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Applicability of Motor Assessments in Monitoring Physical Exercise Outcomes in Children with Autism Spectrum Disorder: Scoping Review

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Abstract: *A neurodevelopmental disorder characterized by restricted and repetitive patterns of behavior as well as difficulties in communication and social interaction is defined as Autism Spectrum Disorders (ASD). The specific characteristics observed in children with ASD require carefully selected and methodologically justified instruments for the assessment of motor competence, i.e. the assessment of motor skills and physical abilities. The aim of this study is to broadly examine the application of test procedures (instruments) used by researchers in studies in which physical activity intervention is applied in children with ASD and to analyze the methodological justification of their choice. This scoping review was conducted following a systematic search strategy in accordance with the PRISMA Extension for Scoping Reviews guidelines. Based on the literature search and eligibility criteria, 34 papers were included in the final qualitative synthesis. The reviewed literature reveals considerable heterogeneity in the selection of instruments, with the most frequently used being the Test of Gross Motor Development-2/3, the Bruininks–Oseretsky Test of Motor Proficiency-2 and the Movement Assessment Battery for Children-2. These instruments primarily asess motor skills, although many studies also include additional measures of physical abilities for which the authors do not provide clear references regarding their source or origin, representing a methodological limitation. This review highlights the need for the development of standardized instruments that assess both motor skills and physical abilities while accounting for the unique cognitive and social characteristics of children with ASD and varying levels of support needs.*

Key words: *Motor competence, Motor skills, Assessment tools, Physical activity interventions, Neurodevelopmental disorder*

Introduction

Motor competence (MC) is important for daily functioning, social integration, overall psychomotor development and quality of life (Bertz et al., 2022). It refers to different motor domains and reflects a child's level of motor development, which is determined by the development of motor skills (MS) and physical abilities (PA) (Luiz et al., 2017). Motor competence, as an important factor in a child's social, physical and cognitive development, results from engagement in movement activities and physical exercise. The optimal period for the development of certain motor domains is early childhood, including preschool and early school age, especially for children who have a low level of developmental abilities and skills for a given age, which is the case with children with autism spectrum disorder (ASD) (Molnar, Romanov & Milić, 2024). ASD is one of the fastest growing deviations identified in child development. Compared to children from the typical population, children with ASD are characterized by developmental differences that include difficulties in social interaction and communication, restrictive and repetitive patterns of behavior (World Health Organization, 2019), difficulties across multiple developmental domains of MC (Kodak & Bergmann, 2020), reduced initiative to engage in physical activity programs and decreased participation in motor and play activities (Gehricke et al., 2020). Deviation in motor development, which is observed in children of this population, is one of the potential early identification of ASD (Pokoski et al., 2025). Numerous authors indicate the connection of MC with the development of speech, attention, perception and other cognitive functions, as well as the skills necessary to perform everyday activities (Acar, Erol, & Cimen, 2025). Due to the clearly observed differences in motor development in children with ASD, compared to children of the typical population, experts in the field of kinesiology and related disciplines develop and apply different kinesiology programs aimed at improving motor domains. The development of various programs (physical and sports activities), as well as the monitoring of their outcomes, relies on the application of instruments, used to assess motor development and MC in children with ASD.

In the practical application of instruments, both by clinicians and researchers, a considerable variability in instrument selection can be observed, as well as limitations that affect the standardization of assessment of MC in children with ASD. A lack of methodological rationale in the selection of tests can be observed in the literature, which indicates that they are often chosen on an "ad hoc" basis (Piccolo et al, 2025). It is important to note that the motor instruments were developed according to the developmental norms of children of a typically developing children (Walters et al., 2025). Since adaptations are often required when these instruments are applied with children with ASD, especially in terms of understanding tasks, maintaining attention, motivation and general functional abilities, questions arise about the validity and suitability of the applied instruments. When instruments are used to assess the outcomes of physical activity intervention and to support the development of motor competence in children with ASD, it is important to systematically identify and analyze which instruments and test batteries researchers use to evaluate intervention outcomes. Therefore, the aim of this study is to map the application of instruments used by researchers in studies in which physical activity intervention is applied in children with ASD and to analyze the methodological rationale of their choice.

Material & methods

Protocol and registration

This scoping review was conducted following a systematic search strategy in accordance with the PRISMA Extension for Scoping Reviews (PRISMA-ScR) guidelines (Tricco et al., 2018).

Eligibility Criteria

Eligibility criteria were defined in accordance with the PRISMA-ScR guidelines. Studies were eligible for inclusion if they: (a) were published from 2010-2025 (study with full text access); (b) employed experimental study; (c) included participants diagnosed with ASD according to established diagnostic criteria (DSM-IV, DSM-5, ICD-9, ICD-10, ICD-11) (American Psychiatric Association, 1994, 2013; World Health Organization, 1978, 1992, 2019); (d) implemented a structured physical exercise or physical activity intervention program; (e) assessed motor competence using motor assessment instruments (standardized and non-standardized); (f) involved children and adolescents aged from 3 to 21 years old; and (g) were published in English language.

Studies were excluded if they: (a) were published before 2010; (b) study with no full text access; (c) were review articles, meta-analyses, conference paper, letters, editorials, or preclinical studies; (d) studies that include other developmental disabilities than ASD; (e) studies with absence of a structured exercise program; (f) did not apply motor assessment tests; and (g) included participants under 3 years and older than 21 years old.

Information sources

A comprehensive literature search was performed up to January 13, 2026, by systematically searching the following electronic databases: Scopus, Web of Science and PubMed.

Search strategy

The search approach was customized for each database to accommodate differences in indexing systems, search interfaces and the use of controlled vocabulary. Search terms were organized into key conceptual MC domains related to the population with ASD, motor competence outcomes, physical exercise or physical activity based interventions and motor assessment instruments. Synonymous terms within each domain were combined using Boolean operators to enhance search sensitivity and specificity.

Selection process and Data collection process

Each database and study was independently screened by two authors (Š.D. and R.R.) to ensure consistent application of the eligibility criteria. In case of disagreement, a third author (B.D.) was consulted and consensus was reached through discussion. After screening titles, abstracts and full texts, agreement between Š.D. and R.R. was 95%, with remaining discrepancies resolved by B.D.

Results

The initial database search yielded a total of 359 records and represented in Figure 1.

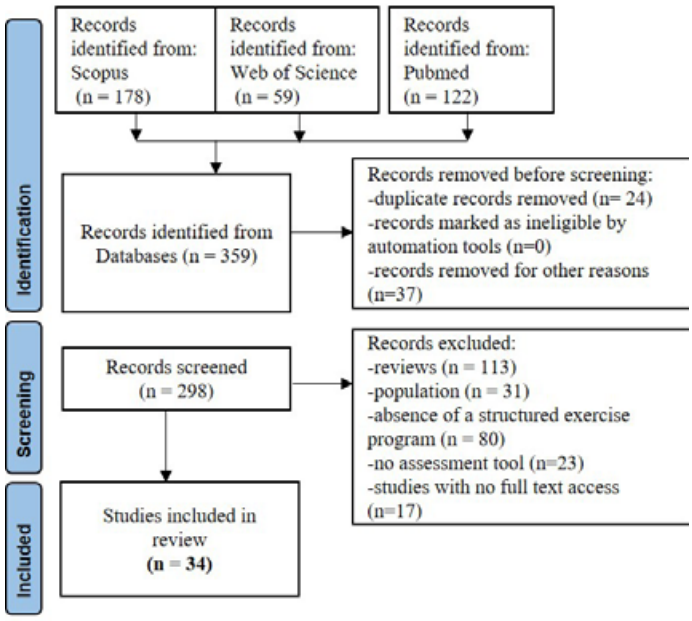

Figure 1. PRISMA flow diagram of the study selection process

After removing duplicates, studies published more than 15 years prior to the search period and non-English studies, 298 records remained for screening. During title and abstract screening, 113 records were excluded (reviews and meta-analyses), 31 due to inappropriate population, 80 due to the absence of a structured exercise program and 23 due to the lack of a motor competence assessment tool. An additional 17 studies were excluded because full texts were unavailable. Following full-text screening and application of the eligibility criteria, 34 studies were included in the final qualitative synthesis of this systematic review. Data were extracted for all assessment instruments used to evaluate motor competencies in children with ASD up to 21 years of age. Both standardized and non-standardized tools were included to capture the full spectrum of instruments currently applied by practitioners, as well as those with potential for future development. Studies involving participants older than 21 years or with other neurodevelopmental or intellectual disorders were excluded. The following data were collected for each included study: (a) study identification information (first author and year of publication), (b) intervention type, (c) participant characteristics (autism severity/intellectual level), (d) motor competence assessment instruments, (e) motor competence domains assessed, (f) study outcomes. These data are summarized in Table 1.

Table 1. *Data collected for each included study*

	Study/ year	Inter. type	Participants (Autism severity/intellectual level)	Assessment tools	Motor Outcomes
1.	Arabi & Kakhki (2025)	FMSI	n=60 children with ASD, 6–12 yrs; Mild to moderate levels ASD, non verbal, IQ>70	BOT-2-short form	Gross and fine motor skills, coordination
2.	Arabi et al. (2019)	SMI	n=60 children with ASD, 6–12 yrs; Mild to moderate levels of ASD, non-verbal IQ < 60,	TGMD-2	Locomotor and object control skills
3.	Arslan et al. (2020)	PAI	n=28 boys with ASD and TD 9-11yrs; Atypical autism (DSM-V)	BOT-2 (6 subtests); sit and reach, handgrip, Newtest 1000 reaction device	Speed and agility, balance, coordination, strength, flexibility and reaction time
4.	Bo et al. (2018)	FMSI	n=9 children with ASD, 8–13 yrs; ASD without intellectual disabilities	TGMD-3	Locomotor and object control skills

5.	Casey et al. (2015)	SBI	n=2 children with ASD, 7 and 10 yrs; High functional level	The Pediatric balance Scale, Flamingo test, The Floor to Stand Test, The timed up and Go test, Timed Up and Down Stairs test, 6 min walk test	Static, dynamic and anticipatory balance; functional mobility; walking speed, submaximal endurance
6.	Castaño et al. (2024)	FMSI	n=20 children with ASD, 4-6 yrs; Autism severity: NR	Abbreviated Development Scale -3	Gross motor and fine motor skills
7.	Chiva-Bartoll et al. (2021)	FMSI	n=25 children with ASD, 7-13 yrs High-functioning ASD, IQ > 70	MABC-2	Manual Dexterity, Aiming & Catching, Balance
8.	Colebourn et al. (2017)	FMSI	Single child with ASD, 9 yrs Receptive/expressive language & sensory integration difficulties	BOT-2 (upper limb coordination); TGMD-2 (Object Control)	Upper-limb coordination, overhand throwing skill
9.	Gaber (2025)	SMI	n=70 boys with ASD, 6-9 yrs Moderate ASD	Gross motor skills scale (GMSS) Fine motor skills scale (FMSS)	Gross and fine motor skills
10.	Hashemian et al. (2025)	FMSI	n=36 boys with ASD, 4.5–14 yrs Autism severity: NR	BOT-2	Fine Manual Control, Manual Coordination, Body Coordination, Strength & Agility
11.	Henderson (2016)	FMSI	n=37 children with ASD, 5–12 yrs; Moderate to severe autism	TGMD-2+visual support cards	Locomotor and object control skills
12.	Howells et al. (2021)	SBI	n=35 children with ASD, 5-12yrs; Autism severity: NR	MABC-2	Manual dexterity, aiming and catching, balance
13.	Imai et al. (2023)	SBI	n=9 children with ASD, 6–12 yrs; Autism-Spectrum Quotient (AQ) 26–38.	BOT-2 –Short form+BOT2 4 subtests	Bilateral Coordination, Balance, Running Speed & Agility, Strength
14.	Jia & Xie (2021)	FMSI	n=24 children with ASD Autism severity: NR	TGMD-2+visual support cards and „Basic motor skills assessment“	Locomotor and object control skills balance
15.	Kanzari et al. (2025)	SMI	n=21 children with ASD, 5–13 yrs; ASD Level 1–2 support needs – (DSM-5-TR)	BOT-2	Fine Manual Control, Manual Coordination, Body Coordination, Strength & Agility
16.	Kaplánová (2023)	FMSI	n=20 children with ASD, 5–10 yrs; Autism severity: NR	TGMD-2	Locomotor and object control skills
17.	Ketcheson et al. (2016)	FMSI	n=20 children with ASD, 4–6 yrs; Autism severity: NR	TGMD-2 + visual support cards	Locomotor and object control skills
18.	Ketcheson et al. (2021)	FMSI	n=25 children with ASD, 3–5 yrs; Autism severity: NR	TGMD-3 + 4 subtests from Brockport Physical Fitness test	Locomotor and ball skills
19.	Kozlowski et al. (2020)	PAI	n=58 children with ASD, 7–12 yrs; IQ>70	Sit and reach, push ups, sit ups, body weight squats, long jump; PACER	Flexibility, strength, power, cardiovascular endurance
20.	*Lourenço et al. (2015)*	*SMI*	*n=16 children with ASD, 4–8 yrs; Autism severity: NR*	*BOT-2 Short form; standing long jump*	*Gross & fine motor skills, coordination, strength, agility*
21.	Marzouki et al (2022)	SBI	n=27 children with ASF, 6-7 yrs; CARS>30; IQ ≥ 80	TGMD -2	Locomotor skills and object control skills
22.	Maussier (2025)	SBI	n=31 children with ASD, 6–10 yrs; Different levels of autism severity	TGMD-3	Locomotor and object control skills
23.	Morales et al. (2022)	SBI	n=40 children with ASD, 9-13 yrs; IQ range 55–70	TGMD-3+visual support cards	Locomotor and object control skills
24.	Özcan, Özer & Pınar (2025)	FMSI	n=34 children with ASD 3- 6 yrs; Autism severity: NR	The Peabody Motor Development Scale (PMDS)-2	Locomotor skills and manipulative skills, balance
25.	Palmer et al. (2023)	FMSI	n = 11 children 3-10yrs (ASD: n = 4; TD: n = 7) Autism severity: NR	TGMD-2 + visual support “LAMP” device	Locomotor and object control skills
26.	Pan et al. (2016)	SBI	n=22 boys with ASD, 6-12yrs High-functioning ASD	BOT-2	Fine Manual Control, Manual Coordination, Body Coordination, Strength & Agility
27.	Rafie et al. (2017)	SMI	n=20 adolescents with ASD, 9–12 yrs; Mild ASD level; IQ≥80	BOT-2	Balance, bilateral coordination, strength, agility, upper-limb coordination

28.	Rafiei Milajerdi et al. (2021)	FMSI+PAI	n=60 children with ASD, 6-10 yrs; Autism severity: NR	MABC-2	Manual Dexterity, Aiming & Catching, Balance
29.	Salvador-Garcia et al. (2021)	FMSI	n=31 children with ASD, 4-16 yrs Autism severity: NR; IQ>70	MABC-2	Manual Dexterity, Aiming & Catching, Balance
30.	Sarabzadeh et al. (2019)	SBI	n=18 children with ASD, 6-12 yrs; Autism severity: NR; Without ID	MABC-2	Manual dexterity, aiming and catching, balance
31.	Svensson et al. (2024)	SMI+ FMSI	n=10 children, 4–10 yrs Autism level 2 or 3 (DSM-V-TR) Moderate i high support needs	TGMD-3 (visual support); BOT-2 subtests	Locomotor skills, bilateral coordination, balance
32.	Touali, et al. (2025)	SMI+PAI	n=14 children with ASD aged, 6-12 yrs Moderate level of ASD (LVL 2, by DSM-5-TR)	UQAC-UQAM -test battery protocol with adaptations	Gross motor factors: limb movement speed, agility, balance, coordination and reaction time
33.	Wang et al. (2025)	FMSI	n=25 children with ASD, first-grade students, age NR; Moderate autism	TGMD-3	Locomotor and object control skills
34.	*Wen & Wu (2025)*	*SMI*	*n=40 children with ASD, 6–12 yrs; SPM ≤≤ 30*	*BOT-2*	*Balance, coordination, fine motor control and gross motor skills*

Note: *ASD – Autism Spectrum Disorder; TD – Typical Development; FMSI – Fundamental Motor Skill Intervention; PAI – Physical Abilities Intervention; SMI – Sensory-Motor Intervention; SBI – Sport-Based Intervention; BOT – Bruininks-Oseretsky Test of Motor Proficiency; TGMD – Test of Gross Motor Development; MABC – Movement Assessment Battery for Children; CARS – Childhood Autism Rating Scale; NR – Not reported; EG – Experimental group; CG – Control group.*

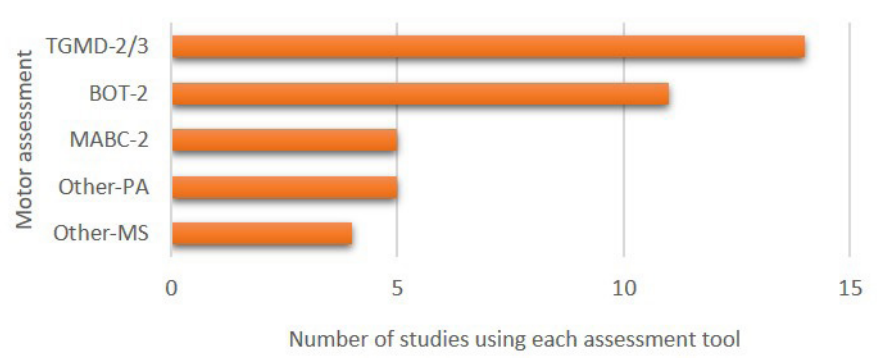

Figure 2. Frequency of motor assessment tools used in the included studies

Based on the data extracted from the included studies, the most frequently used motor assessment tools are presented in Figure 2. The TGMD-2/3 was the most applied instrument, used in 14 studies, followed by the BOT-2, which was used in 11 studies. The MABC-2 was applied in five studies. Additionally, other assessments measuring physical abilities (other PA) were identified in five studies, while other instruments assessing motor skills (other MS) were reported in four studies.

To examine the potential association between intervention type and the selection of assessment instruments, interventions were classified into four categories according to their primary motor objectives: (a) fundamental motor skills intervention (FMSI), (b) physical abilities intervention (PAI), (c) sensory-motor intervention (SMI) and (d) sport-based intervention (SBI).

Some interventions included components from more than one category. It was noted that in some of the analyzed studies, more than one instrument for assessing MC was used. The distribution of assessment tools across intervention types is presented in Figure 3.

Autism severity and intellectual level were not reported in all studies and the scales used to describe autism-related participant characteristics varied, limiting direct comparison. Among the studies that reported IQ, BOT-2, TGMD-2/3 and MABC-2 were used with similar frequency in participants with IQ ≥ 70, whereas TGMD-2/3 was predominantly used in participants with IQ < 70 (Figure 4). Based on the available data, test selection did not show a clear correspondence with autism severity.

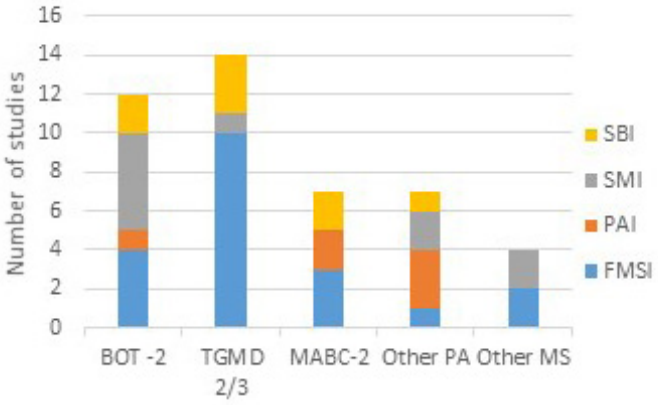

Figure 3. The distribution of motor assessment instruments varied across intervention types

Regarding age-based distribution, TGMD-2/3 was most frequently applied in preschool children (3-6 years), BOT-2, TGMD-2/3 and MABC-2 appeared with similar frequency in school-age children (7-12 years) and no participants were included in the older school-age/adolescent category (13-21 years) (Figure 5.).

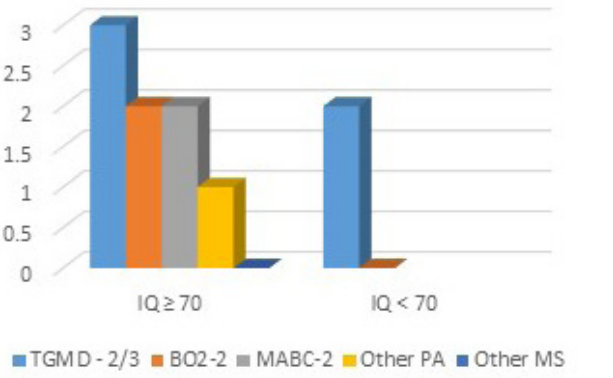

Figure 4. Distribution of Motor Assessment tools by Intellectual Level

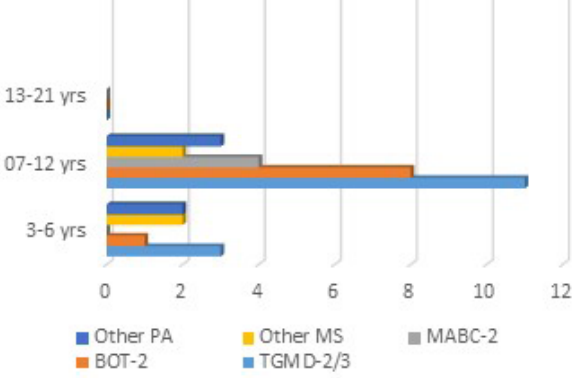

Figure 5. Distribution of Motor assessment tools across age groups

Discussion

The aim of this study is to provide an overview of MC assessment instruments used by researchers in studies examining physical activity interventions in children with ASD and to analyze the methodological justification for their selection. The reviewed literature reveals considerable heterogeneity in the choice of instruments within this population, encompassing both standardized and non-standardized instruments. This distribution indicates the absence of a unified approach to motor assessment in the context of physical exercise intervention in children with ASD. The most frequently used tests are Test of Gross Motor Development (Second and Third edition; TGMD-2/3), Bruininks–Oseretsky Test of Motor Proficiency-2 (BOT-2) and Movement Assessment Battery for Children-2 (MABC-2). The results of this study are consistent with previous studies (Battah, Lotan & Moran, 2023; Downs et al., 2020), which report a dominant application of the TGMD-2/3 tests for ages 3 to 6 years. For ages 7 to 16, the following tests are equally applied: TGMD-2/3, BOT-2 and MAC-2. No studies with subjects older than 16 years were identified, indicating a potential lack of research in older adolescents with ASD.

The TGMD-2/3 was identified as the most frequently used instrument, being applied in studies, which may indicate its potential as „gold standard“ for assessing motor competence in children with ASD. This supported by reliability and validity studies (Clutterbuck, Ho & Dwyer, 2025; Ulrich, 2013;) conducted among children with intellectual disabilities. According to the recommendations of the test authors, when the instrument is used with children with developmental disorders, it should be administered with visual support (cards), which ensures its validity for

population of children with ASD.

In the present review, visual supports were included in the assessment instruments only in studies involving participants with moderate to severe autism (Henderson et al., 2016), mild intellectual disabilities (Morales et al., 2022), or moderate to high support needs (Svensson et al., 2024). The use of the TGMD-2/3 in this population is further supported by its applicability for intervention design, with test items also used as intervention tasks and visual cards serving as instructional support (Bo et al., 2019; Henderson et al., 2016; Ketcheson et al., 2016; Wang et al., 2025). The test stands out due to its ease of administration, established validity and sensitivity to changes following physical activity interventions, particularly in children with lower verbal and cognitive abilities (Henderson et al., 2016; Ketcheson et al., 2016; Maussier et al., 2025). This is further supported by Arabi et al. (2019), who applied TGMD-3 in children with an IQ lower than 60, whereas the BOT-2 test was used for children with an IQ above 70 (Arabi et al., 2025).

In several studies, testing procedures showed high task completion rates. Children with ASD were also observed to engage in test tasks with enjoyment and motivation (Ketcheson et al., 2016), highlighting the importance of positive experience for successful participation. Only in the study by Svensson et al. (2024) did children with high support needs fail to complete the TGMD-3 and BOT-2 tests due to difficulties in following instructions and performing the required tasks. These difficulties may be partly related to limitations in language comprehension, as research suggests that understanding visual representations and task demands in children with ASD is more strongly associated with language abilities than with non-verbal intellectual functioning (Hartley, Trainer & Allen, 2019). Svensson et al. (2024) emphasize that although these tests have been validated in children with ASD with lower support needs, their reliability and validity have not yet been confirmed with children requiring higher levels of support.

The Bruininks–Oseretsky Test of Motor Proficiency-2 (BOT-2) is designed to assess general motor proficiency, including domains such as fine manual control, manual coordination, body coordination, strength and agility (Bruininks & Bruininks, 2005). The BOT-2 has been used in several studies due to its comprehensive approach to MC, particularly in terms of performance and movement efficiency, as well as its validation in children with developmental disabilities, including high functioning ASD (Pan et al., 2016). In addition to the complete form, BOT-2 Short Form (SF) provides a quicker assessment while maintaining reliability and sensitivity (Arabi et al., 2025) The SF may represent an appropriate choice for children with ASD due to potential difficulties related to attention and motivation during testing.

In this study, it was observed that the BOT-2 was the test most supplemented with other motor assessments. Imai et al. (2020), in addition to the SF, used four other items of BOT-2 full form to assess motor skills (bilateral coordination, balance, running speed, agility and strength), as the intervention focused on activities involving gross motor skills. Arslan et al. (2020) used six items of the BOT-2 (assessing speed, agility, balance and coordination), along with additional tests of flexibility, handgrip strength and visual-auditory reactions, when enabled a comprehensive assessment of physical abilities.

On the other hand, Rafie et al. (2017) interpreted the results within the framework of perceptual-motor skills rather than motor proficiency alone, to align with the focus of the intervention. Not all subtests showed significant improvement, particularly the bilateral coordination task (drawing circles with the fingers while alternately striking with the feet or catching a falling ruler as quickly as possible). This was attributed to the complexity of the task and requirement for simultaneous coordination of the upper and lower extremities, focused attention and rapid perceptual processing. The authors also suggested that alternatives such as the MABC-2 test might be more sensitive to detect changes in this population.

However, most authors believe that the BOT-2 is capable of detecting significant changes after intervention, which confirms its sensitivity (Pan et al., 2016). The application of the BOT-2 in the analyzed studies illustrates its ability to cover a wide range of motor domains while also indicating limitations in detecting changes in the most demanding tasks.

The Movement Assessment Battery for Children-2 (MABC-2) (Henderson, Sugden, & Barnett, 2007) enables the assessment of motor skills according to developmental norms for children. It covers three age groups (3–6 years, 7–10 years and 11–16 years) and consists of eight tasks divided into three components: manual dexterity, aiming and catching and balance. In all five studies that applied this test, participants had an intellectual disability level with IQ > 70. Howells et al. (2021) reported that not all children were able to complete the grasping and fine motor tasks, as

these tasks require precise coordination and attention, which may represent a potential barrier for children with ASD and cognitive impairments (Lin et al., 2024). In addition, the results of this study were not normally distributed in relation to the identified mean values, which may be a consequence of differences in the functional level of the participants. This suggests that the test may be demanding for children with ASD with lower functional levels, as indicated by the results of this study (Figure 3), but also that these tests do not assess only the motor aspect of development and may be influenced by other domains. Rafiei Milajerdi et al. (2021) stated that a key limitation of their study was the selection of the MABC-2 test for assessing short-term changes, because the authors of the test recommend an interval of three months between two measurements. In their study, the intervention interval was shorter, which may have contributed to minimal program effects, particularly considering that children with ASD often require more time to achieve visible effects after physical exercise interventions.

The analyzed studies indicate that, in relation to the goals and characteristics of physical exercise intervention, the TGMD-2/3 test was often used to assess motor skills in programs specifically focused on learning skills. In contrast, the test was less frequently used to assess physical abilities as an outcome, which aligns with the nature of interventions. Although sensory motor interventions are theoretically based on improving basic neuromotor process (vestibular and proprioceptive integration, motor planning and body awareness), these studies indicate that the BOT-2 was predominantly used to assess these neuromotor competencies, while no study applied the MABC for the same purpose. Although the BOT-2 primarily measures motor competence rather than sensory processing as a separate construct, some of its subtests (e.g., balance, bilateral coordination and fine manual control) are functionally dependent on effective sensory integration. This may partly explain its frequent use in sensory-motor intervention research despite its broader focus on motor efficiency.

In interventions based on the development of physical abilities (PA based interventions), single tests such as push-ups, sit-ups, sit and reach, PACER, standing long jump and 6MWT were dominantly used (Arslan et al.,2020; Kozlowski et al., 2020; Touali et al., 2025), while standardizes batteries were rarely applied. Also, in the analyzed studies, the use of additional tests was observed, however, the authors did not refer to the validity of these tests although it is noticeable that some of the additional tests were taken from other test batteries such as Eurofit or Eurofit special test battery (Council of Europe,1988; Skowroński et al., 2009). Only some studies emphasized the use of standardized instruments, such as the Brockport Physical Fitness Test or the UQAC-UQAM battery (Ketcheson et al., 2021; Touali et al., 2025). The study by Touali et al. (2025) had a dual aim: to examine the effects of intervention and to evaluate the applicability of the UQAC-UQAM protocol in children with ASD. Although the participants required a moderate level of support (level 2) and had IQ >70, the protocol was adapted to their specific characteristics. The study by Touali et al. (2025) had a dual aim: to examine the effects of the intervention and to evaluate the applicability of the UQAC-UQAM protocol in children with ASD. Although the participants required a moderate level of support (level 2) and had an IQ > 70, the protocol was adapted to their specific characteristics. Its use was justified by its practicality, as it requires minimal space, equipment, time, and financial resources, while its validity and reliability have been supported by previous research (Touali et al., 2025). Given the positive outcomes, the UQAC-UQAM battery may represent a suitable tool for assessing physical abilities in this population, although further research across different age and clinical subgroups is needed. In sport-based interventions, TGMD-2 was the most frequently used instrument, reflecting the focus of these programs on developing fundamental motor skills. BOT-2 and MABC-2 were also used to assess broader aspects of motor competence and coordination.

Conclusion

This scoping review provides an overview of the application of instruments for assessing MC in children with ASD and represents a bridge between previous literature and future practice and research in this area. In the analyzed studies, TGMD-2/3, BOT-2 and MABC-2 were mapped as dominant assessment instruments. Based on the results of this study, it can be concluded that there is a clear need for further standardization and adaptation of these tests when applied to children with ASD with different levels of support needs and cognitive abilities. It was identified that alongside the dominant instruments, additional tests were applied to provide more comprehensive insights into specific MC domains. However, these tests were not always referenced, which raises questions about their validity, sensitivity and reliability. All the above points to methodological (in)justification in the choice of testing procedures for the assessment of applied interventions (physical activity, sports activity) in children with ASD. This suggests that

future researchers should align the selection of instruments with research goals but should also focus on developing instruments that consider the social and cognitive characteristics of the population of children with ASD, as well as their varying levels of motor skills and physical abilities.

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References

Acar, G., Erol, E., & Cimen, K. (2025). Parallels between motor skill development and language development in children. *International Journal of Holistic Health, Sports and Recreation, 4*(1), 23-36. https://doi.org/10.5281/zenodo.15762971

American Psychiatric Association. (1994). *Diagnostic and statistical manual of mental disorders* (4th ed.). American Psychiatric Association.

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). American Psychiatric Publishing.

Arabi, M., Saberi Kakhki, A., Sohrabi, M., Soltani Kouhbanani, S., & Jabbari Nooghabi, M. (2019). Is visuomotor training an effective intervention for children with autism spectrum disorders? *Neuropsychiatric Disease and Treatment, 15*, 3089-3102. https://doi.org/10.2147/NDT.S214991

Arabi, S. M., & Saberi Kakhki, A. (2025). Comparing the effects of fine, gross and fine-gross motor exercises on the motor competence of 6–12-year-old autistic children: A quasi-experimental study with a follow-up test. *Acta Psychologica, 254*, 104842. https://doi.org/10.1016/j.actpsy.2025.104842

Arslan, E., Ince, G., & Akyüz, M. (2022). Effects of a 12-week structured circuit exercise program on physical fitness levels of children with autism spectrum condition and typically developing children. *International Journal of Developmental Disabilities, 68*(4), 500-510. https://doi.org/10.1080/20473869.2020.1819943

Battah, H. W., Lotan, M., & Moran, D. S. (2023). The need for a motor assessment tool for children with autism: An opinion article. *Diagnostics, 13*(12), 2095. https://doi.org/10.3390/diagnostics13122095

Bo, J., Pang, Y., Dong, L., Xing, Y., Xiang, Y., Zhang, M., et al.. (2019). Does social functioning moderate the motor outcomes of a physical activity program for children with autism spectrum disorders? A pilot study. *Journal of Autism and Developmental Disorders, 49*(1), 415–421. https://doi.org/10.1007/s10803-018-3717-4

Bruininks, R. H., & Bruininks, B. D. (2005). *Bruininks-Oseretsky test of motor proficiency* (2nd ed.). Pearson.

Casey, A. F., Quenneville-Himbeault, G., Normore, A., Davis, H., & Martell, S. G. (2015). A therapeutic skating intervention for children with autism spectrum disorder. *Pediatric Physical Therapy, 27*(2), 170-177. https://doi.org/10.1097/PEP.0000000000000139

Castaño, P. R. L., Suárez, D. P. M., González, E. R., et al.. (2024). Effects of physical exercise on gross motor skills in children with autism spectrum disorder. *Journal of Autism and Developmental Disorders, 54*, 2816-2825. https://doi.org/10.1007/s10803-023-06031-5

Chiva-Bartoll, O., Maravé-Vivas, M., Salvador-García, C., & Valverde-Esteve, T. (2021). Impact of a physical education service-learning programme on ASD children: A mixed-methods approach. *Children and Youth Services Review, 126*, 106008. https://doi.org/10.1016/j.childyouth.2021.106008

Clutterbuck, G. L., Ho, C., & Dwyer, G. M. (2025). The feasibility and reliability of the test of gross motor development (TGMD-3) for children with disabilities in regional Australia: A pragmatic pilot study. *Physical and Occupational Therapy in Pediatrics, 45*(4), 572–593. https://doi.org/10.1080/01942638.2025.2463350

Council of Europe. (1988). *Eurofit: Handbook for the EUROFIT tests of physical fitness*. Council of Europe.

Downs, S. J., Boddy, L. M., McGrane, B., Rudd, J. R., Melville, C. A., & Foweather, L. (2020). Motor competence assessments for children with intellectual disabilities and/or autism: A systematic review. *BMJ Open Sport and Exercise Medicine, 6*(1). https://doi.org/10.1136/bmjsem-2020-000902

Gaber, S. A., Alzahrani, A. S., Dawsari, I. A., Hamad, A. M., & Alhajri, A. S. (2025). Developing gross and fine motor skills using sensory integration in children with moderate autism spectrum disorder. *European Journal of Educational Research, 14*(1), 297–308. https://doi.org/10.12973/eu-jer.14.1.297

Gehricke, J. G., Chan, J., Farmer, J. G., Fenning, R. M., Steinberg-Epstein, R., Misra, M., Parker, R. A., & Neumeyer, A. M. (2020). Physical activity rates in children and adolescents with autism spectrum disorder compared to the general population. *Research in Autism Spectrum Disorders, 70*, 101490. https://doi.org/10.1016/j.rasd.2019.101490

Hartley, C., Trainer, A., & Allen, M. (2019). Investigating the relationship between language and picture understanding in children with autism spectrum disorder. *Autism, 23*(1), 187-198. https://doi.org/10.1177/1362361317729613

Henderson, H., Fuller, A., Noren, S., Stout, V. M., & Williams, D. (2016). The effects of a physical education program on the motor skill performance of children with autism spectrum disorder. Palaestra, 30(3).

Henderson, S. E., Sugden, D. A., & Barnett, A. L. (2007). *Movement Assessment Battery for Children-2* (2nd ed.). The Psychological Corporation.

Imai, Y., Naruse, H., Kurita, R., Hiratani, M., & Tomori, K. (2023). A hybrid intervention combining group-based physical activity and an individual goal-oriented approach for children with developmental disabilities: A pre–post intervention study. *International Journal of Disability, Development and Education, 70*(1), 1-17. https://doi.org/10.1080/1034912X.2020.1856793

Jia, W., & Xie, J. (2021). Improvement of the health of people with autism spectrum disorder by exercise. *Revista Brasileira de Medicina do Esporte*, 27(3), 282-285. https://doi.org/10.1590/1517-8692202127032021_0081

Kanzari, C., Hawani, A., Ayed, K. B., Mrayeh, M., Marsigliante, S., & Muscella, A. (2025). The impact of a music- and movement-based intervention on motor competence, social engagement, and behavior in children with autism spectrum disorder. *Children, 12*(1), 87.

https://doi.org/10.3390/children12010087
Kaplánová, A., Šišková, N., Grznárová, T., & Vanderka, M. (2023). Physical education and development of locomotion and gross motor skills of children with autism spectrum disorder. *Sustainability, 15*(1), 28. https://doi.org/10.3390/su15010028
Ketcheson, L., Hauck, J., & Ulrich, D. (2017). The effects of an early motor skill intervention on motor skills, levels of physical activity and socialization in young children with autism spectrum disorder: A pilot study. *Autism, 21*(4), 481-492. https://doi.org/10.1177/1362361316650611
Ketcheson, L., Staples, K., Pitchford, E. A., & Loetzner, F. (2023). Promoting positive health outcomes in an urban community-based physical activity intervention for preschool-aged children on the autism spectrum. *Journal of Autism and Developmental Disorders, 53*, 633–647. https://doi.org/10.1007/s10803-021-04871-7
Kodak, T., & Bergmann, S. (2020). Autism spectrum disorder: Characteristics, associated behaviors, and early intervention. *Pediatric Clinics of North America, 67*(3), 525-535. https://doi.org/10.1016/j.pcl.2020.02.007
Kozlowski, K. F., Lopata, C., Donnelly, J. P., Thomeer, M. L., Rodgers, J. D., & Seymour, C. (2021). Feasibility and associated physical performance outcomes of a high-intensity exercise program for children with autism. *Research Quarterly for Exercise and Sport, 92*(3), 289-300. https://doi.org/10.1080/02701367.2020.1726272
Lin, L. Y., Hwang, I. T., Hsu, C. F., Yu, W. H., Lai, P. C., Chen, Y. W., & Tu, Y. F. (2024). Comparing fine motor performance among young children with autism spectrum disorder, intellectual disability, ADHD, and developmental coordination disorder. *Frontiers in Pediatrics, 12*, 1372980. https://doi.org/10.3389/fped.2024.1372980
Marzouki, H., Soussi, B., Selmi, O., Hajji, Y., Marsigliante, S., Bouhlel, E., Muscella, A., Weiss, K., & Knechtle, B. (2022). Effects of aquatic training in children with autism spectrum disorder. *Biology, 11*(5), 657. https://doi.org/10.3390/biology11050657
Molnar, D., Romanov, R. & Milić, Z. (2024). The Efects of Adapted Physical Exercise on Gross Motor Function and Motor Abilities in Child with Multiple Disabilities. *Sport Science and Health, 14*(2), 173-178. https://doi.org/10.7251/SSH2402173M
Morales, J., Pierantozzi, E., Fukuda, D. H., Garcia, V., Guerra-Balic, M., Sevilla-Sánchez, M., & Carballeira, E. (2022). Improving motor skills and psychosocial behaviors in children with autism spectrum disorder through an adapted judo program. *Frontiers in Psychology, 13*, 1067310. https://doi.org/10.3389/fpsyg.2022.1067310
Pan, C. Y., Chu, C. H., Tsai, C. L., Sung, M. C., Huang, C. Y., & Ma, W. Y. (2017). The impacts of physical activity intervention on physical and cognitive outcomes in children with autism spectrum disorder. *Autism, 21*(2), 190–202. https://doi.org/10.1177/1362361316633562
Piccolo, A., Raciti, C., Di Cara, M., Portaro, S., Muratore, R., De Domenico, C., et al.. (2025). Motor coordination assessment in autism spectrum disorder: A systematic review. *Diagnostics, 15*(17), 2118. https://doi.org/10.3390/diagnostics15172118
Pokoski, O. M., Furnier, S. M., Gangnon, R. E., Howerton, E. M., Kirby, A. V., Protho, T., et al.. (2025). Prevalence of motor milestone delays in autistic children. *JAMA Pediatrics, 179*(7). https://doi.org/10.1001/jamapediatrics.2025.0216
Rafie, F., Ghasemi, A., Zamani Jam, A., & Jalali, S. (2017). Effect of exercise intervention on perceptual-motor skills in adolescents with autism. *Journal of Sports Medicine and Physical Fitness, 57*(1-2), 53-59. https://doi.org/10.23736/s0022-4707.16.05919-3
Salvador-Garcia, C., Chiva-Bartoll, O., Belaire-Meliá, A., & Valverde-Esteve, T. (2022). Motor performance in school-aged children with autism spectrum disorder: Effects of an extracurricular physical education program and socio-ecological correlates. *Journal of Developmental and Physical Disabilities, 34*(2), 355-372. https://doi.org/10.1007/s10882-021-09802-z
Sarabzadeh, M., Azari, B. B., & Helalizadeh, M. (2019). The effect of six weeks of Tai Chi Chuan training on motor skills of children with autism spectrum disorder. *Journal of Bodywork and Movement Therapies, 23*(2), 284-290. https://doi.org/10.1016/j.jbmt.2019.01.007
Skowroński, W., Horvat, M., Nocera, J., Roswal, G., & Croce, R. (2009). Eurofit special: European fitness battery score variation among individuals with intellectual disabilities. *Adapted Physical Activity Quarterly, 26*(1), 54-67. https://doi.org/10.1123/apaq.26.1.54
Tricco, A. C., Lillie, E., Zarin, W., O'Brien, K. K., Colquhoun, H., Levac, D., & Straus, S. E. (2018). PRISMA extension for scoping reviews (PRISMA-ScR): Checklist and explanation. *Annals of Internal Medicine, 169*(7), 467-473. https://doi.org/10.7326/M18-0850
Ulrich, D. A. (2013). The test of gross motor development-3 (TGMD-3): Administration, scoring, and international norms. *Spor Bilimleri Dergisi, 24*(2), 27-33.
Walters, G. W., Cooper, S., Carlevaro, F., Magno, F., Boat, R., Vagnetti, R., et al.. (2025). Normative percentile values for the TGMD-3 for Italian children aged 3-11+ years. *Journal of Science and Medicine in Sport, 28*, 398-407. https://doi.org/10.1016/j.jsams.2024.12.013
Wang, Q., Jia, S., Ding, F., Wang, X., Si, Y., Wang, X., & Sun, J. (2025). Effect of fundamental movement skills practice on executive function and social interaction ability in children with moderate autism: A randomized controlled trial. *BMC Complementary Medicine and Therapies, 25*(1), 354. https://doi.org/10.1186/s12906-025-05107-2
Wen, L., & Wu, Z. (2025). The impact of sensory integration-based sports training on motor and social skill development in children with autism spectrum disorder. *Scientific Reports, 15*(1), 19974. https://doi.org/10.1038/s41598-025-05393-3
World Health Organization. (1978). *International classification of diseases* (9th rev.). World Health Organization.
World Health Organization. (1992). *The ICD-10 classification of mental and behavioural disorders: Clinical descriptions and diagnostic guidelines*. World Health Organization.
World Health Organization. (2019). *International classification of diseases for mortality and morbidity statistics* (11th rev.). https://icd.who.int/

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