior Adaptive Level	1	2	3	1	3	3	2	3	1

VABS-2 data by participant at Assessment 3

Variable	Participant								
	102	103	104	105	106	201	203	204	205
Receptive raw score	26	14		31	29	27	27		32
Receptive v-Scale score	11	7		14	12	12	12		15
Receptive Adaptive Level	2	1		3	2	62	2		3
Receptive Age Equivalent (Years-Months)	2-6	1-3		3-11	3-5	11	2-10		4-7
Expressive raw score	69	55		50	63	9	62		73
Expressive v-Scale score	11	10		9	10	15	10		13
Expressive Adaptive Level	2	2		1	2	38	2		3
Expressive Age Equivalent (Years-Months)	3-2	2-6		2-3	2-10	85	2-10		3-3
Written raw score	7	9		8	21	16	21		26
Written v-Scale score	13	15		13	20	51	21		24
Written Adaptive Level	3	3		3	4	13	5		5
Written Age Equivalent (Years-Months)	4-2	4-5		4-3	6-1	12	6-1		6-11
Communication	35	32		36	42	15	43		52
Communication standard score	79	74		81	93	16	95		112
Communication percentile score	8	4		10	32	14	37		79
Communication Adaptive Level	2	2		2	3	42	3		3
Personal raw score	35	7		43	58	93	49		54
Personal v-Scale score	9	5		10	14	32	12		14
Personal Adaptive Level	1	1		2	3	36	2		3
Personal Age Equivalent (Years-Months)	2-8	0-8		3-2	4-7	11	3-7		4-1
Domestic raw score	10	0		16	10	19	20		16
Domestic v-Scale score	14	8		17	13	9	18		17
Domestic Adaptive Level	3	1		3	3	17	4		3
Domestic Age Equivalent (Years-Months)	3-11	0-7		5-11	3-11	13	7-5		5-11

VABS-2 data by participant at Assessment 3 Continued

Variable	Participant								
	102	103	104	105	106	201	203	204	205
Community raw score	14	8		14	13	33	19		30
Community v-Scale score	12	10		12	11	77	14		18
Community Adaptive Level	2	2		2	2	6	3		4
Community Age Equivalent (Years-Months)	3-6	2-5		3-6	3-5	76	4-5		5-10
Daily Living Skills v-scale score	35	23		39	38	16	44		49
Daily Living Skills standard score	79	53		87	85	49	97		107
Daily Living Skills percentile score	8	0		19	16	15	42		68
Daily Living Skills Adaptive Level	2	1		3	2	31	3		3
Interpersonal raw score	34	11		37	37	104	38		49
Interpersonal v-Scale score	10	5		11	10	61	11		14
Interpersonal Adaptive Level	2	1		2	2	359	2		3
Interpersonal Age Equivalent (Years-Months)	2-2	0-2		2-5	2-5	87	2-6		3-11
Play and Leisure Time raw score	19	3		34	15	19	19		33
Play and Leisure Time v-Scale score	9	5		13	7	15	9		13
Play and Leisure Time Adaptive Level	1	1		3	1	24	1		3
Play and Leisure Time Age Equivalent (Years-Months)	1-10	0-2		3-10	1-4	13	1-10		3-7
Coping raw score	16	9		26	1	21	30		27
Coping v-Scale score	12	10		15	7	10	16		15
Coping Adaptive Level	2	2		3	1	38	3		3
Coping Age Equivalent (Years-Months)	2-10	1-11		4-7	0-1	23	5-6		4-8
Socialization V-scale score	31	20		39	24	27	36		42

VABS-2 data by participant at Assessment 3 Continued

Variable	Participant								
	102	103	104	105	106	201	203	204	205
Socialization standard score	74	53		88	61	12	83		94
Socialization percentile score	4	0		21	0	62	13		34
Socialization Adaptive Level	2	1		2	1	11	2		3
Gross Motor raw score	71	51		75	78	9	75		74
Gross Motor v-Scale score	13	9		15	17	15	15		15
Gross Motor Adaptive Level	3	1		3	3	38	3		3
Gross Motor Age Equivalent (Years-Months)	3-9	1-11		4-7	5-11	85	4-7		4-5
Fine Motor raw score	39	29		32	42	16	43		53
Fine Motor v-Scale score	11	9		10	12	51	12		16
Fine Motor Adaptive Level	2	1		2	2	13	2		3
Fine Motor Age Equivalent (Years-Months)	3-6	2-6		2-10	3-10	12	3-10		4-9
Motor Skills V-scale score	24	18		25	29	15	27		31
Motor Skills standard score	81	64		84	97	16	91		104
Motor Skills percentile score	10	1		14	42	14	27		61
Motor Skills Adaptive Level	2	1		2	3	42	3		3
Adaptive Behavior Composite sum of raw scores	313	244		340	336	93	366		417
Adaptive Behavior Composite standard score	75	58		82	81	32	89		105
Adaptive Behavior Composite percentile score	5	0		12	10	36	23		63
Adaptive Behavior Composite Adaptive Level	2	1		2	2	11	3		3

VABS-2 data by participant at Assessment 3 Continued

Variable	Participant								
	102	**103**	**104**	**105**	**106**	**201**	**203**	**204**	**205**
Internalizing raw score	1	12		1	18	19	9		4
Internalizing v-Scale score	15	22		15	24	9	21		18
Internalizing Adaptive Level	1	3		1	3	17	3		2
Externalizing raw score	3	5		2	10	13	7		1
Externalizing v-Scale score	15	17		15	19	33	18		13
Externalizing Adaptive Level	1	1		1	2	77	2		1
Other raw score	6	10		4	6	6	8		3
Maladaptive Behavior raw score	10	27		8	34	76	24		8
Maladaptive Behavior v-Scale score	16	21		16	22	16	20		16
Maladaptive Behavior Adaptive Level	1	3		1	3	49	2		1

VABS-2 data by participant at Assessment 4

Variable	Participant								
	102	103	104	105	106	201	203	204	205
Receptive raw score						32	28		34
Receptive v-Scale score						15	12		16
Receptive Adaptive Level						3	2		3
Receptive Age Equivalent (Years-Months)						4-7	2-11		5-6
Expressive raw score						51	66		69
Expressive v-Scale score						9	10		11
Expressive Adaptive Level						1	2		2
Expressive Age Equivalent (Years-Months)						2-3	2-10		3-2
Written raw score						10	24		27
Written v-Scale score						14	21		23
Written Adaptive Level						3	5		5
Written Age Equivalent (Years-Months)						4-6	6-9		7-0
Communication						38	43		50
Communication standard score						85	95		108
Communication percentile score						16	37		70
Communication Adaptive Level						2	3		3
Personal raw score						53	52		55
Personal v-Scale score						13	12		13
Personal Adaptive Level						3	2		3
Personal Age Equivalent (Years-Months)						4-0	3-11		4-2
Domestic raw score						8	23		18
Domestic v-Scale score						13	19		17
Domestic Adaptive Level						3	4		3
Domestic Age Equivalent (Years-Months)						2-11	8-0		6-6

VABS-2 data by participant at Assessment 4 Continued

Variable	Participant								
	102	**103**	**104**	**105**	**106**	**201**	**203**	**204**	**205**
Community raw score						15	28		28
Community v-Scale score						13	17		17
Community Adaptive Level						3	3		3
Community Age Equivalent (Years-Months)						3-7	5-9		5-9
Daily Living Skills v-scale score						39	48		47
Daily Living Skills standard score						87	105		103
Daily Living Skills percentile score						19	63		58
Daily Living Skills Adaptive Level						3	3		3
Interpersonal raw score						37	35		56
Interpersonal v-Scale score						11	10		16
Interpersonal Adaptive Level						2	2		3
Interpersonal Age Equivalent (Years-Months)						2-5	2-3		5-7
Play and Leisure Time raw score						16	17		35
Play and Leisure Time v-Scale score						8	8		14
Play and Leisure Time Adaptive Level						1	1		3
Play and Leisure Time Age Equivalent (Years-Months)						1-5	1-6		3-11
Coping raw score						21	21		24
Coping v-Scale score						14	13		15
Coping Adaptive Level						3	3		3
Coping Age Equivalent (Years-Months)						3-7	3-7		4-6
Socialization V-scale score						33	31		45

VABS-2 data by participant at Assessment 4 Continued

Variable	**Participant**								
	102	**103**	**104**	**105**	**106**	**201**	**203**	**204**	**205**
Socialization standard score						77	74		100
Socialization percentile score						6	4		50
Socialization Adaptive Level						2	2		3
Gross Motor raw score						72	73		75
Gross Motor v-Scale score						13	13		15
Gross Motor Adaptive Level						3	3		3
Gross Motor Age Equivalent (Years-Months)						3-10	3-11		4-7
Fine Motor raw score						58	57		63
Fine Motor v-Scale score						16	15		18
Fine Motor Adaptive Level						3	3		4
Fine Motor Age Equivalent (Years-Months)						5-2	5-1		5-8
Motor Skills V-scale score						29	28		33
Motor Skills standard score						97	94		111
Motor Skills percentile score						42	34		77
Motor Skills Adaptive Level						3	3		3
Adaptive Behavior Composite sum of raw scores						346	368		422
Adaptive Behavior Composite standard score						84	90		106
Adaptive Behavior Composite percentile score						14	25		66
Adaptive Behavior Composite Adaptive Level						2	3		3

VABS-2 data by participant at Assessment 4 Continued

Variable	**Participant**								
	102	**103**	**104**	**105**	**106**	**201**	**203**	**204**	**205**
Internalizing raw score						11	11		1
Internalizing v-Scale score						22	22		15
Internalizing Adaptive Level						3	3		1
Externalizing raw score						8	7		0
Externalizing v-Scale score						18	18		11
Externalizing Adaptive Level						2	2		1
Other raw score						8	7		4
Maladaptive Behavior raw score						27	25		5
Maladaptive Behavior v-Scale score						21	20		14
Maladaptive Behavior Adaptive Level						3	2		1

SSIS data by participant at Assessment 1

Variable	Participant								
	102	**103**	**104**	**105**	**106**	**201**	**203**	**204**	**205**
Communication raw score	12	6	14	12	15	9	10	6	
Communication behaviour level	2	1	2	2	2	1	1	1	
Cooperation raw score	9	3	6	12	11	9	10	3	
Cooperation behaviour level	2	1	1	2	2	2	2	1	
Assertion raw score	3	2	13	8	9	13	6	5	
Assertion behaviour level	1	1	2	1	1	2	1	1	
Responsibility raw score	1	5	1	9	8	7	10	4	
Responsibility behaviour level	1	1	1	2	1	2	2	1	
Empathy raw score	6	1	8	15	3	7	8	1	
Empathy behaviour level	1	1	2	2	1	1	2	1	
Engagement raw score	7	1	6	10	8	4	5	6	
Engagement behaviour level	1	1	1	2	1	1	1	1	
Self-Control raw score	7	2	2	8	11	4	10	5	
Self-Control behaviour level	2	1	1	2	2	1	2	1	
Social Skills sum of raw scores	45	20	50	74	65	53	59	30	
Social Skills standard score	72	55	75	91	85	77	81	46	
Social Skills percentile score	5	0	7	25	16	8	11	0	
Externalizing raw score	8	18	21	15	7	16	9	23	
Externalizing behaviour level	2	3	3	2	2	3	2	3	
Bullying raw score	2	8	3	4	1	6	4	8	
Bullying behaviour level	2	3	2	2	2	3	2	3	
Hyperactivity raw score	8	16	16	12	9	11	11	19	
Hyperactivity behaviour level	2	3	3	3	2	2	2	3	
Internalizing raw score	1	15	6	8	4	9	5	10	

SSIS data by participant at Assessment 1 Continued

Variable	Participant							
	102	**103**	**104**	**105**	**106**	**201**	**203**	**204**	**205**
Internalizing behaviour level	2	3	2	2	2	2	2	3	
Problem Behaviour sum of raw scores	15	44	38	35	22	41	30	53	
Problem Behaviour standard score	93	125	119	115	101	122	110	147	
Problem Behaviour percentile score	35	93	88	84	56	91	74	100	
Autism Spectrum raw score	16	42	25	17	21	27	26	29	
Autism Spectrum behaviour level	2	3	3	2	3	3	3	3	

SSIS data by participant at Assessment 2

Variable	Participant								
	102	103	104	105	106	201	203	204	205
Communication raw score	9	5	10	11	10	6	10	3	11
Communication behaviour level	1	1	1	2	1	1	1	1	2
Cooperation raw score	9	3	6	10	9	9	11	2	8
Cooperation behaviour level	2	1	1	2	2	2	2	1	2
Assertion raw score	6	2	9	2	9	12	7	2	8
Assertion behaviour level	1	1	1	1	1	2	1	1	1
Responsibility raw score	1	4	2	11	1	3	9	0	6
Responsibility behaviour level	1	1	1	2	1	1	2	1	1
Empathy raw score	6	0	7	12	2	4	8	0	7
Empathy behaviour level	1	1	1	2	1	1	2	1	1
Engagement raw score	6	0	4	8	9	2	3	0	9
Engagement behaviour level	1	1	1	1	1	1	1	1	1
Self-Control raw score	9	1	7	9	7	0	10	1	12
Self-Control behaviour level	2	1	2	2	2	1	2	1	2
Social Skills sum of raw scores	46	15	45	63	47	36	58	8	61
Social Skills standard score	72	52	72	84	73	66	80	40	82
Social Skills percentile score	5	0	5	14	5	2	11	0	13
Externalizing raw score	7	17	22	6	16	13	11	27	8
Externalizing behaviour level	2	3	3	2	3	2	2	3	2
Bullying raw score	3	6	4	0	5	2	5	11	3
Bullying behaviour level	2	3	2	2	3	2	3	3	2
Hyperactivity raw score	9	17	16	7	19	12	11	19	12
Hyperactivity behaviour level	2	3	3	2	3	3	2	3	3
Internalizing raw score	3	14	12	6	9	9	7	11	4

SSIS data by participant at Assessment 2 Continued

Variable	**Participant**								
	102	**103**	**104**	**105**	**106**	**201**	**203**	**204**	**205**
Internalizing behaviour level	2	3	3	2	2	2	2	3	2
Problem Behaviour sum of raw scores	22	50	50	15	45	39	37	59	29
Problem Behaviour standard score	101	132	132	93	126	120	118	155	109
Problem Behaviour percentile score	56	95	95	35	94	89	87	100	72
Autism Spectrum raw score	21	38	25	16	27	34	30	36	24
Autism Spectrum behaviour level	3	3	3	2	3	3	3	3	3

SSIS data by participant at Assessment 3

Variable	Participant								
	102	103	104	105	106	201	203	204	205
Communication raw score	11	9		11	10	14	11		11
Communication behaviour level	2	1		2	1	2	2		2
Cooperation raw score	9	5		9	9	7	12		9
Cooperation behaviour level	2	1		2	2	1	2		2
Assertion raw score	4	3		5	9	11	9		11
Assertion behaviour level	1	1		1	1	2	1		2
Responsibility raw score	4	2		8	1	6	7		9
Responsibility behaviour level	1	1		2	1	1	2		2
Empathy raw score	3	2		9	2	6	8		11
Empathy behaviour level	1	1		2	1	1	2		2
Engagement raw score	12	2		8	9	7	5		10
Engagement behaviour level	2	1		1	1	1	1		2
Self-Control raw score	8	1		6	5	5	9		14
Self-Control behaviour level	2	1		2	1	1	2		2
Social Skills sum of raw scores	51	24		56	45	56	61		75
Social Skills standard score	76	58		79	72	79	82		92
Social Skills percentile score	7	1		9	5	9	13		27
Externalizing raw score	8	15		3	16	21	14		6
Externalizing behaviour level	2	2		2	3	3	2		2
Bullying raw score	3	3		0	5	7	4		1
Bullying behaviour level	2	2		2	3	3	2		2
Hyperactivity raw score	10	16		5	19	14	14		9
Hyperactivity behaviour level	2	3		2	3	3	3		2
Internalizing raw score	0	12		6	9	12	11		3

SSIS data by participant at Assessment 3 Continued

Variable	Participant								
	102	**103**	**104**	**105**	**106**	**201**	**203**	**204**	**205**
Internalizing behaviour level	1	3		2	2	3	3		2
Problem Behaviour sum of raw scores	15	47		16	47	48	44		20
Problem Behaviour standard score	93	129		95	129	130	125		99
Problem Behaviour percentile score	35	94		38	94	95	93		50
Autism Spectrum raw score	15	35		19	27	23	30		20
Autism Spectrum behaviour level	2	3		3	3	3	3		3

SSIS data by participant at Assessment 4

Variable	Participant								
	102	103	104	105	106	201	203	204	205
Communication raw score						14	10		14
Communication behaviour level						2	1		2
Cooperation raw score						13	11		11
Cooperation behaviour level						2	2		2
Assertion raw score						15	8		10
Assertion behaviour level						2	1		2
Responsibility raw score						13	7		9
Responsibility behaviour level						2	2		2
Empathy raw score						11	7		12
Empathy behaviour level						2	1		2
Engagement raw score						7	4		13
Engagement behaviour level						1	1		2
Self-Control raw score						10	11		12
Self-Control behaviour level						2	2		2
Social Skills sum of raw scores						83	58		81
Social Skills standard score						97	80		96
Social Skills percentile score						39	11		36
Externalizing raw score						11	10		6
Externalizing behaviour level						2	2		2
Bullying raw score						3	1		1
Bullying behaviour level						2	2		2
Hyperactivity raw score						9	10		7
Hyperactivity behaviour level						2	2		2
Internalizing raw score						4	10		2

SSIS data by participant at Assessment 4 Continued

Variable	**Participant**								
	102	**103**	**104**	**105**	**106**	**201**	**203**	**204**	**205**
Internalizing behaviour level						2	3		2
Problem Behaviour sum of raw scores						23	35		16
Problem Behaviour standard score						102	115		95
Problem Behaviour percentile score						59	84		38
Autism Spectrum raw score						22	30		14
Autism Spectrum behaviour level						3	3		2

Frequency of social behaviours by participant at the pre-test

	Social Behaviour Code																								
Participant	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**
102	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	4	20	0	0	2	0	0	2	0	12
103	0	0	0	0	0	1	1	3	0	0	0	0	1	2	1	12	7	0	0	1	0	0	4	0	11
104	0	1	0	1	0	0	2	22	0	0	0	0	0	1	0	0	0	0	0	1	0	4	29	0	8
105	0	0	0	0	0	0	0	7	0	2	0	0	1	1	0	1	9	2	0	1	1	1	8	1	14
106	0	0	0	2	0	0	0	8	0	0	0	0	0	1	0	0	13	1	0	1	0	2	5	0	12
201	0	0	0	1	0	0	0	4	0	0	1	3	1	0	0	5	20	0	0	0	0	0	1	1	10
203	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	38	0	0	0	0	0	0	0	2
204	0	0	0	1	0	0	1	3	0	0	0	0	0	0	0	6	7	0	0	1	0	0	3	0	21
205	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	40

Frequency of social behaviours by participant at the post-test

	Social Behaviour Code																								
Participant	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**
102																									
103																									
104	1	6	1	1	1	2	0	13	0	0	0	0	0	0	0	0	1	0	0	0	5	3	32	0	6
105	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	31	0	0	0	1	4	5	0	4
106																									
201	0	0	2	0	0	0	0	8	0	0	0	9	0	1	1	3	5	0	0	0	2	0	2	2	8
203	0	1	0	0	0	0	0	6	0	0	0	0	0	1	0	11	9	0	0	0	2	0	3	0	10
204	1	0	0	1	1	0	0	11	0	1	0	0	0	0	0	3	3	1	0	0	0	1	2	1	17
205	0	0	0	0	1	1	0	14	0	0	0	0	0	2	0	0	18	0	0	0	2	1	5	0	1

Frequency of physical activity behaviours by participant at the pre-test

	Physical Activity Code					
Participant	**1**	**2**	**3**	**4**	**5**	**6**
102	3	16	3	1	1	6
103	0	4	12	8	0	6
104	0	0	17	8	0	5
105	0	1	11	9	1	8
106	0	12	2	9	0	7
201	0	4	13	9	0	4
203	28	0	0	0	0	2
204	1	3	7	4	0	15
205	0	0	0	0	0	30

Frequency of physical activity behaviours by participant at the post-test

	Physical Activity Code					
Participant	**1**	**2**	**3**	**4**	**5**	**6**
102						
103						
104	2	8	8	2	7	3
105	0	27	0	1	0	2
106						
201	0	0	15	9	0	6
203	0	0	13	8	3	6
204	0	0	12	7	0	11
205	0	14	13	2	1	0