Motor skills predict adaptive behavior in autistic children and adolescents

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Abstract

There is a well-documented difference between IQ and adaptive behavior scores in autism, with autistic children having lower adaptive behavior scores than would be predicted based on their IQ scores. Differences in motor skills may explain the variability in their adaptive behavior scores. The current study examined how motor skills might explain autistic individuals' low adaptive behavior scores and which individual components of IQ (i.e., verbal comprehension and perceptual reasoning) and motor skills (i.e., manual dexterity, aiming and catching, and balance) may drive this effect. We examined the relationships between IQ, motor skills, calibrated severity, and adaptive behavior scores in 45 autistic children and adolescents. We found a significant difference in the full-scale IQ and the adaptive behavior scores indicating that our participants' adaptive behavior scores were lower than would be expected given their full-scale IQ. We investigated whether motor skills predicted adaptive behavior in autistic children and adolescents and found that motor skills scores were related to adaptive behavior scores. To further investigate these relationships, we examined how individual components of IQ and motor skills predicted adaptive behavior scores in autistic children and adolescents. Our results indicated that manual dexterity scores were related to adaptive behavior scores. These findings clearly illustrate the need for further understanding of autistic individuals' difficulties with adaptive behavior and the potential role of motor skill difficulties that may underlie these difficulties.

Keywords

Autism Spectrum Disorder; Motor Skills; Intelligence; Adaptive Behavior; Movement Disorder

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Adaptive behavior skills are vital for independent living. Difficulties with adaptive behaviors in domains such as self-care (e.g., brushing teeth, dressing), self-feeding (e.g., eating with utensils), and play (e.g., drawing, manipulating puzzle pieces) can negatively impact quality of life and limit participation in activities (Delgado-Lobete et al., 2021; Magalhães, Cardoso, & Missiuna, 2011). In autism, there is a well-documented difference between adaptive behavior scores and intelligence quotient (IQ) scores. Autistic children score lower on adaptive behavior assessments than would be predicted based on their scores on IQ assessments (Alvares et al., 2020; Duncan & Bishop, 2015; Kraper et al., 2017; Perry et al., 2009; Smith et al., 2012). Specifically, autistic children's IQ scores were not significantly related to their adaptive behavior scores, suggesting that using IQ scores to estimate functional ability is unproductive and, in some cases, harmful (Alvares et al., 2020). Overestimating autistic children's adaptive behavior skills based on their IQ scores may cause caregivers and service providers to underestimate the supports that autistic children need (Alvares et al., 2020). In turn, this lack of support may lead to increased anxiety and depression (Zukerman, Yahav, & Ben-Itzhak, 2021).

Motor skills may explain the gap between adaptive behavior and IQ scores in autism. Motor difficulties are related to adaptive behavior in related neurodevelopmental disorders, such as Developmental Coordination Disorder (Delgado-Lobete et al., 2021; Magalhães et al., 2011), and there is strong evidence that autistic children have similar clinically-significant motor difficulties (Bhat, 2020; Green et al., 2010; Miller et al., 2021). Green and colleagues (2010) reported that 79-89% of autistic children had definitive or borderline motor difficulties, respectively. Bhat (2020) reported that 86.9-88% of autistic children are at-risk for motor difficulties according to caregivers' survey responses, with the risk of motor difficulties being 22 times greater than that of the general population. Further, Miller et al. (2021) reported that more than 90% of autistic children met criteria for clinically-significant motor difficulties on a gold-standard standardized assessment of motor ability. Examining specific motor skills, researchers have measured differences in quiet standing (Lim et al., 2017), leaning (Miller et al., 2019; Wang et al., 2016), stepping (Bojanek et al., 2020), reaching (Glazebrook et al., 2006), grasping (Carment et al., 2020; Mosconi et al., 2015; Travers et al., 2017), catching (Chen et al., 2019), and tool use (Mostofsky et al., 2006). These motor difficulties are implicated in social, cognitive, and adaptive function and in turn, have implications for autistic children's quality of life and mental health (Tamplin & Miller, 2020).

For autistic individuals, fine motor skills may impede the development of adaptive behavior. Travers et al. (2017) demonstrated that fine motor skill difficulties constrain adaptive behavior and lead to decreased participation in activities of daily living over time in autistic children and adolescents. In a related study of children with clinically-significant motor difficulties, fine motor skills fully mediated the relationship between individual constraints and delayed learning on activities of daily living, highlighting the relationship between fine motor skills and adaptive behavior (Delgado-Lobete et al., 2021). Importantly, fine motor skill difficulties in autism have been shown to increase with time, reducing the likelihood of independent living in adulthood (Travers et al., 2017). Fine motor skill difficulties that reduce an individual's capacity to engage in activities of daily living may also limit access to developmental opportunities in other domains (e.g., social, communication, language; Adolph & Hoch, 2018; Houwen, Visser, van der Putten, & Vlaskamp, 2016).

Given the discrepancy between autistic individuals' adaptive behavior and IQ scores and their documented motor difficulties, this study aimed to determine (1) how measures of motor skills might

explain autistic individuals' low adaptive behavior scores and (2) which individual components of IQ (i.e., verbal comprehension and perceptual reasoning) and motor skills (i.e., manual dexterity, aiming and catching, and balance) may drive this effect. We hypothesized that motor skills would be related to autistic individuals' adaptive behavior scores, and that manual dexterity and balance in particular would drive this effect.

Methods

Participants

We tested 45 autistic children and adolescents (Male = 38, Female = 7). The participant's guardian reported their child had a prior diagnosis of autism spectrum disorder or Asperger's syndrome from an educational or healthcare professional according to DSM-IV or DSM-V criteria. A member of the study team with research-level reliability training on the ADOS-2 (Lord et al., 2012) confirmed participants' community diagnosis.

Potential participants with a current or prior diagnosis of a genetic or neurological disorder (not including autism), brain injury, meningitis, structural brain abnormality, motion sickness, neurofibromatosis, seizure disorder, head injury or concussion with loss of consciousness, psychiatric diagnosis (not including anxiety or depression), movement disorder (e.g., cerebral palsy), oculomotor disorder, or a full-scale IQ score of <70 on the WASI-II (Wechsler, 2011) were excluded from participation, as well as those who were currently taking benzodiazepines or antipsychotics. This study was approved by the North Texas Regional Institutional Review Board.

Procedure

Participants were assessed using the MABC-2 (Henderson, Sugden, & Barnett, 2007) and the WASI-II. Standard scores for movement total and for the manual dexterity, aiming and catching, and balance subscales were calculated from the MABC-2. Standard scores for full-scale IQ and for the verbal comprehension, and perceptual reasoning subscales were calculated from the WASI-II. Participants' guardians reported the participants' adaptive behavior abilities on the Vineland-3 (Sparrow, Cicchetti, & Saulnier, 2016). Calibrated severity scores were calculated with the ADOS-2 (Hus & Lord, 2014; Lord et al., 2012). Standard scores for adaptive behavior were calculated with the Vineland-3. Descriptive statistics are presented in Table 1.

Table 1.*Descriptive statistics for participants' age and standardized assessment scores*

Variable	Mean	SD	Median	Min	Max
Age (years)	12.30	3.48	12.44	5.18	17.80
VABS-3 Adaptive Behavior Composite	78.49	12.59	79	48	110
MABC-2 Movement Total	4.22	2.56	5	1	10
MABC-2 Manual Dexterity	4.71	2.74	4	1	11
MABC-2 Aiming & Catching	5.22	2.95	5	1	10
MABC-2 Balance	5.71	3.40	6	1	14
WASI-II Full-Scale IQ	103.87	16.53	105	70	138
WASI-II Verbal Comprehension	103.33	15.78	105	74	132
WASI-II Perceptual Reasoning	103.87	18.46	106	67	138
ADOS-2 Calibrated Severity	9.07	1.30	10	5	10

Note. All scores reported are standard scores. ADOS-2: Autism Diagnostic Observation Schedule (2nd edition); MABC-2: Movement Assessment Battery for Children (2nd edition); WASI-II: Weschler Abbreviated Scale of Intelligence (2nd edition); VABS-3: Vineland Adaptive Behavior Scales (3rd edition).

Results

Difference between IQ and adaptive behavior scores

We used a paired-samples *t*-test to examine whether our data set replicated the previously found difference between full-scale IQ and adaptive behavior scores. We found a significant difference ($M_{\text{diff}} = 25.38, t = 8.91, p < .001$) between mean full-scale IQ ($M = 103.87$) and mean adaptive behavior score ($M = 78.49$), indicating that our participants' adaptive behavior scores were lower than would be expected given their full-scale IQ.

Relationship between age and standardized assessment scores

We used correlation analyses to examine the relationship between participants' age and each of the variables derived from the standardized assessments. These analyses resulted in two notable correlations between the MABC-2 and adaptive behavior (movement total, $r = 0.35, p = .017$; manual dexterity, $r = 0.32, p = .031$) indicating that movement total and manual dexterity scores are individually related to adaptive behavior scores. The full correlation matrix is presented in Table 2.

Table 2.

Correlation analyses for participants' age and standardized assessment scores

Variable	1	2	3	4	5	6	7	8	9	10
1. Age	1.00	-0.41*	-0.14	-0.15	-0.29*	-0.05	-0.11	-0.08	-0.11	0.33*
2. VABS-3 Adaptive Behavior	-0.41*	1.00	0.35*	0.32*	0.22	0.21	0.16	0.15	0.08	0.01
3. MABC-2 Movement Total	-0.14	0.35*	1.00	0.85*	0.64*	0.80*	0.49*	0.27	0.53*	-0.25
4. MABC-2 Manual Dexterity	-0.15	0.32*	0.85*	1.00	0.51*	0.49*	0.59*	0.31*	0.67*	-0.21
5. MABC-2 Aiming & Catching	-0.29*	0.22	0.64*	0.51*	1.00	0.31*	0.32*	0.22	0.27	-0.45*
6. MABC-2 Balance	-0.05	0.21	0.80*	0.49*	0.31*	1.00	0.34*	0.20	0.36*	-0.13
7. WASI-II Full-Scale IQ	-0.11	0.16	0.49*	0.59*	0.32*	0.34*	1.00	0.85*	0.85*	-0.16
8. WASI-II Verbal Comprehension	-0.08	0.15	0.27	0.31*	0.22	0.20	0.85*	1.00	0.46*	-0.20
9. WASI-II Perceptual Reasoning	-0.11	0.08	0.53*	0.67*	0.27	0.36*	0.85*	0.46*	1.00	-0.07
10. ADOS-2 Calibrated Severity	0.33*	0.01	-0.25	-0.21	-0.45*	-0.13	-0.16	-0.20	-0.07	1.00

Note. * indicates $p < .05$. ADOS-2: Autism Diagnostic Observation Schedule (2nd edition); MABC-2: Movement Assessment Battery for Children (2nd edition); WASI-II: Weschler Abbreviated Scale of Intelligence (2nd edition); VABS-3: Vineland Adaptive Behavior Scales (3rd edition).

Predictors of adaptive behavior

We investigated whether motor skills predict adaptive behavior in autistic children and adolescents by regressing adaptive behavior standard scores onto age, ADOS-2 calibrated severity scores, full-scale IQ scores, and movement total scores with a linear regression. Results indicated that age ($F_{1,40} = 9.76$, $b = -1.59$, $SE = 0.51$, Cohen's $f^2 = 0.24$, $p = .003$, Figure 1) and movement total score ($F_{1,40} = 5.67$, $b = 1.81$, $SE = 0.76$, Cohen's $f^2 = 0.14$, $p = .022$, Figure 1) were related to adaptive behavior standard scores. ADOS-2 calibrated severity scores and, as expected, full-scale IQ scores were not ($p > .05$). This indicates that participants with higher movement total scores had higher adaptive behavior scores, even when controlling for ADOS-2 and IQ scores.

To further investigate these relationships, we regressed adaptive behavior standard scores onto age, ADOS-2 calibrated severity scores, individual component scores of full-scale IQ (i.e., verbal comprehension, perceptual reasoning), and the individual component scores of the movement total scores (i.e., manual dexterity, aiming and catching, balance). Results indicated that age ($F_{1,37} = 9.96$, $b = -1.63$, $SE = 0.52$, Cohen's $f^2 = 0.27$, $p = .003$) and manual dexterity standard scores ($F_{1,37} = 4.75$, $b = 2.12$, $SE = 0.97$, Cohen's $f^2 = 0.13$, $p = .036$) were related to adaptive behavior standard scores. Perceptual reasoning trended toward significance ($F_{1,37} = 3.79$, $b = -0.26$, $SE = 0.13$, Cohen's $f^2 = 0.10$, $p = .059$). ADOS-2 calibrated severity scores, verbal comprehension scores, aiming and catching scores, and balance scores were not significantly related to adaptive behavior standard scores ($ps > .05$). This indicates that participants with higher manual dexterity scores, and potentially higher perceptual reasoning scores, had higher adaptive behavior scores.

Figure 1. Movement total standard scores and age are related to adaptive behavior scores in autistic children and adolescents. Ages plotted indicate the 25th percentile (9.51 years), mean (12.30 years), and 75th percentile (15.02 years) of the sample.

Discussion

Motor skills are related to autistic individuals' adaptive behavior scores. Specifically, autistic individuals' manual dexterity explains a significant proportion of the variability in their adaptive behavior scores even when controlling for ADOS-2 scores, verbal comprehension, perceptual reasoning, and other motor skills. These results are highly impactful, clearly illustrating the need for further understanding of the impact of motor difficulties on autistic individuals' adaptive behavior.

Given the breadth of established motor interventions for young children, motor skills are of particular interest for supporting and improving autistic individuals' adaptive behavior. There is substantial research from the fields of kinesiology, physical therapy, and occupational therapy on improving young children's motor skills and educators and clinicians in early childhood settings are capable of implementing these interventions (Logan, Robinson, & Wilson, 2012, Robinson et al., 2012). This research should be adapted to serve as a starting point for development of motor skill interventions targeting the specific difficulties experienced by autistic individuals.

Early improvement of motor skills may also have cascading effects for autistic children, as motor skills are often necessary for accessing developmental opportunities in other skill domains such as social engagement, communication, and play (Adolph & Hoch, 2018; Houwen, Visser, van der Putten, & Vlaskamp, 2016). For example, children who struggle with motor skills may have difficulty keeping up with their peers when playing games on the playground. This limits their opportunities for social engagement with peers, as well as opportunities to practice and refine their communication strategies. More research is needed to understand the interaction of multiple skill domains across development in autism.

Overall, motor difficulties play a substantial role in quality of life. Untreated motor difficulties among autistic children and adolescents may impact their mental health negatively by increasing the likelihood of social isolation and lower self-esteem (Tamplain & Miller, 2020). It may also impact their physical health by making them less likely to engage in physical activity (Tyler, MacDonald, & Mearns, 2014; MacDonald, Esposito, & Ulrich, 2011), increasing the risk of chronic health conditions like obesity (Curtin, Anderson, Must, & Bandini, 2010).

Future Directions

There are still many unanswered questions about the relationship between autistic individuals' motor skills and their adaptive behavior. There is a dearth of longitudinal studies on the development of motor skills in autism and how this may impact adaptive behavior. In particular, there is a need to establish the causality of motor skill difficulties with respect to differences in adaptive behavior observed in autism. We also need to understand how the relationship between motor skills and adaptive behavior may change over time, so that we can develop more effective supports and interventions across the lifespan. Specifically, we need to identify motor skills intervention targets that increase the depth and breadth of adaptive behaviors that an individual is able to use effectively. By improving our understanding of the relationship between autistic individuals' motor skills and adaptive behavior across the lifespan, we can increase developmental opportunities, reduce barriers to participation, and increase quality of life.

Declaration of Conflicting Interests

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Supplemental Material

Supplemental material for this article is available online.

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