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A multiple-method review of accommodations to gross motor assessments commonly used with children and adolescents on the autism spectrum

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Abstract

The purpose of this study is to understand the common accommodations used during standardized motor assessment of children on the autism spectrum. This study was completed in three parts: (1) a narrative review of the literature; (2) an open-ended survey sent to the first authors of the identified articles; and (3) a descriptive analysis of responses. Results revealed that 56.7% of the identified articles did not report enough information of assessment procedures, 18.9% followed the assessment manual, 16.9% provided accommodations on a needs basis, and 7.5% used a consistent modified protocol. Individual responses showed that extra demonstrations ($n = 5$) were the most frequent accommodation, followed by extra breaks ($n = 3$), picture cards ($n = 2$), and hand-over-hand assistance ($n = 1$); some respondents stated that they did not provide accommodations. The findings indicate that a clear set of accommodation for motor skill assessments does not exist, though some commonalities were reported. Further research is necessary to understand the impact of accommodations in the assessment process, as well as which accommodations are needed and/or effective.

Lay abstract

Research has shown that children and adolescents on the autism spectrum develop gross motor skills such as running, jumping, throwing, and kicking at slower rates than their non-autistic peers. Accommodations to these types of assessments can help improve the performance and reduce the anxiety of children on the autism spectrum. However, there is little consensus regarding these accommodations, especially within the research process. In this study, the authors searched the literature for studies that used gross motor skill assessments with youth on the autism spectrum, then sent a survey to the first authors of those studies asking them to describe their assessment protocol. By understanding the assessment protocol, the authors looked for commonalities of application of gross motor assessment. Little consensus exists among the literature and in the reported practices of researchers. The findings of this work can help those providing gross motor assessment to youth on the autism spectrum, though further research is needed to understand how to best provide accommodations and under which circumstances.

Keywords

autism spectrum disorder, fitness assessment, gross motor assessment, modifications, motor development

A growing body of research has suggested that many individuals on the autism spectrum experience delays in motor skill development and coordination (Bhat, Landa, & Galloway, 2011; Fournier, Hass, Naik, Lodha, & Cauraugh, 2010). This delay is evident early in a child's life (Ketcheson, Hauck, & Ulrich, 2018; Lloyd, MacDonald, & Lord, 2013) and persists as children age (Liu, Hamilton, Davis, & ElGarhy, 2014; Staples & Reid, 2010). Given the evidence

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of decreased physical activity participation (Jones et al., 2017; MacDonald, Esposito, & Ulrich, 2011) and increased risk for obesity (Healy, Aigner, & Haegele, 2018) in this population, despite evidence of the benefits of physical activity (Healy, Nacario, Braithwaite, & Hopper, 2018), building motor skill competence is a vital component for future physical activity participation (Haubenstricker & Seefeldt, 1986; Stodden et al., 2008).

Delays in gross motor skill development among children on the autism spectrum may be associated with the defining core symptoms of autism identified in the *Diagnostic and Statistical Manual of Mental Disorders* (5th ed.; DSM-5; American Psychiatric Association [APA], 2013). For example, differences in social communication have been found to be correlated with gross motor skills (Colombo-Dougovito & Reeve, 2017; Pusponegoro et al., 2016; Sipes, Matson, & Horovitz, 2011). Furthermore, individuals on the autism spectrum who have a greater demonstrated delay in their gross motor skills have also been shown to have greater social skills delays, including less receptive language skills (Mody et al., 2017), less pragmatic language skills (Stevenson, Lindley, & Murlo, 2017), lower social communicative skills (MacDonald, Lord, & Ulrich, 2013b; Papadopoulos et al., 2012), as well as lower facial processing and other social skills (Leonard et al., 2014; Sumner, Leonard, & Hill, 2016). Delays in gross motor skill development have also been shown to impact adaptive daily living skills (MacDonald, Lord, & Ulrich, 2013a; Travers et al., 2016). In addition, parents have reported a lower quality of life for their children on the autism spectrum when their children experienced greater delays in their motor skills development (Ayers, Taylor, Branscum, & Hofford, 2016; Hedgecock, Dannemiller, Shui, Rapport, & Katz, 2018; Toscano, Carvalho, & Ferreira, 2017). Finally, lower physical fitness scores were also reported among children in this population who experienced delayed motor skills (Pan, 2014). Acquiring gross motor skills is particularly important for the development of the human body, which contributes to almost every area (e.g. physical, psychological, and cognitive aspects) of growth and well-being across the lifespan (Anderson, 2018), and is vital for later physical activity participation (Haubenstricker & Seefeldt, 1986; Stodden et al., 2008). As children grow, gross motor skills are necessary for participation in more complex movements such as in organized sport or lifetime leisure activities (Clark & Metcalfe, 2002). To ensure that interventions and programming to build gross motor skills are started early enough and in the most appropriate way, standardized assessments are the vital first step.

Since children on the autism spectrum may not receive information and instruction in the same way as their typically developing peers, following gross motor skill or fitness instruction may be difficult (Berkeley, Zittel, Pitney, & Nichols, 2001; MacDonald et al., 2013b). This suggests that an adaptation of the learning or assessment context is necessary (Horvat, Kelly, Block, & Croce, 2018). For instance, the typical administration of standardized gross motor assessments, such as the Test of Gross Motor Development (TGMD-2/TGMD-3; Ulrich, 2000, 2019), is a visual demonstration followed by verbal instruction by the assessor. Staples and Reid (2010) demonstrated that some children on the autism spectrum may have difficulty following this assessment protocol. In one of the earliest accounts of gross motor skill delay in populations on the autism spectrum, Berkeley et al. (2001) stated that many participants were focused on "moving from point A to point B as the main objective versus 'seeing" that the form used to get from point A to point B was different" (p. 413). This subtle misinterpretation and lack of understanding during the assessment process have potentially large implications for reported scope or magnitude of gross motor skill delay in this population.

Given the ubiquity of gross motor skill and fitness assessment in program planning and interventions, it is imperative that assessment procedures are provided in an accessible manner for the individual being assessed to understand (Block & Taliaferro, 2014). Due to barriers in communication (APA, 2013) and the potential differences in the ability to imitate among children on autism spectrum (Chetcuti, Hudrey, Grant, & Vivanti, 2019; Williams, Whiten, & Singh, 2004), researchers have often resorted to providing accommodations to the assessment procedures, as needed, to ensure that study participants "understand" what is expected of them during a particular assessment. Evidence demonstrates that when researchers provide accommodations, such as visual supports, those accommodations can have a significant impact on the scores of those being assessed (Breslin & Rudisill, 2011, 2013). In a 2017 case study, Liu, Breslin, and ElGarhy compared four reliable and valid instruments: the Bruininks–Oseretsky Test of Motor Proficiency-2 (BOT-2; Bruininks & Bruininks, 2005), the Movement Assessment Battery for Children-2 (MABC-2; S. E. Henderson, Sugden, & Barnett, 2007), the Peabody Developmental Motor Scale-2 (PDMS-2; Folio & Fewell, 2000), and the TGMD-2 (Ulrich, 2000). The experienced assessor in this project added pictures, short verbal instructions, and demonstrations to the original protocols to support the child's individual needs. The study revealed that the 5-year-old boy on the autism spectrum achieved the best results on the PDMS-2 and the BOT-2 with the additional accommodations, allowing researchers to conclude that appropriate assessment instruments should be chosen in accordance to the project and evaluation goals (Liu et al., 2017). Yet, when providing motor or fitness assessments with the intention of comparing scores to other participants within the same study, unless each person receives the appropriate, necessary accommodations, the data lose their comparability. As mentioned

previously, gross motor skill development and fitness may play an important role for the overall development of children on the autism spectrum (Pusponegoro et al., 2016; Sipes et al., 2011; Sumner et al., 2016). Unfortunately, unless commonalities among assessment procedures are found and guidelines are presented, the continued inability to determine the magnitude of delay will remain.

The present argument is not that gross motor skill delays or fitness differences do not exist in populations on the autism spectrum; there is a plethora of evidence to suggest that these differences exist, though our understanding of the magnitude is still unclear (Staples, MacDonald, & Zimmer, 2012). However, given the differences in social communication, potential difficulty with person-to-person imitation (Chetcuti et al., 2019; Williams et al., 2004), and documented differences with motor coordination (Fournier et al., 2010), the difficult work remains in understanding if the present documented motor delay, as well as differences in fitness and motor skills, is truly due to: (1) limited motor ability, (2) a limited understanding of what is asked, and/or (3) a poor administration of the assessment protocols. Therefore, to have a better foundation to understand the gross motor delays seen in populations on the autism spectrum, the purpose of this study was to explore what common accommodations have been used by researchers during past standardized assessments of children on the autism spectrum.

Methods

To gain insight into the procedures being used to assess children on the autism spectrum, studies were identified that measured on the gross motor skills or fitness ability of children on the autism spectrum by using a standardized assessment. The study was completed in three parts: (1) a narrative review of the literature, (2) an open-ended survey sent to the first authors of the identified articles, and (3) a descriptive analysis of responses.

Narrative review

A narrative review of literature was completed in April 2018 to identify studies that have assessed youth on the autism spectrum using a standardized gross motor skill or fitness assessment. Following PRISMA guidelines (Moher, Liberati, Tetzlaff, & Altman, 2009), search strategies for the study were developed around several keywords determined by the authors. Three lines of identified search terms were as follows: (1) *autism, Autism Spectrum Disorder, Pervasive Developmental Disorder, PDD-NOS, Childhood Disintegrative Disorder, Rett disorder, developmental disorder*; (2) *gross motor performance, gross motor skills, gross motor ability, gross motor assessment, fitness assessment, fitness ability, fitness performance, physical activity assessment, sedentary behavior assessment*; and (3) *children, youth, adolescent, teenager*. These search terms were used to search articles in the following databases: Eric, PubMed, ProQuest, SportDiscus, PsycInfo, ScienceDirect, UlrichsWeb Directory, and JSTOR. In order to determine whether articles were relevant, this search was conducted in three stages. In stage 1, two authors searched each of the identified databases and keywords. If the title appeared relevant to the context of the study, the author saved the article; after completing the initial screening, all duplications were removed. In stage 2, all authors independently screened the abstracts of the saved articles; if the abstract did not provide sufficient information related to the inclusion criteria or appeared to be unavailable, it was excluded from the study. Prior to stage 3, the reference section of the available full-text manuscripts was searched for additional articles not captured during the initial search. In stage 3, each author independently reviewed the remaining articles in full-text form for further screening; if the articles did not meet inclusion criteria, they were excluded from the study. Disagreements among authors were discussed until consensus was achieved.

To be considered for inclusion, studies needed the following: (1) a sample population of youth between the ages of 2 and 17 years with a diagnosis of autism spectrum disorder (ASD) or similar; (2) must have been published in English in a peer-reviewed journal after 2000 until spring 2018 with the full-text available; and (3) must have been used as a standardized gross motor skill or fitness assessment to assess participants in the study.

The search identified a total of 1683 articles. After screening the titles, abstracts, and keywords and removing duplications, a total of 118 articles were identified for full-text review. The reference section of each identified article was reviewed for any further articles that may have been missed during the initial search, and no additional articles were identified. All authors reviewed the full text of the articles for the inclusion criteria; only articles with complete agreement were considered for the next step. Articles were re-reviewed in cases in which the majority but not all of the authors of this study were in full agreement. A total of 53 articles met all the inclusion criteria. See Figure 1 for the flow of the review.

Open-ended survey

After the literature review was completed, the first author's contact information (i.e. email address) was retrieved from the article; in certain cases (i.e. an author changing jobs), updated author information was retrieved from the author's faculty page. An email was used to send a consent form and an open-ended survey that asked the following information:

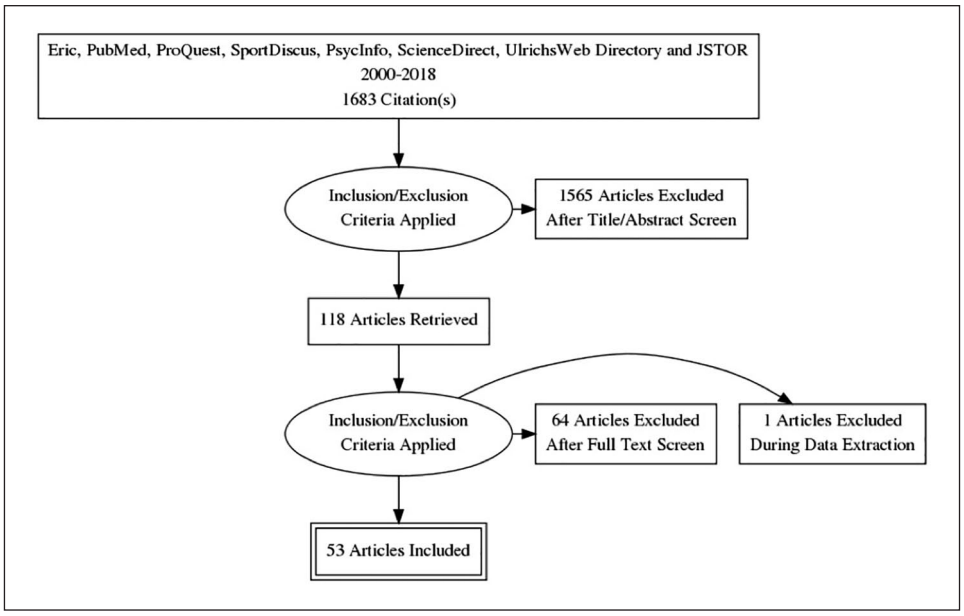

Figure 1. Flow of article selection during narrative review.

1. When was your study conducted?
2. What was your sample population?
3. What was your sample age range?
4. What was your sample gender breakdown?
5. What standardized assessment did you use?
6. Did you modify the assessment protocol?
7. Please provide the assessment protocol?
8. Was this protocol given to every participant universally?
9. If not, how did the protocol differ between participants? How did you decide who received each protocol?
10. What was the main outcome from your study?
11. In your opinion, how did the assessment protocol affect the outcome of your study?
12. If you were to replicate this study, what would you change about the assessment protocol?

Emails containing a link to the consent form and the aforementioned survey were sent on three separate occasions to the first authors of the 53 identified articles. Of the 53 articles identified, 43 unique first authors were identified. Of the 43 authors contacted, 12 consented and provided a response, and the response rate was 27%. Of the 12 respondents, 2 reported on multiple studies, as they received multiple emails and chose to respond in aggregate. The two authors who responded on multiple studies accounted for 5 of the 53 articles identified. All reported survey data were coded for the frequency of procedures, and responses were analyzed descriptively. In addition to coding responses, the method section of each of the identified articles was analyzed and descriptively coded for the assessment employed and type of accommodation described.

Results

Of the 53 identified studies, the majority were published after 2009 with only two manuscript published before 2006 (both in 2001; Figure 2). A large number of articles were published between 2012 and 2017, with only one published in 2018. As this review occurred early in 2018, that is entirely not surprising.

Motor assessments

The TGMD ($n=16$; Ulrich, 1985, 2000, 2019) and the MABC ($n=15$; S. E. Henderson & Sugden, 1992; S. E. Henderson et al., 2007) were the most frequently reported assessment measures, followed by the Bruininks–Oseretsky Test of Motor Performance ($n=8$; Bruininks, 1978; Bruininks & Bruininks, 2005) and PDMS-2 ($n=6$; Folio & Fewell, 2000; Figure 3). See Table 1 for breakdown of the reported assessments. Despite inclusion within the search terms, few articles reported fitness-based assessments. This may be due to a reliance of the field to use more objective measures, such as pedometers or accelerometers, or difficulty with the assessment itself. In an article that was excluded from analysis, Lotan, Isakov, and Merrick (2004) stated that physical fitness levels "could not be measured with formal tests because of the fact that such tests require walking to a distance of a mile or a half a mile" (p. 732).

Accommodations

Of the reported procedures in each article, 56.7% ($n=30$) of the identified articles did not report enough information to

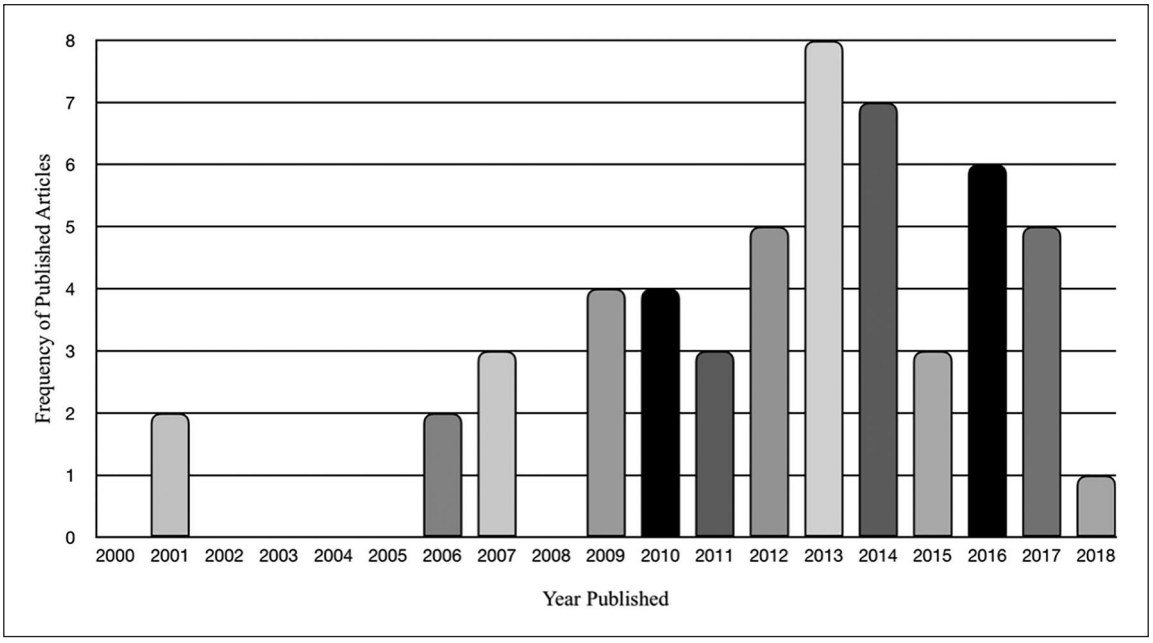

Figure 2. Frequency of the included published articles.

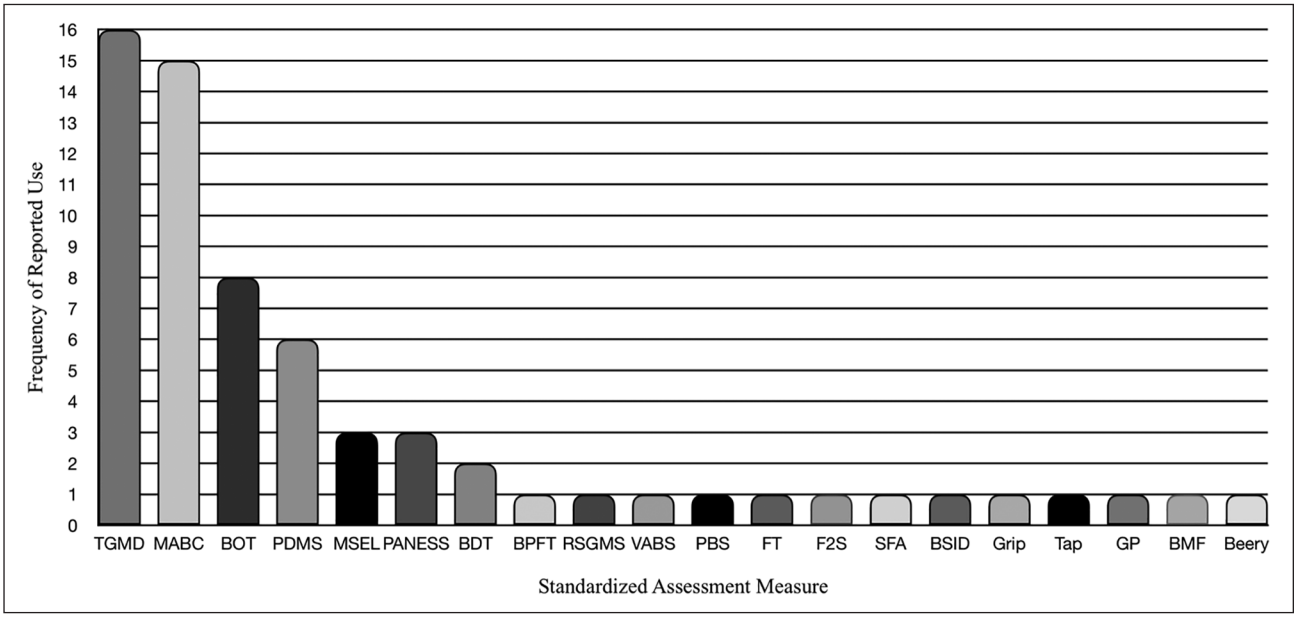

Figure 3. Reported standardized assessment of the included review articles.
TGMD: Test of Gross Motor Development; MABC: Movement Assessment Battery for Children; BOT: Bruininks–Oseretsky Test of Motor Proficiency; PDMS: Physical and Developmental Motor Scales; MSEL: Mullen Scales of Early Learning; PANESS: Physical and Neurological Examination of Subtle Signs; BDT: Battelle Development Inventory; BPFT: Brockport Physical Fitness Test; RSGMS: Rett Syndrome Gross Motor Scale; VABS: Vineland Adaptive Behavior Scales; PBS: Pediatric Balance Scale; FT: Flamingo Test; F2S: Floor to Stand; SFA: School Function Assesment; BSID: Bayley Scales of Infant Development; Grip: Grip Strength; Tap: Tapping Test; GP: Grooved Pegboard; BMF: Basic Motor Function; Beery: Beery Visual-Motor Integration.

determine the assessment procedures; the authors merely mentioned the assessment that was being used, the properties of the assessment, and/or the psychometric properties of the assessment. In 10 (18.9%) articles, the authors specifically stated that the researchers precisely followed the instructions in the procedural manual for the associated assessment. However, it should be noted that one study used a 3-week familiarization period prior to assessment and one had a caregiver present, but not assisting, during assessment; both, otherwise reported adherence to

Table 1. Articles identified for using standardized assessment by year.

No.	Articles	Assessments	Accommodations
1	Berkeley, Zittel, Pitney, and Nichols (2001)	TGMD	Manual
2	Hauck and Dewey (2001)	Battelle Developmental Inventory	N/A
3	Hilton et al. (2007)	MABC	Manual, no specific instructions, use any strategies to help participants understand task demands
4	Jasiewicz et al. (2006)	PANESS	N/A
5	Lopata, Hamm, Voelkel, Sowinski, and Thomeer (2007)	BOT	N/A
6	Provost, Heimerl, & Lopez (2007)	PDMS-2	N/A
7	Provost, Lopez, & Heimerl (2007)	PDMS-2	N/A
8	Dowell, Mahone, and Mostofsky (2009)	PANESS	N/A
9	Jasmin et al. (2009)	PDMS-2	Caregiver present, but asked not to support
10	Pan, Tsai, and Chu (2009)	TGMD-2	Additional demonstration with instructions as needed
11	Zachor, Ilanit, and Itzchak (2010)	PDMS-2	N/A
12	Debolt, Clinton, and Ball (2010)	TGMD	Manual
13	Duronjic and Valkova (2010)	MABC-2	Manual translated to Czech
14	Kopp, Beckung, and Gillberg (2010)	MABC	N/A
15	Staples and Reid (2010)	TGMD-2	N/A
16	Breslin and Rudisill (2011)	TGMD-2	Acclimatization period, picture task cards (individually), short verbal prompts, physical demonstration, picture activity schedule (all skills fixed in order, with short verbal prompts)
17	Papadopoulos et al. (2012)	MABC	N/A
18	Sipes, Matson, and Horovitz (2011)	Battelle Developmental Inventory 2	N/A
19	List Hilton, Zhang, Whilte, Klohr, and Constantino (2012)	BOT-2	Additional demonstration, incentives to foster compliance, parents and siblings present, rewards such as food or favorite songs, breaks as needed
20	Lotan, Schneider, Wine, and Downs (2012)	Rett Syndrome Gross Motor Scale	N/A
21	MacNeil and Mostofsky (2012)	PANESS	N/A
22	Schurink, Hartman, Scherder, Houwen, and Visscher (2012)	MABC	N/A
23	Whyatt and Craig (2012)	MABC-2	Standardized procedures
24	Abu-Dahab, Skidmore, Holm, Rogers, and Minshew (2013)	Grip strength, tapping test, and grooved pegboard	N/A research technicians were trained for administrating/scoring and supervised for ongoing monitoring of reliability
25	Breslin and Rudisill (2013)	TGMD-2	Manual, picture activity schedule, picture task card
26	Kaur, Gifford, Marsh, and Bhat (2013)	BOT	N/A
27	Liu (2013)	MABC-2	Additional instructions as needed
28	Liu and Breslin (2013b)	MABC-2	Manual, additional instructions and demonstrations as needed
29	Liu and Breslin (2013a)	MABC-2	Manual, pictures, additional instructions and demonstrations as needed
30	MacDonald et al. (2013a)	MSEL	N/A
31	MacDonald et al. (2013b)	TGMD-2	Break as needed
32	Bremer, Balogh, and Lloyd (2014)	PDMS-2, MABC-2	N/A
33	Hawkins, Ryan, Cory, and Donaldson (2014)	BOT-2	N/A
34	Leonard et al. (2014)	Vineland Adaptive Behavior Scale, MSEL, MABC-2	N/A
35	MacDonald, Lord, and Ulrich (2014)	MSEL	N/A

(Continued)

Table 1. (Continued)

No.	Articles	Assessments	Accommodations
36	McPhillips, Finlay, Bejerot, and Hanley (2014)	MABC-2	N/A
37	Miller, Chukoskie, Zinni, Townsend, and Trauner (2014)	Basic Motor Function, Beery Visual-Motor Integration	N/A
38	Pan (2014)	BOT-2	Standardized procedures
39	Abdel Karim and Mohammed (2015)	PDMS-2	Manual
40	Ament et al. (2015)	MABC-2	N/A
41	Casey, Quenneville-Himbeault, Normore, Davis, and Martell (2015)	Pediatric Balance Scale (modified version of Berg Balance Scale), Flamingo Test, Floor to Stand Test	Verbal instruction
42	Ayers, Taylor, Branscum, and Hofford (2016)	TGMD-2	N/A
43	Bremer and Lloyd (2016)	TGMD-2	Picture task cards
44	A. Henderson et al. (2015)	TGMD-2	N/A
45	Mache and Todd (2016)	TGMD-3	Manual
46	Mahajan, Dirlikov, Crocetti, and Mostofsky (2016)	MABC-2	N/A
47	Pan et al. (2016)	Physical Fitness Test of Brockport Physical Fitness Test (BPFT)	N/A
48	Allen, Bredero, Van Damme, Ulrich, and Simons (2017)	TGMD-3	Comparative between traditional and combination of picture cards, short verbal prompts and physical demonstrations as needed
49	Colebourn, Gould-Victor, and Pazey (2017)	TGMD-2, BOT-2, School Function Assessment	N/A (verbal cues)
50	Guest, Balough, Dogra, and Lloyd (2017)	TGMD-2	N/A
51	Ketcheson, Hauck, and Ulrich (2017)	TGMD-2	Picture task cards (supplemented as needed) with visual demonstration
52	Liu et al. (2017)	BOT-2, MABC-2, PDMS-2, and TGMD-2	Manual, additional simple and short verbal instructions, additional demonstrations and pictures as needed
53	Kaur, Srinivasan, and Bhat (2018)	BOT-2	Pictures to illustrate activity, visual demonstration, use of simple instructions, and provision of practice trial with manual feedback as needed

TGMD: Test of Gross Motor Development; MABC: Movement Assessment Battery for Children; PANESS: Physical and Neurological Examination of Subtle Signs; PDMS: Peabody Developmental Motor Scales; BOT: Buininks–Oseretsky Test of Motor Proficiency; MSEL: Mullen Scales of Early Learning.

Table 2. Reported modifications from authors' responses.

Accommodations	Environmental cues	Video modeling	Picture cards	Extra breaks	Extra demonstrations	Hand-over-hand
Frequencies	None	None	2	3	5	1

standardized protocols listed in respective assessment manuals.

In the remaining articles ($n=13$), the authors stated that an accommodation to the manual was used. Of those, nine articles (16.9%) used the accommodations *as needed* for each participant. Accommodations included the following: (1) additional verbal instructions, (2) additional demonstrations, (3) pictures or other visuals, (4) breaks or rewards, and (5) physical assistance. Four (7.5%) of the included articles used a *consistent* modified protocol across all participants, often attempting to test the impact of each set of accommodations on the performance of the participants. In these studies, accommodations included the following: (1) acclimatization, (2) picture task cards, (3) picture activity schedule, and (4) additional short verbal prompts.

Survey results

Of those authors ($n = 12$) who responded to the short, open-ended survey, five reported that extra demonstrations were used, three provided extra breaks or rewards, two used picture cards, and one used hand-over-hand assistance (Table 2). One respondent reported that the official protocol was used; however, this respondent also stated that the protocol was not provided universally. This respondent did not report how the protocols differed, only that it was not modified. There were no reports of using other visuals aids, such as spots on the ground or extra targets, or videos.

Of the 12 respondents, 50% ($n = 6$) stated that the protocol was used universally and 50% ($n = 6$) stated that it was not. This contradicts the findings of the reported methods in the each of the reviewed articles. However, a misinterpretation in the wording of the question, "Was this protocol given to every participant universally?," could have occurred, as participants in the aforementioned question reported the assessment protocol. For example, it was reported that participants would receive an extra trial or demonstration within the protocol. Some children may have needed this, some not, yet the protocol was provided universally.

Answers varied when respondents were asked to reflect on the way the assessment protocol affected the outcome of the study, though two commonalities emerged. Respondents suggest that accommodations to standardized assessments: (1) increased reliability of findings and (2) increased enjoyment. On the reliability of the findings, one respondent stated, "Adjusting the protocol helped me to feel more confident that I was actually assessing their motor skills and not just assessing their comprehension or behavior." Another, echoing that sentiment, stated, "It helped to ensure that I was actually assessing motor skills and not just behavior or understanding" and "adjustments increased the accuracy of our outcomes." Not only did the possibility for increased reliability improve because of the accommodations, one respondent said, "We thought it made the data more reliable as the children were able to enjoy the session or sessions." As assessments can be a trying and overstimulating experiences for children on the autism spectrum, accommodations allow flexibility for both the researcher and child that can reduce potential friction allowing assessments to be completed. Accommodations of the assessment created a situation of comfort and trust that one responded stated, "as critical."

Discussion

The purpose of this study was to explore the commonly used accommodations during past standardized motor skill assessments among youth on the autism spectrum. Based on the reported procedures in the reviewed articles, results found that accommodations were provided to participants on the autism spectrum in only 25% of the cases. Many of the reviewed studies did not report enough information on the assessment procedures used, so it was difficult to determine if any systematic accommodations were provided. More interestingly, there were four studies (Bremer & Lloyd, 2016; Breslin & Rudisill, 2011, 2013; Ketcheson, Hauck, & Ulrich, 2017) in which strict adherence to the testing protocols were followed. In most cases, it is important for comparability and replicability that adherence to the testing protocols are precisely followed. However, one of the core characteristics of those on the autism spectrum is differences in communication. Strict adherence to the testing protocols—either to the manual or a modified protocol—may not utilize the communicative affinities of the child and only focus on those that they do not, thus, disallowing the child to show their true motor abilities. It may also be possible that not *all* children on the autism spectrum need accommodations. The included studies demonstrate it is a common practice to provide alternative protocols during the assessment process. Yet, of the reviewed studies that included enough information to identify the testing protocol, there is a great variety across the included studies, potentially, limiting the comparability between, and even within, studies. Furthermore, lack of reporting information limits the replicability of each of the study's findings. Finally, without common guidelines for providing accommodations to children on the autism spectrum, some children may, ultimately, receive accommodations that do not need them and vice versa. With a limited understanding of the processes used, it is difficult to determine with utmost certainty the landscape of development in this area for children on the autism spectrum.

Aggregating different procedures

The literature on ASD is replete with suggestions for how to present information to accommodate differences with communication, particularly when the information is presented verbally (e.g. Bernard-Opitz & Häußler, 2011; Bondy & Frost, 2011; Cohen & Sloan, 2008). Many items on motor skill assessments are presented in a combination of verbal cues and demonstrations, while in some cases items within tests are only presented verbally. For example, there are select items in the BOT-2 and MABC where only a verbal description is presented and then the child is expected to complete the task. In this assessment, the child may appear to have a motor deficit when in fact the child simply did not understand the instructions as they were provided. Similarly, both the BOT and the MABC have items that require "speed" (e.g. sorting cards as quickly as possible or string beads as quickly as possible). The concept of "as quickly as possible" coupled with confusion as to the expectation which limit a participant's scores on these items. Again, are the results measuring receptive communication skills or measuring true motor ability?

These same sentiments were voiced by several researchers who completed the surveys in this study regarding the need for accommodations. Allowing accommodations to account for different communication modes, particular receptive verbal skills, certainly seems warranted when administering motor assessments to children on the autism spectrum (Block & Taliaferro, 2014).

Furthermore, despite the respondent's beliefs about increased reliability, major issues arise when published studies begin to be analyzed in aggregate. The idea of accommodation provides a potentially ideal situation for researchers and participants. However, this may result in unintended bias within the outcomes. Accommodations that are provided, but do not meet the needs of the individuals in that particular study, will do little to address this issue. In addition, the comparability of the assessment is lost when comparing a study that uses different protocols during the assessment process. Despite evidence that motor development occurs independently of intellectual ability (Lloyd et al., 2013), an element of cognitive function should be considered in the parlance of the assessment process. As many gross motor assessments necessitate a basic level of executive function to complete, this process must be considered in the conduct and interpretation of these measures. However, according to the respondents, simple items such as building in an acclimation period or practice test to ensure that the assessment is not of a novel skill can be beneficial. This could include having procedures in the clinical setting that are "friendly" to children on the autism spectrum, though no evidence was available to support this claim in the present review. However, it was clear through the reported responses that all respondents recognized this issue during the assessments of children on the autism spectrum and the potential it may have on the assessment itself.

Are visuals enough?

When accommodations were provided, they included additional verbal instructions, additional demonstrations, pictures or other visuals, breaks or rewards, and physical assistance. As noted earlier, extra verbal directions might provide limited benefit given the differing modes of communication associated on the autism spectrum (Breslin & Liu, 2015). Extra verbal cues for a certain child on the autism spectrum may be akin to speaking louder to child who is deaf, while well intentioned, such accommodations may not be effective. However, some of these studies may have included participants with fewer support needs or greater communication skills whom may have benefited from repeated verbal cuing. Unfortunately, many of the reviewed studies did not specify participants' communication skills, so it is difficult to judge whether additional verbal directions were appropriate.

Certainly, the addition of visual supports is keeping with the literature on what is recommended to be effective for children on the autism spectrum (Breslin & Liu, 2015; Cohen & Sloan, 2008). Visual supports such as visuals to show where to stand, visuals to show the movement, and visuals to show the schedule for session can all be useful in helping participants on the autism spectrum understand what to do, stay on task, and limit anxiety (Block, Klavina, & Davis, 2016; Fittipaldi-Wert & Mowling, 2009). Recently, visual accommodations, when provided systematically, have been shown to be reliable compared to the manual alone and can significantly improve performance (Allen, Bredero, Van Damme, Ulrich, & Simons, 2017). It was unclear, however, if the reported visual supports included video modeling. Recent research suggests that video modeling can be an effective means of helping children on the autism spectrum understand the nuances of a task (Bellini & Akullian, 2007; Hong et al., 2015; Spriggs, Gast, & Knight, 2016), and video modeling certainly could be effective when trying to explain how to perform specific motor tasks on motor assessments. However, items on the BOT and MABC in particular have been designed to be unique and may not be clear through verbal direction alone.

Are assessments capturing motor ability or receptive language?

Regarding types of motor tests used in the reviewed studies, tests of motor abilities (e.g. MABC and BOT) were used in approximately 40% of the studies, tests of fundamental motor patterns (e.g. TGMD) were used in approximately 25% of the studies, and developmental motor tests (e.g. PDMS) were used in approximately 13% of the studies. Some of the issues associated with motor ability tests and children on the autism spectrum were noted earlier, including not knowing exactly what is expected and moving cautiously/slowly on timed items. Do children on the autism spectrum understand the cue, "go as fast as you can?" Are children on the autism spectrum motivated to complete a task as quickly as possible or simply complete the task as a more leisurely pace? Several researchers (Berkeley et al., 2001; Staples & Reid, 2010) have commented the selective focus of some participants during assessing, with participants focusing on the *what* (e.g. going from point A to point B) rather than the *how* (e.g. skipping, jumping, or running). Again, the comparability of motor assessments using timed items certainly should be questioned when given to children on the autism spectrum.

Tests that examine qualitative components of fundamental motor patterns such as the TGMD also present replicability questions when used with children on the autism spectrum. For example, many items on the TGMD require a forceful movement to allow all the components of the pattern to emerge. Throwing, striking, and kicking are examples of object control skills that require forceful effort to generate weight shift and follow through. Jumping, hopping, and running are examples of locomotor skills that

require forceful effort to demonstrate arm action and flight phases. If a child does not perform any of these skills forcefully, then these components will not be demonstrated. Do children on the autism spectrum with low or no verbal communication understand, "try your hardest," 'kick it as far as you can "jump really far," or "run as fast as you can?" Even if a child on the autism spectrum understands the concept of try your hardest, lack of motivation/interest in the task may still prevent the child from displaying the most skillful pattern (Block & Taliaferro, 2014).

In addition, children on the autism spectrum might not have been asked to perform a skill forcefully or following a particular qualitative pattern due to a focus of many interventions on the hallmark characteristics of ASD (Staples et al., 2012) and a limited number of motor interventions (Colombo-Dougovito & Block, 2019). For example, children on the autism spectrum being taught using reinforcement-based programming (e.g. applied behavior analysis) are reinforced for completing a task. Yet, reinforcement is rarely associated with the quality of the movement required in fundamental motor patterns and little to no evidence exists to support such a program. Alternatively, programs using visual supports focus on completing tasks but not necessarily the quality or speed of completing tasks. As a result, it can be difficult to help children on the autism spectrum understand the concept of moving forcefully or quickly in order to display qualitatively mature movement patterns. The child on the autism spectrum who does not understand the concept of "try your best" through verbal or visual cues or is not motivated to put in the necessary effort into the movement by the assessor will not score well on tests of fundamental motor patterns and, therefore, may appear to be delayed motorically.

Fairness or standardization

As noted earlier, accommodations such as extra visuals including videos that highlight specific components (Obrusnikova & Rattigan, 2016), protracted demonstrations focusing the child's attention on specific components (e.g. arm action in locomotor patterns), and extra practice to make sure the child truly understands the task at hand is warranted. The goal of motor assessment should be to determine if a child on the autism spectrum has a true and significant motor deficit that needs remediation, and providing accommodations certainly seems warranted if this is the ultimate goal.

Although the appropriate delivery of accommodations to ensure sustained comparability and replicability across assessments is necessary, it seems unjust to provide an assessment without accommodations for the needs of the individual for the sake of standardization alone. Following the examiner protocol as provided is necessary in comparison to normative sample; yet, if without accommodations an individual score poorly, what does that assessment infer? What programmatic changes are to be made? This is a paradox for which the authors cannot provide a definitive response. Without accommodation, assessment scores are likely capturing only a limited picture of the motor capabilities of youth on the autism spectrum, especially those with differing modes of communication. Yet, with accommodation, cross-study or within-study comparisons become difficult and interpretation becomes limited as to the generalized findings. It is clear, however, that there lacks a consensus among the research community as to the solution. Many found benefit in providing accommodation, yet only a few identified the potential issues with the current usage. Future research is needed to better understand the who, how, when, and what of accommodations for motor assessment, without which even the best intentioned and designed interventions will provide hollow evidence of growth.

Limitations

Three limitations warrant caution in interpreting the findings of this study: (1) potential missed accommodations due to the limits of the included search terms and databases; (2) a misrepresentation of the frequency of accommodations due to limited description of assessment procedures in reviewed articles; and (3) limited triangulation of reported procedures and first author response. Regarding the first limitation, the authors attempted to include all potential identifiers for physical fitness and motor skill assessment during each database search; however, results included limited information of fitness assessments. These types of accommodations would be particularly important for secondary physical educators and personal trainers, when fitness assessment is more prominent than at younger ages. Future searches should further investigate the procedures demonstrated in the literature. Regarding the second limitation, it is concerning that only approximately 43% of the included articles had enough information about the assessment procedures to determine if accommodations were included or the manual was followed explicitly. Finally, the limited response from each first author did not provide a full account of each of the included studies. It is possible that many of the procedures used by authors of the included studies contained a variety of accommodations for motor skill and fitness assessments. Yet, due to limited information provided in text and lack of response from every author, it is difficult to make certain claims about the assessment processes for children on the autism spectrum. Future studies should make a greater attempt to provide clear information about assessment procedures; without adequate procedural information, replication studies and confirmatory results will be difficult to attain. This, however, may not be a critique of the authors, so much as, the journal and review process that places emphasis on the findings and interpretation over procedure with limited word counts and page limits.

Conclusion

Recent research (Fournier et al., 2010; Liu et al., 2014; Lloyd et al., 2013; Staples & Reid, 2010) has shown the differences in motor skill development of children on the autism spectrum compared to their peers; however, as this study shows, the procedures on which those conclusions are made are not entirely consistent. Due to the core characteristics of autism (APA, 2013), the assessment process may present unique difficulties for children and adolescents on the autism spectrum to navigate. According to the recent literature (Breslin & Rudisill, 2011, 2013), visuals, such as picture cards or visual schedule, may allow for a greater transfer of information during the assessment process, while also potentially improving performance (Allen et al., 2017). It is encouraging that research has increasingly provided accommodations during the assessment process for children on the autism spectrum. However, differences between study protocols and minimally worded method sections limit the comparability of the aggregate findings and chance for replications, respectively. Future research should continue the work of Breslin and Rudisill (2011, 2013) and Allen et al. (2017) by investigating the effects of visuals on the assessment process. Additional accommodations, such as verbal cues, breaks, acclimation, and, even, the environment itself, need further research to understand the variables influencing the assessment process for children on the autism spectrum. Moreover, research should emphasize how best to effectively provide information to children on the autism spectrum so that assessments measure not only their motor ability but also their understanding or communication ability.

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