2013

The impact of motor skill training on balance, hand-eye coordination and reaction in a group of adults with autism and an intellectual disability

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A Thesis
Submitted to the Faculty of Graduate Studies
through **the Department of Kinesiology**
in Partial Fulfillment of the Requirements for
the Degree of **Masters of Human Kinetics**
at the University of Windsor

Windsor, Ontario, Canada

2013

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ABSTRACT

Individuals with autism and intellectual disability (ID) commonly display motor impairments, and these impairments are positively correlated to intellectual level and autism symptoms. In the present thesis, an intervention involving motor skills training, whole body exercise, sports and games was used to improve balance, fine and gross motor manual control and reaction time in a group of adults with autism and ID. Fine motor skill was measured using the 25 Grooved Pegboard Test, gross motor skill of the upper extremities was measured with the Box and Blocks Test, and reaction time was measured with the Stick Catching Test. Additionally, medial-lateral (ML) and anterior-posterior (AP) displacement and velocity, as well as sway area of each participant's Center of Pressure (COP), were measured using a force platform. Significant fine motor improvement occurred at retention when compared to baseline and gross motor improvement approached statistical significance but only when the sums of both trials at each session were taken. Statistically significant improvements were not found for reaction time testing or for any static balance variables. Future studies should include a control group and assess for hand dominance, repetitive behaviour and sex differences.

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CHAPTER 1

Introduction

ASD is one of the most common pediatric conditions in the United States, with prevalence rates of one in 88 for both sexes and one in 54 for boys (Gentile et al., 2012), and Matson & Kovzlowski (2011) report that the prevalence is rising. Males develop the condition four times as often as females (Belfer, 2008; Filipek et al., 2000) and each year, approximately 36,500 new cases emerge, amounting to a national U.S. total of 730,000 cases in 2009 (Centers for Disease Control, 2009). Costs for the family and society at large can be astronomical. Ganz (2007) estimated that the societal cost for an individual with autistic disorder across his or her lifetime was $3.2 million. The majority of this cost is accounted for by adult care and a loss of productivity for the individuals with autism, as well as their parents (Ganz, 2007).

According to the *Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition* ASD is characterized by deficits in two behavioral domains: 1) social interaction and language communication and 2) range of interests and activities (American Psychiatric Association, 2013). Recently, it has been suggested that motor impairments are widespread within this population, and therefore can justifiably be considered a core symptom of ASD (Fournier, Hass, Naik, Lodha, & Cauraugh, 2010; Bhat, Landa, & Galloway, 2011). ASD is a behaviorally defined syndrome with a wide variety of both genetic and non-genetic causes (Muhle, Trentacoste, & Rapin, 2004). There is no current evidence that ASD is linked exclusively to any particular genetic or non-genetic cause (Muhle et al., 2004; Levy, Mendell, & Schultz, 2009).

Intellectual Disability (ID) is another behaviorally defined neurobiological disorder, which has also been linked to a number of genetic and non-genetic causes (Muhle et al., 2004). Durkin (2002) suggested that the prevalence of severe cognitive disability is often found to lie between 2 and 5 per 1,000 children in developed countries. In developing countries, however, prevalence is more variable and spans from 2.9 children per 1,000 in Beijing to 22 children per 1,000 in the poorest regions of Lahore, Pakistan (Durkin, 2002). Moreover, Islam, Durkin, and Zaman (1993) discuss that low socioeconomic status in developing countries is strongly correlated with severe ID. With the exception of Beijing, China, estimates from low-income countries suggest prevalence rates of ID to be above 5 per 1,000, while those from developed countries suggest prevalence rates lower than 5 per 1,000 (Durkin, 2002). Prevalence rates of mild ID in both developing and developed countries are thought to be even higher than that of severe ID (Durkin, 2002).

Despite these statistics, Jankowicz-Szymanska, Mikolajczyk, and Wojtanowski (2012) argue that the exact prevalence of ID is unknown, due to the absence of epidemiological research in children and adolescents. A diagnosis of ID is given to individuals who demonstrate particularly debilitating difficulties with adaptive and intellectual functioning before 18 years of age (Jankowicz-Szymanska et al., 2012; Matson, Dempsey, LoVullo, & Wilkins, 2008; Matson, Dempsey, & Fodstad, 2009). The four domains that are included in the evaluation of intellectual functioning are communication, daily living skills, social skills, and motor skills (Sparrow & Cicchetti, 1985). The diagnosis will depend upon the extent of disability possessed by an individual in at least two of these four domains.

ID commonly occurs with ASD, with an estimated 25.8% of children diagnosed with ASD also having a diagnosis of ID (Chakrabarti & Fombonne, 2001; Chakrabarti & Fombonne, 2005). Moreover, Chakrabarti and Fombonne (2001; 2005) showed in their study that 70% of children who met the strict criteria for autism disorder had also been given a diagnosis of ID. Furthermore, the severity of ID is positively correlated with the severity of autistic symptoms (Bouras, Holt, Day, & Dosen, 1999; Kraijer, 1997; LaMalfa, Lassi, Bertelli, Salvini, & Placidi, 2004). However, individuals with ASD show greater difficulties with social skills compared to individuals without the condition but with the same level of intellectual functioning (Matson & Shoemaker, 2009).

The presence of motor impairment in persons with ASD (Fourier et al., 2010; Bhat et al., 2012; Cornish & McManus, 1996) and ID (Carmeli, Bar-Yossef, Ariav, Levy, & Lieberman, 2008; Arnold et al., 2005) has important implications for adaptive functioning and overall health. More specifically, problems with postural control, balance, gait, upper extremity coordination and motor planning commonly occur in both ASD (Fournier et al., 2010) and ID (Carmeli et al., 2008). Additionally, sedentary lifestyles and premature aging in those with ASD and ID (Sowa & Muelenbroek, 2011; Temple & Walkley, 2007) make it difficult for these individuals to engage in exercise and health related behaviours. Although there is evidence that adolescents and young adults with ASD are capable of learning multi-step procedural tasks through trial and error (Gidley Larson, Bastian, Donchin, Shadmehr, & Mostofsky, 2008), depending upon the severity of ASD and ID, an individual may have considerable difficulty learning more complex, multi-step skills (Mostofsky, Goldberg, Landa, & Denckla, 2000). If such is the case, then more explicit forms of teaching, such as through clear and literal verbal explanations, visual modelling and physical guidance are recommended (Bhat et al., 2012). Evidence has suggested that individuals with ASD may respond better to proprioceptive feedback or physical guidance compared to visual feedback, although both forms have been shown to be effective (Glazebrook, Gonzalez, Hansen, & Elliott, 2009).

Moreover, the way in which instructional feedback is given can result in different responses from the learner. There are three different types of prompting that have shown varying degrees of effectiveness in this population: Most to Least (MTL: MacDuff, Krantz, & McClannahan, 2001), Least to Most (LTM: Cooper, Heron, & Heward, 2007) and No-No Prompting (NNP: Newsom, 1998). Each method has its own advantages and disadvantages. For instance, MTL prevents the production of mistakes but limits the individual's process of trial and error (Fentress & Lerman, 2012). On the other hand, LTM allows the individual to make mistakes that he or she could then learn from, but these mistakes may also lead to the development of improper habits (Fentress & Lerman, 2012). NNP achieves a balance between the two by allowing for individual trial and error, but only to a certain point (Newsom, 1998). After two attempts at the skill by the learner without prompting, the instructor would then prompt the learner more explicitly, with verbal, visual or physical prompting. After these two mistakes the instructor could adopt either a MTL or LTM approach.

In addition to the benefits that apply to the general population, physical activity has a number of especially noteworthy benefits for people with ASD and ID. These benefits include a reduction in stereotyped and maladaptive behaviours (Elliot, Dobbin, Rose, & Soper, 1994) and improvements in social skills (Matson et al., 2009; Sowa & Muelenbroek, 2011). The studies that have implemented motor control training as an important part of their intervention have focused primarily on repetitive gross motor skills in adolescents and children (Sowa & Muelenbroek, 2011). There has been a comparative lack of studies that have systematically improved progressively complex motor skills in adult populations.

In order to address the lack of research on motor skill development in adult populations with ASD and ID, an intervention incorporating fine motor skills training, whole body exercise, and sports and games was provided to a group of adults diagnosed with autism and ID. The instructional approach involved a LTM procedure during a participant's initial attempts and once a skill had been learned properly, a NNP-like approach was adopted. LTM and NNP share the benefit of allowing for more independent learning by the participant (Fentress & Lerman, 2012). The purpose of the present study was to integrate the skills of the program into each participant's movement repertoire.

CHAPTER 2

Literature Review

Research on genetics, early intervention and behavioural modification in Autism Spectrum Disorder (ASD) is much more extensive than research that is focused on adaptive living skills (Matson et al., 2009) and motor impairment. From the research to date, differences were found in adaptive living skills between individuals with autism, Pervasive Developmental Disorder – Not Otherwise Specified (PDD-NOS), and ID without an ASD (Dawson, Matson & Cherry, 1998; Njardvik, Matson & Cherry, 1999; Matson et al., 2009). In a study that compared individuals with each of these diagnoses, Matson et al. (2009) reported that those with autism presented with the highest level of impairment in adaptive functioning, while individuals in the PDD-NOS group demonstrated less impairment and those with ID showed the least impairment overall. These behaviours were primarily related to dressing oneself, grooming behaviour, and personal hygiene and the results of the study suggest that individuals with a diagnosis of both autism and ID would display severe impairments in adaptive behaviour (Matson et al., 2009). Social activities, such as recreation and employment require varying levels and types of movement skill. Adaptive living skills require differing levels of motor control as movement requires proper neuromuscular coordination (Tortora, 2005). Specifically, bilateral visual-manual control has been described as an area that is integral to these activities of daily living (Carmeli et al., 2008). Furthermore, any form of pathology which disrupts the ability to balance the body, coordinate the limbs or properly plan the movements will have negative implications for daily functional tasks (Leary & Hill 1996).

If fundamental motor control problems exist for individuals with ASD and ID then such problems will assuredly impact all aspects of a person's life, from the domestic to the social realm. Motor impairment has been recognized as a characteristic of both ASD and ID but much of this research has focused on children and adolescents. Not only has little work in this area been performed on adults with both of these conditions but determining the extent to which such impairments can be reversed has also received little attention. In the sections that follow, ASD will be described and a relationship between ASD and ID will be established. These sections will be followed by a summation of the evidence representing motor impairment in these conditions. A discussion of motor skill interventions will then be undertaken and the gaps which the present study attempted to address will be underscored.

2:1: Overview of Autism Spectrum Disorder

Baker (2007) stated that ASD is the fastest growing developmental disability in North America. Shattuck (2006) found that the prevalence of ASD had increased in U.S.A. from 0.6 to 3.1 per 1000 children between 1994 and 2003, while the prevalence of ID and learning disabilities had each decreased. Elsabbagh et al. (2012) performed a systematic review of epidemiological surveys of ASD worldwide. Elsabbagh et al. (2012) found that the median of prevalence estimates of ASD was one in 162. However, an earlier report found a prevalence of one in 110 (Weintaub, 2011). Even more recently, the prevalence was suggested to be one in 88 for both sexes and one in 54 for boys (Gentile et al., 2013).

Matson and Kozlowski (2011) suggested that the increasing prevalence of ASD may be related to environmental and cultural factors, as well as improvements and variability in diagnostic techniques. King and Bearman (2009) found that approximately 25% of the rise in ASD over the past two decades can be attributed to diagnostic accretion. This occurs when some children who would have been diagnosed with Intellectual Disability (ID) previously are now given a diagnosis of both ID and ASD (King & Bearman, 2009). Furthermore, a purported growing awareness of ASD has been attributed to 15% of the rise in prevalence while geographic associations account for 4% of the rise (King & Bearman, 2011). Another 10% of the increase may relate to people having children when they are older (King, Fountain, Dakhlallah, & Bearman, 2009). Some research has found that children born to parents older than 35 have a higher risk of being diagnosed with autism, with the mother's age being a more critical factor (King et al., 2009). Despite these explanations, King and Bearman (2011) reported that 46% of the increase in ASD cannot be explained.

ASD is characterized by two categories of disability: impaired sociability and the presence of repetitive behaviours. Social deficits include difficulties interacting with peers, and a lack of socio-emotional reciprocity (APA, 2013; Phetrasuwan, Miles, Mesibov, & Robinson, 2009), in addition to delays and deficits in language communication skills. These include difficulties initiating or engaging in conversation with others, repetitive language use, and impairments in imitative play (APA, 2013; Phetrasuwan et al., 2009). Repetitive and stereotypical interests and behaviours constitute the second characteristic of ASD (APA, 2013; Phetrasuwan et al., 2009). This repetition can manifest as a preoccupation with particular activities in restricted areas of interest, with intense levels of focus and an inflexibility to changes in routine (APA, 2013; Filipek et al., 2000; Strock, 2007). Although social and language impairments, along with repetitive behaviours are the defining features of ASD, motor dysfunction has been identified as a core feature by a number of authors (e.g., Fourier et al., 2010; Matson, Matson, & Beighley, 2011). The diagnostic categories that make up ASD are now commonly regarded as general phenotypic clusters that cover many specific underlying etiologies (Fields, 2012). According to Fields (2012), why these behavioral features of ASD (social and communicative impairment, along with repetitive stereotyped behaviour) should appear in concert is still a mystery.

There has been limited research on the progress of individuals with ASD as they move from childhood and adolescence into adulthood and old age. However, studies that have been done have shown that outcomes in adolescence and adulthood are highly variable, with some individuals improving significantly, others experiencing deterioration in functioning, and still others continuing on a stable maturational course (Levy & Perry, 2011). The major factor affecting social outcomes in adulthood are autism severity, cognitive functioning, language development, concomitant psychopathology, and access to appropriate education in adaptive living skills (Levy & Perry, 2011). Shattuck et al. (2012) investigated the rates of post-secondary education and employment in individuals with ASD and found that those with ASD had the lowest rates of employment compared with the youth in the sample who had other disabilities (Shattuck et al., 2012). Higher income and greater functional ability were associated with a greater likelihood of participation in post-secondary employment and education (Shattuck et al., 2012). Although job placement programs can be effective in this population (Persson, 2000) many adults with ASD remain highly dependent on their families or other support services well into their late 20s and beyond (Levy & Perry, 2011). Even among the most able groups with only minor or borderline cognitive deficits, the majority of these individuals (50–60 %) still live with their parents or in sheltered residential placements (Beadle-Brown, Murphy, & Wing, 2006; Billstedt, Gillberg, & Gillberg, 2005; Cederland, Hagberg, Billstedt, Gillberg, & Gillberg, 2008; Eaves & Ho, 2008).

2.2: Co-occurrence of Intellectual Disability and Autism Spectrum Disorder

Individuals with ID have limited intellectual functioning (IQ scores of 70 or lower), as well as difficulties in at least two of the four domains of adaptive functioning: communication, daily living skills, social skills or motor skills (Jankowicz-Szymanska et al., 2012; Sparrow & Cicchetti, 1985). The condition develops before the age of 18 and affects cognition and behaviour; disturbing the diagnosed individual's perception of his or herself, as well as his or her perception of others, thereby affecting inter-personal relations (Jankowicz-Szymanska et al., 2012). Like ASD, ID can be caused by a number of genetic and non-genetic factors (Muhle et al., 2004). Jankowicz- Szymanska et al. (2012) state that ID is a complex dysfunction that is difficult to define accurately. Like ASD, there is a continuum of severity in ID.

A limited amount of research has been conducted on the degree to which ID severity affects the expression of ASD symptoms in adults (Green et al., 2009; Schatz & Hamdan-Allen, 1995). Chakrabarti and Fombonne (2001) studied the prevalence rates of developmental disabilities. The authors examined 15,500 children aged 2.5-6.5 in Staffordshire, England. Any individuals who demonstrated particular symptoms were subsequently assessed by a team qualified to diagnose developmental disabilities. They found that 25.8% of children diagnosed with ASD had also been diagnosed with ID; however, when the different subcategories of ASD were analyzed separately, 69% of those children who met the specific criteria for autism also had ID (Chakrabarti & Fombonne, 2001). In a follow-up study with the identical protocol, 66% of children diagnosed with autism also had ID (Chakrabarti & Fombonne, 2005). These percentages of co-occurrence demonstrate the convergent nature of these two conditions (Goin-Kochel, Peters & Treadwell-Deering, 2008). The fact that ASD and ID are behaviourally and cognitively related represents an underlying commonality of neural function and dysfunction between the two conditions (Green et al., 2009).

2.3: Motor Impairment in Autism Spectrum Disorder and Intellectual Disability

A brief explanation of the motor impairments that are commonly found in ASD will be provided, followed by a description of those found in ID. Evidence of abnormal motor functioning in individuals with ASD and ID has been found using a variety of movement assessments, by evaluating the level of unilateral limb dominance, as well as by evaluating a number of brain regions (Fournier et al., 2010; Carmeli et al., 2008; Jankowicz-Szymanska et al., 2012). The results of such research converge on the notion that motor impairment is widespread in children and adults with ASD (Fournier et al., 2010; Ben-Sasson et al. 2009) and ID (Carmeli et al., 2008; Jankowicz-Szymanska et al., 2012).

Fournier et al. (2010) conducted a meta-analysis that included 51 studies that focused on motor coordination, arm movements, gait, and/or postural stability problems. Data extraction consisted of between-group comparisons for ASD and age-matched controls. Meta-analytic techniques employed by the authors involved random effects models, forest and funnel plots, publication bias, fail-safe analysis, and moderator variable analyses. Results indicated that there was a large effect size between the two groups, suggesting that individuals across the entire spectrum, from mild forms of ASD to more severe forms of the condition showed motor impairment. Fournier et al. (2010) concluded that dysfunctions in postural systems, balance, gait, movements of the upper and lower extremities, as well as movement planning are widespread in ASD. These authors explained how, with a poorly developed postural system, motor development of the limbs would be hindered (Fournier et al., 2010). With regards to hand manipulation skills, improper coordination between one's hand and head, along with constrained reflexes may create problems early in life, which would then lead to atypical motor capabilities later in life (Shumway-Cook & Woollacott, 2001). Additionally, problems with the initiation of movements (akinesia), difficulty while executing movement (bradykinesia) and overall problems with carrying out voluntary movement compounded by the presence of involuntary movement (dyskinesia) were reported (Fournier et al., 2010). Fournier et al. (2010) stated that the scarcity of longitudinal data addressing motor function in ASD makes it difficult to speculate on the developmental prognoses for such individuals who do have impairments as children. Of these studies, only seven included individuals above 18 years of age (Glazebrook, Elliot, & Lyons, 2006; Glazebrook, Elliot, & Szatmari, 2008; Gowen, Stanley, & Miall, 2008; Hallet et al., 1993; Hardan, Kilpatrick, Keshavan, & Minshew, 2003; Muller, Cauich, Rubio, Minzuno, & Courchesne, 2004; Turner, Frost, Linsenbart, McIlroy, & Muller, 2006).

One of these seven studies compared measures of fine motor control and gross motor strength between adults with autism and age-matched controls. Hardan et al. (2003) examined differences in scores on a timed pegboard test between a group of adolescents and young adults with autism and without ID. These scores were then compared with volumetric magnetic resonance imaging results of the basal ganglia of all participants involved. They found no volumetric differences in the caudate nuclei after brain volume was adjusted for, but they did find differences between scores in the Grooved Pegboard and grip strength. Those with autism had significantly slower Grooved Pegboard scores and weaker grip strength, suggesting that these fine and gross motor impairments may also be widespread in populations of adults with autism.

Another of the seven studies investigated movement time in a group of adolescents and adults with autism (Glazebrook et al., 2008). Glazebrook et al. (2008) investigated how individuals with autism plan their movements, through two experiments: First, they provided information about hand, direction and or movement amplitude ahead of time, before a participant had performed the manual movement. Second, the authors had participants perform aiming movements to one of two targets that were either identical or different in size. Results indicated that individuals with autism did use advance information to plan their movements when the information was direct. When strategies were self-generated their performance became stereotyped and thus less adaptive to new skill learning.

One year after the meta-analysis by Fournier et al. (2010), another group of authors reiterated these notions of motor impairment in populations of individuals with autism. Bhat et al. (2011) performed a review paper on motor impairment in ASD and within it they stated that individuals with ASD from childhood to adulthood have shown poor upper limb coordination during visual-motor and manual dexterity tasks, as well as poor lower-limb coordination during tasks requiring balance, agility, and speed. The studies described in this review typically quantified performance using standardized measures such as the Bruininks-Oseretsky Test of Motor Proficiency (Bruininks, 1978) and the Movement Assessment Battery for Children (Henderson & Sugden, 1992), and such studies demonstrated that individuals with ASD from ages 7 through 32 have motor impairment (Bhat et al., 2011; Dewey, Cantell & Crawford, 2002; Ghaziuddin & Butler, 1998; Green et al., 2009). In sum, individuals with ASD have been reported to have a wide array of movement problems, from postural and balance difficulties, to fine and gross motor control problems involving the limbs, in addition to deficits in imitation, motor persistence, and motor planning (Bhat et al., 2011). Bhat et al. (2012) also emphasized that the motor impairments commonly observed in individuals with ASD cannot solely be attributed to cognitive delays. Although many studies have confirmed that movement impairments are common in children with ASD (Green et al., 2009), there has been a comparative dearth of research that has investigated the status of motor impairment in adults, let alone the prospect for improvement with motor training interventions. Therefore, more research is warranted which addresses the developmental trajectories specific to motor functioning and how it can be improved in adults with ASD.

It is important to note that individuals with ID and without ASD also display problems with motor control, such as poor visual and motor coordination, distorted body sensibility, poor spatial orientation, difficulties with speed and accuracy of movements, balance problems, and difficulties in learning new skills (Jankowicz-Szymanska et al., 2012). Individuals with ID often have difficulty performing motor tasks that require a combination of two or more activities (i.e. throwing and catching a ball, performing run-up jumps, throwing a ball up in the air after jumping). Needless to say, such problems with motor control cause difficulty with daily tasks (Jankowicz-Szymanska, et al., 2012).

Carmeli et al. (2008) reported that adults with even mild ID showed deficits in fine motor and gross motor control of the upper extremities, as well as slower reaction time compared with age-matched controls who did not have ID. They compared adults with mild ID to age-matched controls on the 25 Grooved Pegboard Test, Box and Blocks Test and the Stick Catching Test and found that scores of those with mild ID were significantly lower compared to the controls. The authors suggest that with increasing severity of ID, these deficits would only be exacerbated (Carmeli et al, 2008). The degree to which ID affects movement function in ASD is poorly understood (Fournier et al., 2010) but with increasing severity of both ASD and ID, there is a concomitant increase in neurological damage to both motor and cognitive systems (Green et al., 2009).

Much like with language, motor development has a critical period wherein which one of the cerebral hemispheres specializes, resulting in a preference for using one limb over the other (Blumenfeld, 2010). When there is no particular dominance at all it is thought that neither hemisphere has specialized to any significant degree (Blumenfeld, 2010). Hand dominance, therefore, is thought to be representative of a capacity for the development of complex manual skills and a lack of dominance may hinder skill acquisition of all kinds (Blumenfeld, 2010). Complex manual skills such as writing, eating with a utensil, brushing one’s teeth, throwing, catching, and other activities of this nature involve highly precise and intricate coordination of the muscles of one’s hand(s) (Tortora, 2005) and therefore such skills may indeed require varying degrees of cerebral specialization in order to develop (Blumenfeld, 2010).

Individuals with ASD and ID have increased rates of ambiguous handedness (AH) (Soper et al., 1986) and pathological left-handedness (PLH) (Cornish & Mcmahon, 1996; Satz, Orsini, Saslow, & Henry, 1985; Arnold et al., 2005). AH can be described by a person not having a dominant side of their body when moving and showing no particular dominance of either hand within any given task (Soper et al., 1986). This is not to be confused with ambidextrous handedness, which is to demonstrate proficiency within a given task and to be able to switch hands across tasks (Soper et al., 1986). Contrastingly, PLH involves having dominance in one's left hand relative to his or her right; however, manual proficiency of one's left hand in this case would be poor, thereby leaving an affected individual with no particular strong side (Satz et al., 1985). AH is thought to develop from bilateral damage to the cerebral cortex, which has been said to represent severe damage to neurological systems (Kinsbourne, 1988). PLH, on the other hand, is thought to manifest when an individual who was genetically and neurologically predisposed to develop right handedness undergoes some form of brain injury which disrupts this developmental trajectory (Cornish & McManus, 1996; Satz et al., 1985). A recent meta-analysis found that non-right handedness, including AH and PLH, was correlated with language impairment, hypotonia (low muscle tone), ankle immobility, and dyslexia (Ming, Brimacombe, & Wagner, 2007). AH and PLH therefore pose barriers to motor skill acquisition (Cornish & McManus, 1996). Since unilateral dominance is consolidated well before puberty (Cornish & McManus, 1996), the critical period for such development will have been passed when considering hand dominance in adults. Therefore, seeing results from motor interventions for adults with motor impairment and a lack of hand dominance is likely to take longer than seeing results from motor training in a population of individuals with hand dominance.

Essentially, motor impairments that develop throughout the course of an individual's childhood may have their roots in an early lack of cerebral specialization. Once an individual reaches adolescence and adulthood, teaching motor skills may be considerably more difficult because of this underlying neural pathology. If such a capacity for motor skill development is reduced in ASD and ID then slower rates of improvement could be expected compared to individuals to whom these diagnoses have not been given.

2.4: Interventions for motor skill training

Shumway-Cook & Woollacott (2008) suggested that motor learning principles could form the basis for teaching motor skills to individuals with ASD, much as they would to a neurotypical population. Practicing a given skill ordinarily leads to proficiency as such systematic repetition leads to modifications in neural areas associated with the skill in question (Ruitenberg, Abrahamse, & Verwey, 2013). Neural structures that have been implicated in the underlying neural pathology of motor impairment in ASD are structures that have been found to be integral for the development of skill acquisition (Fatemi et al., 2012). Therefore individuals with ASD could be expected to incur slow rates of learning and such difficulties with skill acquisition should correlate with the extent to which these critical structures are damaged.

Interventions can be broadly divided into the following categories: types of motor skills, practice, and feedback (Bhat et al., 2011). The types of motor skills practiced should be relevant to the individual in question, and given the heterogeneity of ASD and ID there may be considerable differences in motor skill from one individual to the next and from one task to another. Given the difficulties in motor functioning that have been outlined above, difficulties with fine and gross motor skills, as well as difficulties with balance and reaction time could be expected from a group of adults with ASD and ID.

In terms of practice, evidence suggests that older children with ASD have the ability to learn procedural motor skills through trial and error (Gidley-Larson et al., 2008). However, these individuals may have difficulty learning increasingly complex, multistep motor skills (Mostofsky et al., 2000). Therefore, if a child or adult has difficulty improving motor performance despite continued exhaustive practice and repetition, highly explicit forms of instruction and feedback are necessary (Bhat et al., 2011). When more direct forms of instruction are required, clear and literal verbal explanations of each step within the entire activity, as well as visual modeling and direct physical assistance are recommended (Bhat et al., 2011). Evidence also suggests that children with ASD have difficulty understanding movement goals, and such difficulty would affect movement planning (Fabbri-Destro, Cattaneo, Boria, & Rizzolatti, 2009). Therefore, it is important to emphasize the end goal for every task that is being instructed.

Children and adults with ASD also tend to have difficulty with perceptual processing and therefore the type of feedback provided may be important when teaching motor skills (Bhat et al., 2011). Glazebrook et al. (2009) investigated whether children with ASD have the ability to use visual or proprioceptive feedback during motor learning. Thirty-two with ASD, 26 children with developmental disabilities and 28 age-matched controls were taught a novel manual motor task and provided with visual and proprioceptive feedback. Their results suggest that individuals with ASD do indeed have the ability to use both proprioceptive and visual feedback to improve their coordinated arm movements; however, the individuals in this particular study took longer to process visual information. Although visual modelling was effective in facilitating movement instruction, these results suggest that individuals with ASD may ultimately respond more favourably to proprioceptive instruction (Glazebrook et al., 2009). If visual feedback is used, clear demonstrations and pictures of the steps involved should be provided (Maione & Mirenda, 2006).

In addition to the types of prompting that support skill acquisition, the way in which those prompts are delivered is important. Three different types of prompting have shown different levels of effectiveness: Most to Least (MTL) (MacDuff et al., 2001), Least to Most (LTM) (Cooper et al., 2007) and No-No prompting (NNP) (Newsom, 1998). In MTL prompting, the instructor provides the prompt(s) concurrently with the instruction and then gradually decreases the intrusiveness of the prompts over time (Libby, Weiss, Bancroft, & Ahearn, 2008) and the learner has an opportunity to respond independently only after prompts have been faded. In contrast, LTM prompting has the instructor initiate every learning trial with limited assistance and then provide increasingly more intrusive prompting depending on the learner's response (MacDuff et al., 2001). The type of prompt chosen could be verbal, visual or physical, and with more trials practiced, it is thought that the learner will respond to progressively less intrusive prompting (Horner & Keilitz, 1975). Both LTM and MTL prompting have shown effectiveness in teaching motor skills, yet each method has its advantages and disadvantages (Fentress & Lerman, 2012). For instance, although MTL prompting decreases the likelihood of mistakes, it also restrains the learner's opportunities to respond without prompts (Fentress & Lerman, 2012). However, learners have more opportunities to respond without any prompting under the LTM procedure, but there are more opportunities to make mistakes (Fentress & Lerman, 2012).

Another prompting procedure that has been described in the literature is referred to as No-No prompting (NNP) (Newsom, 1998). This procedure provides the learner with even more opportunities for independent responding than LTM prompting (Fentress & Lerman, 2012) but also allows for more errors to occur. When practicing a new skill or refining a developed skill, NNP requires the instructor to say ‘‘no’’ to the learner when the first and second mistake is made and then on the third attempt the learner is prompted (Newsom, 1998). Leaf, Sheldon & Sherman (2010) compared NNP to simultaneous prompting, which is similar to MTL, and NNP was shown to be more effective in the development of the skill that was being instructed. Leaf et al (2010) suggested that since NNP allows for attempts that are independent of feedback and prompting, learners are able to consolidate the movement pattern on their own and thereby internalize the contingencies of a given pattern. In another study that compared MTL to NNP, MTL led to mastery more frequently than NNP (Fentress & Lerman, 2012). The authors cautioned the reader to be conservative with their inferences regarding the use of prompts, as many more studies need to be done (Fentress & Lerman, 2012). They did conclude, however, that the NNP procedure may be more effective for more advanced learners when compared to individuals who demonstrate a slower pace of acquisition (Fentress & Lerman, 2012). Furthermore, NNP is recommended for situations where a learner must perform a skill that has previously been mastered (Leaf & McEachin, 1999).

The prompting methods that have been described above have not been extensively explored or used in studies of adult populations with both ASD and ID. Previous research in this area that has used exercise and movement conditioning paradigms as interventional frameworks has held the primary impetus of improving social skills and reducing stereotyped and maladaptive behaviors (Sowa & Muelenbroek, 2011). For instance, Elliot et al. (1994) investigated the impact of different exercise conditions on maladaptive and stereotypic behaviour in six adults diagnosed with autism and moderate to profound intellectual impairment. Participants engaged in each of three conditions: one non-exercise control group, one group that engaged in motor control training, and one group that engaged in vigorous aerobic training. It should be noted that the motor control training activities involved only gross motor movements, such as riding a stationary bike, using a stair stepper, lifting weights, or walking. Each participant completed five sessions of each of these conditions, accumulating to 15 sessions in total. The results showed that only the aerobic condition decreased maladaptive and stereotypic behaviour when it preceded the vocational task. The authors concluded that aerobic exercise is effective for reducing maladaptive and stereotypic behaviour when compared to motor skill training paradigms, and, when motor skills are to be trained, vigorous aerobic exercise may allow for more effective learning during the motor task. Therefore if motor impairments abound in this population, incorporating the training of such skills into a larger whole body exercise program may be most appropriate. Despite similarities to the present study, Elliot et al. (1994) did not have motor control as an outcome measure, but rather used motor control training as a means to reduce stereotypical behaviours. Motor control improvements may have occurred for the participants, but were not systematically tracked throughout the duration of the study.

The present study engaged participants in strength training, aerobic training, and more complex fine motor control training over a period of 24 sessions. Lochbaum and Crews (2008) compared strength and aerobic conditioning in a group of five adolescents and young adults with autism over a period of 18 sessions. They found benefits in muscular strength and aerobic capacity for both conditions, with the more significant improvements occurring in the aerobic condition. Three participants were in the aerobic (ages 16, 20, and 21) and two were in the strength-training condition (ages 16 and 17). The three individuals in the aerobic condition increased their aerobic capacity by 33%, 33% and 50%, respectively over these 18 sessions. Those in the muscular strength training group increased their bench press weight by 19% and 28%, their leg press by 29% and 12% and their low row by 47% and 21%, respectively. This study shows that neuromuscular improvements are possible for adolescents in 18 sessions of training (Lochbaum & Crews, 2008).

Todd and Reid (2006) also employed exercise as an intervention, and their study occurred over a much longer period than the one developed by Lochbaum & Crews (2008). Their intervention involved six months of outdoor physical activity (30 min. snowshoeing/ jogging/ walking) (Todd & Reid, 2006). Three adolescents with autism (ages 15, 16, and 20) increased the distance walked/jogged over the course of the program (1.26 km, 1.14 km, and 0.83 km, respectively) while reinforcements were decreased (Todd & Reid, 2006). This study showed that improvement in gross motor function is possible in this population and that simply engaging them in exercise and skill learning can yield meaningful improvements.

Moreover, Garcia-Villamisar & Dattilo (2010) investigated the impact of leisure activities on stress and quality of life with 37 adults diagnosed with autism and Asperger Syndrome (22 males and 15 females, ages 17-39). Reductions in stress and improvements in quality of life were the focus in this study, and although the results were encouraging and the time frame and sample size were ambitious, the intervention did not systematically attempt to improve motor skills (Garcia-Villamisar & Datillo, 2010).

Sowa & Muelenbroek (2012) performed a meta-analysis where motor skills were measured in 12 of the 16 studies; however, although motor function improved, half of the samples were individual case studies or small group studies. Ten of the studies used children with sample sizes ranging from 1-19 [mean (SD): 7.6 (6.6)]. One study focused exclusively on adolescents, with a sample size of three, while three other studies focused exclusively on adults [sample size range: 1-37, mean (SD): 14.6 (19.5)]. Despite the heterogeneity of the studies in the meta-analysis, Sowa & Muelenbroek (2011) concluded that exercise interventions are effective at improving social skills, reducing repetitive behaviours and improving motor skills. Any conclusions about improvement in motor function need to be interpreted carefully because these studies primarily employed gross motor movements such as aquatic exercise, walking, jogging, stationary biking, or snowshoeing in their interventions. Additionally, the authors suggested that individual exercise interventions led to more significant improvements in motor skills than did the group interventions (Sowa & Muelenbroek, 2011). Individualized interventions require more exercise trainers and therefore may not be as practical as group exercise for many individuals with ASD and ID. Group exercises may then be considered as a more resourceful way of helping many individuals simultaneously.

The scarcity of studies that have systematically improved motor skills of adults with ASD and ID makes it difficult to determine what kind of improvements can be expected over a given training period. Practical difficulties with recruitment and the inevitable variability of function in this demographic may create methodological challenges for researchers. Nevertheless if the problem of motor dysfunction in adults with ASD and ID is to be addressed then studies that attempt to facilitate improvements of such skills must be undertaken.

2.5: Summary

Research has shown that there is widespread impairment of motor control in children and adolescents with ASD and ID (Bhat et al., 2011; Fourier et al., 2010; Carmeli et al., 2008; Jankowicz-Szymanska et al., 2012), however, there is limited research on motor skill acquisition in adults with ASD and ID. Given how integral movement skills are for activities of daily living, recreation, and employment (Matson et al., 2009; Carmelli et al., 2008), more research is warranted in adult populations.

Gidley-Larson et al. (2008) stated that individuals with ASD are capable of learning multi-step motor skills but as the complexity of skill increases, more explicit forms of instruction may be required. Developing movement skills may enable individuals with ASD and ID to become more involved in community recreational programs and other physical activities. Moreover, daily skills requiring manual dexterity, reaction time and static balance may pose less of a challenge to these individuals should such skills be improved. Time frames required for improvements to occur in fine and gross motor skills, reaction time and skills of static balance in adults with a combination of ASD and ID is poorly understood. Therefore, more research is warranted which addresses the developmental trajectories specific to motor functioning and how it can be improved in adults with these two conditions.

The purpose of this study was to improve the balance skills, fine- and gross-motor visual-manual skills and reaction time of adults with ASD and ID. Although minimal work with adults has been done, work with children has shown that motor learning is possible throughout childhood and adolescence of those diagnosed with both ASD and ID (Sowa & Muelenbroek, 2011). It was therefore hypothesized that the individuals who participated in our study would experience significant improvements in these domains of motor skill throughout the duration of the study. Improvements were anticipated after the first six weeks, followed by more significant improvements realized after 12 weeks. Furthermore, it was hypothesized that the motor skill improvements would be retained following four weeks of no training. Retention of skill was expected as the passage of time has been found to impact the degree to which a skill is learned and retained. Savion-Lemieux and Penhune (2004) showed that the distribution of practice over days was a more important factor than the amount of practice affecting motor learning and retention. The authors suggest that the passage of time is essential for skill learning and consolidation (Savion-Lemieux & Penhue, 2004). Therefore after 12 weeks of training, four weeks of no program activity may facilitate the learning and consolidation of the skills that constituted the program.

CHAPTER 3

Methodology

3.1: Participants

Fourteen participants were recruited for this study. Community Living Essex County (CLEC), an organization that supports individuals with ID and their families in Windsor and Essex County, assisted with recruitment for the study. Their involvement was instrumental throughout the 16-week duration of our project.

Inclusion criteria for the participants consisted of the following:

1. Participants had to be 18 years of age or older with a diagnosis of both ASD and ID. Each participant's physician made these diagnoses.
2. Participants had to complete a Physical Activity Readiness Questionnaire (PAR-Q). If they answered 'yes' to any items on the PAR-Q, they then had their physician complete a Physical Activity Readiness Medical Questionnaire (PARMED-X).
3. Participants had to have written permission from a nurse practitioner or physician to begin physical activity.
4. Participants had to be capable of following instructions and completing a physical activity regimen with assistance from the support staff.
5. Participants had to be able to attend all Tuesday and Thursday sessions from September to December and the retention test in January.

Participants were excluded from the study if they had a history of violent or aggressive behavior. CLEC made this determination, as they had each participant's history on file. Individuals with the need for ambulatory support, in the form of wheelchairs, walkers, crutches, or canes were also not eligible to participate in this program due to the testing and intervention protocol. Even though participants were tested only against themselves, over half of the stations in the intervention required ambulatory bipedalism, such as the relay station, the squat and vertical press station, and the lunge and bicep curl station. Also, since bipedal balance accounted for one quarter of the assessment protocol, individuals who required support for locomotion would only be comparable in three of the four tests that were used.

3.2: Consenting and Assenting Procedures

Prior to beginning the program, all eligible individuals were taken through the consent form by their guardian and/or support worker. Guardians/support workers provided consent on behalf of individuals who were unable to provide consent on their own. The University of Windsor's Research Ethics Board approved the consent/assent forms (Appendix A). Participants and/or their guardians were then asked to fill out a brief form referred to as the Participant Profile (Appendix B). This form included basic information, such as phone number, street address, age, height and mass.

Upon arriving at the St. Denis Centre on every day of the intervention, each participant checked in with the program staff. If the participant's guardian originally signed the consent form, the participant's support worker was then asked to sign the attendance sheet upon his or her arrival. If the participant provided the initial consent, then ongoing consent was obtained through him or her directly. This ongoing consent or "rolling consent" allowed for the determination of attendance, as well as the willingness of each participant to engage in the exercise session on every day of the program. The participants were able to withdraw at any time without consequences. Despite the occasional absence, all 14 participants completed the program. The rolling consent form is provided in Appendix C.

3.3: Twelve-week Exercise Program

The intervention required the researchers to meet with all participants twice a week for 12 weeks at the St. Denis Centre. Participants were divided into groups based on their residential proximity and morning availability as many of them required transportation from CLEC. Participants arrived with the CLEC Shuttle at their respective time (either 9:00 AM or 10:30 AM) and each session lasted approximately one hour and twenty minutes. Support workers helped the students communicate with the participants and provided physical guidance when necessary.

3.3.1. The Student Instructors

Internship students were recruited through Kinesiology’s internship program and volunteers were recruited through the Kinesiology, Nursing and Biology programs. One volunteer and one internship student were assigned two participants for the duration of the 12-week program (from here on the student interns and volunteers will be referred to as “instructors”). In addition to ensuring safety, the role of each instructor was to teach all of the exercises of the program to the participants. Approximately three hours of training was provided to the instructors prior to the start of the program regarding ASD and ID, which included how activities were to be done, and how the measurement protocol were to be carried out. Students practiced teaching the activities and exercises by taking turns as both the instructor and participant. They performed mock trials of exercise sessions and testing days, and during these practice trials members of the research staff coached them. By the end of the training sessions, each instructor confirmed that they felt confident in their abilities to teach the entirety of the program to a participant. Due to the fact that the research staff and support workers supervised and worked with the instructors closely throughout the duration of the program, this quantity and quality of training was considered sufficient.

3.3.2. Method of Instruction

The instructors provided LTM prompting (MacDuff et al., 2001), whereby the exercise was demonstrated initially and then followed by verbal and progressively more emphatic visual prompting. If a participant adopted a given movement pattern quickly then very little additional prompting was provided. Physical guidance was at the latter end of the prompting hierarchy and was only engaged if participants were unable to adopt the movement pattern that was being demonstrated and explained. When physical guidance was necessary, the instructor cooperated with the support worker to direct the participant's movement. Whatever the extent of prompting required, once a participant could perform the movement without assistance, prompting was faded accordingly.

Every session and each exercise involved a LTM manner of prompting with the same order that was provided initially: visual and verbal prompting followed by physical guidance. For individuals who had mastered a movement sequence during a prior exercise session and then had forgotten it on a subsequent session, a NNP-like procedure (Newsom, 1998) was initiated. This involved the same hierarchy of prompting, whereby gentle verbal, visual and physical prompts were provided to the participant only after he/she was given a few opportunities to perform the pattern correctly on his/her own. The intent was to have the participants engage in all of the program's movements with as little prompting as possible from the instructors and support workers.

3.3.3. Sports and Games Component

Participants moved either to the sports and games station or the fine motor training station after they completed the rolling consent. Sports and games activities were undertaken for approximately 20 minutes during each session, and these activities included nerf footballs, basketballs, and volleyballs, as well as badminton and ping-pong equipment. Instructors initiated games of catch with a ball or games of "back and forth" with the paddles and/or rackets in an attempt to build excitement, warm-up the body and promote bonding amongst group members. As participants arrived on the day of their session, the instructor initiated some kind of sport/game activity for approximately 10 minutes, with an additional 10 minutes taking place during the last 20 minutes of the program.

3.3.4. Motor Skills Training Component

Participants engaged in the fine motor control training component for a total of 20 minutes each session and were instructed on how to perform a variety of fine motor tasks within this time frame. These activities involved picking up and sorting paper clips and manipulating screws, nuts, bolts, and pegs in different and progressive ways. For every task that involved these objects, the same quantity of practice was undertaken for both the participants' right and left hands. Instructors were in charge of motivating their participants to perform more activities with increasing difficulty every session, and to ensure that there was an even balance of time spent at both the fine motor station and the sports and games station.

3.3.5. Whole Body Exercise Component

Participants began the exercise protocol once they had completed the sports and games and fine motor control training. Cardiovascular training, strength training, flexibility exercises, and gross motor control exercises constituted this portion of the program. Each participant's instructor led a 10-minute warm-up on the track that was followed by a whole body exercise circuit. Fast and slow paced walking, walking on one's toes, taking larger steps, stepping to the side, and arm circles helped to ready the participants for the more intensive exercise circuit. A progressive approached characterized the warm-up and exercise circuit, with more basic movements practiced at first followed by more challenging movements introduced incrementally. Each group of participants was assigned to a station prior to the start of the program, and that was the station they started at for every subsequent session. After the warm-up, five minutes were spent at each of the seven stations, for a total of 35 minutes. Photographs depicting the exercises, with the exception of station four, are provided in Appendix D. The circuit was set up as follows:

Station 1: Squats and vertical shoulder presses for one minute's duration.

Station 2: Upper body exercises with a resistance band. With two hands on the band at all times, participants were guided by their group intern and volunteer in how to move their arms. The exercises collectively engaged all of the upper body muscles in varying combinations. Green bands were the most resistant and were given to the participant initially. If the participant could not generate and maintain tension for any of the exercises engaged then the thinner white bands were provided to them.

Station 3: Riding a stationary bike and different forms of lunge walking. Participants at this station alternated between these two types of exercise.

Station 4: Relay racing with nerf footballs, badminton rackets and skipping rope. An example of the obstacle course that was used is as follows:

1. Participants started by attempting to throw a soft football into a bucket placed three meters in front of them.
2. After scoring once (or after three missed attempts) they ran to the bucket and picked up a badminton racket, and then attempted to hit a shuttlecock into another bucket placed 10 feet in front of them.
3. After scoring once (or, after three missed attempts), participants picked up a skipping rope and performed 10 revolutions of the rope, after which they were encouraged to run back to the starting line.

Station 5: Core and stability exercises, such as push-ups, planks, and the use of stability balls.

Station 6: Lunge and bicep curl combination movement, along with a set of lower body stretches. A lunge is a movement that emphasizes activity in the gluteal and quadriceps muscles. The movement began by stepping forward with one leg while the other was left in place. The longer one's step, the greater the involvement of the gluteals in the leg moving forward, while a shorter lunge emphasizes the quadriceps of the moving leg (Tortora, 2005).

Station 7: Yoga movements and balance exercises. The balance exercises included narrow standing, wide standing, tandem standing (i.e., standing with the toes of one foot touching the heel of the other), and standing on one leg.

Participant progress was documented daily with tracking sheets (Appendix G).

In sum, all of the motor skills that were tested as dependent variables were engaged during the intervention sessions. Gross motor skill and reaction time were targeted during the sports and games component, fine motor skills were practiced during the fine motor station, and reaction time and balance were challenged during the exercise stations, as well as the sports and games activities.

3.4. Data Collection

The dependent variables in this study were:

1. Fine Motor Control: 25 Grooved Pegboard test (number of pegs inserted).
2. Gross Motor Control: Box and Blocks test (number of blocks transferred).
3. Reaction Time: Stick Catching test (displacement in centimeters).
4. Balance: Centre of Pressure (COP) medial-lateral displacement (COPx) and velocity (Vx), anterior-posterior displacement (COPy) and velocity (Vy), sway area (mm^2)

Before the intervention began, the research team took baseline measures and subsequent testing occurred at the end of six and 12 weeks, followed by retention testing occurring at the end of 16 weeks. Testing at 16 weeks allowed for evaluation of skill retention after four weeks of detraining. Data sheets used to record the scores for the four following tests (Appendix E) and the resultant means and standard deviations (SD)

(Appendix F) are provided. All four motor control measures are described in the following sections.

3.4.1. 25 Grooved Pegboard Test

Manual fine motor skill is represented by the movements required for success in the 25 Grooved Pegboard Test (Desrosiers, Hebert, Bravo, & Dutil, 1995; Ruff & Parker, 1993) (Figure 1). In its standard form, the test assesses the time it takes one to insert 25 pegs into the standard grooved board, one peg at a time. Individuals are provided with two trials per hand at a given testing session and their raw scores are represented as a unit of time in seconds. For the present study, modifications were made in order to facilitate administration of the test. Instead of a unit of time representing a participant's score, quantity of pegs inserted within a one-minute time frame represented each participant's score. This change was implemented in anticipation of some participants having difficulty with staying on-task until all 25 pegs were inserted. The participants were told to grasp and insert as many of the pegs as they could, one peg at a time, into a wooden board within a one-minute time frame. The one-minute time frame began once the participant touched the first peg and finished once the 60 seconds had elapsed. The test was performed with each hand separately in alternative order. The participants were given two opportunities with each hand, for a total of four trials. Analysis was performed

Figure 1: 25 Grooved Pegboard. Image: http://compasshealthcaresupply.com/en/motor-skills/28-grooved-pegboard-test.html.

on the sum of scores for the left and right hand and on the best (highest) scores for each hand at each session.

3.4.2. Box and Blocks Test

Gross motor manual skill was represented by the standardized Box and Blocks Test (Mathiowetz, Volland, Kashman, & Weber, 1985; Desrosiers Bravo, Hebert, Dutil, & Mervier, 1994) (Figure 2). In its standard form, this test requires a participant to transfer as many blocks as possible within a 15 second time frame. The number of blocks moved represents a participant's score. Modifications were also made to this test for the present study: Participants were given 60 seconds to complete the test, rather than only 15 seconds. The participants were told to transfer as many blocks as possible from one side of a divided box to the opposite side (one block at a time) within one minute. This test was modified to last a minute so that any distractions experienced by a participant within the first 15 seconds would not compromise that participant's score. Essentially, there was a concern that the Box and Blocks would not be long enough in its standard form. Each hand was measured twice, amounting to four trials in total. Analysis was performed on the sum of scores for the left and right hand and on the best (highest) score for each hand at each session.

Figure 2: Box and Blocks Test Image: http://irr-nancy.fr/IMG/Image/ PREH ENboxWeb.jpg

3.4.3. Stick Catching Test

Reaction time, or the time taken between the presentation of a sensory stimulus and the subsequent behavioral response (Naito et al., 2000) was measured using the standardized stick catching test (Kauranen & Vanharanta, 1996). Participants stood with their elbow at approximately 90° degrees and with their forearm parallel to the ground. A metre stick was placed between the participant's thumb and index finger, such that the index finger lined up with the top of the black tape that was wrapped around the bottom of the metre stick. Before the ruler was dropped, the participant was notified that the test was about to begin and the ruler was dropped within a few seconds of the participant's confirmed readiness. The distance travelled by the metre stick before the participant stopped its downward trajectory constituted the reaction time score: the greater the distance, the slower one's reaction time. Flight time of the metre stick was calculated using these scores of displacement (Kauranen & Vanharanta, 1996; Carmeli et al., 2008). Reaction time is defined by the flight time of the metre stick, as this number represented the time it took for participants to grasp the stick after they saw it begin to fall (Liebermann & Goodman, 2007; Carmeli et al., 2008). Each participant was given two trials for each hand for a total of four trials.

Figure 3: The Stick Catching Test Image: http://media.npr.org/assets/blogs/health/ images/ 2010/02/puckb77d1bacc051680930e 71d0 69de83abce36a42e7 -s6-c30.jpg

Trials were discarded from the statistical analyses if a participant refused to perform the test altogether or was unable to grasp the meter stick before it fell to the ground. All data for a participant was discarded if that individual failed to register proper trials at more than one session for a given condition (ie. right hand or left hand). For each testing session, a participant's best score in centimeters for each hand was used for analysis.

3.4.4. Static Balance Testing

Balance was quantified based on measurements of center of pressure (COP). COP is an indirect measure of postural sway and has been defined as the body's centermost aspect of gravitational pressure into the ground (Kim, Ferdjallah, & Harris, 2009; Winter, 2005). COP measurements were obtained using an AMTI OR6-7 2000 force platform (Advanced Mechanical Technologies Inc., Watertown, Massachusettes, U.S.A). This platform provides direct measurement of force in the vertical direction (F_z) and horizontal directions (F_x, F_y), as well as moments around the x-axis (M_x: medial-lateral, or side-to-side), y-axis (M_y: anterior-posterior, or front-to-back), and z-axis (M_z: longitudinal, or head-to-toe) (Molloy, Dietrich, Bhattacharya, 2003). The x- and y-coordinates of the COP (COPx and COPy, respectively) were calculated based on these forces and moments (Robertson, Caldwell, Hamill, Kamen, & Whittlesey, 2004). Force plate data was acquired at a rate of 200 Hz, using AMTI NetForce software (Version 2.4.0).

Figure 4: Force Platform Image: http://www.a-tech.ca/img_series/OR6-7.JPG

Trials lasting 30 seconds were attempted on the orientation day before the first day of testing. Many participants were distracted and couldn't stay still for the length of the trial. It was decided that 20 second trials would be more appropriate for our group. Participants performed four 20-second second quiet standing trials on the force platform; two with their eyes open (EO) and two with eyes closed (EC). A 30° angle was marked with tape on the platform surface, signifying where each participant was to place his/her feet. In the EO trials, the participants were instructed to look forward into the open room. If a participant demonstrated difficulty remaining still on the platform then he/she was told to look forward at his/her support worker or a member of the research staff, who stood directly in front of the participant. The EC version consisted of the same stance but with the participants' eyes closed. If necessary, a member of the research staff or the support worker would count to 20 out loud, to help the participant stay focused on the task and stay on the platform for the full duration of the trial.

Data analysis was conducted using customized LabView software (LabView 2011, National Instruments, Austin, TX, USA). In order to visualize the trajectory of the COP along the x- and y-axes in the horizontal plane, a plot was generated. This plot is referred to as a stabilogram (Figure 6). Calculations done in LabView adjusted for slight variations in foot position. The software plotted the x-y position of the COP with respect to the mean position of the COP during the trial, so that the position of the COP was expressed as a deviation from the mean position (Molloy et al., 2003). Displacement (mm) of the COP was measured in the medial-lateral (ML) direction (COPx), as well as the anterior-posterior (AP) direction (COPy). These numbers were then used to calculate the sway area, which has been suggested to be an accurate representation of one`s

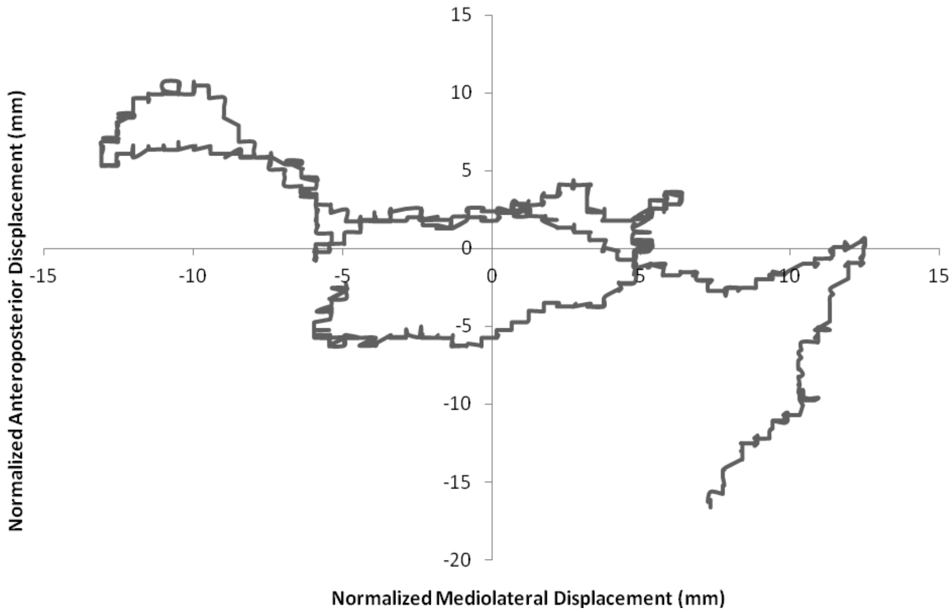

Figure 5: Example of a stabilogram. Displacement of the COP in the medial-lateral and anterior-posterior directions, normalized to the mean COP positions in each of these directions, respectively, is plotted.

balance skills (Molloy et al., 2003). In other words, the smaller the sway area, the less postural sway and (indirectly) the better the participant`s static balance. In addition to ML and AP displacement, velocities (mm/s) in each of these directions were calculated.

Only the middle 10 seconds were used in the analyses. The initial five seconds and the final five seconds consisted of the most movement, as the initial 5 seconds involved a transition to stillness and the final five seconds brought about restlessness with our group. Even with the reduction of the trial length to 20 seconds, participants often exhibited movement during the first and/or last few seconds of the trials. Thus, these portions of the trial were discarded. In some cases, entire trials had to be discarded. Trials were discarded from the statistical analyses for the following reasons: opening eyes during the middle 10 seconds of an EC trial; moving one's feet during the middle 10 seconds of any trial; or moving one's legs and/or arms throughout any trial. All trials from a participant in a condition (EO or EC) were discarded if that participant failed to register valid trials in that condition during at least three of the sessions. For each testing session, a participant's best scores were taken, one for the EO condition and one for the EC.

3.5*: Statistical Analyses*

For the 25 Grooved Pegboard and Box and Blocks Test, the resultant data points were analyzed in two different ways: First, a participant's greatest score for his or her left hand and the greatest for his or her right hand at each session were taken for analysis. Second, a participant's scores were summed for each hand (respectively) at each session. This allowed for the evaluation of both the totality of participant scores, as well as the best performances across the sessions. A 2 (hand: left vs. right) X 4 (session: baseline vs. mid program vs. post program vs. retention) repeated measures ANOVA was performed on the (respective) data sets of the 25 Grooved Pegboard and Box and Blocks Test. Where violations of sphericity were present, the degrees of freedom were adjusted using the Greenhouse Geisser correction.

Linear Mixed Modeling (LMM) was used to test for significant differences at each level of the dependent variable (flight time) from the Stick Catching Test. The model included fixed effects of session (baseline, mid program, post program, retention), hand (left, right), and a nested term (hand nested within session). All factors were modeled with compound symmetry repeated covariance structure.

Linear Mixed Modeling (LMM) was also used to test for significant differences at each level of each dependent variable from the balance tests. The model for each dependent variable included fixed effects of condition (eyes open, eyes closed), session (baseline, mid program, post program, retention) and a nested term (condition nested within session) to test for higher order interactions. All factors were modeled with compound symmetry repeated covariance structure.

Significant *F* tests ($\alpha < 0.05$) for the variables analyzed with repeated measures were evaluated further with Bonferroni-corrected pairwise comparisons. All statistical analyses were conducted using the Statistical Package for Social Sciences (SPSS) for Windows (version 20) (SPSS v20.0: SPSS Inc, Chicago, IL).

CHAPTER 4

RESULTS

Two individuals were omitted from the data analysis completely due to problems with test administration. Although these two individuals met the inclusion criteria, they each had considerable difficulties with the four motor tests that were administered. Despite such omission from the project`s analytical components, these two individuals still participated in the program. Participant numbers then varied for each motor test, as some participants' trials had to be removed due to difficulties with test administration. The sample size for each test can be seen in Table 1.

Table 1

Participant Demographics and Sample Sizes for each Motor Test

Test	Participants	Age (years)	Height (m)	Mass (kg)
25 Grooved Pegboard	11	35.6 ± 11.3	1.7 ± 0.1	83.7 ± 19.3
Box and Blocks	11	35.6 ± 11.3	1.7 ± 0.1	83.7 ± 19.3
Stick Catching Right Hand	10	34.0 ± 12.6	1.7 ± 0.1	90.8 ± 25
Stick Catching Left Hand	9	31.0 ± 8.8	1.7 ± 0.08	92.7 ± 25.9
Balance Eyes Open	10	37.1 ± 10.6	1.74 ± 0.1	85.5 ± 19.3
Balance Eyes Closed	9	35.3 ± 12.6	1.73 ± 0.1	85 ± 18.3

Participants varied in the severity of their autistic symptoms and intellectual levels. Some individuals could speak and respond reliably to questions requiring one-word answers, while others would not respond coherently and often not at all in a reliable way. Some individuals were very compliant with the teachings provided to them by their instructors, while others had difficulties following along. In some cases this difficulty complying with the instructions seemed to be due to the autistic symptoms, namely involving repetitive behaviour. However, in other cases this difficulty with comprehension seemed to stem from an intellectual level. Despite this variability, all individuals had IQ's lower than 70 and a diagnosis of autism and therefore possessed the symptoms associated with ID and autism in similar capacities.

4.1: 25 Grooved Pegboard

A 2 X 4 ANOVA with fixed effects of session (baseline, mid program, post program, retention), hand (left or right) and a nested term of hand within session was performed on the best scores and sum of trials obtained from the 25 Grooved Pegboard and the Box and Blocks Tests. There was a significant main effect of Hand on the best scores [$F(1, 137.5) = 17.5$, $p = 0.002$], such that scores for the left hand (15.9 ± 1.8 pegs) were significantly lower than those for the right (18.4 ± 2.2 pegs). There was also a significant main effect of Session [$F(1.9, 26.1) = 3.61$, $p = 0.049$]. Scores were significantly better at retention compared to those at baseline (baseline: 16.0 ± 2.1 pegs, retention: 18.0 ± 2.0 pegs, $p = 0.002$). No other pairwise comparisons achieved significance ($p > 0.05$). The Session X Hand interaction [$F(3, 2.7) = 1.5$, $p = 0.23$] was not significant. The main effect of Session is shown in Figure 6.

There was a significant main effect of Session on the sum of scores [$F(3, 78.7) = 5.9$, $p = 0.003$], such that scores were significantly better at retention compared to those at baseline (baseline: 30.8 ± 4.1 pegs, retention: 34.8 ± 4 pegs, $p = 0.0002$). No other pairwise comparisons achieved significance. There was also a significant main effect of Hand on the best scores [$F(1, 397.4) = 11$, $p = 0.008$], such that scores for the left hand

(30.6 ± 3.6 pegs) were significantly lower than those for the right hand (34.8 ± 4.3 pegs). The Session X Hand interaction [$F(3, 7.1) = 1.01$, $p = 0.40$)] was not significant. No other comparisons achieved significance ($p > 0.05$). The main effect of Session is shown in Figure 7.

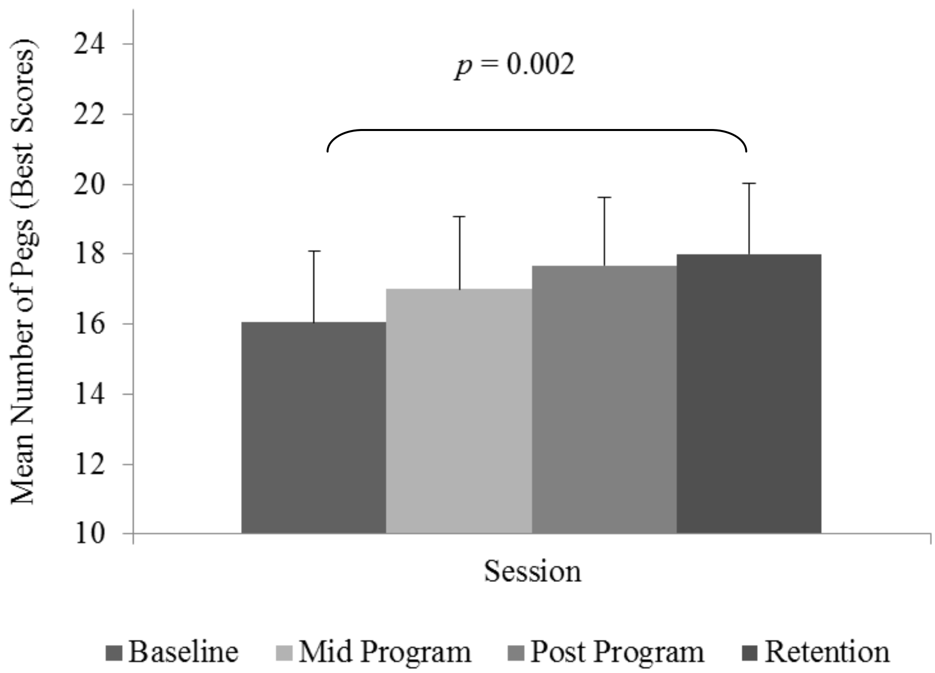

Figure 6: Mean (SE) best scores from the 25 Grooved Pegboard Test. Scores were significantly better at baseline compared to retention (baseline: 16.0 ± 2.1 pegs, retention: 18.0 ± 2.0 pegs, $p = 0.002$).

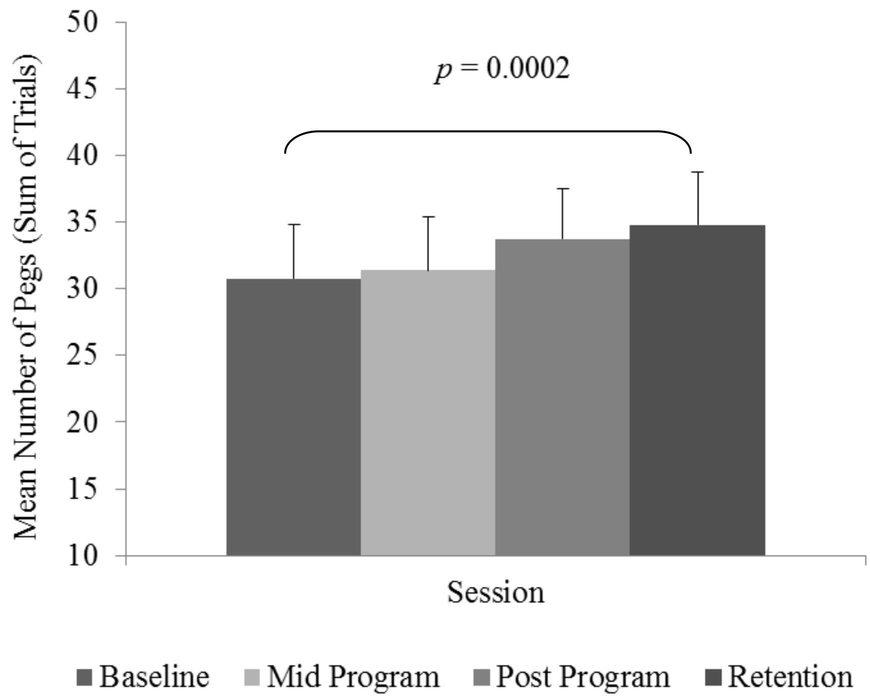

Figure 7: Mean (SE) sum of trials from the 25 Grooved Pegboard Test. Scores were significantly better at baseline compared to retention (baseline: 30.8 ± 4.1 pegs, retention: 34.8 ± 4 pegs, p = 0.0002).

4.2. Box and Blocks Test

There was a significant main effect of Session [$F(3, 195.9) = 3.26$, $p = 0.04$)] when the best scores were analyzed, however, pairwise comparisons revealed that scores were not significantly different at any measurement period ($p > 0.05$). There was a significant main effect of Hand [$F(1, 70.9) = 20.3$, $p = 0.001$], such that scores of the left hand (42.5 ± 6.0 blocks) were significantly lower than scores of the right hand (44.3 ± 6.2 blocks). The Session X Hand interaction was not significant [$F(3, 7.5) = 1.97$, p = 0.14). There was a significant main effect of Session [$F(3, 603.2) = 3.36$, $p = 0.03$] when the sum of trials were analyzed, however, only the scores from retention approached significance when compared to scores at baseline (baseline: 77 ± 12.6 blocks; retention:

84.5 ± 12.6, *p* = 0.051). No other pairwise comparisons achieved significance ($p > 0.05$). The main effect of Hand approached statistical significance [$F(1, 92.1) = 4.8$, $p = 0.05$). The Session X Hand interaction was not significant [$F(3, 10.44) = 0.52$, $p = 0.67$). The main effect of Session is shown in Figure 8.

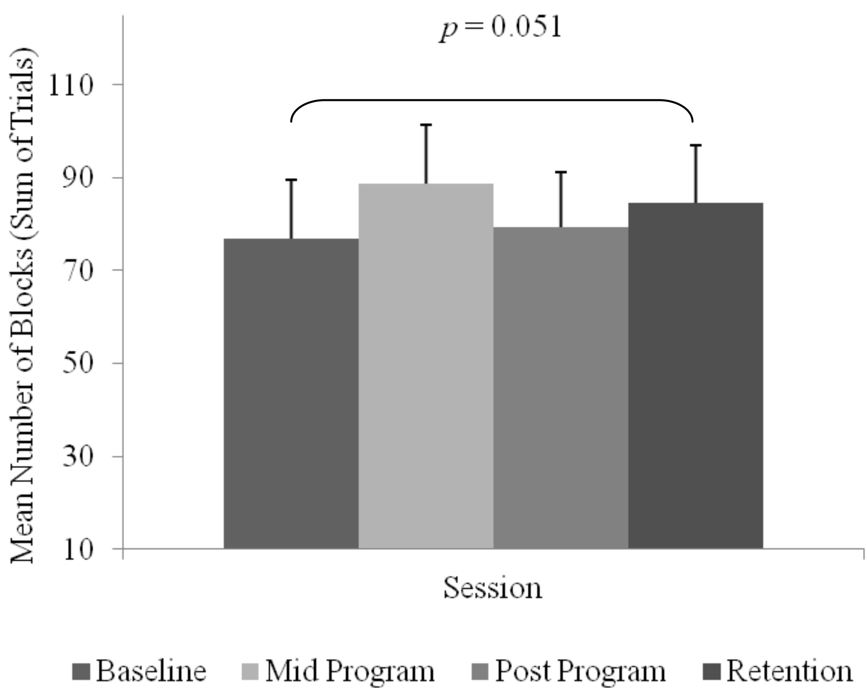

Figure 8: Mean (SE) sum of trials from the Box and Blocks Test. Scores were significantly better at retention compared to baseline (baseline: 77 ± 12.6 blocks, retention: 84.5 ± 12.6, *p* = 0.051).

4.3: Stick-Catching Test

One participant who had been omitted from the analysis of the three other motor tests was included in the analysis of the Stick Catching Test. Two individuals who were part of the analysis the other three motor measures were removed from this analysis because they failed to register scores in at least three of the four testing sessions for both their right and left hand. Another individual's left hand scores were omitted from analysis because this person also failed to register scores in at least three of the testing sessions. Additionally, there were two right hand trials and one left hand trial obtained from other participants at baseline testing that had to be removed; however, these did not affect the sample size in terms of the number of participants providing trials for the analysis. Linear mixed modelling revealed that there was no effect of Session [$F(3, 54.4) = 1.07$, $p = 0.37$], Hand [$F(1, 57.4) = 1.79$, $p = 0.19$], and there was no Session X Hand interaction [$F(3, 56.2) = 1.85$, $p = 0.15$]. The means and standard error values for the Stick Catching Test can be found in Appendix F.

4.4: Static Balance Testing

One participant was removed from all eyes open (EO) analyses and two were removed from all eyes closed (EC) analyses, because they were unable to provide at least three trials over the course of the four testing sessions (ie. EO or EC). One additional EO retention trial and three EC retention trials also were also removed.

There were no significant effects of Session [$F(3, 54.7) = 1.35$, $p = 0.27$], Condition [$F(1, 59.77) = 0.29$, $p = 0.60$], or Condition within Session [$F(1, 54.69) = 0.76$, $p = 0.52$] on ML displacement (COPx). Similarly, analysis of AP displacement (COPy) revealed that there were no significant effects of Session [$F(3, 54.94) = 2.51$, $p = 0.07$], Condition [$F(1, 58.71) = 0.22$, $p = 0.64$], or Condition within Session [$F(1, 54.95) = 0.17$, $p = 0.92$]. The group means for displacement and the corresponding standard error values are depicted in Appendix F.

There were no significant effects of Session [$F(3, 54.62) = 0.94$, $p = 0.43$], Condition [$F(1, 59.72) = 0.53$, $p = 0.47$], or Condition within Session [$F(3, 54.61) = 0.75$, $p = 0.53$] on velocity in the ML direction. There were also no significant effects of

Session [$F(3, 54.56) = 1.5$, $p = 0.23$], Condition [$F(1, 56.97) = 0.81$, $p = 0.37$], or Condition within Session [$F(3, 54.58) = 0.03$, $p = 0.99$] on velocity in the AP direction. The group means for velocity and the corresponding standard error values are depicted in Appendix F.

There were no significant effects of Session $F(3, 55.34) = 1.24$, $p = 0.31$], Condition [$F(1, 59.63) = 0.46$, $p = 0.5$], or Condition within Session [$F(3, 55.34) = 0.4$, $p = 0.75$] on Sway Area. The group means and corresponding standard error values are depicted in Appendix F.

4.5: Summary

Improvements were statistically significant for in the 25 Grooved Pegboard Test and the Box and Blocks Test at retention compared to baseline. However, the Box and Blocks Test exhibited this trend only when the sum of all scores at each session was taken, and not when the best scores at each session were taken. In contrast, the 25 Grooved Pegboard exhibited this trend when both the sum of scores and best scores were analyzed. Performance on the Stick Catching Test did not improve significantly at any of the sessions and performance on the balance variables (displacement, velocity and sway area) also did not change significantly over time.

CHAPTER 5

Discussion

The purpose of this study was to improve the balance skills, fine- and gross-motor visual-manual skills and reaction time of adults with ASD and ID by means of a 12-week intervention involving motor skills training, whole body exercise, and sports and games activities. Although the functional abilities of the participants were quite different, with some displaying considerable motor impairment and others showing less obvious movement difficulties, every participant was compared only to his or her own scores (served as their own controls). This allowed for analyses to be performed on the relative change in motor function experienced by the group from one testing session to another. The primary focus of the study was to facilitate relative improvement of motor function for each participant. All of the exercises were adapted to the skill level of each participant and considerable care was taken to ensure that participants maintained proper form and pace of movement during each exercise.

After obtaining baseline scores in each of the four domains of motor skill, participants were then tested again after six weeks of the intervention, again after 12 weeks and then after four weeks of no program activity. It was hypothesized that improvements would occur in these motor skills at each of the subsequent testing periods and that at retention testing, improvements would stabilize. Significant improvements were found in the scores of the 25 Grooved Pegboard Test and the Box and Blocks test at retention when compared to baseline. The analysis of the data acquired from the reaction time test and balance assessments did not reveal statistically significant improvements.

5.1: 25 Grooved Pegboard and Box and Blocks Tests

The results from the 25 Grooved Pegboard Test suggested that, as a group, the participants had significantly better fine motor dexterity at four weeks after finishing the 12 week intervention compared to baseline, before the program began. Likewise, results from the Box and Blocks Test showed significant improvements at retention testing when all of the trials for each participant were included in the analysis. When each participant's best scores were analyzed, significant improvements were not found. Given that significant improvements were found only at retention testing and not during the post testing, one must consider the possibility that repeated practice on these tests resulted in greater improvements from baseline. Since there was no control group, it is difficult to conclude whether the significant improvements that occurred were due to the intervention or repeated exposure to the motor tests. However, it must be noted that the participants did not practice these standardized tests at all during the intervention and only had exposure to them during the testing periods, which were spaced by a minimum of four weeks. Furthermore, participants were not given any additional practice with the tests on the testing days. Therefore, each participant performed only eight trials for each hand with both the 25 Grooved pegboard and Box and Blocks Test from baseline to retention testing, making practice effects less likely. Future studies should implement a control group in order to determine what benefits derive primarily from the intervention itself.

Furthermore, if the intervention was entirely responsible for the improvements seen with motor dexterity, it is still difficult to conclude which part of the intervention was responsible for such improvement. The fine motor control training tasks engaged dexterous muscles of both the left and right hand equitably, thus improvements in dexterity could be attributed to practice during this portion of the program. However, aerobic exercise has been found to reduce repetitive behaviours in this population (Elliot et al., 1994) and repetitive behaviours have been shown to negatively correlate with proficiency in balance and postural stability (Radonovich, Fournier, & Hass, 2013). Therefore improvements in aerobic capacity as a result of participation in the present intervention may have brought forth improvements in upper extremity dexterity as a secondary outcome through a reduction in repetitive behaviours. This connection between repetitive behavior and motor control will be discussed further in section 5.2. Future studies should evaluate the impact of whole body exercise, sports and games activities and upper extremity motor skill training separately so that any improvements found in motor skills can be appropriately attributed to the corresponding type of intervention.

Another factor to consider involves the concept of hand dominance. There was a difference in hand performance at the outset of the program, but both hands improved at approximately the same rate. Although the 25 Grooved Pegboard has been considered as a performance measure for handedness assessments, the test in itself is insufficient when designating hand dominance (Corey, Hurley, & Foundas, 2001). Determination of hand dominance was not the purpose of the present study, and so no formalized method of assessment was used. Even if hand dominance were to be determined, the direction of skill transference between the dominant and non-dominant hand is still misunderstood empirically. For instance, there are some studies that suggest that training the non-dominant hand results in a greater degree of skill transference to the dominant (Parlow & Kishbourne, 1990; Niebor et al., 2012), while others suggest the opposite, that there is better transference from the dominant to the non-dominant limb (Criscimagna-Hemminger et al., 2003; Redding & Wallace, 2008). Therefore future studies should investigate the impact of hand dominance on skill transference in this population. As this relationship becomes increasingly understood, information on hand dominance for participants would help to inform hypotheses of projected improvements for each hand. Additionally, such information would inform retrospectively imposed explanations as to why differences in improvement between the dominant and non-dominant hand may have occurred.

Another consideration involves the different results brought forth by analyzing the best scores per session and the sum of scores per session. By accounting for only the best scores, one is essentially filtering the data of the less optimal trials and is thereby creating a bias of proficiency for data analysis. However, when one includes all of the trials, results of the test that may underestimate the capabilities of participants are included. Thus, one is potentially diluting the data with sub-optimal outlying trials. One cannot as assuredly conclude that the participants improved their *gross motor* upper extremity skill as repeated measures of the Box and Blocks Test revealed that statistically significant improvements only occurred from baseline to retention in the sum of scores analysis. That the participants improved their upper extremity *fine motor* skill is more convincing because repeated measures analysis of the best scores per session, as well as the sum of scores in the 25 Grooved Pegboard Test revealed that significant improvements occurred from baseline to retention.

5.2: Stick Catching Test

The results of the Stick Catching Test showed that there were no significant effects of session or hand and there was no interaction between either of these two variables. Many of the participants had problems executing the test, and this may have contributed to the variability associated with the resultant dataset. For instance, some individuals did not react quickly enough with the metre stick, resulting in the stick falling through their hands to the floor. It is difficult to determine whether this was due to an exceptionally slow reaction time, a lack of understanding the test's objective, or an unwillingness to perform the test. For example, some individuals would not grasp the metre stick as it fell, but had no problem playing catch with a foam football. It was decided to test these individuals by substituting the metal metre stick for a Styrofoam cylinder at post-program testing. As suspected, these participants would grasp the cylinder as it fell. This suggested that they understood the task, and were simply unwilling to grasp the metal metre stick. Due to the success that this modification had at post-program testing, it was used again during retention testing. Although this allowed these individuals to obtain a score for this test, the resultant heterogeneity of protocol necessitated the removal of these scores from the analysis.

Despite the fact that statistically significant improvements were absent, the Stick Catching Test demonstrated some success in the present study. Future researchers are advised to attempt this test as instructed by Carmeli et al. (2008) but if participants experience problems then researchers are advised to situate a Styrofoam covering or something cylindrical onto the metre stick that can facilitate manual gripping. Although this test can be done seated, some of the participants did not react quickly enough during their first exposure to the test during the orientation day that occurred before baseline testing. In order to accommodate for this, every test from baseline onward was done with all participants standing.

The Stick Catching test is a visually contingent assessment of reaction time and in addition to simplifying a test of visual reaction time; future studies should investigate reaction time with other senses, such as those of audition and somato-sensation. Research has shown that individuals with ASD and ID have difficulties with sensory integration (Collignon et al., 2013; Iarocci & McDonald, 2006; Carmeli et al., 2008) and so it would be a worthwhile pursuit to determine the differences in response time where reaction time depends on different senses.

5.3: Static Balance Testing

Data from the balance testing was too variable for statistical analyses to yield significance. Part of the reason why the standard deviations were so large was due to inherent variability within our sample; however, for the participants, the test itself was challenging and so it was difficult to obtain proper trials from many of them. Balance testing aside, standing still on or off of the force platform was difficult for many of our participants, regardless of whether or not their eyes were opened or closed. It could be argued, however, that the EC condition was the more difficult condition of the two, given that only nine individuals were included in the EC analysis while 10 were included in the EO analysis. As described in Chapter 3, if an individual opened his or her eyes during the middle 20 seconds of an EC trial, then that trial was excluded from subsequent analyses. Also, for any trials where the participant moved either his or her heels or toes away from the force platform during the middle 20 seconds, the trial was excluded. Additionally, some data points were excluded if the participant swayed his or her body or moved his or her legs and/or arms throughout the trial. Removing trials may have lowered the chances of achieving statistical significance due to a reduce sample sizebut it was necessary in order to maintain validity within the analysis.

One reason why there was such difficulty with standing still for the participants likely involves the repetitive behaviours that are often expressed by those with autism and ID. Although repetitive behaviours are most likely underpinned by a variety of etiological and neurological factors (Lewis & Kim, 2009), Radonovich et al. (2013) has discussed that postural and balance problems are closely related to the presence of repetitive behaviours. The sample population in their study involved children with ASD and without ID, but previous research has shown that there is a relationship between motor control problems and repetitive behaviours in individuals with ID (Bodfish, Parker, Lewis, Sprague, & Newell, 2001). Radonovich et al. (2013) found that the overall intensity and frequency of scores on the Repetitive Behaviour Scale-Revised (RBS-R: Bodfish, Symons, Parker, & Lewis, 2000) were significant predictors of COP sway areas in ASD. These results are consistent with previous findings of motor impairment in ASD (Fournier et al., 2010; Bhat et al., 2011), and suggest that controlling for repetitive behaviours while concurrently testing motor function is an imperative to which all future studies of motor control should pay attention. Rather than being a wholly differentiated behavioural phenotype, repetitive behaviours may actually involve a deficient motor system that is continuously attempting to maintain stability and engage in purposeful movement (Bodfish et al., 2001). Thus, a limitation to the present study is that repetitive behaviours were not quantified during any of the testing periods. Future studies should implement a measurement of repetitive behavior, such as the Repetitive Behaviour Scale-Revised (Bodfish et al., 2000) along with measurements of COP displacement, velocity, and sway area using a force platform.

5.4: Strengths, Limitations and Additional Recommendations for Future Researchers

Difficulties associated with assessing motor function in this population were demonstrated in the present study. The 25 Grooved Pegboard and Box and Blocks Test were successfully implemented, and future researchers are encouraged to use these tests in their standardized forms or with the modifications that were made in the present study. If the participants are unable to initiate their own involvement in these tests in response to an instructor's request, then applying the modifications that were used in the present study will help to facilitate administration of the measurement protocol.

Tests of reaction time using the Stick Catching Test and balance using the force platform were more difficult to administer. Measurements of reaction time with the Stick Catching Test may be performed in a seated position or standing, if the participants are capable of grasping the metre stick and responding before it falls to the ground. If participants refuse to grasp the metre stick or are unable to do so, then encapsulating the metre stick with a Styrofoam cylinder will help to obtain scores from these participants. Future studies implementing measures of balance should perform the test in a quiet room with limited extraneous stimuli. In addition to this, a measure of repetitive behaviour should be implemented along with balance testing in order to control for the compounding effect that such behaviours have on motor function (Radonovich et al., 2013). Furthermore, future interventions should build upon the measurement protocol described herein by incorporating tests such as the Halstead Finger Oscillation test and grip strength in order to ascertain a better understanding of hand dominance within the study sample.

Providing one instructor for each participant was an effective arrangement that allowed for a thorough provision of safety and an interactive method of instruction. However, such an ideal number of instructors may not be feasible in every low-cost, community-based setting. This highlights the benefit of academia cooperating with the surrounding community, as individuals educated in human anatomy and exercise science were able to volunteer between class times or to enrol as a student through an internship program. Future studies should also experiment with different types of interventions, such as those with a vigorous aerobic focus, those with a fine motor control focus, those with a balance and stability focus, etc. Whole body exercise, sports and games accompanied by motor training made for a comprehensive intervention, but if specific motor control improvements are sought, then a narrower focus on the type of training is advisable. Moreover, future studies should emphasize proper technical movement patterns throughout training, as well as focus on progressing the quality movement rather than the quantity of repetitions for a given movement pattern. Proper movement technique was the focus of the present study and the importance of this tenet cannot be understated. Improper movement progression could lead to injury and subsequent discouraging feelings that may render a participant resentful of the program wherein the injury was sustained. Since coordination is often difficult for those with autism and ID, enhancement of coordination should take precedence over the development of strength and intensity.

It is important to consider the duration of time and quantity of practice that is required for improvements to occur in the motor functioning of adults having ASD with ID. Future studies should experiment with longer interventions and more intensive motor training protocols in order to explore the potential for improvement in this population. However, generalizing time frames of improvement to the entire population of those with ASD and ID would be difficult, given the heterogeneity of these conditions. Therefore a more regionalized, community-based focus that individualizes exercise programs for those participants in the surrounding community would be in the best interest of every participant.

Instructing the participants and providing the appropriate feedback was successful in most instances. Instructors provided written reflections regarding their teaching and participants' responses to such instruction and prompting. Capturing the success of the prompting quantitatively was challenging. Instructors reported improvements for their participants in every aspect of the program and so it is reasonable to surmise that the instructional process demonstrated at least partial success. In accordance with the LTM nature of the prompting style, the initial instruction was provided as a visual demonstration with an accompanying explicit verbal explanation. Depending on how accurate a participant's first attempt was, visual prompting was provided in the form of exaggerated demonstrations that highlighted that participant's misrepresentations. Determining when exactly it was appropriate to intervene with physical prompting was difficult but with the ongoing supervision of the support workers and research staff, this uncertainty was navigated carefully.

When prompting a participant physically it was the support worked that provided the physical guidance. As the sessions continued, instructors would slowly and carefully provide the physical guidance if the support worker thought it appropriate and if the participant seemed receptive. Physical guidance was removed as the participant began to perform the aspect of the movement without the prompt. If participants regressed then prompting was increased accordingly. Once someone could perform a given exercise without visual of physical prompting, a NNP format would be enacted. If a participant made mistakes on subsequent attempts then the instructor would simply say “No” and on a third consecutive mistake a visual prompt was made. If the visual prompts did not correct the mistake then physical guidance would be instigated and the hierarchy would resume. Future researchers developing studies like the present one are advised to attempt a quantitative analysis and comparison of prompts used. These prospective interventions should attempt to keep track of how many prompts, what kinds of prompts (visual, physical, verbal), and in what manner (MTL, LTM, NNP) such prompts are used in order to elicit the appropriate responses from the participants.

Throughout the 12-week intervention, anecdotal improvements were seen in many participants’ coordination for a number of the exercises that were practiced. Previous studies have investigated the impact of video modeling (Bellini & Akullian, 2007), but these were primarily for the purpose of instruction. Video Self Modeling (VSM) allows not only for the use of a participant’s previous attempts in the ongoing instructional process, but also for the visual tracking of a participant’s movement skill across time. VSM allows the participant to learn from his or her own previous successful attempts at the particular skill that is being developed and reinforced (Bellini & Akullian, 2007).

This supports the notion proposed by Bandura (1977), that one is more likely to effectively learn through observation of individuals with whom they share a close resemblance. Therefore, VSM should be considered for use in future interventions with this population for the purposes of both documenting progress and facilitating instruction over time (Bellini & Akullian, 2007).

In order to videotape a participant successfully performing a given skill, one must first help that participant achieve success with that particular skill. In doing so, modeling performed first by the instructor or the participant’s support worker would be advisable. In the present study, the support workers attended the sessions and assisted the instructors in visually demonstrating the skills that were being taught. As an additional reference, pictures of the exercises were posted at each station so video modeling was deemed unnecessary for the present study. Video modeling would be very helpful if there were a shortage of instructors and support workers who had exercise training. This would ultimately still require a kinesiologist or exercise physiologist to supervise the support workers, but the convenience of having an instructional video that could be taken to a participant’s house is a noteworthy benefit.

Another factor that should be considered for future studies of this nature regards sex differences in motor skill. Dissimilarities in fine and gross motor skills have been found in men and women without ASD and ID. For instance, research has shown that females demonstrate greater levels of skill with movements involving the small muscles of the hands (Tiffin, 1987), while males show greater skill in activities that involve proficient proximal muscle control, such as with throwing (Watson & Kimura, 1991; Sanders & Kadam, 2001). This relationship has been shown to occur in adults (Tiffin, 1987; Watson & Kimura, 1991) as well as in prepubescent children (Sanders & Kadam, 2001), and therefore may have prenatal underpinnings. Moreover, a relationship has been found between fine motor skills of the hands and levels of sex hormones in women (Bayer & Hausmann, 2010), and therefore future studies are advised to control for not only the sex of participants but also (ideally) for the hormonal levels of each sex. With the resources for recruitment available to us in the present study, there were only two eligible females for participation in our intervention. Given the resultant small total sample size collapsing the groups into one was necessary for the purposes of our research but most importantly, for the purposes of our program.

Although capturing more objective measures of motor skill improvement was difficult in the present study, the daily progress reports (exercise tracking sheets) revealed improvements for all of the participants. Reports written by the student instructors indicated improvement in the fine motor skills, such as moving more pegs and paper clips in shorter lengths of time. Also, improvements were reported for the gross motor sports and games, such as throwing the nerf balls longer distances and more consistently and striking badminton birdies and ping pong balls more effectively. Also, improvements were reported for the exercise stations, including increased weight lifted, increased numbers of repetitions and sets performed, increased time holding yoga poses and stances on top of the balancing discs, as well as gradually improved steadiness on top of the stability balls. Although this is insufficient to objectively conclude that all participants improved their balance, on an individual level meaningful improvements occurred for every participant. Discussions with support worker revealed that other improvements occurred, such as participants being calmer and more relaxed after the program. Also, they noticed that the participants became increasingly motivated to attend the sessions as the intervention progressed. Moreover, one participant has since joined a fitness club and another has undertaken Zumba. Improvements like this may not only reflect confidence and motivation for exercise and movement but also may reflect improved social comfort and confidence. Future studies should also employ detailed reports of success of balance exercises over a number of stability activities, as this can supplement empirical findings and be very encouraging to the participants.

5.5: Conclusion

Research on motor functioning and training in adults with autism and ID is limited, and this lack of data served as the rationale for the present study. Autism and ID are associated with motor impairment (Fournier et al., 2010; Jankowicz-Szymanska, 2012) and corresponding damage to critical structures involved in motor learning (Fatemi et al., 2012). Therefore, improvements resulting from motor training that could be expected in a neurotypical population should be extended with caution to those with Autism and ID. Skills of daily living involve varying degrees of motor skill, such as those involved with recreation and employment but also those of a more domestic nature. Understanding how to most effectively instruct motor skills to this population will assist these individuals in becoming more active in the community and more independent around their homes.

The purpose of the present study was to evaluate changes in the motor skill of 14 adults with autism and ID following engagement in a 12-week exercise and motor control intervention. Measurements of fine- and gross-motor skills of the upper extremities, as well as measures of balance and reaction time were taken at baseline, mid program, post program and after four weeks of no activity (retention) on a group of 14 participants. Significant improvements occurred in 25 Grooved Pegboard Test at retention compared to baseline. Similar improvements were seen in the Box and Blocks Test. Results from the Stick Catching Test indicated that reaction time did not significantly improve during or after the intervention. Results of the balance analysis revealed that balance did not significantly improve over the course of the 16 week measurement period.

As a research endeavor and community program, this study brought together university students, professors, adults from Windsor-Essex community with autism and ID and their support workers. Everyone involved was impacted in a positive way and due to the success of the program a follow-up study is already being organized. Cooperation of academia and the surrounding community will be integral for future of research in this area and the corresponding developments of motor skill related interventions for this population. If the field assessment and intervention procedures can continue to be refined, then future programs will be better equipped to assist adults with ASD and ID in their ongoing motor development.

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APPENDICES

Appendix A

<u>Participant Consent Form</u>

University of Windsor

CONSENT TO PARTICIPATE IN RESEARCH

Title of Study: **The Impact of Motor Skill training on Hand-Eye Coordination in Adults with Autism and Intellectual Disabilities:** consenting adults

You are asked to participate in a research study conducted by Phillip McKeen, Kelly Carr, Dr. Sean Horton, Dr. Nadia Azar, and Professor Chad Sutherland from the Kinesiology Department at the University of Windsor.

If you have any questions or concerns about the research, please feel to contact Mr. Phillip McKeen by phone XXXX or email: mckeenp@uwindsor.ca, Kelly Carr by phone (519) 255-3000 ext: 4049 or email: carrk@uwindsor.ca, Dr. Sean Horton by phone (519) 253-3000 ext: 2442 or email: hortons@uwindsor.ca, Dr. Nadia Azar by phone (519) 253-3000 ext: 2473 or email: azar5@uwindsor.ca, Prof. Chad Sutherland by phone (519) 253-3000 ext: 4050 or email: chads@uwindsor.ca

PURPOSE OF THE STUDY
The purpose of this research is to improve the hand-eye coordination in persons who have been diagnosed with autism and an intellectual disability. By improving the hand eye coordination of our participants, we hope to increase their chances at securing a healthier lifestyle and eventually, employment opportunities.The purpose is also to improve the overall physical fitness of our participants by engaging them in a variety of different exercises. Throughout our program, we plan to educate the participants on how to safely use exercise equipment and how to increase their daily physical activity to feel better about working out. Lastly, all hand-eye coordination training tasks included in this study will be used to develop a new chapter within an Adapted Physical Activity Training Manual. The participants can use this manual to continue to improve motor function and stay physically active after the completion of the study.

PROCEDURES
If you volunteer to participate in this study, you will be asked to participate in:

1) a pre-testing session (30 minutes in duration)
2) 24 training sessions (twice a week for 12 weeks; approximately 1 hour to 1 hour and 30minutes in duration)
3) a post-testing session (30 minutes)

Inclusion Criteria:

In order to participate in this study you must:

1) Receive support from Community Living Essex County through either 24 hour supported living, independent living arrangements, or receive occasional respite support
2) Be 18 years or older
3) Be diagnosed with autism and have an intellectual disability
4) Have a signed medical note by your doctor stating you are able to safely start physical activity
5) Answer no to all the questions on the Physical Activity Readiness Questionnaire (PAR-Q) form or if you answered yes to any questions on the PAR-Q form then you need a Physical Activity Readiness Medical Examination (PARmed-X) form signed by your doctor
6) Capable of understanding instructions (all possible adaptations will be made for all interested people to participate)
7) Capable of participating in physical fitness regimen (all possible adaptations will be made for all interested people to participate)

Pre-testing Session:

At the beginning of the project the research team will take baseline measures. During the pre-testing session, your height, weight, age, and gender will be recorded. Cardiovascular endurance will be measured with a twelve minute walking test. Muscular strength will be measured in both hands with a grip strength test. Flexibility will be measured with a sit and reach test. Finally, balance will be measured by standing on two feet on a force plate for 30 seconds. All tests will be performed in the Kinesiology Laboratory in the Human Kinetics building except the walking test, which will be performed in the St. Denis Centre field house, joined to the Human Kinetics building.

In order to test your hand-eye coordination, three additional tests will be performed. First, we will have you perform the pegboard test, where you will pick up and insert 25 pegs into a wooden board, one peg at a time with one hand. We will give you two tries per hand. The second test for hand-eye coordination will have you pick up blocks from one box, one at a time, and place them in a second box, one hand at a time. Both of these tests are to be done as quickly as you can manage. The final test will measure your reaction time and to do this we will hold a ruler above one of your hands and drop it without telling you. You will be asked to catch the ruler as soon as you realize it has been dropped.

Training Sessions:

Participants will be divided into two groups with both groups completing the exact same training, with one exception. The experimental group will practice tasks that require hand-eye coordination. All training sessions will be performed within the St. Denis Centre field house and the Forge Fitness Centre. For the control group each session will be about 1 hour, and for the experimental group each session will be about 1 hour and 30 minutes. The first hour will consist of a warm-up, exercise regimen, and cool-down. After the first hour, the experimental group will head up to the Multi-purpose lab where they will engage in hand-eye training tasks for approximately 30 minutes. You will be given breaks between activities and breaks will be provided during each of the activities. Your typical warm-up will include you being asked to participate in activities such as easy-paced walking, marching, or pedalling on a stationary bike. The warm-up will also include you being invited to perform some stretching activities, such as heel raises, knee lifts, arm circles, shoulder lifts, and toe touches. For the strength training program, you will work with a Kinesiology student who will lead you through the activity. You will perform a variety of exercises using different muscle groups and the workout will take place at the Forge Fitness Centre. You will start by completing 1 set of 12 repetitions and gradually increase to a maximum of 2 sets of 12 repetitions over the 12 weeks with a weight you can complete comfortably. For the activity portion of the training sessions, you will be invited to participate in a variety of sports including; badminton, basketball, indoor lawn bowling, bean bag toss, and pickle ball. Finally each training session will end with you being invited to perform a whole body stretching routine, which will be demonstrated by the investigator.

Post-testing Session:
Your post-testing session will be exactly the same as the pre-testing session.

POTENTIAL RISKS AND DISCOMFORTS
You may experience some minor muscle soreness, which is very common when participating in physical activity (e.g. if you go for a walk and your legs feel a little sore after you are done). In order to minimize the muscle soreness, when you are performing the strength exercises the investigators will only prescribe a weight that is comfortable for you to complete. Furthermore, the training sessions will begin with a proper warm-up and end with a proper cool-down to minimize any potential muscle soreness. You will be free to withdraw from the experiment at any time should you feel excessive discomfort.

POTENTIAL BENEFITS TO PARTICIPANTS AND/OR TO SOCIETY
Engaging in regular physical activity will allow you to improve your physical strength, fitness, flexibility, balance, self-esteem and confidence. You will also have the opportunity to increase your knowledge on the safe use of exercise equipment, personal nutrition, and the importance of leading a healthy lifestyle. The scientific community will benefit from understanding the effects of a 12 week fitness training program on the health measures of an intellectually disabled population with diagnoses of autism. Furthermore, the development of a 12 week Adapted Physical Activity Manual will have a very positive impact on helping other people within our community and across other agencies incorporate physical activity into an intellectually disabled population.

COMPENSATION FOR PARTICIPATION
For your participation in this study, you will receive a Kinesiology Research t-shirt.

CONFIDENTIALITY
Any information that is obtained in connection with this study and that can be identified with you will remain confidential and will be disclosed only with your permission.

All your data will be treated as confidential and only group data will be used in any publication or presentation. Your name will not be revealed, you will be identified using a subject code. Your personal information will be kept anonymous on all documents using the subject coding system, which will be known only to the investigators. A file linking your name to the subject code will be stored separately from the data. Your digital data will be stored on a password protected computer and your hard copy records will be stored in a locked filing cabinet. All your data collected during the study will be secured in a locked office within the Human Kinetics building. Only the investigators will have knowledge of the keys or passwords required to access this information. Upon completion of the study, your data will be transferred to a hard disc and locked within the office of Prof. Chad A. Sutherland (HK building 132). After a period of 5 years all your digital material will be erased and all your hard copies will be shredded. There will also be no video recording or digital photos taken during the training or testing sessions.

PARTICIPATION AND WITHDRAWAL

You can choose whether to be in this study or not. If you volunteer to be in this study, you may withdraw at any time without consequences of any kind. You may also refuse to answer any questions you don't want to answer and still remain in the study. The investigator may withdraw you from this research if circumstances arise which warrant doing so.

FEEDBACK OF THE RESULTS OF THIS STUDY TO THE PARTICIPANTS

You will receive your individual results at the end of the post testing session. After the study, the participants will be permitted to view their individual scores over the course of the 16 weeks. Complete results of the study (group data only) will be provided to the participants through Community Living Essex County. Furthermore, each participant will receive one copy of the Adapted Physical Activity Manual at the end of the post testing session.

SUBSEQUENT USE OF DATA

This data will not be used in subsequent studies.

RIGHTS OF RESEARCH PARTICIPANT

You may withdraw your consent at any time and discontinue participation without penalty. If you have questions regarding your rights as a research subject, contact: Research Ethics Coordinator, University of Windsor, Windsor, Ontario, N9B 3P4; Telephone: 519-253-3000, ext. 3948; e-mail: ethics@uwindsor.ca

SIGNATURE OF RESEARCH PARTICIPANT

I understand the information provided for the study **The impact of motor skill training on hand-eye coordination in adults with high functioning autism spectrum disorder and an intellectual disability** as described herein. My questions have been answered to my satisfaction, and I agree to participate in this study. I have been given a copy of this form.

____

Name of PARTICIPANT

______________________________________ ____________________

Signature of PARTICIPANT Date

Consent form for parents

CONSENT TO PARTICIPATE IN RESEARCH

Title of Study: **The impact of motor skill training on hand-eye coordination in adults with autism and intellectual disabilities:** guardian

Your family member is asked to participate in a research study conducted by Phillip McKeen, Kelly Carr, Dr. Sean Horton, Dr. Nadia Azar, and Professor Chad Sutherland from the Kinesiology Department at the University of Windsor.

If you or your family member have any questions or concerns about the research, please feel to contact Mr. Phillip McKeen by phone XXXXX or email: mckeenp@uwindsor.ca, Kelly Carr by phone (519) 255-3000 ext: 4049 or email: carrk@uwindsor.ca, Dr. Sean Horton by phone (519) 253-3000 ext: 2442 or email: hortons@uwindsor.ca, Dr. Nadia Azar by phone (519) 253-3000 ext: 2473 or email: azar5@uwindsor.ca, Prof. Chad Sutherland by phone (519) 253-3000 ext: 4050 or email: chads@uwindsor.ca

PURPOSE OF THE STUDY

The purpose of this research is to improve the hand-eye coordination in persons who have been diagnosed with autism and an intellectual disability. By improving the hand eye coordination of our participants, we hope to increase their chances at securing a healthier lifestyle and eventually, employment opportunities.The purpose is also to improve the overall physical fitness of our participants by engaging them in a variety of different exercises. Throughout our program, we plan to educate the participants on how to safely use exercise equipment and how to increase their daily physical activity to feel better about working out. Lastly, all hand-eye coordination training tasks included in this study will be used to develop a new chapter within an Adapted Physical Activity Training Manual. The participants can use this manual to continue to improve motor function and stay physically active after the completion of the study.

PROCEDURES

If your family member volunteers to participate in this study, he/she will be asked to participate in:

1) a pre-testing session (30 minutes in duration)
2) 24 training sessions (twice a week for 12 weeks; approximately 1 hour to 1 hour and 30minutes in duration)
3) a post-testing session (30 minutes)

Inclusion Criteria:

In order to participate in this study your family member must:

1) Receive support from Community Living Essex County through either 24 hour supported living, independent living arrangements, or receive occasional respite support
2) Be 18 years or older
3) Be diagnosed with autism and have an intellectual disability
4) Have a signed medical note by his/her doctor stating he/she is able to safely start physical activity
5) Answer no to all the questions on the Physical Activity Readiness Questionnaire (PAR-Q) form or if he/she answered yes to any questions on the PAR-Q form then he/she needs a Physical Activity Readiness Medical Examination (PARmed-X) form signed by his/her doctor
6) Capable of understanding instructions (all possible adaptations will be made for all interested people to participate)
7) Capable of participating in physical fitness regimen (all possible adaptations will be made for all interested people to participate)

<u>Pre-testing Session:</u>
At the beginning of the project the research team will take baseline measures. During the pre-testing session, your family member's height, weight, age, and gender will be recorded. Cardiovascular endurance will be measured with a twelve minute walking test. Muscular strength will be measured in both hands with a grip strength test. Flexibility will be measured with a sit and reach test. Finally, balance will be measured by standing on two feet on a force plate for 30 seconds. All tests will be performed in the Kinesiology Laboratory in the Human Kinetics building except the walking test, which will be performed in the St. Denis Centre field house, joined to the Human Kinetics building. In order to test your family member's hand-eye coordination, three additional tests will be performed. First, we will have him/her perform the pegboard test, where he/she will pick up and insert 25 pegs into a wooden board, one peg at a time with one hand. We will give him/her two tries per hand. The second test for hand-eye coordination will have your family member pick up blocks from one box, one at a time, and place them in a second box, one hand at a time. Both of these tests are to be done as quickly as he/she can manage. The final test will measure his/her reaction time and to do this we will hold a ruler above one of his/her hands and drop it without telling him/her. He/she will be asked to catch the ruler as soon as he/she realizes it has been dropped.

<u>Training Sessions:</u>
Participants will be divided into two groups with both groups completing the exact same training, with one exception. The experimental group will practice tasks that require hand-eye coordination. All training sessions will be performed within the St. Denis Centre field house and the Forge Fitness Centre. For the control group each session will be about 1 hour, and for the experimental group each session will be about 1 hour and 30 minutes. The first hour will consist of a warm-up, exercise regimen, and cool-down. After the first hour, the experimental group will head up to the Multi-purpose lab where they will engage in hand-eye training tasks for approximately 30 minutes. Your family member will be given breaks between activities and breaks will be provided during each of the activities. The typical warm-up will include your family member being asked to participate in activities such as easy-paced walking, marching, or pedalling on a stationary bike. The warm-up will also include him/her being invited to perform some stretching activities, such as heel raises, knee lifts, arm circles, shoulder lifts, and toe touches. For the strength training program, your family member will work with a Kinesiology

student who will lead him/her through the activity. He/she will perform a variety of exercises using different muscle groups and the workout will take place at the Forge Fitness Centre. Your family member will start by completing 1 set of 12 repetitions and gradually increase to a maximum of 2 sets of 12 repetitions over the 12 weeks with a weight he/she can complete comfortably. For the activity portion of the training sessions, he/she will be invited to participate in a variety of sports including; badminton, basketball, indoor lawn bowling, bean bag toss, and pickle ball. Finally each training session will end with him/her being invited to perform a whole body stretching routine, which will be demonstrated by the investigator.

Post-testing Session:
Your family member's post-testing session will be exactly the same as the pre-testing session.

POTENTIAL RISKS AND DISCOMFORTS
Your family member may experience some minor muscle soreness, which is very common when participating in physical activity (e.g. if you go for a walk and your legs feel a little sore after you are done). In order to minimize the muscle soreness, when your family member is performing the strength exercises the investigators will only prescribe a weight that is comfortable for him/her to complete. Furthermore, the training sessions will begin with a proper warm-up and end with a proper cool-down to minimize any potential muscle soreness. Your family member will be free to withdraw from the experiment at any time should he/she feel excessive discomfort.

POTENTIAL BENEFITS TO PARTICIPANTS AND/OR TO SOCIETY
Engaging in regular physical activity will allow your family member to improve his/her physical strength, fitness, flexibility, balance, self-esteem, and confidence. Your family member will also have the opportunity to increase his/her knowledge on the safe use of exercise equipment, personal nutrition, and the importance of leading a healthy lifestyle. The scientific community will benefit from understanding the effects of a 12 week fitness training program on the health measures of an intellectually disabled population with diagnoses of autism. Furthermore, the development of a chapter focused on the training of hand-eye coordination within the Adapted Physical Activity Manual will have a very positive impact on helping other people within our community and across other agencies incorporate these skills into a regular routine.

COMPENSATION FOR PARTICIPATION
For your family member's participation in this study, he/she will receive a Kinesiology Research t-shirt.

CONFIDENTIALITY
Any information that is obtained in connection with this study and that can be identified with your family member will remain confidential and will be disclosed only with your permission.

Your family member's data will be treated as confidential and only group data will be used in any publication or presentation. His/her name will not be revealed, he/she will be identified using a subject code. His/her personal information will be kept anonymous on all documents using the subject coding system, which will be known only to the investigators. A file linking his/her name to the subject code will be stored separately from the data. Your family member's digital data will be stored on a password protected computer and his/her hard copy records will be stored in a locked filing cabinet. All the data collected during the study will be secured in a locked office within the Human Kinetics building. Only the investigators will have knowledge of the keys or passwords required to access this information. Upon completion of the study, your family member's data will be transferred to a hard disc and locked within the office of Prof. Chad A. Sutherland (HK building 132). After a period of 5 years all your family member's digital material will be erased and all his/her hard copies will be shredded. There will also be no video recording or digital photos taken during the training or testing sessions.

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SIGNATURE OF GUARDIAN

I understand the information provided for the study **The impact of motor skill training on hand-eye coordination in adults with high functioning autism spectrum disorder and an intellectual disability** as described herein. My questions have been answered to my satisfaction, and I agree to participate in this study. I have been given a copy of this form.

By signing below I authorize the Community Living Essex County support worker to provide consent on behalf for my family member to participate in each training session.

____________________ ________________________ ____________________

Name of PARTICIPANT Name of Guardian

____ ____________________

Signature of Guardian Date

Appendix B

Participant Profile

Participant Profile

NAME: ______________________________

AGE: _____

CIRCLE: MALE or FEMALE

PHONE NUMBER: _______________________

STREET ADDRESS:

____

HEIGHT: _______________

MASS: ______________

DIAGNOSIS:

____

____

____

____

____

Appendix C

Rolling Consent Form

Sign In Sheet

Week 1 – Session 1
1/32

Hospital visits since we last saw you? ☐ YES ☐ NO

Comments:

____

____

Medication change since we last saw you? ☐ YES ☐ NO

Comments:

____

____

Would you like to participate in our exercise program today? ☐ YES ☐ NO

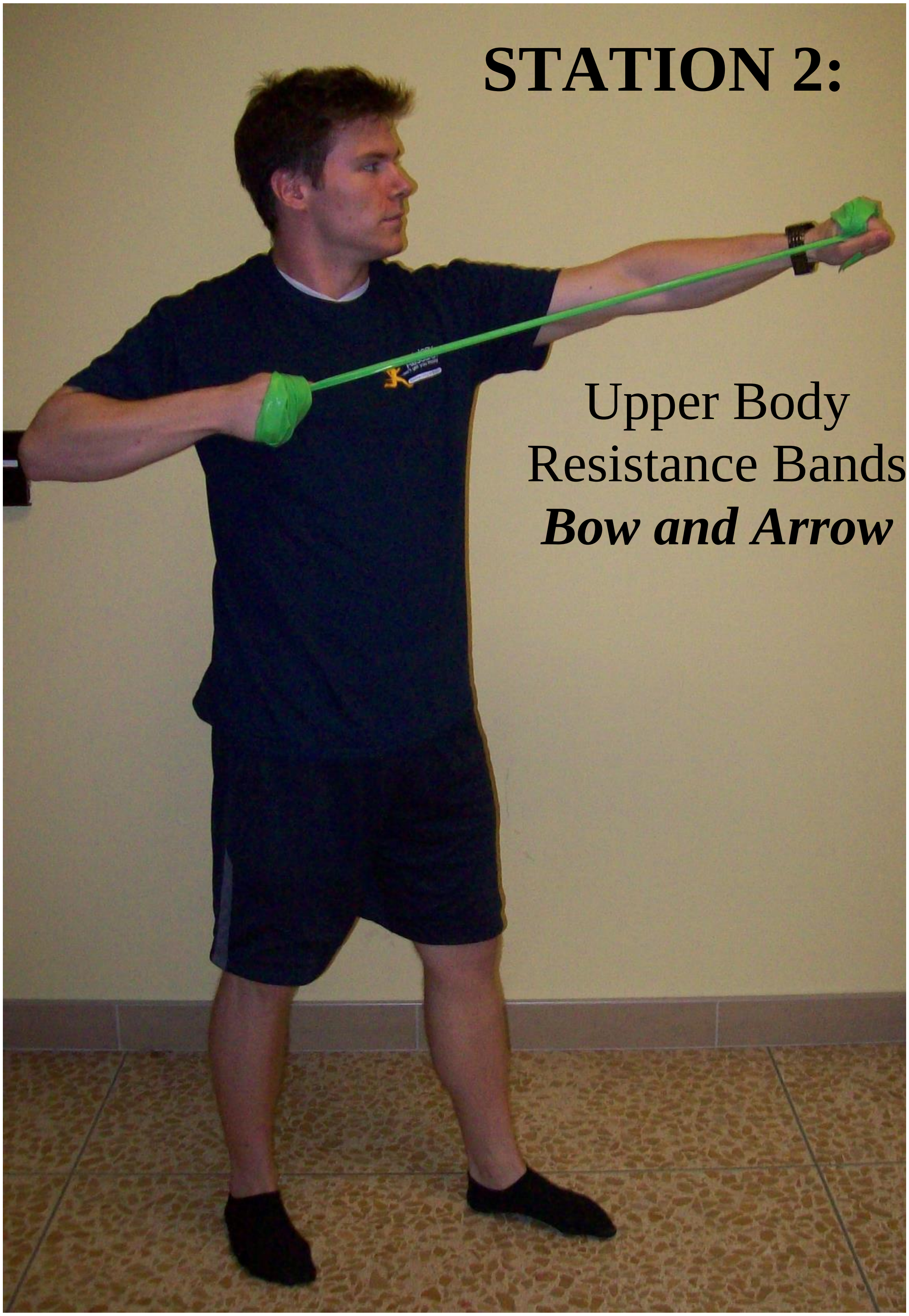
____ ____________________

Signature of Participant/Support Worker Date

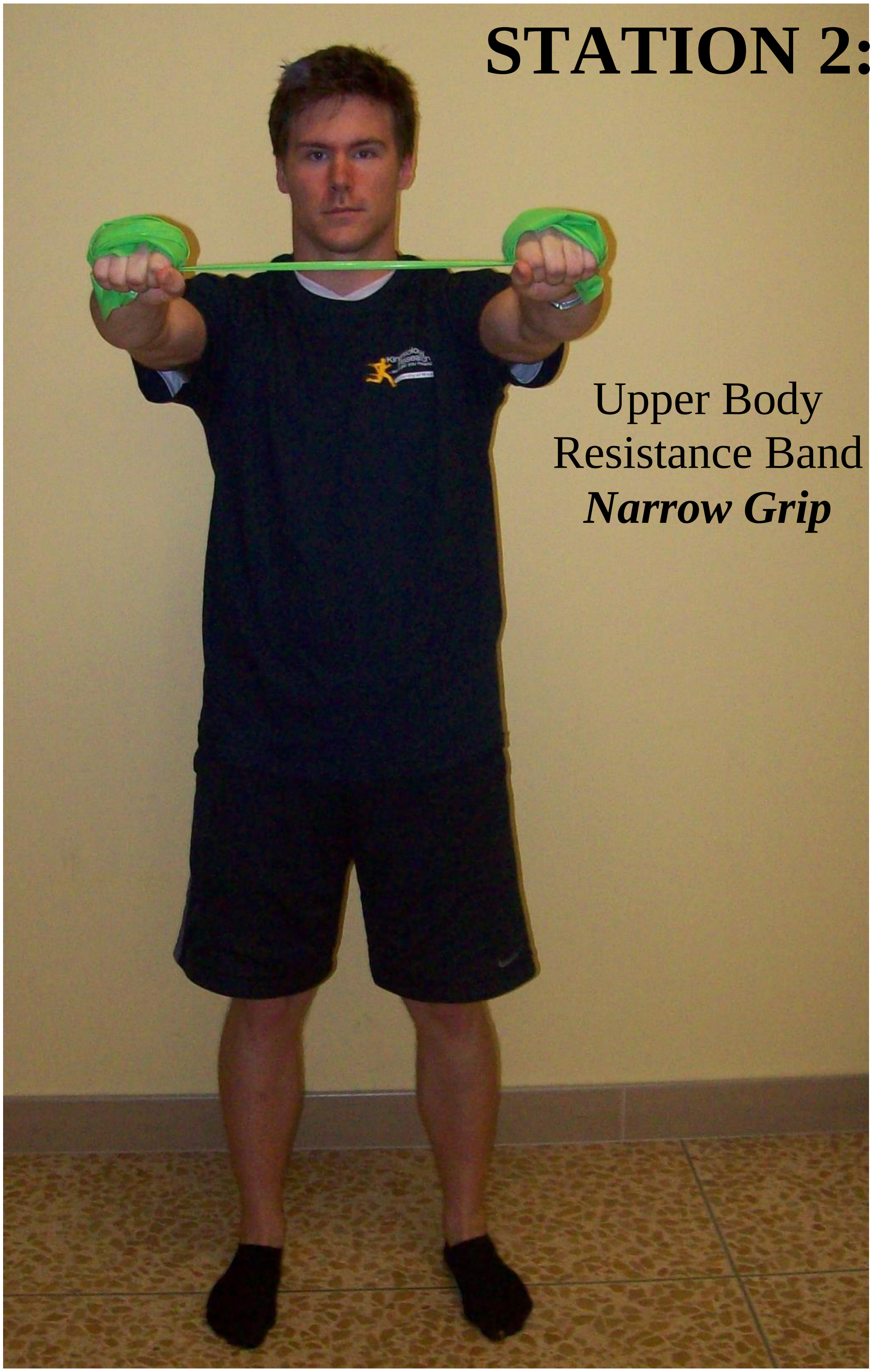
****Note: Rolling consent will consist of 32 identical boxes as seen above.*

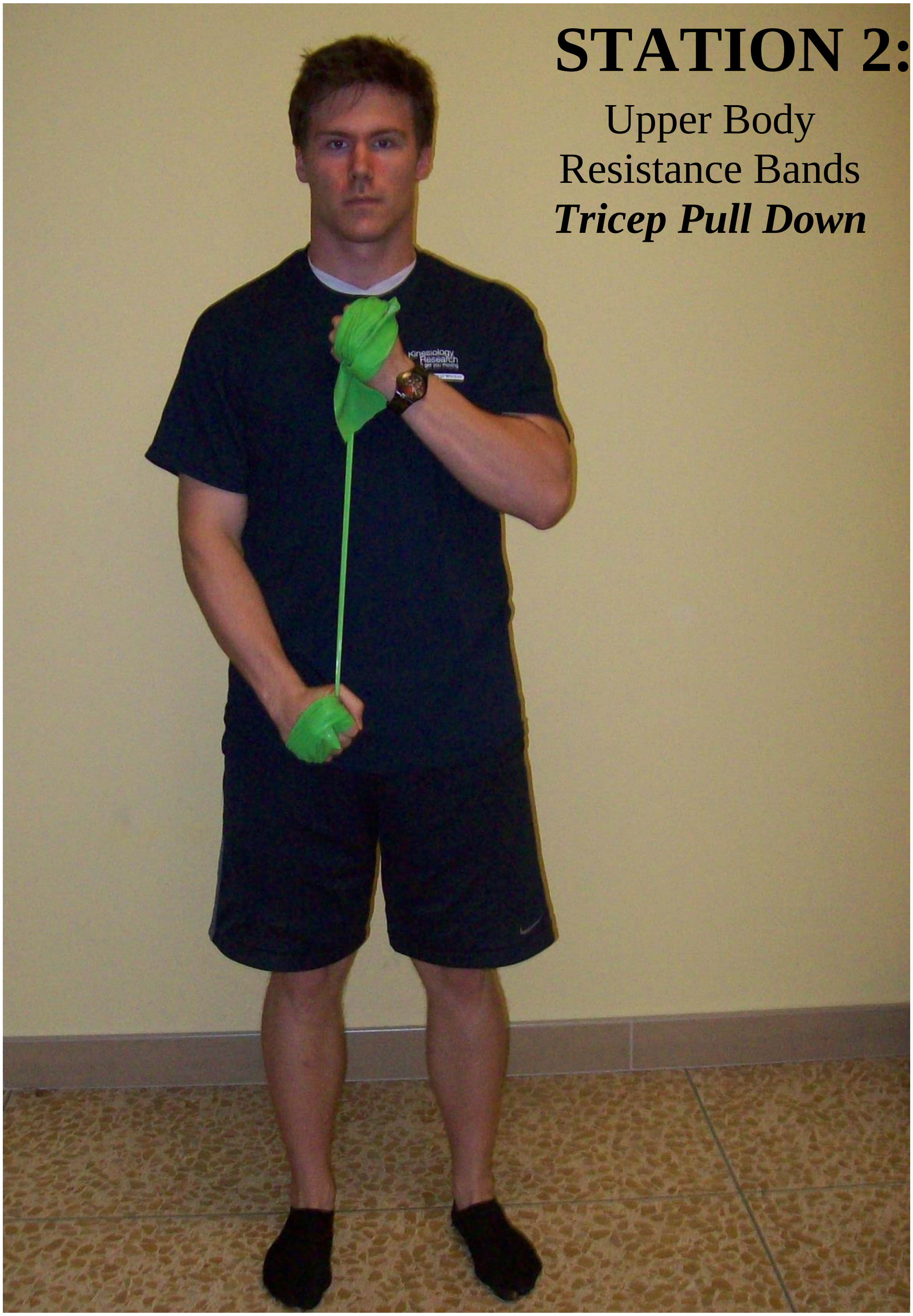
Appendix D

Pictures of Exercises


STATION 2:
Upper Body
Resistance Bands
Bow and Arrow


STATION 2:
Upper Body
Resistance Bands
Chest Press


STATION 2:
Upper Body
Resistance Band
Narrow Grip



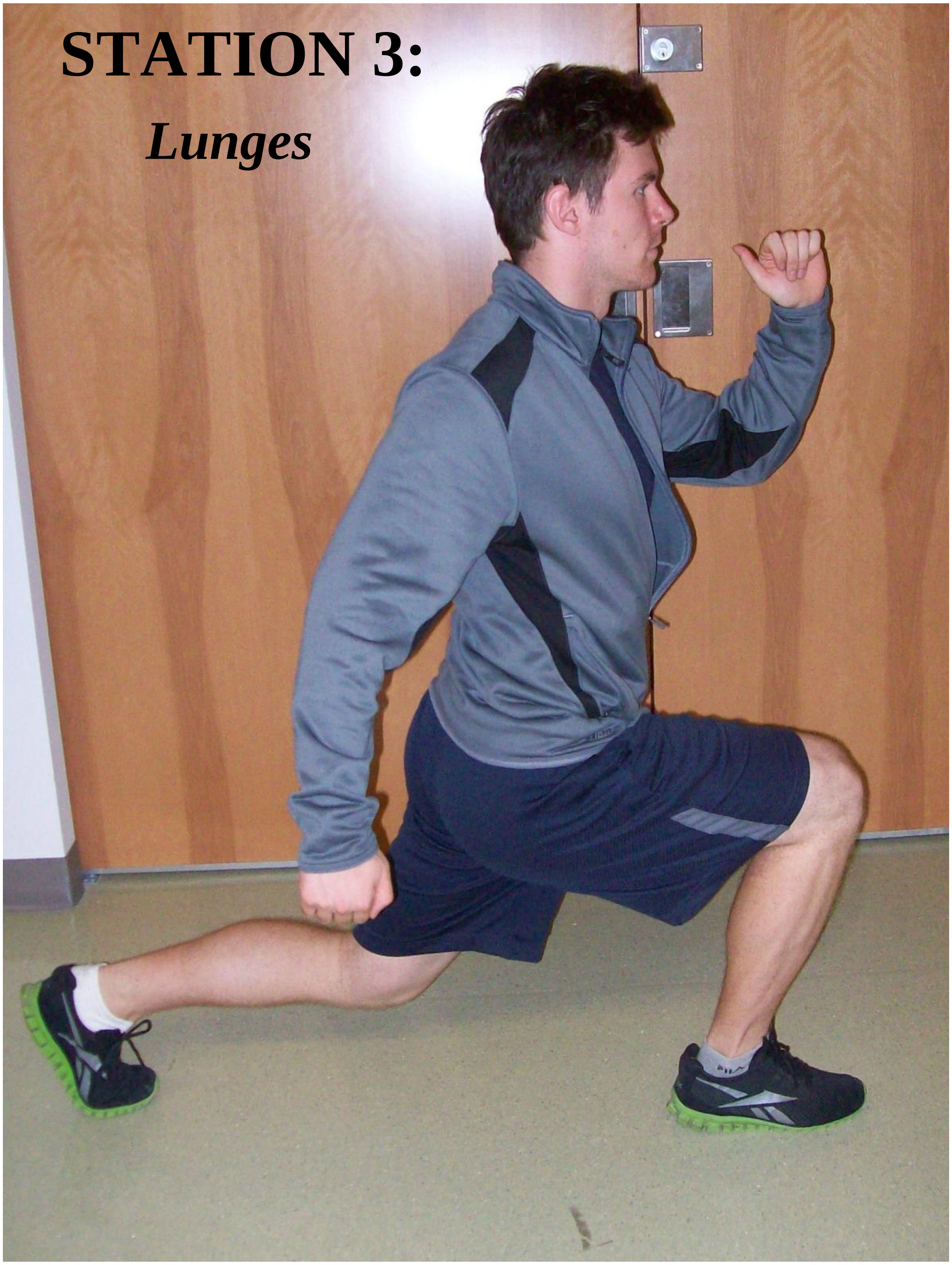
STATION 2:

Upper Body
Resistance Bands
Tricep Pull Down


STATION 3:
Stationary Bike
MONARK


STATION 3:
HeelKicks


STATION 3:
High Knees


STATION 3:
Lunges

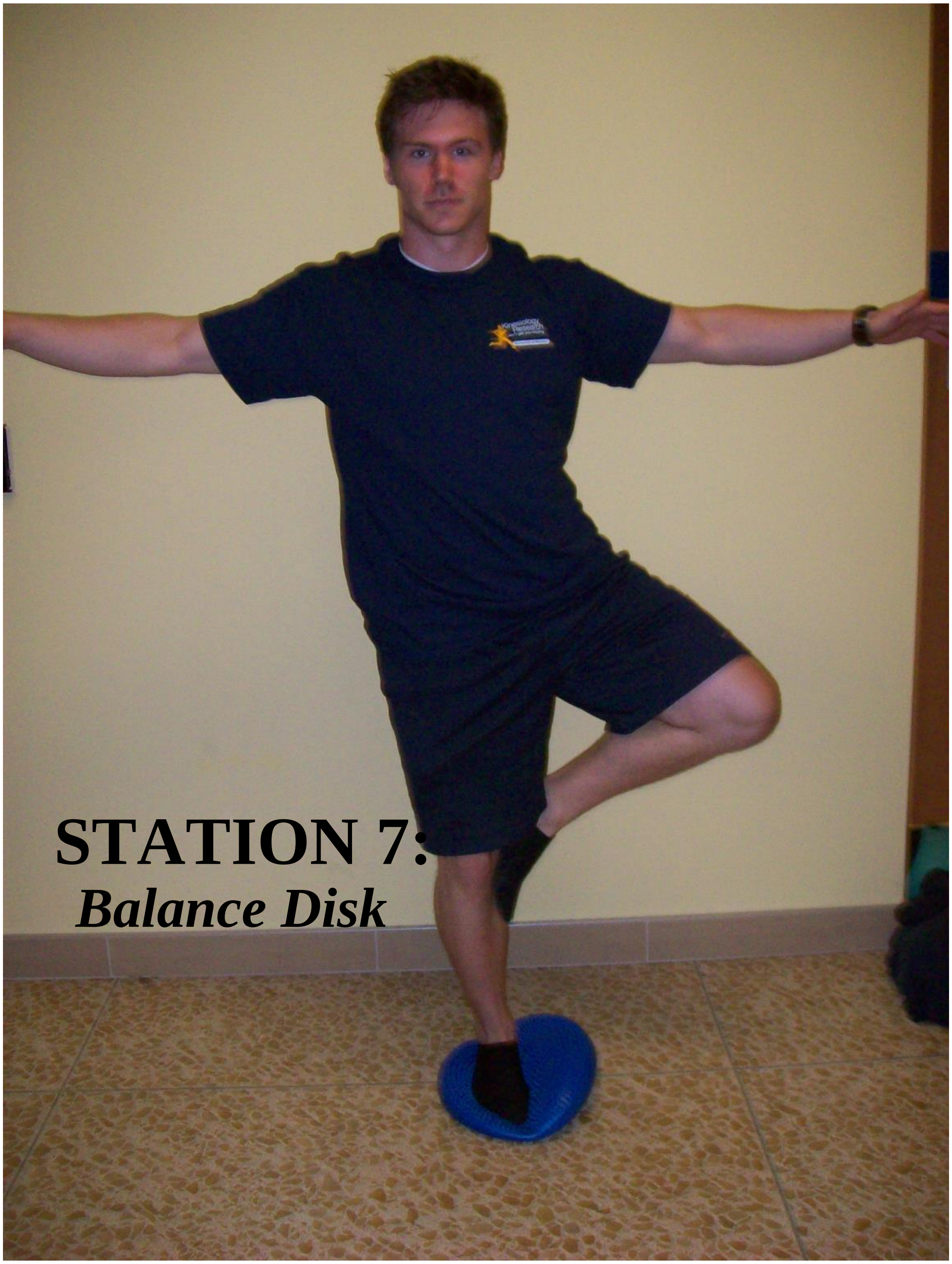

STATION 5:
Plank

STATION 5:

Push-ups

STATION 5: *Sitting Leg Raises*

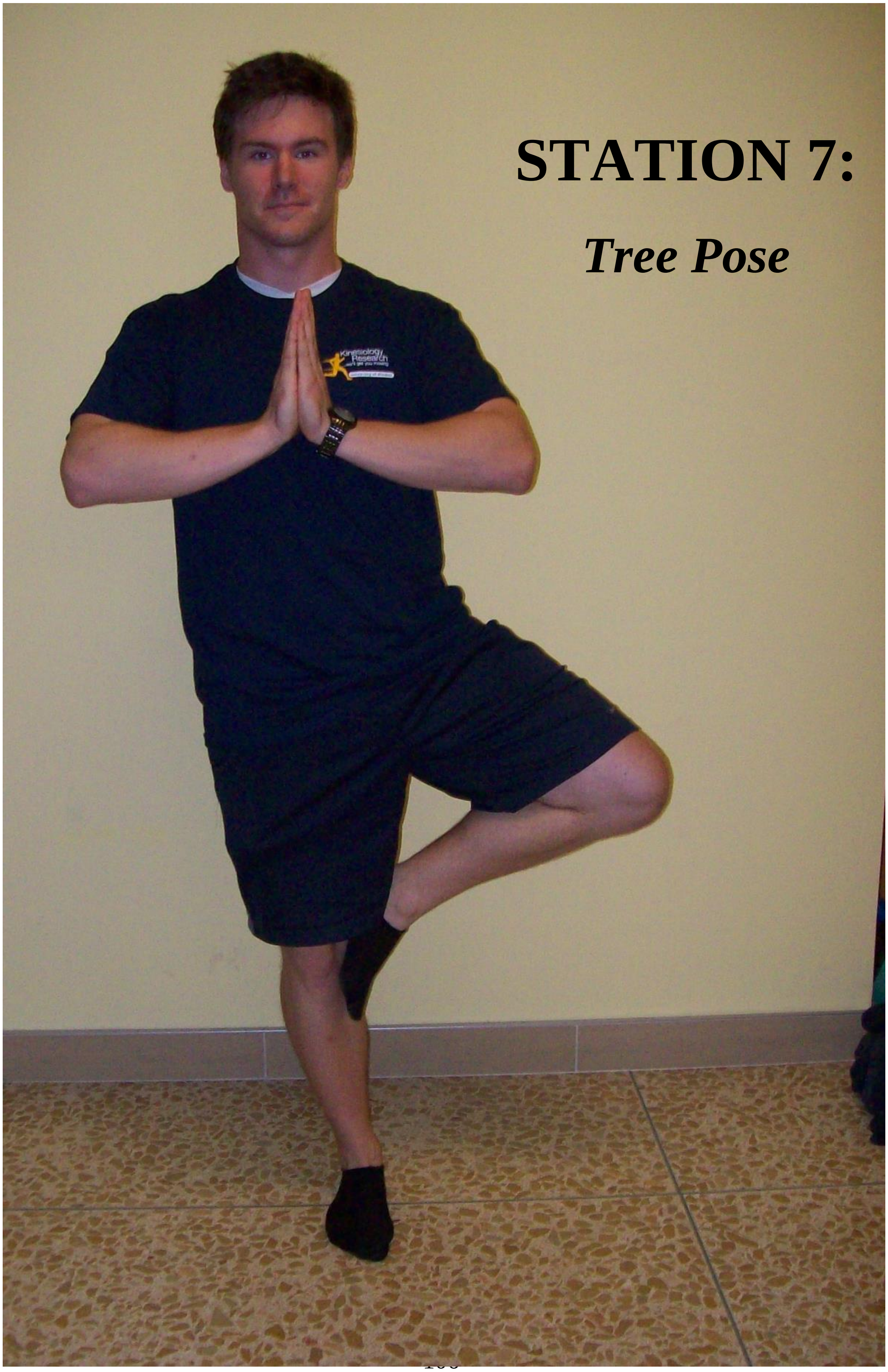
STATION 6: ***Lunge and Curl***


STATION 7:
Balance Disk

STATION 7:
Cobra

STATION 7: ***Downward Dog***

STATION 6: *High Lunge Pose*


STATION 7:
Tree Pose

STATION 7:

Warrior I Pose

STATION 7:
Wobble Board

Appendix E

Data Collection Sheet

Pegboard

Measured in Seconds

	Baseline	**6 Weeks**	**12 Weeks**	**16 Weeks**
LEFT HAND				
Trial 1				
Trial 2				
RIGHT HAND				
Trial 1				
Trial 2				

Box and Block Test

Measured by number of blocks

	Baseline	**6 Weeks**	**12 Weeks**	**16 Weeks**
LEFT HAND				
Trial 1				
Trial 2				

RIGHT HAND				
Trial 1				
Trial 2				

Stick Catching Test

Measured in centimeters

	Baseline	6 Weeks	12 Weeks	16 Weeks
LEFT HAND				
Trial 1				
Trial 2				
RIGHT HAND				
Trial 1				
Trial 2				

Appendix F

Tables of Means and Standard Errors for All Motor Tests

Table 1

25 Grooved Pegboard Test: Best Scores and Sum of Scores for the Right and Left Hand (Number of Pegs)

Session	Right Hand	Left Hand	Right Hand	Left Hand
Baseline	17.7 ± 2.3	14.4 ± 1.9	33.7 ± 4.6	27.8 ± 3.7
Mid Program	18.3 ± 2.3	15.7 ± 2.0	33.1 ± 4.4	29.7 ± 3.8
Post Program	18.9 ± 2.1	16.5 ± 1.9	35.7 ± 4.2	31.7 ± 3.6
Retention	18.8 ± 2.2	17.2 ± 1.9	36.6 ± 4.3	32.9 ± 3.8

Table 2

Box and Blocks Test: Best Scores and Sum of Scores for the Right and Left Hand (Number of blocks)

Session	Right Hand	Left Hand	Right Hand	Left Hand
Baseline	41.4 ± 6.2	39.8 ± 6.2	78.5 ± 12.5	75.5 ± 12.7
Mid Program	49.1 ± 6.6	45.7 ± 6.3	90.4 ± 12.8	86.9 ± 12.8
Post Program	42.6 ± 6.1	40.9 ± 5.9	79.7 ± 12.0	78.9 ± 11.9
Retention	44 ± 6.6	43.5 ± 6.3	84.9 ± 12.8	84 ± 12.4

Table 4

Stick Catching Test Best Scores for the Right and Left Hand: Flight Time of the Metre Stick in miliseconds (ms)

Session	Right Hand (ms)	Left Hand (ms)
Baseline	27.6 ± 1.8	32.9 ± 1.8
Mid Program	33.1 ± 1.7	31.8 ± 1.7
Post Program	29.5 ± 1.6	30.9 ± 1.7
Retention	31.0 ± 1.6	31.0 ± 1.7

Note: Two decimal places were used for this analysis because rounding to only one would nullify the SD at Post program for the Right Hand and at retention for the Right and Left Hand.

Table 5

Medial-Lateral (ML) and Anterior-Posterior (AP) Velocity for the Eyes Open (EO) and Eyes Closed (EC) Condition: Measured in Millimetres per Second (mm/s)

Session	MLV Open	MLV Closed	APV Open	APV Closed
Baseline	32.5 ± 10.2	36.4 ± 10.7	39.6 ± 7.7	36.4 ± 8.0
Mid Program	30.7 ± 10.2	30.7 ± 10.7	40.8 ± 7.7	35.1 ± 8.0
Post Program	33.8 ± 10.2	33.7 ± 10.7	49.6 ± 7.7	46.1 ± 8.0
Retention	59.4 ± 10.7	34.9 ± 12.9	45.4 ± 8.0	41.6 ± 9.0

Table 6

Medial-Lateral (ML) and Anterior-Posterior (AP) Displacement for the Eyes Open (EO) and Eyes Closed (EC) Condition: Measured in Millimetres (mm)

Session	MLD Open	MLD Closed	APD Open	APD Closed
Baseline	5.2 ± 1.8	7.3 ± 1.9	8.1 ± 1.8	7.2 ± 1.8
Mid Program	3.9 ± 1.8	3.2 ± 1.9	6.3 ± 1.8	4.7 ± 1.8
Post Program	5.7 ± 1.8	4.9 ± 1.9	9.4 ± 1.8	9.7 ± 1.8
Retention	8.6 ± 1.9	5.2 ± 2.3	7.4 ± 1.8	7.5 ± 2.2

Table 7

Sway Area for the Eyes Open (EO) and Eyes Closed (EC) Condition: Measured in Millimetres Squared (mm^2)

Session	EO	EC
Baseline	51.8 ± 37.4	59.8 ± 39.1
Mid Program	27.9 ±37.4	15.0 ± 39.1
Post Program	68.3 ± 37.4	70.2 ± 39.1
Retention	12.1 ± 39.1	54.2 ± 46.7

VITA AUCTORIS

Name: Phillip Mc Keen, BHK, MHK

School: University of Windsor

Interests: Music, exercise, imagination, contemplating, writing, public speaking