

REVIEW STUDY

Motor proficiency of children with autism spectrum disorders and intellectual disabilities: a review**Gkotzia E.¹, Venetsanou F.², Kambas A.¹**¹School of Physical Education and Sport Science, Democritus University of Thrace, Greece²School of Physical Education and Sport Science, National & Kapodestrian University of Athens, Greece.egkotzia@phyed.duth.gr**Introduction**

In recent decades the interest of researchers in the importance of children's motor proficiency on their overall development, especially when they are at risk of developmental disorders, has increased (Equia, Capio & Simons, 2015; Green et al., 2009). A great part of relevant research is dedicated to the investigation of the motor proficiency of children with autism spectrum disorder (ASD) and intellectual disabilities (ID). ASD is the fastest growing neurodevelopmental disorder in America. About one in 68 children have been diagnosed with ASD (Centers for Disease Control and Prevention, 2015). As reported in the Diagnostic and Statistical Manual of Mental Disorders

Abstract

The purpose of this study was to present a review of studies that have examined the motor proficiency (MP) of children with autism spectrum disorder (ASD) and intellectual disabilities (ID) by using standardized motor assessment tools (Movement Assessment Battery for Children; Bruininks-Oseretsky Test of Motor Proficiency; Test of Gross Motor Development). The search conducted in three electronic databases, following specific criteria, revealed 17 studies considering children with ASD and 9 with ID. Their review revealed that, regardless of the motor assessment tool used, children with ASD and ID demonstrate difficulties in their fine and gross motor skills. Moreover, children within the same disorder spectrum exhibit various MP levels. This information, although limited, is valuable and should be deployed if the negative consequences of poor MP are to be countered and the daily living of those populations is to be improved.

Keywords: motor proficiency deficits; standardized movement assessment tools; autism



(DSM-V), individuals with ASD are characterized by impairments in the social and communicational domains, and they also demonstrate repetitive behaviors (American Psychiatric Association, APA, 2013). Moreover, according to Bhat, Landa and Galloway (2011), apart from linguistic, social, and cognitive differences that are indicative of ASD, this population also demonstrates motor difficulties. Although motor difficulties are not a part of the diagnostic criteria for ASD, there is a plethora of articles in the literature reporting that a percentage of 50-73% of children with ASD demonstrate motor dysfunctions or delays compared to their typically developing peers (Berkeley, Zittel, Pitney & Nichols, 2001; Breslin & Rudisill, 2011; Green et al., 2002, 2009; Liu & Breslin, 2013a; Staples & Reid, 2010; Whyatt & Craig, 2012)

Intellectual disability, according to the DSM-V, "... is a disorder with onset during the developmental period that includes both intellectual and adaptive functioning deficits in conceptual, social, and practical domains" (APA, 2013, p., 33). These domains determine how well an individual can cope with daily activities (APA, 2013). Although researchers' attention has focused mainly on the cognitive and adaptive functions of children with ID, the literature suggests that motor dysfunctions are not uncommon in this population (Hartman, Houwen, Scherder & Visscher, 2010; Simons et al., 2007; Vuijk, Hartman, Scherder & Visscher, 2010).

Movement is a fundamental component of human life and, according to Robinson, Webster, Logan, Lucas and Barber (2012), is the catalyst that supports the interaction of children with others and with their environment. This parameter is vital in the overall development of children, and of those at risk of neurodevelopmental disorders in particular. A strong relationship between motor proficiency, physical activity (Lubans, Morgan, Cliff, Barnett & Okely, 2010; Stodden et al., 2008), and obesity has been proposed (Stodden et al., 2008). Sufficient levels of motor skills may also contribute towards the improvement of daily



activities (Watkinson, et al., 2001) and participation in sports (Wall, 2004), and also reduce sedentary behavior (Wrotniak, Epstein, Dorn, Jones & Kondilis, 2006).

Information about the motor proficiency of children with neurodevelopmental disorders could be useful in the development of intervention programs in order to counter the negative impacts of poor motor skills, such as obesity and sedentary behavior. Early identification of motor proficiency is necessary in order to ensure that a child has the appropriate support through intervention programs targeted at the specific deficits identified in each specific population (Piek, Hands & Licary, 2012).

Children's motor proficiency can be assessed with standardized movement assessment tools, which are often the first step in identifying motor deficits in a reliable and valid manner. Among the most used movement assessment tools are (a) the Movement Assessment Battery for Children (Henderson & Sugden, 1992 [MABC]; Henderson, Sugden & Barnett, 2007 [MABC-2]); (b) the Bruininks-Oseretsky Test of Motor Proficiency (Bruininks, 1978 [BOTMP]; Bruininks & Bruininks, 2005 [BOT-2]); and (c) the Test of Gross Motor Development (Ulrich, 1985 [TGMD]; Ulrich, 2000 [TGMD-2]).

The purpose of the present study was to investigate motor proficiency of children and adolescents with ASD and ID as reported by researchers using the abovementioned standardized movement assessment tools.

Methods

A search for literature related to the motor proficiency of children with ASD and ID was performed with MEDLINE, Scopus, and Google Scholar electronic databases. In order to include all possible relevant published studies, no date range was specified.

The search was conducted combining terms related to three central key concepts (motor proficiency, ASD and ID): *motor proficiency* (key words: motor skills, motor delays,



motor deficits, clumsiness) and *autism spectrum disorders* (key words: autism, high function autism, low function autism, Asperger syndrome, pervasive developmental disorders) were used in order to examine motor proficiency in individuals with ASD; for motor proficiency in individuals with ID the key concepts used were *motor proficiency* (key words: motor skills, motor delays, motor deficits, clumsiness) and *intellectual disability* (key words: mental retardation, intellectual disabilities).

Included in the review were only studies meeting the following criteria: a) comparison between ASD or ID groups with a group of typically developing (TD) children or normative data, b) the examination of motor proficiency among children of different degree/level of the same diagnosis, and c) the use of the standardized movement assessment tools mentioned above. Surveys that compared the motor proficiency of ASD or ID groups with that of children with other developmental disorders were excluded. Also excluded were studies that examined children with Down syndrome, Williams syndrome, and other co-existing ID syndromes in an attempt to minimize the confounding of data.

Results

The database searches revealed 931 potentially relevant articles. Screening of titles and abstracts reduced that list to 26 articles. Of the articles retrieved through the aforementioned search, 17 studied the motor proficiency of children with ASD and nine studied the motor proficiency of children with ID. Concerning the movement assessment tools used in order to assess motor proficiency, a version of the MABC (Henderson & Sugden, 1992; Henderson et al., 2007) was used in 11 articles, a version of the TGMD (Ulrich, 1985; Ulrich, 2000) was used in 10 articles, and a version of the BOTMP (Bruininks, 1978; Bruininks & Bruininks, 2005) was used in five articles (Table 1).



Review of motor proficiency among children with ASD and ID

The review of literature referring to parameters of motor proficiency in children with ASD and ID using standardized movement assessment tools is presented below. In order to better organize and compare the results, the review is divided according to the tool used.

Movement Assessment Battery for Children

The M-ABC is a standardized tool that measures both fine and gross motor skill performance examining the constructs of manual dexterity, ball skills, static, and dynamic balance. In 1984, Stott, Henderson and Moyes conducted a revised version, the Test of Motor Impairment – Henderson Revision (TOMI-HR). A few years later, in 1992, the test was revised again creating the MABC (Henderson & Sugden, 1992), while in 2007, the third revision of the test, the MABC-2 (Henderson et al., 2007), was released. The performance of an examinee on each item of the test is scored on a scale from 0 to 5, with high scores indicating poor performance. Summing the item scores of each sub-test (manual dexterity, ball skills, balance) provides a sub-scale score. Those scores can, then, be added to give a total score ranging from 0 to 40. Moreover, the total score, as well as the sub-scale and item ones, can be converted into percentile scores that reflect examinee's level of performance in comparison with MABC norms.

The manuals in all MABC versions provide guidelines for the evaluation of examinees' performance. In the TOMI-HR (Stott et al., 1984), scores 0-3.5 indicate average competence, scores 4 -5.5 suggest a moderate motor problem, and scores 6 -16 indicate a definite motor problem. In the MABC (Henderson & Sugden, 1992), children with a score between the 100th and 16th percentile are regarded as having 'no motor problems', those scoring between the 15th and 6th percentile as having 'borderline motor problems', and those scoring from the 5th percentile and below as having 'definite motor problems'. The test percentile scores for the



MABC-2 (Henderson et al., 2007) are presented in a traffic light scoring system that includes a red zone (scores $\leq 5^{\text{th}}$ percentile) indicating a significant movement difficulty, an amber zone (scores between the 5^{th} and 15^{th} percentile) indicating risk of movement difficulty, and a green zone (score $> 15^{\text{th}}$ percentile) indicating no movement difficulty.

To our knowledge, ten studies have used a version of the MABC to assess gross and fine motor skills in children with ASD. One of them used the TOMI-HR version (Stott et al., 1984), four used the MABC (Henderson & Sugden, 1992), and five the MABC-2 (Henderson et al., 2007). Manjiviona and Prior (1995) compared the MI level of twelve children with Asperger syndrome (AS) with that of nine high-functioning autism (HFA) children, aged 7-17 years, using the TOMI-HR (Stott et al., 1984). The results showed that 50% of children with AS and 67% of children with HFA scored in the definitely impaired range of motor performance on the TOMI-HR. All the subjects seemed to have motor deficits in both fine and gross motor skills, and especially on manual dexterity and ball skills, when compared to the norms reported on TOMI-HR.

Green et al. (2002) assessed the motor skills of 11 children with AS, aged 6-11 years, using the MABC (Henderson & Sugden, 1992). According to their results, all of the children scored below the 15^{th} percentile on the test and nine of them scored below the 5^{th} percentile (a finding indicative of definite movement problems), with their performance being worst on the manual dexterity tasks. Similar were the results of the study of Green et al. (2009), who used the same tool to explore the degree of motor impairment in children with ASD (45 with childhood autism and 56 with other ASDs) and a wide Intellectual Quotient (IQ) range. More specifically, 79.2% of the participants had definite movement problems, while the proportion of children with definite movement problems was similar between the childhood autism group (82.2%) and the broader ASD group (76.8%), proving the prevalence of motor impairment throughout the autistic spectrum disorders.



In several studies, the motor proficiency of children with AS was compared to that of TD children. Hilton et al. (2007) administered the MABC (Henderson & Sugden, 1992) on 51 children with AS and on 56 TD children, aged 6-12 years, and found that the performance of the TD group was in the no impairment range, while 65% of the AS group was in the definite impairment category and 25% was in the borderline impairment category. In particular, the AS group demonstrated higher impairment levels on manual dexterity and the lower impairment levels on static and dynamic balance.

Papadopoulos et al. (2011) examined the motor proficiency of children throughout the autism spectrum disorders [AS group n=22, high functioning autism (HFA) group n=23, low functioning autism (LFA) group n=8] in comparison with a TD group (n=20) of children. According to their results, all participants in the TD group scored within the normal percentile range reported in the MABC (Henderson & Sugden, 1992). The scores of children throughout the spectrum, varied for the HFA (63% scored < 5th percentile; 18% scored 5-15th percentile), the AS (28% scored < 5th percentile; 5% scored 5-15th percentile), and the LFA (100% < 5th percentile). The HFA group performed significantly worse than both the TD group and the AS group. More specifically, the HFA group performed significantly worse on manual dexterity, ball skills, and balance than the TD group, and also differed from the AS group in ball skills and balance but not in manual dexterity. The LFA group performed significantly worse than the HFA on manual dexterity and static and dynamic balance subtests but not in the ball skill subtests.

Using the MABC-2 (Henderson et al., 2007), Whyatt and Craig (2012) assessed motor skills in children (aged 7-10 years) with autism (n=18) comparing them to two groups of age-matched TD children: a receptive vocabulary matched group (n=19) and a nonverbal IQ matched group (n=22). The results revealed that the mean MABC-2 manual dexterity standard score for the group with ASD was significantly lower than the vocabulary matched control



group only; however, for the mean MABC-2, Ball Skill and Balance component standard score, the ASD group was significantly lower than both control groups. Moreover, Liu and Breslin (2013a) examined the fine and gross motor skill performance of children with ASD (n=30), aged 3-16 years, using an age-matched TD group of children (n=30). Descriptive data showed that all TD children were in the green zone of MABC-2, whereas, 80% of children with ASD were classified in the red and amber zones on MABC-2. More specifically, 77% of children with ASD were in the red zone, demonstrating significant motor delays, and 3% were in the amber zone, indicating potential motor delay risk. In addition to this, differences were found between children with and without ASD on each of the three subtests of the MABC-2, with ASD children demonstrating significant delay.

Stins, Emck, de Vries, Doop and Beek (2015) applied only the balance subtest of the MABC-2 in nine children diagnosed with ASD and nine age-matched TD ones, and found that there were no significant differences on the static balance items, or on the dynamic ones. According to the authors these results were obtained because the ASD participants “.... were mildly autistic, so motor problems were probably in the sub-clinical domain, making it harder to detect these with a coarse-grained measure such as the M-ABC” (Stins et al, 2015, p. 202).

Siaperas et al. (2012) investigated whether individuals with AS have impaired motor skills. Fifty males, aged 7-14 years, and 50 age-matched TD controls were examined with the MABC-2. The control group scored higher than the AS one on all the MABC-2 items, while the AS group demonstrated significantly impaired performance on ball skills, manual dexterity, and balance. When age was entered as a covariate predictor, it was found to be insignificant. There were no significant effects of age or interaction effects for overall MABC-2 score or in MABC-2 components.

Although motor deficits of children with ASD on the MABC-2 are obvious, according to Liu and Breslin (2013b), their performance could be improved when a picture activity



schedule protocol is implemented during the measurement. In their study, Liu and Breslin (2013b) examined the impact of a picture activity protocol on the performance of 25 children with ASD on the MABC-2 in comparison to the traditional measurement protocol. The results revealed that 76% of participants were delayed (or at risk for delay) in terms of their motor skill development, regardless of how instructions were provided. However, when the picture activity schedule protocol was utilized, children with ASD demonstrated higher MABC-2 percentile scores.

Regarding children with ID, our search revealed only one study having used the MABC (Henderson & Sugden, 1992). Vuijk et al. (2010) assessed the performance of children with ID ($n=170$) according to the norms of MABC (Henderson & Sugden, 1992). Children's IQ scores were used in order for them to be classified into a mild intellectual disability (MID) group ($50 \leq IQ \leq 70$, $n=55$) and a borderline intellectual disability (BID) group ($71 \leq IQ \leq 84$, $n=115$). The results revealed that 81.8% of the children with MID and 60% of the children with BID had borderline or definite motor problems. More specifically, 70.9% of the children in the MID group demonstrated difficulties on the sub-scale of manual dexterity and 63.6% demonstrated difficulties on the sub-scale of ball skill and balance. For the BID group, 56.5% of the children had motor problems on the sub-scale of manual dexterity and 44.3% on the sub-scale of ball skills and balance. The results indicated that children with ID demonstrated motor deficits when compared to the normative sample. Children with BID performed better than children with MID, indicating an association between the degree of ID and performance on the total score on the MABC.

Test of Gross Motor Development

The TGMD (Ulrich, 1985; 2000) evaluates fundamental movement skills and is divided into two sub-tests: the locomotor skill and the object control skill sub-test. The sub-test



standard scores range from 1 to 20 and are characterized as: very poor (1–3); poor (4–5); below average (6–7); average (8–12); above average (13–14); superior (15–16); very superior (17–20). Both sub-test scores are then summed in order to determine the Gross Motor Development Quotient (GMDQ). A GMDQ converts to a range of scores from 46 to 154 for the TGMD (Ulrich, 1985) and from 46 to 160 for the TGMD-2 (Ulrich, 2000). GMDQ scores divide the performance into seven levels: GMDQ <70 = very poor; 70–79 = poor; 80–89 = below average; 90–110 = average; 111–120 = above average; 121–130 = superior and >130 = very superior.

To our knowledge, four studies have used the TGMD (Ulrich, 1985; 2000) to examine the gross motor performance of children with ASD and six that of children with ID. Berkley et al. (2001) studied the locomotor and object control skills of 10 boys and five girls with HFA, aged 6–8 years, and compared their performances with the norms of the TGMD (Ulrich, 1985). The results showed that 73% of the participants were placed in the very poor and poor performance categories. More specifically, all of the girls demonstrated delays on both locomotor and object control skills, while their object control scores were slightly lower. As for the boys, 70% demonstrated a delay in locomotor skills, but only 30% were found to have delays in object control skills.

In the study of Staples and Reid (2010) the performance on the TGMD-2 of children with ASD (n=25, aged 9–12) was compared to that of three TD groups. One group (n=25) was matched on chronological age (CA), one (n=22) was developmentally matched (DEV) on movement skills demonstrated by children with ASD (aged 4.9–6.9 years), and one group (n=19, aged 4.9–10.7 years) was matched on mental age (MA) with the ASD group. According to the results, the CA group demonstrated significantly better performance than the ASD group, while children with ASD performed similarly to children of approximately half their age (DEV group), suggesting a significant delay in development. The comparison between



the ASD and the MA group revealed that children with ASD were more impaired, despite the fact that the two groups demonstrated the same mental age. Finally, the CA group scored significantly higher on locomotor and object-control sub-tests, as did the MA group in comparison with the ASD group.

The study of Liu, Hamilton, Davis and ElGarhy (2014) focused on assessing fundamental motor skills of children across the full range of the autism spectrum (ASD $n=21$) compared with age-matched TD ($n=21$) children (aged 5-10) using TGMD-2. Ninety one percent of those with ASD were considered developmentally delayed and in need of early supportive interventions, in contrast to the group of TD children. More specifically, for the locomotor sub-test, about 67% of the children with ASD were classified in the poor and 40% in the very poor performance category. For the object control sub-test, 60% of the participants with ASD were classified in the poor and 33% of them in the very poor performance category.

Although fundamental motor skills of ASD children as they are measured by the TGMD-2 seem to be impaired, Breslin and Rudisill (2011) state that those children's performance could be improved by the use of a picture task protocol in the measurement. In their survey, participants ($n=22$, male= 16, female= 6, age 3.5-10.92 years) were examined under three different protocols (traditional protocol, picture task card protocol, and picture activity schedule protocol). The results indicated that regardless of the protocol used, children with ASD demonstrated delays on the TGMD-2; however, it was also indicated that gross motor quotient was significantly higher ($p=0.008$) when using the picture task card protocol rather than the traditional protocol or the picture activity schedule protocol.

Regarding children with ID, three studies examining their fundamental motor skills with the TGMD-2 (Ulrich, 2000) were identified. More specifically, Simons et al. (2007) tried (a) to assess aspects of validity and reliability of the TGMD-2 for measuring fundamental movement skills in children with MID ($n=99$, IQ range=52-70), and (b) to compare their



scores to those of TD children as reported by Ulrich (2000). According to the results, children without disabilities performed better than children with MID both in the sub-tests and the overall GMDQ. Moreover, from the evaluation concerning its reliability and validity, the TGMD-2 was proved an appropriate tool for assessing children with MID.

Using the same test, Frey and Chow (2006) examined the fundamental motor skills in a large sample of youths with MID (n=244, aged 6-18), focusing on the relationship among the body mass index (BMI), physical fitness, and motor skills of these youths. For that purpose, participants' physical fitness was measured by five tasks (1-min sit-up; isometric push-up; sit and reach; 6-min (ages 6–8 years) or 9-min (ages 9–18 years) run/walk test; triceps and calf skinfold measures) and evaluated according to the fitness norms for Hong Kong youths (Hong Kong Education and Manpower Bureau, 1998-2000). The results showed that children with MID scored in the very poor performance category both in the locomotor and object control sub-tests. Moreover, approximately 20% of the sample was classified as overweight/obese. When age and gender were controlled, BMI had a small, negative influence on aerobic performance and muscular strength in youths with MID. Furthermore, overweight/obesity was minimally associated with aerobic fitness and muscular strength in youths with mild ID, while BMI was not associated with motor skill performance.

In a more recent study (Eguia, Capio & Simons, 2015), both the fundamental motor skills of 60 children with ID (aged 5-14 years) and the potential influence of those skills on children's pedometer physical activity were investigated. According to the results, children with ID scored significantly below the norms as reported by Ulrich (2000) both in the locomotor and object control sub-scales.

Three studies comparing motor performance of children with ID with that of TD children were identified. Hartman et al. (2010) examined the motor skills as well as the executive functions in school-age children with BID (n=61, IQ range=71-79) and MID (n=36,



IQ range=54-70) in comparison to aged-matched TD children (n=97). Participants' motor skills were evaluated using the TGMD-2 (Ulrich, 2000). According to the results, the performance of children with BID and MID on the TGMD-2 was poor comparing to the performance of TD children. Regarding the locomotor skills, children with MID scored significantly lower than children with BID but no significant differences were found between the two groups for the object control skills. Similar were the results of Westendorp, Houwen, Hartman and Visscher (2011), who compared the gross motor skills of 88 children with BID (mean IQ= 75.3) and 68 children with MID (mean IQ=65) with that of 255 TD children, aged 7–12 years, using the TGMD-2 (Ulrich, 2000). The children with ID scored significantly lower than the TD children. More specifically the authors found that children with BID were less impaired on the locomotor skills than the MID group, but their performance on the object-control skills was comparable.

Furthermore, Rintala and Loovis (2013) examined the fundamental motor skills of children with ID (n=20) and that of a matched TD sample (n=20), aged 7-11 years, using the TGMD-2. The results revealed significant differences in the GMQ, locomotor, and object control sub-tests, with the control group scoring higher than the one with ID. For the locomotor sub-test, the mean delay for the ID group, according to the TGMD norms, was six years and six months. For the object control sub-test, the boys from the ID group had a mean delay of five years and three months, while for the girls the delay was six years and six months.

Bruininks-Oseretsky Test of Motor Proficiency

The BOTMP (Bruininks, 1978) and its revision, BOT-2 (Bruininks & Bruininks, 2005), both have a complete form, consisting of 48 (BOTMP) or 53 items (BOT-2), and a short one, consisting of 14 items, that assess fine and gross motor skills. When the short form is administered, the examinee's raw scores on the individual items are converted to point



scores that are added to produce the total motor composite score. For the complete form, the individual point scores are added to produce the motor composite scores (two composites for the BOTMP and four composites for the BOT-2). The composite scores are then combined to yield a total motor composite score that can be characterized as "Well-Below Average", "Below Average", "Average", "Above Average" or "Well-Above Average". According to our research, the abovementioned standardized test of motor proficiency was used in three studies including children with ASD and in two studies in children with ID.

Ghaziuddin, Butler, Tsai and Ghaziuddin (1994) used the BOTMP (Bruininks, 1978) in order to evaluate motor proficiency in children with AS (n=11, aged 9-19), comparing it to that occurring in HFA (n=9, aged 7-17), and to comment on its role as a possible diagnostic marker for this syndrome. When compared with age-matched population norms given by the BOTMP (Bruininks, 1978), problems of coordination were found in both groups. More specifically, the AS group performed marginally better on the BOTMP than the HFA group. As reflected by the battery composite scores, no significant differences were found in any of the individual categories of the battery between the two groups, indicating that the existence of motor proficiency deficits may not be useful in the distinction of AS from autism on the basis of the BOTMP.

Four years later, Ghaziuddin and Butler (1998) conducted a similar investigation with 10- and 11-year-olds, but, in addition to participants with AS (n=12) and HFA (n=12), the authors also included a group of children with pervasive developmental disorders not other specified (PDD-NOS) (n=12). All three groups demonstrated difficulties on gross motor, fine motor, and battery test scores, but children with AS demonstrated a marginally better performance than those with HFA and PDD-NOS. Using the BOT-2 (Bruininks & Bruininks, 2005), Pan (2014) examined motor proficiency in adolescents with (n=31) and without ASD



(n=31), aged 10-17 years, and found that participants with ASD had statistically significantly lower scores than the controls on all BOT-2 sub-tests, composites, and total composite scores.

The BOT was used only in two studies examining motor proficiency in children with ID. Wang, Wang, Huang, and Su (2008) described the sensorimotor profile of children with MID (n=233, aged 7-8, average IQ=57.91) and to examine the association between their cognitive and motor functions. Fifty-two percent of children scored in the designated impaired range on gross motor composite of the BOTMP, while their fine motor scores were significantly better. The authors concluded that motor performance varied as a function of child IQ even in the same diagnostic category (i.e., mild ID). One year later, Wang, Lin, and Su (2009), examined the measurement properties of the BOT-2 in children with ID. For that purpose, they utilized Rasch analysis on the BOT-2 scores of 446 children and adolescents with ID, aged 4-18 years. In the Rasch model 17 items were identified as problematic and were removed from the assessment. After rescore, items in each composite of the revised BOT-2 provided a healthy mechanism of differentiating motor performance between children with MID and those with moderate to severe ID.

Discussion

Even though motor deficits are not included among the diagnostic criteria of the DSM-V (APA, 2013) for ASD and ID, children with these neurodevelopmental disorders usually demonstrate deficits in their motor proficiency. In the present study, an attempt was made to provide evidence concerning the motor proficiency of children with ASD and ID, as it was assessed by standardized movement assessment tools, with the strong belief that knowledge is important in order to facilitate participation of these children in physical activities.

Autism Spectrum Disorders



Motor proficiency in children with ASD has been examined by several researchers (Ghaziuddin & Butler, 1998; Green et al., 2002; 2009; Hilton et al., 2007; Manjiviona & Prior, 1995; Staples & Reid, 2010; Siaperas et al., 2012) using a range of standardized assessment tools. In some of those studies, the motor proficiency of children throughout the spectrum has been compared to the norms provided by the motor assessment tools (Berkeley et al., 2001; Breslin & Rudisill, 2011; Green et al., 2002, 2009; Liu & Breslin, 2013b; Manjiviona & Prior, 1995; Staples & Reid, 2010). In several others, the performance of children with ASD has been compared to that of their typically developing peers (Hilton et al, 2007; Liu & Breslin, 2013a; Pan et al., 2009; Papadopoulos et al, 2011; Stins et al, 2015; Siaperas et al, 2012; Whyatt & Craig, 2012).

The literature review revealed that regardless of the motor assessment tool that is used (MABC, BOTMP or TGMD), children with ASD demonstrate difficulties or deficits in their overall motor development when compared to either assessment tools norms or a group of TD children. In studies in which the MABC was used, children throughout the spectrum scored in the impaired range of overall motor performance, indicating a definite problem in manual dexterity, ball skills, and balance tasks (Green et al., 2002; 2009; Liu & Breslin, 2013a; Manjiviona & Prior, 1995; Siaperas et al., 2012; Whyatt & Craig, 2012). The only study in which no significant differences were observed between ASD and TD children was that of Stins et al., (2015) who found that the performance of the aforementioned groups in MABC-2 balance subtest was similar.

Deficits of ASD children were also revealed on locomotor and object control skills of the TGMD (Breslin & Rudisill, 2011; Liu et al., 2014; Staples & Reid, 2010). More specifically, ASD children performed similarly to children that have approximately half their age, suggesting demonstrated a significant delay in development (Staples & Reid, 2010). According to Barkeley et al., (2001), children with HFA demonstrated a better performance



in object control skills than in locomotor skills, even though the majority of their HFA participants were placed in the poor and very poor performance categories. Using the BOTMP and the BOT-2, it has also been found that children throughout the autism spectrum demonstrated difficulties on gross motor, fine motor, and battery test scores (Ghaziuddin et al., 1994; Ghaziuddin & Butler, 1998; Pan, 2014).

Apart from the differences between ASD children and typically developing populations, differences are also present across the ASD spectrum. A hugely diverse and heterogeneous clinical population is represented as the spectrum spans from low functioning autism, through to pervasive developmental disorders –not other specified to high functioning autism, and Asperger syndrome. Surveys comparing motor proficiency of the abovementioned sub-categories demonstrated that motor deficits are obvious throughout the spectrum (Green et al., 2009; Manjiviona & Prior, 1995; Pan, 2014), with the AS group performing marginally better than those with LFA, HFA or PDD-NOS (Ghaziuddin et al., 1994; Ghaziuddin & Butler, 1998), especially on ball skills and balance (Papadopoulos et al., 2011; Hilton et al., 2007). These findings indicated that motor proficiency deficits are more frequent and more severe in children with ASD with low intellectual functioning rather than broader ASD.

Many researchers believe that one of the factors responsible for the poor motor performance of children with ASD is the poor understanding of instructions, especially in children demonstrating low IQ scores, such as LFA. The truth is that movement assessment tools were designed for typically developing populations and participants' difficulties to understand the instructions are addressed in several studies (Breslin & Rudisill, 2011; Liu & Breslin, 2013b; Staples & Reid, 2010). In the study of Staples and Reid (2010), the authors individualized the instructions of the TGMD-2 according to the needs of each participant, allowing them to perform each movement skill to their greatest potential. Furthermore, Breslin



and Rudisill (2011) and Liu and Breslin (2013b), have found that using a visual support protocol to provide instructions during assessment with standardized movement assessment tools, results in a more valid test score when used in children with ASD. However, despite the fact that picture activity schedule protocol may elicit better motor skills performance, children's scores are still in the impairment categories. These results are in accordance to the notion that individuals with ASD exhibit a relative strength when visual information is used but have difficulty in handing out and interpreting auditory information (Tissot & Evans, 2003).

Intellectual disabilities

Although deficits in motor functioning are evident in individuals with ID, there is little research in this field, especially using standardized motor assessment tools. In this paper, the focus was on children with mild or borderline intellectual disabilities rather than intellectual disabilities with a known etiology in an attempt to minimize confounding of data.

The motor functioning of children with ID was compared either to the norms of the standardized movement assessment tools (Frey & Chow, 2006; Equia et al., 2015; Vuijk et al., 2010) or to a group of TD children (Hartman et al., 2010; Westendorp et al., 2011; Rintala & Loovis, 2013). From the results it was revealed that ID children were behind their age norms (Frey & Chow, 2006; Equia et al., 2015; Rintala & Loovis, 2013; Simons et al., 2007; Vuijk et al., 2010). More specifically, children with ID not only lagged behind their TD peers on manual dexterity, ball skills, and balance items of the MABC (Vuijk et al., 2010), but also on locomotor and object control skills using the TGMD (Equia et al., 2015; Frey & Chow, 2006; Simons et al., 2007). According to Rintala and Loovis (2013), children with ID demonstrated a mean delay of six years and six months on the locomotor sub-test of the TGMD-2, but in



the object control sub-test, the mean delay was found to be from five years and three months to six years and six months.

Few studies divided ID groups of children into BID and MID groups according to their IQ scores (Hartman et al., 2010; Vuijk et al., 2010; Westendorp et al., 2010). In these, both ID groups scored significantly lower than their TD peers but those with BID demonstrated better performance on the manual dexterity, ball skill, and balance sub-test of the MABC (Vuijk et al., 2010) and on the locomotor sub-test of the TGMD, than children with MID (Hartman et al., 2010; Westendorp et al., 2011). Using the BOTMP, and according to Wuang et al. (2008), children with MID performed better on fine motor skills than on gross motor skills. From the above, it can be concluded that there is an association between the degree of ID and performance on overall motor development, indicating a complex relationship between IQ and motor proficiency. This notion is in close agreement with empirical studies which support the contribution of cognitive level to movement skills in children with developmental coordination disorders (DCD) (Hamilton, 2002) or attention deficit hyperactive disorders (ADHD) (Klimkeit, Sheppard, Lee & Bradshaw, 2004). Further investigation would be necessary in order for this statement to be justified in children with ID.



Table 1. Descriptive features of reviewed studies

Assessment tool used	Authors	Participants		Main findings
		Disorder/sample size	Age	
TOMI-HR (Stott, Henderson, & Moyes, 1984)	Manjiviona & Pnor, 1995	AS (n=12) HFA (n=9)	7-17 years	<ul style="list-style-type: none"> 50% of AS and 67% of HFA children scored in the definitely impaired range
	Green et al., 2002	AS (n=11)	6-11 years	<ul style="list-style-type: none"> All the children from the AS group scored below the 15th percentile. 81% demonstrated definite motor impairment, 10% borderline motor impairment
	Green et al., 2009	Childhood autism (n=45) other ASD (n=56)	10-14 years	<ul style="list-style-type: none"> Definite motor impairments in 79,2% of the ASD group
	Hilton et al., 2007	ASD (n=51) TD (n=56)	6-12 years	<ul style="list-style-type: none"> Definite motor impairment in 65% of ASD group ASD group was significantly worse than TD on manual dexterity.
	Papadopoulos et al., 2011	AD (n=22), HFA (n=23) LFA (n=8) TD (n=20)	6-13 years	<ul style="list-style-type: none"> LFA group performed significantly worse than the HFA HFA group performed significantly worse than both the TD group and the AD group
	Vuijk et al., 2010	MID (n=55) BIF (n=115)	7-12 years	<ul style="list-style-type: none"> Borderline or definite motor problems in 81.8% of the MID group and 60% of the BIF group Children with BID performed better than children with MID Significant motor delays in 77% of ASD group
MABC-2 (Henderson, Sugden & Barnett, 2007)	Liu & Breslin, 2013a	ASD (n=30), TD (n=30)	3-16 years	<ul style="list-style-type: none"> 76% of participants were found to be delayed (or at risk for delay) in their motor skill development regardless of how instructions were provided Performance improvement where found in the picture activity schedule protocol
	Liu & Breslin, 2013b	ASD (n=25)	3-16 years	<ul style="list-style-type: none"> The AS group demonstrated significantly impaired performance on ball skills, manual dexterity and balance
	Siaperas et al., 2012	AS (n=30) TD (n=50)	7-14 years	<ul style="list-style-type: none"> No significant differences between the groups on the static and dynamic balance subtest
	Stins et al., 2015	ASD (n=9) TD (n=9)	Mean age: 10.8 ± 1.2 years	<ul style="list-style-type: none"> ASD group scored significantly lower than both control groups
	Whyatt & Craig, 2012	Autism (n=18) receptive vocabulary matched TD group (n=19) nonverbal IQ matched TD group (n=22)	7-10 years	
FGMD (Ulrich, 1985)	Berkeley et al., 2001	HFA (n=15)	6-8 years	<ul style="list-style-type: none"> 73% of the participants were placed in the very poor and poor performance category.
TCMD-2 (Ulrich, 2000)	Breslin & Rudisill, 2011	ASD (n=22)	3.5-10.92 years	<ul style="list-style-type: none"> Children with ASD were developmentally delayed, regardless of the protocol used Performance improvement where found in the picture task card protocol
	Liu et al., 2014	ASD (n=21) TD (n=21)	5-10 years	<ul style="list-style-type: none"> 91% of the ASD group were considered developmentally delayed when compared to the TD group
	Staples & Reid, 2010	ASD (n=25) Three TD groups matched: 1) on chronological age (CA, n=25) 2) in movement skills (DEV, n=22) 3) on mental age (MA, n=19)	9-12 years	<ul style="list-style-type: none"> The CA and MA groups scored higher on locomotor and object control subtests than the ASD group. The ASD and the DEV group did not differ on locomotor and object control performance
	Eguia et al., 2015	ID (n=60)	5-14 years	<ul style="list-style-type: none"> ID group scored significantly below the norms both in the locomotor and object control sub-tests
	Frey & Chow, 2006	MID (n=244)	6-18 years	<ul style="list-style-type: none"> MID group scored lower on the locomotor and object control sub-tests than their TD peers
	Hartman et al., 2010	BID (n=61) MID (n=36) TD (n=97)	7-12 years	<ul style="list-style-type: none"> MID group scored significantly lower on locomotor skills than BID group No significant differences were found between the two groups for the object control skills
	Rintala & Loovis, 2013	ID (n=20) TD (n=20)	7-11 years	<ul style="list-style-type: none"> ID groups scored significant lower than the TD group
	Simons et al., 2008	MID (n=99)	7-10 years	<ul style="list-style-type: none"> Children without disabilities performed better than children with MID.
	Westendorp et al., 2011	BID (n=88) MID (n=68) TD (n=255)	7-12 years	<ul style="list-style-type: none"> MID and BID groups scored significantly lower than the TD group. BID group were less impaired on the locomotor skills than the MID group Their performance on the object-control skills was comparable
	Ghaziuddin et al., 1994	AS (n=11) HFA (n=9)	9-19 years (AS) 7-17 years (HFA)	<ul style="list-style-type: none"> Both ASD groups demonstrated coordination problems AS group performed marginally better than the HFA group
BOTMP (Bruininks, 1978)	Ghaziuddin & Butler, 1998	AS (n=12) HFA (n=12) PDD-NOS (n=12)	10-11 years	<ul style="list-style-type: none"> All three groups demonstrated motor difficulties AS group were found to be less impaired than HFA and PDD-NOS groups.
	Wuang et al., 2008	MID (n=233)	7-8 years	<ul style="list-style-type: none"> 52% of MID group scored in the impaired range on GM skills but they scored significantly better on FM skills
	Pan, 2014	ASD (n=31), TD (n=31)	10-17 years	<ul style="list-style-type: none"> ASD group demonstrated significantly lower scores than the control group
BOT-2 (Bruininks & Bruininks, 2005)	Wang et al., 2009	ID (n=446)	4-18 years	<ul style="list-style-type: none"> The revised BOT-2 provided a healthy mean of differentiating motor performance between children with MID and those with moderate to severe ID.



Conclusions

Recent findings highlight the existence of motor dysfunctions in children with ASD and ID. Even though there is a small amount of research in this area, data collected from this review are valuable for educators, therapists, and professionals with an interest in children with ASD and ID. In order for them to be successfully involved in sports and physical activities it is important to address deficits in this population as early as possible and this could be accomplished only through accurate assessment provided by standardized assessment tools. Children with neurodevelopmental disorders might benefit from an intervention that addresses their most impaired motor skills, which without appropriate assessment can be hardly identified. Professionals should be aware of the deficits demonstrated in children with ASD or ID in order to design appropriate intervention programs that will not only improve motor skills, but also prevent or reduce health, learning, and psychosocial problems associated with poor motor proficiency (Piek et al., 2012), as well as improve movement competence and social skills of these children.

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