Analysis of the acquisition of motor development and language in children with autism spectrum disorder: systematic review

Análise da aquisição do desenvolvimento motor e da linguagem em crianças com transtorno do espectro do autismo: revisão sistemática

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ABSTRACT
The relationship between motor development and language skills has important implications for autism spectrum disorder (ASD). The aim of the present study was to analyze the acquisition of motor development and language in children with ASD. Guiding questions: Is the acquisition of language and motor development altered in children with ASD? What instruments are used to measure these aspects? Methods: A systematic review was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). Searches were conducted in the PubMed (National Library of Medicine), Scopus and Web of Science databases using the following search terms: "Autism Spectrum Disorder" AND "Language Development" AND "Motor" OR "Motor Skills Disorders" in the period between April and June 2022. Results: A total of 1262 articles were retrieved from the electronic databases. After the discerning selection process, five articles were included in the present systematic review. Conclusion: The findings suggest that children with low motor development have a certain delay in the acquisition of language. The main instruments used for the assessment of these skills are the Mullen Scales of Early Learning, Peabody Developmental Motor Scales-2, Movement Assessment Battery for Children 2, Vineland Adaptive Behavior Scales II and British Picture Vocabulary Scale III.

Keywords: motor development, language, autism spectrum disorder.

RESUMO
Mullen de Aprendizagem Precoce, Escalas do Motor de Desenvolvimento Peabody-2, Bateria de Avaliação de Movimento para Crianças 2, Escalas de Comportamento Adaptativo Vineland II e Escala Britânica de Vocabulário de Imagem III.

**Palavras-chave:** desenvolvimento motor, linguagem, transtorno do espectro do autismo.

### 1 INTRODUCTION

Evidence of the relationship between motor development and social communication skills in typical development has important implications for autism spectrum disorder (ASD), which is a neurodevelopmental disorder characterized by social communication deficiencies and restrictive and repetitive behaviors (RRBs). While RRBs are part of the autism triad, motor abnormalities *per se* are not part of the core diagnostic criteria.

According to the literature, among infants of the same age who are crawlers and independent walkers, the latter have increased vocalizations, directed gestures and greater social interaction, although such relationships are likely bidirectional. The transition between crawling and walking was found to predict receptive, expressive vocabulary in infants with typical development. This relationship may also be partially explained by a change in the nature of the communication of infants after the onset of walking, which, in turn, alters the verbal responses of mothers.

There is a growing consensus that motor development is atypical in children with ASD. Although the disorder is characterized by language delays and difficulties in nonverbal social communication, few studies have investigated the relationship between motor and social communication skills in this population. One study demonstrated correlations between fine motor development and expressive language, social comprehension and personal social development in three-year-old children with ASD. Another study used retrospective parental reports of manual motor skills to predict current verbal fluency in children with ASD between two and 18 years of age.
A recent study analyzing motor skills and the rate language development in infants with a high family risk of developing ASD (older sibling with a diagnosis of the disorder and therefore a 20% greater risk of developing the disorder) prospectively followed up the children in the first years of life and found that the gross motor score at seven months predicted the subsequent expressive language rate, but not the receptive language rate in those that developed ASD. Bhat, Landa & Galloway (2011) also found that early motor difficulties were related to poor communication results at 18 months of age in high-risk infants.

Therefore, the aim of the present study was to conduct a systematic review to analyze the acquisition of motor and language development in children with ASD. Guiding questions: Is the acquisition of language and motor development altered in children with ASD? What instruments are used to measure these aspects?

2 METHODS

The present systematic review was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA).

2.1 SELECTION CRITERIA

Studies were included based on the following criteria: (1) study design: cohort studies and clinical trials; (2) participants: children with ASD from birth to 10 years of age with no other associated diagnosis; (3) all types of language and motor assessments; (4) articles published in English and Portuguese.

Studies were excluded based on the following criteria: abstracts, annals of conferences and dissertations. Moreover, studies published prior to 2012 were not included so as to focus on current research using contemporary methods for the diagnosis of ASD, such as the Autism Diagnosis Observation Schedule (ADOS) and Diagnostic and Statistical Manual of Mental Disorders fourth (DSM-IV) or fifth (DSM-V) edition.
2.2 INFORMATION SOURCES

Searches were conducted in the PubMed (National Library of Medicine), Scopus and Web of Science databases for articles published up to July 2022. Year of publication was restricted to articles published after 2012. The language was restricted to English and Portuguese.

2.3 SEARCH STRATEGY

The search strategy involved the following terms: “Autism Spectrum Disorder” AND “Language” OR “Language Development” AND “Motor” OR “Motor Skills Disorders”. Searches were conducted between April and July 2022.

2.4 DATA MANAGEMENT, SELECTION AND DATA COLLECTION PROCESS

Three independent reviewers (LBC, MMTS and JBS) examined the titles and abstracts of articles retrieved from the electronic databases. In cases of a divergence of opinion, a fourth reviewer was consulted to make the judgment. After preselection based on the titles and abstract, the reviewers read the full texts and excluded duplicates. The reasons for exclusion were recorded in a table.

Two reviewers extracted data extracted from all articles included using a data extraction table created in Microsoft Excel. The data were presented in narrative synthesis form, with numbers and codes for the results section. The following data were extracted: (a) metadata- authorship and year of publication, (b) characteristics of the population – age, clinical characteristics, (c) assessment methods, (d) results.

3 RESULTS

The searches of the databases led to the retrieval of 1,262 articles. After screening, 76 duplicates were removed. One thousand of the remaining 1,186 articles were excluded after the reading of the abstracts and 181 were excluded after the full-text analysis. Thus, five articles were included in the present systematic review (Figure 1).
3.1 METHODOLOGICAL QUALITY

RevMan 5.3.3 (Review Manager 5.3, The Cochrane Collaboration) was used for the Cochrane risk of bias tool\(^\text{10}\), which addresses: random sequence generation, allocation concealment, blinding, missing outcome data (e.g., dropouts) and selective outcome reporting. Possible risk of bias in each of the six domains is judged as high or low. In cases of insufficient data to make the judgment, risk was considered unclear. In cases of doubt, the investigators of the primary study were contacted to obtain more information.

3.2 CHARACTERISTICS OF STUDIES

The characteristics of the studies included in the present systematic review are summarized in Table 1. All studies involved children with ASD of different ages, with assessments of language and motor skills.

Language was assessed using the following instruments:

- Vineland Adaptive Behavior Scales II (VABS-II) to assess 117 items/behaviors. Adaptive behavior is subdivided into five domains; 1. Communication (67 items); 2. Daily Living Skills (92 items); 3. Socialization (66 items); 4. Motor Skills; 5. Maladaptive Behavior (36 items)\(^\text{11}\);
- Mullen Scales of Early Learning (MSEL) to describe and compare global motor capacity relative to fine motor skills. This instrument is divided into five scales: gross and fine motor coordination, visual reception, receptive language and expressive language\(^\text{12}\);
- British Picture Vocabulary Scale III (BPVS-III) – the main tool used to assess receptive vocabulary in non-verbal children. The facilitator speaks a word and the subject answers by selecting an image among four options that best illustrates the meaning of the word\(^\text{13}\).

The following instruments were used for the motor assessment:

- Mullen Scales of Early Learning (MSEL) – subitem for the assessment of fine motor skills\(^\text{11, 14}\);
- Peabody Developmental Motor Scales (PDMS-2), which has five subtests distributed between two components/scales: global motricity and
fine motricity. The results are expressed in three motor behavior domains: fine motor quotient (FMQ), global motor quotient (GMQ) and total motor quotient (TMQ)\(^{15}\);

- Movement Assessment Battery for Children-2 – assesses execution of motor tasks, which are grouped into the following categories: (1) manual dexterity, activities of posting coins, threading beads and bicycle trail; (2) aiming and catching, activities of catching a beanbag and throwing a beanbag at a target; (3) balance, activities of one-leg balance, walking with heels raised and jumping on mats\(^{16}\).

4 DISCUSSION

A perceptible relationship is seen between language and motor skills in the pediatric population with neurodevelopmental disorders. The instruments for assessing receptive and/or expressive language are the Vineland Adaptive Behavior Scales II (VABS-II),\(^{11}\) Mullen Scales of Early Learning (MSEL)\(^{14}\) and British Picture Vocabulary Scale III (BPVS-III).\(^{13}\) Validated instruments are used for the assessment of motor development, such as the Fine Motor Skills subscale of the MSEL\(^{11,14}\), Peabody Developmental Motor Scales (PDMS-2)\(^{12}\) and Movement Assessment Battery for Children-2\(^{13}\).

Yen-Tzu Wu (2021)\(^{15}\) assessed multidimensional motor functioning in children 24 to 36 months of age with ASD and delayed language development compared to those with typical development (TD). Language was assessed using the Receptive Language and Expressive Language subscales of the MSEL, whereas motor skills were assessed using the PDMS-2. The author found a significant correlation between language skills and motor functioning in both groups. However, the ASD group with delayed language development had lower motor functioning scores compared to the ASD group with typical language development and the TD group. This suggests that the risk of delayed receptive and expression language development may by predicted by lower motor scores in children with ASD.\(^{15}\) According to a systematic review and meta-analysis conducted by Fournier, K.A., Hass, C.J., Naik, S.K., Lodha, N., & Cauraugh, J.H.
(2010), individuals with ASD demonstrate significant, generalized alterations in motor performance, with atypical gross and fine motor skills.\(^\text{17}\)

Eve Sauer Le Barton examined the motor skills that emerge in the first year of life in six-month-old children with high and low family risk of ASD using the PDMS-2 (grasping, visual-motor integration and stationary subscales). In Study 1, motor skills at six months predicted the state of ASD at 24–36 meses; ASD was associated with infant motor skill deficits\(^\text{18}\). In Study 2, motor skills at six months predicted expressive language at 30 and 36 months. The score on the stationary subscale of the PDMS-2 predicted expressive language (MSEL) at 30 months and the score on the grasping subscale of the PDMS-2 predicted expressive language (MSEL) at 30 and 36 months, clearly suggesting a link between motor and language development.\(^\text{19}\)

The scientific evidence demonstrates a correlation between motor skills and language development,\(^\text{11-14, 21}\) which underscores the importance of an interdisciplinary assessment associating one of the main characteristics of autism, which is communication/language deficit, with motor development.

5 CONCLUSION

The findings of the present systematic review suggest abnormal language acquisition and motor development in children with ASD. Those with low motor development have delays in receptive and expressive language. The main instruments used for the assessment of motor and language skills are the Mullen Scales of Early Learning, Peabody Developmental Motor Scales-2, Movement Assessment Battery for Children 2, Vineland Adaptive Behavior Scales II and British Picture Vocabulary Scale III.

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Hannant, P. Receptive language is associated with visual perception in typically developing children and sensorimotor skills in autism spectrum conditions. Human movement science, 2018, 58, 297-306.


ANNEXES

Figure 1 - Overview of article selection process.

Identification

Records identified through search of databases (n = 1262)
  PubMed - 997 artigos
  Scopus - 132 artigos
  Web of Science - 133 artigos

Screening

Records after removal of duplicates (n = 1186)

Records excluded (n = 1,000)
  Prior to 2012 = 250
  Irrelevant to topic = 600
  ASD associated with other diseases = 150

Eligibility

Records screened (n = 186)

Full texts of articles assessed for eligibility (n = 186)

Articles excluded, with reasons: (n = 181)
  Did not assess language = 11
  Did not assess motor development = 80
  Associated with other issues, such as cognitive = 90

Inclusion

Articles included in quantitative synthesis (n = 5)

Source: authors.
Table 1- Description of studies included in review

<table>
<thead>
<tr>
<th>Author</th>
<th>Condition</th>
<th>Sample size</th>
<th>Age of participants</th>
<th>Motor assessment</th>
<th>Language assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rachel Bedford,</td>
<td>ASD and Neurotypical</td>
<td>209,</td>
<td>2, 3, 5 and 9 years</td>
<td>MSEL</td>
<td>VABS II</td>
</tr>
<tr>
<td>2016</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hayley C.</td>
<td>ASD</td>
<td>54,</td>
<td>7-36 months</td>
<td>MSEL</td>
<td>VABS II</td>
</tr>
<tr>
<td>Leonard, 2015</td>
<td></td>
<td>76,</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yen-Tzu Wu, 2021</td>
<td>ASD and Neurotypical</td>
<td>76,</td>
<td>24 and 38 months</td>
<td>PDMS-2</td>
<td>MSEL- RL subscale – reflects language comprehension</td>
</tr>
<tr>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eve Sauer LeBarton, 2019</td>
<td>ASD</td>
<td>140,</td>
<td>24 to 36 months</td>
<td>PDMS-2</td>
<td>MSEL- ELC</td>
</tr>
<tr>
<td>Penelope Hannant,</td>
<td>ASD and Neurotypical</td>
<td>18,</td>
<td>7-16 years</td>
<td>Movement Assessment Battery for Children – 2 BPVS-III</td>
<td></td>
</tr>
<tr>
<td>2018</td>
<td></td>
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</tbody>
</table>

Legend: ASD- autism spectrum disorder; MSEL- Mullen Scales of Early Learning; PDMS-2- Peabody Developmental Motor Scales; BPVS-III- British Picture Vocabulary Scale III; ELC- Early Learning Composite; RL- receptive language; VABS-II- Vineland Adaptive Behavior Scales II.

Source: authors.