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Impact of Motor Skills Training in Adults with Autism Spectrum Disorder and an Intellectual Disability

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Abstract

This study employed an intervention involving motor skills training, whole body exercise, and sports and games to improve manual motor skills and reaction time in a group of adults with autism spectrum disorder and an intellectual disability (ASD-ID). Eleven adults with ASD-ID engaged in this intervention for 90 minutes twice a week, for 12 weeks. Modified versions of the 25 Grooved Pegboard, Box and Block, and Stick Catching Tests measured fine and gross motor skills and reaction time, respectively. Motor skills were evaluated at the beginning, middle, and end of the program, and following 4 weeks with no training. Trends indicating improvement in motor skills were evident, but participant difficulties in performing the Stick Catching Test made assessment of reaction time challenging. Despite this, many findings of practical significance emerged from this study, which demonstrated a viable model for implementation of similar programs with multiple participants. Given the importance of motor skills for independence, safety, and quality of life, more research on activities that promote the development of these skills in adults with ASD-ID is warranted. Understanding how to facilitate motor skill development in these individuals will assist them in becoming more active in the community and more independent around their homes.

Autism spectrum disorder (ASD) is one of the most common pediatric conditions in the United States, with prevalence rates of one in 68 children (one in 42 boys, one in 189 girls; Center for Disease Control and Prevention [CDC], 2014). Similar prevalence rates have been reported within Canada (National Epidemiologic Database for the Study of Autism in Canada, 2012), and are on the rise (Ouellette-Kuntz et al., 2014). According to the *Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition,* ASD is characterized by deficits in two behavioural domains: (1) social interaction and language communication, and (2) the range of interests and activities (American Psychiatric Association [APA], 2013). Intellectual disability (ID) is another behaviourally defined neurobiological disorder, whose diagnosis depends on the presentation of deficits in adaptive and intellectual function in conceptual, social, and practical domains during the developmental period (APA, 2013). Intellectual disability (ID) commonly co-occurs with ASD – 31% of those with ASD also have ID (IQ ≤ 70), and 23% have IQ scores between 71 and 85 (CDC, 2014).

In addition to the core characteristics, problems with gait, balance, upper extremity coordination and motor planning are common in individuals with ASD (Bhat, Landa, & Galloway, 2011; Fournier, Hass, Naik, Lodha, & Cauraugh, 2010) and in those with ID (Carmeli, Bar-Yossef, Ariav, Levy, & Lieberman, 2008; Enkelaar, Smulders, van Schrojenstein Lantman-de Valk, Geurts, & Weerdesteyn, 2012). To our knowledge, no research literature to-date has specifically compared the motor skills of individuals diagnosed with both ASD and an ID (ASD-ID) to those of individuals who developed typically. Given that motor impairments are common in ASD and ID (respectively) and the high rate of their co-occurrence, it is likely that individuals with ASD-ID would also present with motor impairments. The presence of motor impairment has important implications for both adaptive functioning and overall health. Movement skills are integral to performing activities of daily living, recreation, and employment (Carmeli et al., 2008); thus, motor skill deficits make it difficult for individuals with ASD-ID to engage in physical activity and other health-related behaviours. In fact, rates of participation in physical activity are substantially lower within this population compared to typically developed peers (Melville, Hamilton, Hankey, Miller, & Boyle, 2007; Srinivasan, Pescatello, & Bhat, 2014). This is noteworthy because in addition to the health benefits, physical activity has a number of additional benefits for these individuals, including reductions in stereotyped and maladaptive behaviours (Lang et al., 2010) and improvements in motor and social skills (Sowa & Muelenbroek, 2012). Thus, motor skill training appears to be an important consideration for individuals with ASD-ID.

To date, studies that have implemented motor skill training as part of their interventions for individuals with ASD and/or ID have focused primarily on gross motor skills in adolescents/young adults (i.e., age < 21 yrs) and children (e.g., Arzoglou, Tsimaras, & Kotsikas, 2013; DeBolt, Clinton, & Ball, 2010; Fragala-Pinkham, Haley, & O'Neil, 2011; Hawkins, Ryan, Corey, & Donaldson, 2014; Magnusson, Cobham, & McLeod, 2012; Pan, 2010; Yanardag, Akmanoglu, & Yilmaz, 2013). There has been a comparative lack of such interventions for adults with ASD (Alison, Basile, & MacDonald, 1991; Elliott, Dobbin, Rose, & Soper, 1994; García-Villamisar & Dattilo, 2010; Hillier, Murphy, & Ferrara, 2011; Persson, 2000; Siaperas & Beadle-Brown, 2006; Smith & Belcher, 1985), and only three of these studies examined improvement in motor skill as a primary outcome measure (Persson, 2000; Siaperas & Beadle-Brown, 2006; Smith & Belcher, 1985). All three studies reported improvements in participants' personal independence skills (e.g., personal grooming, feeding, and vocational skills such as preparing a meal), which were assessed via subjective observations and caregiver surveys/interviews. However, many studies employing exercise or motor skill interventions, including Smith and Belcher (1985) and Persson (2000), have done so with limited study populations (case studies or small groups of $N \leq 7$ (e.g., Alison et al., 1991; DeBolt et al., 2010; Elliott et al., 1994; Finn & Válková, 2007; Hawkins et al., 2014; Magnusson et al., 2012; Yanardag et al., 2013), and few included systematic interventions targeting fine motor skill development (Finn & Válková, 2007; Karim & Mohammed, 2016).

Therefore, the purpose of this study was to investigate whether an intervention incorporating fine motor skills training, whole-body exercise, and sports and games would improve fine- and gross-motor visual-manual skills and reaction time in a group of adults with ASD-ID. This study extends the existing literature in the following ways: (1) by delivering an exercise/motor skill intervention to a group of adults with both ASD and an ID, when much of the literature focuses on children with either ASD or an ID; and (2) by specifically training both fine and gross motor skills. It also demonstrates the feasibility of delivering such an intervention with a larger group relative to the case studies and small groups that currently exist in the literature. It was hypothesized that improvements would occur in these motor skills at each of the subsequent testing periods, and would stabilize at follow-up.

Materials and Methods

Participants

Eleven adults diagnosed with ASD-ID (mean age = 35.5 years; range = 20-61 years; 2 females) participated in this study (same study population as Carr et al., 2015). Previous clinical assessments were consulted to determine participants' diagnoses and IQ scores. Of the 11 participants, 10 had a specific diagnosis of classic autism, and a single participant was diagnosed with atypical pervasive developmental disorder. Intelligence quotient (IQ) scores of all participants were below 70 (lowest score = 20). Of these participants, one individual was nonverbal. Participants were either residents of a community home that provides 24-hour support for adults with intellectual disabilities or were residing with family members and receiving occasional in-home support. To be included in the study, participants were required to: (1) be at least 18 years of age; (2) have diagnoses of both ASD and an ID; (3) complete a Physical Activity Readiness Questionnaire (PAR-Q) or a Physical Activity Readiness Medical Examination (PARMED-X) form signed by their physician (only required if they answered "yes" to any items on the PAR-Q); (4) be capable of following instructions and completing a physical activity regimen with guidance from an instructor; and (5) commit to attending all exercise and testing sessions. The PAR-Q is used as a self-screening tool for potential contraindications for engaging in exercise. Participants who answer "yes" to any of the questions on the PAR-Q are encouraged to seek medical clearance from their physicians prior to beginning a new exercise regimen. To that end, the PARMED-X form is a more detailed version of the PAR-Q, and is to be completed and signed by the participants' physicians. Participants were excluded from the study if they had a history of violent or aggressive behaviour.

Informed consent was obtained from the legal guardians of the participants prior to the commencement of participation. Participants provided assent following a simplified explanation, as well as a demonstration of the task that participants were required to complete. Depending on the participant's cognitive ability, assent was either written or verbal in nature. Ethics clearance was obtained through the Research Ethics Board at the host university.

Twelve-Week Exercise Program

Each participant was paired with a student instructor (1:1 ratio) for the duration of the program. The role of the instructors was to teach the participants how to execute the exercises safely, to motivate them to participate using verbal encouragement, and to document their progress at each session (e.g., weight lifted, number of repetitions performed, duration of balance tasks, qualitative improvement in skill execution such as throwing or catching, etc.) using custom-designed tracking sheets. The instructors were undergraduate and master's level students from the kinesiology, biology, and nursing programs at a medium-sized Ontario university. Some of the students had prior experience working with individuals with ASD and/or ID, but many did not. Regardless of experience, prior to the start of the program all student instructors completed approximately three hours of training on ASD-ID as well as the delivery of the intervention, which included proper techniques and procedures for the various activities. Given 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.

Sports and Games Component

As participants arrived on the day of their session, the instructor initiated these activities for approximately 10 minutes, with an additional 10 minutes taking place at the end of the session. Sports and games activities included using sponge 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 for 20 minutes each session, as a means of warming up/cooling down with the participants and to build excitement and promote bonding among group members. Given the substantially lower rates of participation in sports and physical activity in individuals with ASD-ID (Melville et al., 2007; Shattuck, Orsmond, Wagner, & Cooper, 2011; Srinivasan et al., 2014), we chose to use these activities in addition to traditional warm-up activities (e.g., walking, stretching, etc.) as a means of cultivating interest and confidence in participating in these activities in the future. These activities also challenged participants' reaction time and gross-motor coordination.

Motor Skills Training Component

Participants engaged in fine motor control training for a total of 20 minutes each session. These activities involved manipulating a variety of small objects in different and progressive ways. Examples of such tasks included: picking up and sorting paper clips of different colours; clipping paperclips together to form a chain, then removing clips from the chain one by one; and threading a bolt onto and off of a nut. These tasks were chosen to provide a means of training the fine motor muscles of the hands to improve fine motor dexterity. The tasks were performed in a game-like atmosphere with the participants' respective instructors, to emphasize speed. For every task, the duration of practice was identical for both the participants' right and left hands. These activities challenged participants' fine-motor coordination.

Whole Body Exercise Component

Participants began the exercise protocol once they had completed the sports and games component. This portion of the program consisted of a seven-station circuit including cardiovascular, strength, flexibility, and balance training – see Carr, Horton, Sutherland, and Azar (2014) for a full description of the tasks included at each station. Examples of these tasks included riding a stationary bicycle; combination squat/overhead press with a medicine ball; core and stability exercises, such as holding a plank on a stability ball; and holding various yoga poses. The circuit was designed to align with the Canadian Physical Activity Guidelines (Canadian Society for Exercise Physiology [CSEP], 2011). Specific exercises were chosen that (1) engaged every major muscle group, (2) would be easily demonstrated and safe for the participants, and (3) could be easily incorporated into home fitness regimens in order to promote continuation of healthy active living after the completion of the program. Participants spent five minutes at each of the seven stations, for a total of 35 minutes. With respect to motor skills, these activities challenged participants' gross-motor coordination.

Data Collection

Before the intervention began, the research team took baseline measures of fine- and gross-motor skill and reaction time using standardized motor skill tests (25 Grooved Pegboard Test, Box and Block Test, and Stick Catching Test, respectively). The administration of each test and calculation of outcome variables is described in the sections to follow. Subsequent testing occurred at weeks six and 12, with follow-up testing at week 16. The purpose of the follow-up test was to evaluate skill retention after four weeks of detraining. For the present study, modifications were made to all motor skill tests to facilitate administration for this population.

25 Grooved Pegboard Test

A modified 25 Grooved Pegboard Test was used to assess fine motor manual skill (Ruff & Parker, 1993; Wang et al., 2011) (Figure 1). In its standard form, this test assesses the time it takes to insert 25 pegs into the standard grooved pegboard, one peg at a time. For the present study, the quantity of pegs inserted within 60 seconds represented each participant's score. The test was performed twice with each hand respectively, in alternate order. Analyses were performed on the best (highest) score for each hand at each session.

Figure 1. 25 Grooved Pegboard Test. Participants weregiven60secondstoinsertasmanygrooved pegs as possible.

Box and Block Test

A modified Box and Block Test was used to evaluate gross motor manual skill (Desrosiers, Bravo, Hebert, Dutil, & Mervier, 1994; Mathiowetz, Volland, Kashman, & Weber, 1985) (Figure 2). Participants were given 60 seconds to move as many blocks as possible (one block at a time) from one side of a divided box to the opposite side (the standard version only allows 15 seconds). The test was performed twice with each hand respectively, in alternate order. Analyses were performed on the best (highest) score for each hand at each session.

Figure 2. *Box and Block Test. Participants were given 60 seconds to transfer as many blocks as possible from one side of the divided box to the other.*

Stick Catching Test

Reaction time was measured using a modified Stick Catching Test (Carmeli et al., 2008). Participants stood (standard test is performed while seated) 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 (Figure 3). 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 was used to calculate the flight time in seconds, which reflected the time it took for participants to grasp the stick after they saw it begin to fall (i.e., their reaction time; Carmeli et al., 2008). The test was performed twice with each hand respectively, and analyses were performed on the best (lowest) score for each hand at each session.

Figure 3. *Modified Stick Catching Test. Participants were required to stop the downward trajectory of the metre stick as soon as possible after the investigator dropped it.*

Statistical Analysis

The data were analyzed using 2 (hand: left, right) × 4 (session: baseline, mid-program, post-program, follow-up) repeated measures analyses of variance. Individuals with ASD and ID have increased rates of ambiguous handedness (AH) (Soper et al., 1986) and pathological left-handedness (PLH) (Cornish & McManus, 1996; Satz, Soper, Orsini, Henry, & Zvi, 1985). Therefore, “Hand” was included as a factor in the analyses due to the difficulty in determining hand dominance in this population (Carr et al., 2015). Where violations of sphericity were present, the degrees of freedom were adjusted using the Greenhouse-Geisser correction. Significant F tests ($\alpha < 0.05$) were evaluated further with Bonferroni-corrected pairwise comparisons. All statistical analyses were conducted using SPSS version 22 (IBM Corporation, Armonk, NY, USA).

Results

25 Grooved Pegboard Test

There were significant main effects of Session [$F(1.9, 18.7) = 3.8$, $p = .04$, $\omega^2_{partial} = 0.19$] and Hand [$F(1, 10) = 17.8$, $p = .002$, ω^2 partial = 0.58]. Scores were significantly better at follow-up compared to those at baseline (baseline: 16.0 ± 7.0 pegs, follow-up: 18.0 ± 6.7 pegs, $p = .002$; Figure 4), and for the right hand compared to the left (right: 18.4 ± 7.1 pegs, left: 15.9 ± 6.2 pegs; Figure 5). The Session by Hand interaction was not significant [$F(3, 30) = 1.4$, $p = .27$, ω^2 partial = 0.03].

Box and Block Test

There were significant main effects of Session [$F(3, 30) = 3.0$, $p = .048$, ω^2 partial = 0.15] and Hand [$F(1, 10) = 17.6$, $p = .002$, ω^2 partial = 0.58]. Scores were significantly better for the right hand compared to the left (right: 44.3 ± 20.6 blocks, left: 42.7 ± 19.8 blocks; Figure 6), but when differences between sessions were analyzed pairwise, no statistically significant differences were evident. The Session by Hand interaction was not significant [$F(3, 30) = 2.1$, $p = .12$, ω^2 partial = 0.09].

Stick-Catching Test

Four participants could not provide valid trials for every test period due to difficulties with test administration, thus their data were omitted from the analysis. There were no significant effects of Session [$F(3, 18) = 1.1$, $p = .36$, ω^2 partial = 0.06], Hand [$F(1, 6) = 0.1$, $p = .77$, ω^2 partial = 0], or Session by Hand [$F(3, 18) = 0.77$, $p = .52$, ω^2 partial = 0] on reaction time.

Discussion

The purpose of this study was to examine whether participation in a 12-week intervention involving motor skills training, whole body exercise, and sports and games activities would improve the fine and gross motor visual-manual skills and reaction time of adults with ASD-ID. Participants underwent motor skill testing at baseline, after six weeks and 12 weeks of the intervention, and then after four weeks of no program activity (i.e., follow-up). The results indicated that as a group, the participants had significantly better fine motor dexterity at follow-up testing compared to baseline. There was also a trend toward similar improvement in gross motor dexterity, but pairwise comparisons between sessions did not reach statistical significance. Previous interventions for adults with autism have reported similar findings – that trends were evident but statistical significance was elusive (Persson, 2000; Siaparas & Beadle-Brown, 2006; Smith et al., 1985). Given that significant improvements were found only from baseline to follow-up testing, and the differences in the average number of pegs inserted and blocks transferred between these test sessions were very small (2.0 pegs and 3.1 blocks, respectively); one must consider the possibility that the improvements were not due to the intervention, but were the result of practice effects. Without a control group for comparison, it is difficult to determine whether the improvements were due to the intervention or repeated exposure to the motor skill tests, and whether these improvements are meaningful in a clinical context. In the absence of a control group, a multiple-baseline or crossover design would help establish what constitutes meaningful change on these tests. With respect to practice effects, it must be noted that the participants were not exposed to the standardized tests during the intervention – they only performed them during the testing sessions, which were spaced by a minimum of four weeks, and they were not given any additional practice with the tests on the testing days beyond the two trials with each hand. Therefore, each participant performed only eight trials for each hand with both the 25 Grooved Pegboard and Box and Block Test from baseline to follow-up testing, making practice effects unlikely.

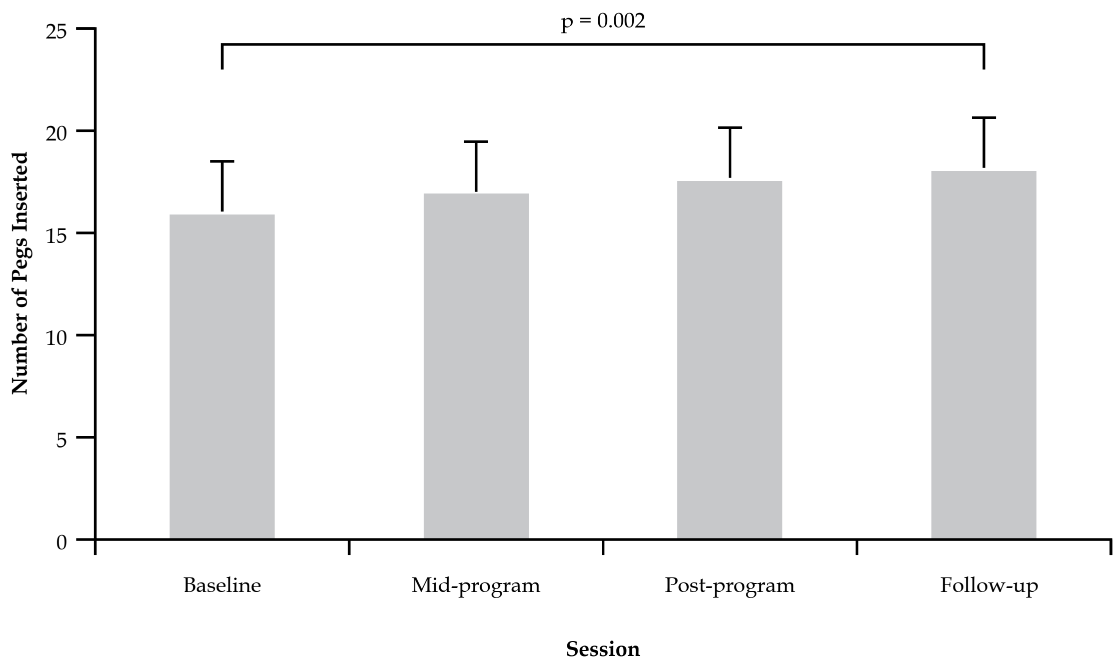

Figure 4. Main Effect of Session on 25 Grooved Pegboard Test Scores. Scores were significantly better at follow-up (18.0 ± 6.7 pegs) than at baseline (16.0 ± 7.0 pegs). Error bars represent the standard error of the mean (SEM).

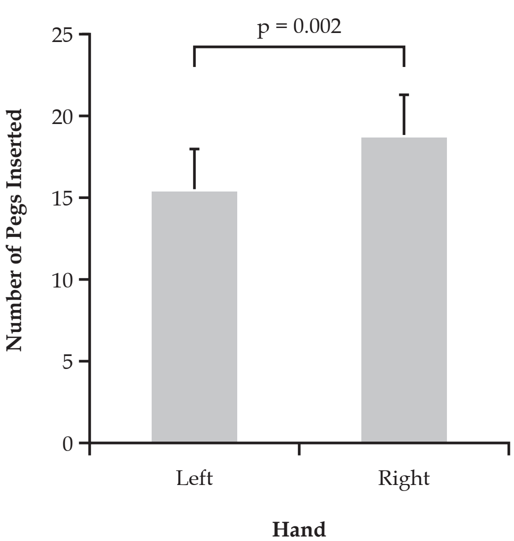

Figure 5. Main Effect of Hand on 25 Grooved Pegboard Test Scores. Scores were significantly better for the right hand (18.4 ± 7.1 pegs) compared to the left (15.9 ± 6.2 pegs). Error bars represent the standard error of the mean (SEM).

There is also the possibility that the selection of the best trials for analysis, rather than the means of the two trials for each hand, inflated the scores and introduced a trend of improvement over time. To test whether inflation occurred, all statistical analyses were repeated using the average of the two trials for each hand. The trends were the same, indicating that selection of the best trials did not inflate the data.

Despite these limitations, many meaningful findings emerged from this study. The customized tracking sheets completed by the instructors at each exercise session indicated that progressions occurred for all of the participants. Improvements were reported for fine motor skills, such as moving more paper clips in shorter lengths of time, and for the gross motor sports and games, such as throwing the sponge balls longer distances and more consistently, and striking badminton birdies and ping pong balls more effectively. Improvements were also 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

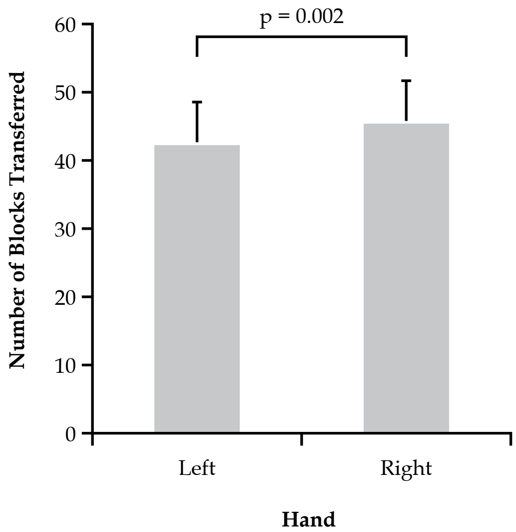

Figure 6. Main Effect of Hand on Box and Block Test Scores. Scores were significantly better for the right hand (44.3 ± 20.6 blocks) compared to the left (42.7 ± 19.8 blocks). Error bars represent the standard error of the mean (SEM).

of the stability balls. Although this is insufficient to objectively conclude that all participants improved over the 12 weeks, these findings supplement our empirical results and suggest that the intervention successfully improved participants' motor skills on a practically meaningful, if not statistically significant, level.

With respect to the motor skill testing protocol, one particularly interesting and unexpected observation was made. Many of the participants in this study had problems executing the Stick Catching Test – they did not react to the metre stick dropping, resulting in the stick falling through their hands to the floor. Consequently, these participants' data sets were removed from the statistical analyses, because they could not register valid trials for this test. However, we suspected that the participants were unwilling to perform this particular test for some reason, because these individuals had no problems playing catch with a foam football during the sports and games component of the program. We decided to test these individuals by substituting the metal metre stick for a foam cylinder at the post-program test session. As suspected, these participants would grasp the cylinder as it fell, confirming that they understood the task and were simply unwilling to grasp the metal metre stick. Future researchers wishing to test reaction time in individuals with ASD-ID are advised to use a more comfortable material for the stick (e.g., wood, plastic, and/or apply a foam covering), or to consider using alternative means of testing reaction time (e.g., computerized testing) to facilitate successful completion of the task.

Research on motor functioning and training in adults with ASD-ID is limited, and this lack of data served as the rationale for the present study. To our knowledge, this study is the first to systematically attempt to improve fine and gross motor skills and reaction time in a group of adults with ASD-ID. Providing one instructor for each participant and actively engaging the support workers to assist the instructors during the exercise sessions allowed for a thorough provision of safety and an interactive method of instruction. However, such an ideal participant:instructor ratio is not always practical in community-based settings. That previous studies were largely single cases or small groups (e.g., Alison et al., 1991; DeBolt et al., 2010; Elliott et al., 1994; Finn & Válková, 2007; Hawkins et al., 2014; Magnusson et al., 2012; Yanardag et al., 2013) speaks to the feasibility of providing high-quality instruction with adequate participant support. This highlights the benefits that can be leveraged through cooperation between academia and the community: a program of this size would not have been feasible without (1) the large number of individuals educated in human anatomy and exercise science who were able to volunteer their time, and (2) the engagement of the support workers and our partnership with their parent organization. Through the cooperation of the parent organization and the university, this program provided a no-cost opportunity for adults with ASD-ID to participate in sports/physical activity, while simultaneously providing students with a rare and valuable opportunity to gain hands-on experience working with these individuals. This model can potentially be replicated in other academic settings, to the benefit of students and participants alike.

The purpose of the present study was to evaluate changes in the motor skill of adults with ASD-ID following engagement in a 12-week exercise and motor control intervention. Although trends indicating improvement were noted; given the importance of motor skills for independence, safety, and quality of life, more research on activities that promote the development of these skills in adults with ASD-ID is warranted. Developing movement skills may facilitate increased involvement in community recreational programs and other physical activities, enabling these individuals to reap the health-related, cognitive, and social benefits these activities can provide. Understanding how to facilitate motor skill development in this population will assist these individuals in becoming more active in the community and more independent around their homes. If motor skill interventions and assessment procedures can continue to be refined, then future programs will be better equipped to assist adults with ASD-ID with their ongoing motor development.

Key Messages From This Article

People with disabilities: There are lots of ways in which physical activities like sports might be good for you, besides helping you stay healthy and fit.

Professionals: Engaging individuals with disabilities in sports/physical activity may promote their motor skill development, which might help them become more active in their communities and independent in their homes.

Policymakers: Policy to support programs that encourage sport participation and motor skill development is worthwhile, as proficiency in these skills may facilitate community integration and independence in adults with ASD-ID. This, along with the expected health benefits, could potentially lessen dependence on government services.

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