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Reliability of Four Subtests of the Jebsen Test of Hand Function Among Adults with Autism and an Intellectual Disability

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Abstract

Motor impairments have been acknowledged as a symptom of autism spectrum disorder (ASD); however, few reliable measures of motor control are available for individuals with ASD, particularly for adults. This study examined the reliability of four Jebsen Test of Hand Function (JTHF) subtests ("card turning," "small common objects," "checkers," "heavy cans") for adults with ASD and an intellectual disability (ASD-ID). Eleven adults with ASD-ID completed these four subtests weekly for three consecutive weeks. Absolute agreement intra-class correlations (ICC) revealed high test re-test reliability for each subtest (ICC > 0.90). These subtests of the JTHF are recommended to monitor change in hand function during motor control interventions designed for adults with ASD-ID.

The rapid rise in the prevalence of autism spectrum disorder (ASD; Elasbbagh et al., 2012) is exemplified by a nearly 80% increase in ASD diagnoses between 2002 and 2008 (Centre for Disease Control and Prevention [CDC], 2012), and a 30% increase from 2008 to 2010 (CDC, 2014). Such increases reflect 1 in 68 children being diagnosed with ASD as of 2010 (CDC, 2014). This trend of rising incidence rates is also evident within regions of Canada, with annual diagnostic increases ranging between 9.7% and 14.6% (Ouellette-Kuntz et al., 2014). While past research indicates a similar increase in the co-occurrence of ASD and intellectual disability (ASD-ID; Matson & Shoemaker, 2009), recent data suggests that this co-occurrence has decreased since 2002 where 47% of ASD cases co-occurred with ID, to 31% of ASD cases in 2010 (CDC, 2014). Despite the decrease in ASD-ID diagnoses, this co-morbid condition exists in nearly one-third of ASD cases, yet minimal research exists examining the distinct challenges faced by these individuals (Matson & Shoemaker, 2009). Furthermore, the vast majority of ASD-related research has focused on children, and studies specific to adults remain limited (Mandell, 2013). This is worrisome given that individuals with ASD receive the large majority of their care during adulthood (Ganz, 2007), and because the core deficits of ASD are life-long impairments (Murphy et al., 2005).

ASD is characterized by limited daily functioning due to (1) impairment in social communication and interaction, and (2) engagement in repetitive and stereotyped behaviours, interests, and activities (American Psychiatric Association, 2013). Recently, deficits in motor control have also been acknowledged as a core symptom of ASD (Bhat, Landa, & Galloway,

2011; Forti et al., 2011; Gowen & Hamilton, 2013). Impairments in motor control have also been reported in children and adults with an ID (Carmelli, Bar-Youssef, Ariav, Levy, & Liebermann, 2008; Vuijk, Hartman, Scherder, & Visscher, 2010). Such impairments are detrimental as they have the potential to impact quality of life and social interactions (Gowen & Hamilton, 2013), as well as one's participation in vocational and recreational activities (Carmelli et al., 2008). In fact, difficulties with motor coordination may limit one's ability to complete activities of daily living (ADL) beyond limitations influenced by cognitive impairments (Kopp, Beckung, & Gillberg, 2010). It is evident that individuals with ASD-ID experience impairments in motor control that create barriers to independence. Therefore, interventions focused on improving motor control in individuals with ASD are warranted (Bhat et al., 2011). Moreover, it is imperative to develop strategies that assess the effectiveness of such interventions. Currently, few reliable tests of motor control are available for individuals with ASD, and of those available, the majority of reliability and validity data pertain to infants and older children (Bhat et al., 2011). Furthermore, characteristics of individuals with ASD may impact the reliability of data collection, as participants often cannot be depended upon to provide such information (Arnold et al., 2000). Specifically, individuals with ASD may be uncommunicative, unable to cooperate during assessments, or present with a cognitive impairment (Arnold et al., 2000). These characteristics may hinder a participant's ability to repeat a performance, which can create reservations around the reliability of the data obtained. Thus, assessment strategies need to have sufficient reliability within a population of individuals with ASD-ID in order to collect accurate data (Matson, 2007).

The Jebsen Test of Hand Function (JTHF) consists of seven subtests developed to objectively measure basic, unilateral hand function relative to one's ability to complete ADL (Jebsen, Taylor, Trieschmann, Trotter, & Howard, 1969; Poole, 2011). The seven subtests reflect a range of functional movements: (1) card turning, (2) picking up small, common objects, (3) checker stacking, (4) lifting light cans, (5) lifting heavy cans, (6) simulated feeding, and (7) writing. Through the administration of weighted and non-weighted practical tasks, this test assesses gross and fine motor functional hand ability (Jebsen et al., 1969). In its entirety, the JTHF takes 10 to 15 minutes to complete (Poole, 2011) and consists of simple, inexpensive materials. The time to complete each subtest is measured in seconds; with longer time to completion indicating greater impairment in hand function (Jebsen et al., 1969). Rudman and Hannah's (1998) review highlights the successful administration of the JTHF in a variety of clinical populations, including adults with stable hand disorders (Jebsen et al., 1969), adults 60 years of age and older (Hackel, Wolfe, Bang, & Canfield, 1992), adult women (Stern, 1992), children (Taylor, Sand, & Jebsen, 1973), patients with rheumatoid arthritis (Jones et al., 1991), Duchenne muscular dystrophy (Wagner, Vignos, Carlozzi, & Hull, 1993), and stroke (Carey et al., 2007). Furthermore, the ability of the JTHF to predict functional ability is supported by previous research conducted by Lynch and Bridle (1989), who identified a correlation between JTHF scores and Klein-Bell scores (therapist assessment of self-care activities). Similarly, a significant correlation exists between the JTHF and ADL and household activity items on the Arthritis Impact Measurement Scales (Poole, 2011). Taken together, the JTHF has received moderate support regarding its construct validity relative to ADL (Rudman & Hannah, 1998).

Beyond the JTHF, the literature includes several other assessments of motor skills. For example, the Bruininks-Oseretsky Test of Motor Proficiency – Second Edition (BOT-2) is an assessment of fine and gross motor skills in children. This assessment includes four motor areas (fine manual control, manual coordination, body coordination, and strength and agility) and is used to screen and support diagnoses of motor impairments, and to evaluate motor interventions (Bruininks & Bruininks, 2005). Similarly, the Zurich Neuromotor Assessment assesses motor task performance among typically developing children (Largo, Caflisch, & Jenni, 2007) through evaluation of pure motor tasks, adaptive tasks, balance, and posture (Rousson, Gasser, Caflisch, & Largo, 2008). Likewise, the Movement Assessment Battery for Children – Second Edition (MABC-2) is an assessment tool used by professionals to identify motor impairments in individuals 3 to 17 years of age. This assessment includes fine and gross motor tasks in three domains: (1) manual dexterity, (2) aiming and catching, and (3) balance. It also utilizes a checklist that necessitates an adult's (e.g., parent, teacher, or caregiver) participation (Brown &

Lalor, 2009). These three assessments share common characteristics that contrast the methods of the JTHF: (1) they were designed for children and adolescents, (2) they assess motor control beyond hand function, and (3) their administration/scoring is more complicated and requires more equipment, training, and time.

For this study, the JTHF was chosen as the measure of hand function as it could accommodate the unique characteristics of individuals with ASD-ID. For example, since the JTHF is easy to administer and takes minimal time to complete (Rudman & Hannah, 1998), it was fitting for individuals who tend to struggle with a short attention span. While the full JTHF (all seven subtests) requires 10 to 15 minutes to complete, alternative measures of motor control (e.g., BOT-2) require up to 60 minutes to complete a full assessment (Deitz, Kartin, & Kopp, 2007). Furthermore, the simplicity of the JTHF minimized the cognitive capacity required of the participants, as well as the training necessary to administer the assessment (Poole, 2011). Additional rationale for the use of the JTHF included: (1) the absence of a floor or ceiling effect, allowing performance to be evaluated regardless of baseline skill (Poole, 2011), (2) the use of the assessment as a means to measure one's ability to complete ADL, and (3) the assessment was designed specifically for individuals over the age of six, or adults with motor impairments (Poole, 2011).

Despite availability of test re-test reliability data and evidence that suggests that the JTHF is suitable for various populations (Rudman & Hannah, 1998), the unique characteristics of individuals with ASD-ID warrant the examination of population-specific psychometric properties. Therefore, the purpose of the present study was to determine the test re-test reliability of four subtests of the JTHF among a group of adults diagnosed with ASD-ID.

Methods

Participants

This study included eleven adults diagnosed with ASD-ID (mean age = 35.5 years; age range = 20–61 years; two females). Previous clinical assessments were consulted to determine participants' diagnoses, as well as intelligent quotient (IQ) scores. Of the 11 participants, 10 had a specific diagnosis of classic autism, while a single participant was diagnosed with atypical pervasive developmental disorder. IQ scores of all participants were below 70 with the lowest IQ score being 20. Of these participants, one individual was nonverbal. All participants were recruited from an adapted physical exercise program that engaged participants in 60 to 90 minute physical activity sessions twice a week. Participants were either residents of a community home which provides 24-hour support for adults with an ID, or were residing with family members and receiving occasional in-home support. Informed consent was obtained from the legal guardians of 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.

Procedure

To evaluate test re-test reliability, participants completed the "card turning," "small common objects," "checkers," and "heavy cans" subtests of the JTHF. In order to reduce the time required for testing, the study design did not include the remaining three subtests. The reduction of testing time was in an attempt to accommodate participants' potential difficulty staying on task. The decisions to remove each of the three subtests was based on the following rationale: (1) the "light cans" subtest was removed due to the similarity with the "heavy cans" subtest, (2) the "simulated feeding" subtest was removed as it was expected to be the most time consuming, and (3) the "writing" subtest was removed due to its dependency on cognitive ability. Each of the four subtests was completed once a week for three consecutive weeks. Due to participants' absences, the third trial for two participants was completed during the fourth week. Familiarization with subtests was provided one week prior to the three trials in which data were collected. The primary investigator administered the majority of the trials (128 of 132 trials); however, uncontrollable circumstances necessitated the administration of four trials by a second investigator. Results

are thought to be unaffected as previous literature suggests that the JTHF has high inter-rater reliability (Delhag & Bjelle, 1999) with ICC values ranging from 0.82–1.00 for the subtests examined within the present study (Hackel et al., 1992). Since data collection occurred during an adapted physical exercise program, evaluation of each trial occurred across two days to reduce disruption to programming. Therefore, the "card turning" and "small common objects" subtests were administered on three consecutive Tuesdays, and the "checkers" and "heavy cans" subtests were administered on three consecutive Thursdays (with the exception of the two absent participants), to yield three trials of each subtest. Administration of two subtests on each day of evaluation took approximately three to four minutes to complete.

Participants were seated directly across a table from the investigator and were provided with instructions and a demonstration of the subtest. A brief overview of the subtests is provided here; for detailed descriptions and standardized guidelines see Jebsen et al. (1969). No modifications were required to the instructions provided by Jebsen et al. (1969), as the use of these instructions ensured standardization, as well as simple wording. However, though guidelines suggested that subtests be completed first with the non-dominant hand, this protocol was problematic, as hand dominance is not easily discerned in this population. Therefore, to allow for standardization, participants first completed each subtest with their left hand followed by their right hand. This was the only modification made to the protocol. The outcome measure of each subtest was time, with a shorter time interval to completion indicating a better performance.

Card Turning

Five index cards positioned vertically were placed in a horizontal row on the table in front of the participant. Participants started with their left hand placed in front of the middle card while their right hand rested at their side. When prompted by the investigator, participants turned each card over starting at the extreme right. This protocol was followed when participants used their right hand; however, the card at the extreme left was turned first (Figure 1).

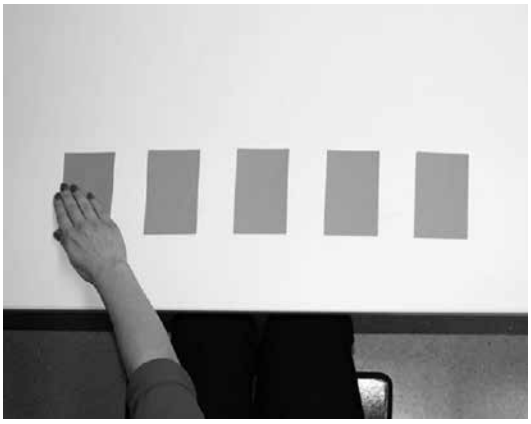

Figure 1. "Card turning" subtest of the Jebsen Test of Hand Function.

Small Common Objects

An empty tin was placed on the table directly in front of the seated participant. Participants started with the left hand behind the tin and six small common objects were placed in a straight line to the left of the tin, 2.54 cm apart. Starting from the extreme left these objects included: two paperclips (2.54 cm in size, oriented vertically), two regular sized bottle caps (2.54 cm in diameter), and two pennies. When instructed, participants started at the extreme left and picked up one object at a time and placed it in the tin with their left hand. The test for the right hand was a mirror image; the objects were lined up to the right of the can and participants first picked up the object to the extreme right (Figure 2).

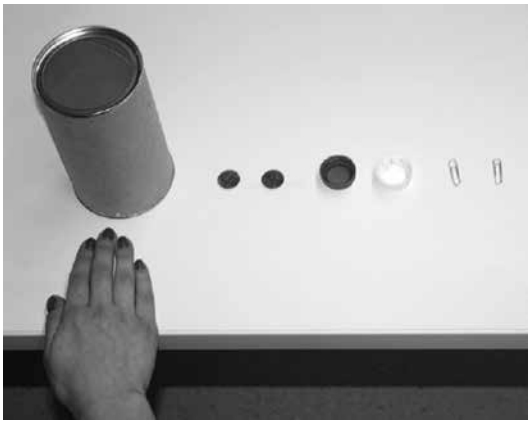

Figure 2. "Small common objects" subtest of the Jebsen Test of Hand Function.

Checkers

Four white checkers were placed in front of and touching a 1.91 cm thick wooden board. The checkers were arranged touching one another and when instructed by the investigator, participants stacked each checker (picking one up at a time) on top of one another on the wooden board. This protocol was followed when participants used their right hand (Figure 3).

Figure 3. "Checkers" subtest of the Jebsen Test of Hand Function.

Heavy Cans

Five (0.45 kg) cans were placed 5.08 cm apart on a table in front of a 1.91 cm thick wooden board, 12.7 cm from the front of the table. Participants started with the left hand placed in front of the middle can, and when prompted by the investigator, participants placed each can onto the wooden board starting at the extreme left. This protocol was followed when participants used the right hand, however, the participant started at the extreme right (Figure 4).

Figure 4. "Heavy cans" subtest of the Jebsen Test of Hand Function.

Statistical Analysis

Test re-test reliability for each of the four subtests of the JTHF was determined across three trials using SPSS version 20.0 (IBM Corporation, 2011). Subtest times were a combination of the times obtained with each hand. Test re-test reliability for each subtest was determined through the calculation of an absolute agreement intraclass correlation (ICC) based on a two-way random effects ANOVA. ICC values greater than or equal to 0.80 represented high reproducibility (Chen, Chen, Hsueh, Huang, & Hsieh, 2009). Repeated measures ANOVAs ($p < 0.05$) were used to determine the presence of systematic improvement across trials. Bonferroni's adjustment for multiple comparisons was used to examine specific between-trial differences.

Results

The ICC values suggest very high test re-test reliability for all JTHF subtests that were examined: "card turning" (ICC = 0.91, 95% CI = 0.75–0.97), "small common objects" (ICC = 0.93, 95% CI = 0.80–0.98), "checkers" (ICC = 0.90, 95% CI = 0.74–0.97), and "heavy cans" (ICC = 0.95, 95% CI = 0.85–0.98). Only the "card turning" subtest of the JTHF showed systematic improvement across the three trials [F (2, 20) = 3.73, p = 0.04, ω^2 = 0.19]. However, following Bonferroni's adjustment for multiple comparisons, differences between specific trials were non-significant. The remaining subtests of the JTHF revealed no systematic improvement across the three trials ("small common objects" [F (2, 20) = 3.23, p = 0.061, ω^2 = 0.16], "checkers" [F (2, 20) = 0.81, p = 0.46, ω^2 = 0.00], and "heavy cans" [F (2, 20) = 0.38, p = 0.69, ω^2 = 0.00]. Performance on each subtest is visually depicted in Figure 5 with standard error of the mean bars illustrating the variability around the mean performance.

Discussion

This study aimed to determine the test re-test reliability of four JTHF subtests among a group of adults with ASD-ID. Taken together, the JTHF subtests examined had very high test re-test reliability, with ICC values greater than 0.90. Systematic improvement across the three trials did not occur, with the exception of the "card turning" subtest. The mean difference between the three trials for this subtest indicated that the systematic improvement was 6.63% and 9.94% from trial one to trial two, and trial two to trial three, respectively. Overall, the very

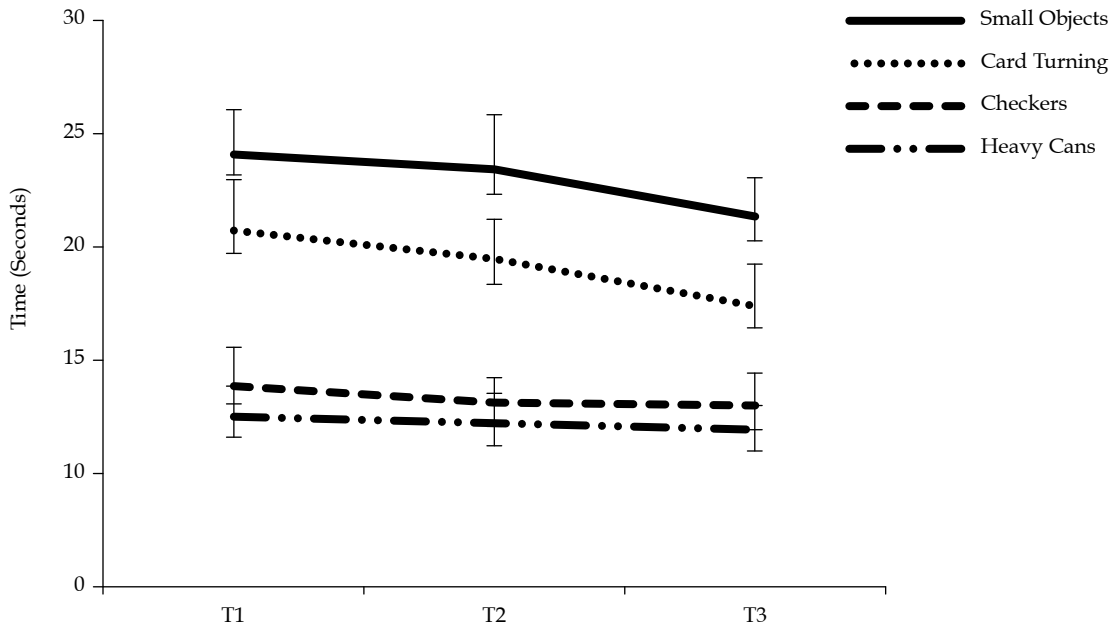

Figure 5. Mean performance on each subtest of the Jebsen Test of Hand Function across three trials. Variability of performance is displayed by standard error of the mean bars.

high test re-test reliability presented herein illustrates the effectiveness of using the JTHF to collect reliable data among individuals with ASD-ID.

In spite of the increasing prevalence of ASD (CDC, 2012), and the growing recognition of associated motor impairments (Bhat et al., 2011; Forti et al., 2011; Fournier, Hass, Naik, Ladha, Cauraugh, 2010; Gowen & Hamilton, 2013; Kopp et al., 2010), the current literature remains limited in regards to population-specific motor control evaluative measures for adults with ASD-ID (Bhat et al., 2011). For example, Bhat et al. (2011) reviewed psychometric properties of motor control assessments for infants, toddlers, and children with ASD, while data specific to the adult population is absent. As such, the primary strength of this work is the novelty of the study and the unique data it offers to the literature. An additional strength of the present study is the recognition of the JTHF as an appropriate means to monitor hand function in the targeted population, as the structure of the JTHF may have minimized the impact of the unique characteristics of ASD-ID (e.g., repetitive movements) on data collection. In order to further accommodate the administration of the JTHF to adults with ASD-ID, three of the seven subtests were removed. Other measures of motor control (i.e., BOT-2, Zurich Neuromotor Assessment, MABC-2) may also benefit from a similar reduction in time to increase the overall appropriateness for individuals of special populations, including those with ASD-ID. However, unique features of the JTHF, such as its simplicity, lack of a baseline skill requirement, its relation to the completion of ADL, and its specificity to adults with motor impairments, further support its use within this context (Poole, 2011). These features of the JTHF may account for its comparable, and often higher, test re-test reliability than the motor control assessments designed specifically for infants, toddlers, and children with ASD (for review see Bhat et al., 2011). Furthermore, the test re-test values obtained within the present study (ICC > 0.90) are consistent with previous work evaluating the reliability of the JTHF among specific populations. For example, the subtests of JTHF have test re-test values among healthy individuals above $r = 0.97$ (Jones et al., 1991), among individuals with stable hand disorders between $r = 0.60$ and $r = 0.99$ (Jebsen et al., 1969), and among older individuals between $r = 0.84$ and $r = 0.85$ (Hackel et al., 1992).

Taken together, these findings have important implications as they identify a reliable tool to measure the effectiveness of programs focused on fine and gross motor control through standardized assessment of movement progression among this specific population. Additionally, through the identification of specific characteristics of the JTHF that make it appropriate for adults with ASD-ID, it provides researchers, clinicians, and therapists with a profile for assessment tools that may be suitable for this adult population. While previous research hinted at difficulties obtaining reliable data from adults with ASD-ID, the work presented herein delivers an optimistic view of the potential for sound data collection among this under-researched group of individuals.

A limitation of the present study is participants' engagement in an adapted physical exercise program between the second and third trial of the JTHF subtests. However, results are thought to be unaffected as the first week of the adapted physical exercise program consisted of familiarization with the program rather than an intense training regimen. Additionally, future researchers are advised to examine the test re-test reliability of all seven subtests of the JTHF in a larger sample of adults with ASD-ID. Future researchers are encouraged to examine population-specific psychometric properties of additional motor control assessments. Currently, the literature emphasizes the detrimental effects of motor impairments associated with ASD (Carmelli et al., 2008; Gowen & Hamilton, 2013; Kopp et al., 2010); however, the literature also highlights limited motor control assessment and intervention strategies available for this unique population (Bhat et al., 2011). Therefore, the results of the present study not only support the use of the JTHF as an evaluative motor control tool among adults with ASD-ID, they also provide a promising foundation for further investigation of assessment tool use among this population. In summary, the JTHF is recommended as a reliable tool to monitor change in hand function during motor control interventions designed for adults with ASD-ID.

Key Messages From This Article

Professionals: When assessing motor skills among adults with ASD-ID it is important to use assessment tools that collect reliable information among people with disabilities.

Policymakers: Policy to support opportunities for motor skill development among adults with ASD-ID is worthwhile, as motor skills are important for independence and the completion of activities of daily living.

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