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Motor Performance in children and adolescents with Autism Spectrum Disorders

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Abstract

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Keywords: Physical Therapy, Autistic Spectrum Disorder, Psychomotor Performance, Motor Skills, Child Development.

1. Introduction

Autistic Spectrum Disorder (ASD) is classified in the neurodevelopmental disorders category in The Diagnostic and Statistical Manual of Mental Disorders, 5th edition - DSM-5, published in 2013. This definition considers ASD as a neurodevelopmental disorder that must be present since childhood, presenting social and communication impairments, and fixed repetitive interests and behaviors (Diagnostic and statistical manual of mental disorders [DSM-5], 2013). The criteria for diagnosis recognize

a complexity of symptoms employing a comprehensive and dimensional approach to diagnosis (Burns & Matson, 2017). It is considered a multifactorial disorder with a strong social impact and can be considered a public health problem due to its high prevalence (Paquet, Olliac, Bouvard, Golse, & Vaivre-Douret, 2016)

The diagnosis of ASD is basically established by clinical criteria and there are some recognized scales in the literature that assist in this process (Assumpção, et al., 2008). Some screening tools, such as the second edition of the Autism Diagnostic Observation System (ADOS-2) and the Autism Diagnostic Interview-Revised (ADI-R) are used and referred to in the national and international literature 5 as tools for assessing autism Myers, Gross, e McReynolds (2013) as tools for assessment for the diagnosis of autism (Teixeira et al. , 2010).

A systematic review of the worldwide prevalence of ASD and other pervasive developmental disorders indicated that the median overall prevalence was 6.2/1,000 cases (Elsabbagh et al.,2012). Data from the Centers for Disease Control and Prevention (CDC) indicated a prevalence of ASD of around 1/68 8-year-old children in the United States (USA), with boys being more affected. The number of cases is increasing, possibly due to the advances in the knowledge of the characteristics of the ASD and in the strategies/tools for diagnosis. Between 2002-2006 there was a 57% increase, and between 2006-2008 a 23% increase in the number of cases identified (Centers for Disease Control and Prevention [CDC], 2018).

Although motor performance is not at the core of the diagnostic criteria and the treatment goals of individuals with ASD, research suggests that motor impairments may be present in the first years of life and could be used as bio-markers for early diagnosis for ASD (Paquete et al.,2016; Bhat, Landa, & Galloway, 2011; Nicole & Jennifer, 2010).

An American meta-analysis study showed that motor impairment could be considered as one of the main characteristics for the diagnostic hypothesis of ASD (Fournier, Hass, Naik, Lodha, & Cauraugh, 2010) considering the Developmental Disorder of Coordination (BDD) as a symptom of ASD (Dziuk et al., 2007; Dowell, Mahone, & Mostofsky, 2009). These commitments would have an impact on schooling, socialization and communication, influencing the overall development of these individuals (Van Waelvelde, Oostra, Dewitte, & Van, 2010). Despite this, studies indicate that there is no recognition of the role of the physiotherapist in health programs directed to this population (Paquete et al., 2016; Mieres, Kirby, Armstrong, Murphy, & Grossman, 2012; Sugden, Henderson, 2007).

Although the literature points to the motor effects associated with ASDs, their extent and relationship to autistic traits or behaviors are still not well understood in children and adolescents with established diagnoses. In addition, no previous study in Brazil has looked at ASD motor performance or investigated autistic traits or characteristics and its relationship with motor performance of children/adolescents.

Thus, the objective of this study is twofold: 1) to evaluate the motor performance of school-aged children and adolescents diagnosed with ASD and to compare them with their typical developing pair; 2) investigate the relationship between autistic traits and motor performance outcomes in children and adolescents with ASD. We hypothesized that the ASD group will present lower motor performance scores when compared to control group; and that the greater the impairment in relation to the characteristics of ASD (autistic traits), the greater the motor deficits.

2. Method

This observational, case-control study was approved by the university research ethics committee.

The two groups of the study comprised: ASD group (ASDG) and control group (CG). The ASDG included school-age children and adolescents (aged 6-16 years) with a medical diagnosis of ASD regardless of your level of intellectual, based on the ICD-10 (Statistical classification of diseases and related health problems [ICD-10], 2016), enrolled in a specialized school for ASD and that could understand and respond to verbal commands. The CG included typical developing children and adolescents, matched by sex and age. Informed consent was obtained from a legal guardian for all participants. We excluded individuals who could not respond to verbal commands, or who presented some pathology that affected their motor performance.

Motor skills were evaluated using the Movement Assessment Battery Scale for Children, Second Edition (M-ABC2), divided into 3 sections by age group: section 1, 3-6 years; section 2, 7-10 years; and section 3, 11-16 years. Each section contains 8 tasks divided into manual dexterity, ball skills, and static and dynamic balance. Overall motor performance is expressed as a standard score (mean = 10, SD = 3), classifying individuals in a traffic light system: red zone (motor performance \leq 5 percentile) indicates significant movement difficulty, amber zone ($> 5\%$ and $\leq 15\%$) suggests a risk of having difficulty in movement and requires monitoring, and green zone ($> 15\%$) no detected difficulty of movement (Henderson, Sugden, & Barnett, 2007).

Autistic behaviors were evaluated using the Autistic Traits Assessment (ATA) scale in its version validated for Brazil (Assumpção, 2008). In 2008, a study indicated good sensitivity (0.82) and specificity (0.75) for the ATA, considering the scale to be of great value to describe the profile of the child, and for the study of autism in Brazil (Teixeira et al., 2010). It comprises 23 subscales evaluating typical behavior relating to ASD characteristics, such as difficulties in social interaction, resistance to change, lack of eye contact, language problems and communication, hyperactivity or hypoactivity, stereotyped and repetitive movements, and others (Assumpção, Kuczynski, Rego, & Rocca, 1999).

The ATA subscale regarding the appearance of ASD before 36 months was not used in this study because of the age range of the participants. For each subscale the maximum score is 2 points, the maximum possible score in this study was 44 points. A higher score is related to the identification of a greater number of autistic traits.

The ASDG motor assessments were performed individually at the clinic-school in a room appropriate to the requirements of the M-ABC2 scale, and the procedures were filmed for later scoring/performance checking. All motor evaluations were performed by a single evaluator, a trained physiotherapist and the principal investigator in this study, and has had routine contact with the participants of the ASDG. In order to guarantee the principal investigator's blindness regarding the evaluation of the autistic traits, the ATA scale was applied by the institution's psychologist, a professional with routine contact with the ASDG participants and with knowledge of the instrument. The CG was evaluated for motor performance following the same procedures used with the ASDG.

2.1 Statistical Analysis

The evaluations were transcribed for the program Statistical Package for Social Sciences for Personal Computer (SPSS / PC version 16.0). Descriptive statistics were used for analysis between groups with measures of central tendency (median), dispersion (minimum and maximum) and frequency of categorical responses. For comparison of groups in manual dexterity, ball skills, balance and overall motor performance in MABC-2, the Mann-Whitney test was used. The Spearman correlation test was used to analyze the relationship between motor performance and autistic traits in GASD / GC. The level of significance was set at $p < 0.05$.

3. Results

The study comprised 28 individuals, 14 with a diagnosis of ASD (ICD F84.0 and F84.1), mean age of 11.86 (± 2.79) years, and 14 with a mean age of 12.7 (± 2.64) years, matched by sex and age comprised the control group (Tables 1 and 2). The groups did not differ in chronological age ($p = 0.837$).

Table 1 shows the description of ASDG in relation to age, sex, motor performance assessed by the MABC-2 scale and total score in the ATA scale. It is important to note that 12/14 participants in the ASDG performed at or below the 5th percentile, which is indicative of significant movement difficulties. In contrast, all the CG participants presented motor performance above the 15th percentile indicating that no movement difficulty was detected in this group (Table 2).

Table 1: Description of the group ASD in relation to age, gender, motor performance evaluated by MABC-2 scale and total score in the ATA scale.

Participants	Age in years	Gender	M-ABC Manual Dexterity ^a	M-ABC ball skills ^a	M-ABC Balance ^a	M-ABC Global Performance ^a	M-ABC Traffic Llights ^b	ATA ^c
1	6	M	11	9	9	9	Green	15
2	9	M	2	9	10	5	Red	31
3	10	M	2	3	1	1	Red	11
4	10	M	5	9	9	7	Green	12
5	11	M	1	5	1	1	Red	9
6	11	M	4	9	1	3	Red	32
7	11	M	5	2	2	2	Red	33
8	12	M	4	2	1	1	Red	21
9	12	F	2	2	12	1	Red	31
10	13	F	2	1	1	1	Red	24
11	14	M	1	1	1	1	Red	33
12	15	M	1	9	6	4	Red	15

13	16	M	3	1	1	1	Red	21
14	16	M	1	1	1	1	Red	27
Average	11,86	-	3,14	4,50	4,00	2,71	-	22,50
SD	2,80	-	2,68	3,63	4,21	2,61	-	8,86
Median	11,50	-	2,00	2,50	1,00	1,00	-	22,50
Minimum	6,00	-	1,00	1,00	1,00	1,00	-	9,00
Maximum	16,00	-	11,00	9,00	12,00	9,00	-	33,00
Participants ≤5% M- ABC2	-	-	-	-	-	-	12/14 or 86%	-
Participants >15% M-ABC2	-	-	-	-	-	-	2/14 or 14%	-

^aExpected average 10 ± 3 10 ± 3 ; ^bRed = Motor performance $\leq 5\%$, Green = Motor performance $> 15\%$ motor $> 15\%$., c Maximum score = 44, highest score related to more autistic characteristics.

Table 2: Control Group description in relation to age, gender and motor performance evaluated by MABC-2 scale.

Participants	Age in years	Gender	M-ABC Manual Dexterity ^a	M-ABC ball skills ^a	M-ABC Balance ^a	M-ABC Global Performance ^a	M-ABC Traffic Lights ^b
1	7	M	12	9	15	11	Green
2	9	M	11	14	11	13	Green
3	10	M	9	8	14	10	Green
4	10	M	9	12	19	19	Green
5	11	M	15	11	14	14	Green
6	11	M	12	14	14	14	Green
7	12	M	7	10	9	8	Green
8	12	M	6	15	14	11	Green
9	13	F	15	11	14	14	Green
10	13	F	13	10	10	12	Green
11	14	M	12	16	14	15	Green
12	15	M	10	10	11	11	Green
13	16	M	11	13	14	13	Green
14	16	M	6	14	6	7	Green
Average	12,07	-	10,57	11,93	12,79	12,29	-
SD	2,64	-	2,93	2,43	3,14	3,02	-
Median	12,00	-	11,00	11,50	14,00	12,50	-
Minimum	7,00	-	6,00	8,00	6,00	7,00	-

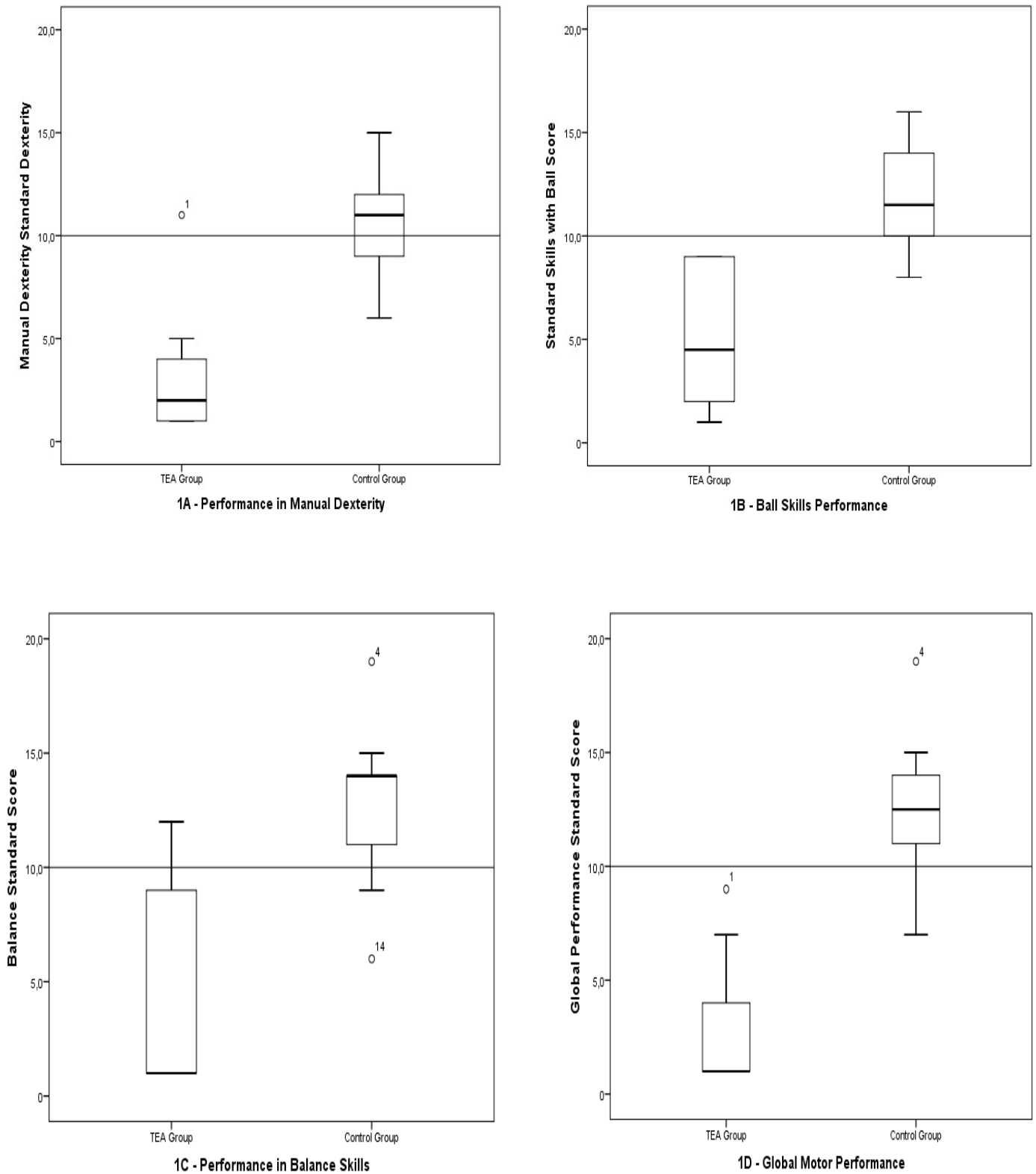
Maximum	16,00	-	15,00	16,00	19,00	19,00	-
Participants >15%							14/14 or 100%
M-ABC2	-	-	-	-	-	-	

^aExpected average 10 ± 3 10 ± 3 ; ^bGreen = Motor performance > 15%.

In relation to the autistic behaviors assessed by the ATA scale, the ASDG obtained a median of 22.5 (minimum 9 and maximum 33) from a possible total of 44 points. These data indicate the heterogeneity of the autistic group in relation to the identified traits, that is, individuals with a small number of characteristics or traits, as opposed to individuals presenting more autistic traits.

Figure 1 (A, B, C and D) shows the motor performance in each follow-up evaluated by the M-ABC2 scale for the ASDG and CG. Considering the average performance established by the M-ABC2 scale (standard score 10 ± 3), the ASDG performance was lower than the CG. Considering only the ASDG, the worst performance was observed in skills that require balance (median = 1.0), followed by manual dexterity (median = 2.0), while the best performance in ball skills (median= 2.5). The CG presented above-average performance in all areas evaluated (Figure 1A, B, C, D). The Mann-Whitney test indicated that, in relation to their peers, the ASDG presented significantly lower than expected motor performance in manual dexterity ($p < 0.001$), ball skills ($p < 0.001$), balance ($p < 0.001$), and overall motor performance ($p < 0.001$). Confirming hypothesis 1 of the study, a significant difference between the groups in relation to motor performance in all areas was observed.

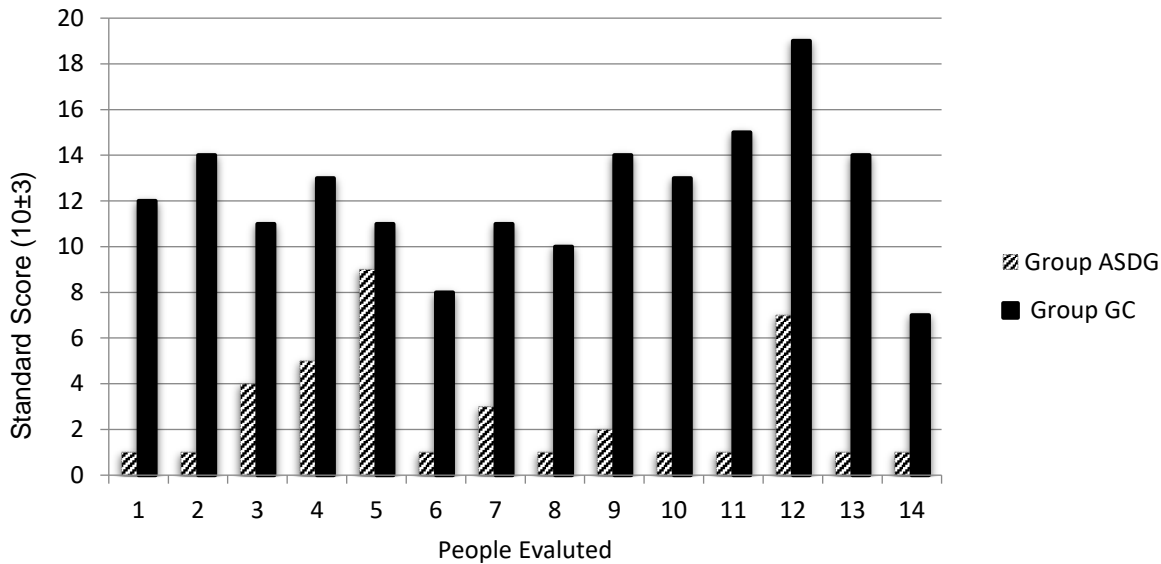
Figure 1 (A,B,C,D) Global motor performance and each segment measured by M-ABC2 scale for TEA and control groups.



¹ Participant described in table 1 of the ASD group / ⁴⁻¹⁴ Participant described in table 2 of the GC.

Figure 2 shows the comparison of the overall motor performance of each study participant, demonstrating that the performance of all the children and adolescents of the ASDG was clearly lower than the performance of the matched CG with typical development.

Figure 02: Global motor performance comparison of the TEA group and control group



There was no evidence of a correlation between autistic traits and motor skills for manual dexterity ($r = 0.27, p = 0.927$), balance ($r = 0.059, p = 0.842$) and overall performance ($r = 0.059; p = 0.842$). For ball skills ($r = - 0.311, p = 0.278$) a moderate negative correlation was observed, indicating that as the autistic traits increases, performance in ball skills decrease.

4. Discussion

This study aimed to evaluate the motor performance of children and adolescents diagnosed with ASD, to compare them with their peers with typical development, and to investigate the correlation between autistic traits and motor performance. Confirming one of the hypotheses, the group with ASD had significant motor underperformance in all the domains assessed by M-ABC2.

In general, the results of the study support previous research that reported on motor impairments in individuals with ASD (CDC, 2008; Van Waelvelde, 2010; Mieres, 2012; Whyatt & Craig, 2012; Green et al., 2002; Green et al., 2009).

A study including individuals with ASD assessed using the M-ABC2, showed that 79.2% of the children had motor deficits requiring intervention, with the majority of this group having an intelligence quotient (IQ) <70, which means that the participants might not understand the verbal commands necessary for the evaluation, not completing all the items evaluated (Green et al., 2009), but individuals with ASD without cognitive impairment also presented poor performance (Paquet et al., 2016; Green et al., 2009; Mandelbaum et al., 2006; Staples & Reid, 2010).

Because of the complexity of the symptoms presented in ASD and the clinical challenge of diagnosis (Assumpção et al., 2008; Myers et al., 2013), establishing markers that could assist in this process could facilitate the early identification of ASD and motor impairments could be considered as a risk marker for ASD. However, the identification of the appearance of this commitment is still not well defined (Bhat et al., 2011; Fournier et al., 2010; Van Waelvelde et al., 2010; Mieres et al., 2012; Cuccolichio et al., 2010). A recent literature review aimed at describing motor impairment in ASD suggests that motor performance changes occur in the early years of life and could assist in the early diagnosis of ASD by facilitating referral to early intervention services (Harris, 2017).

The literature states that individuals who have any type of disability have difficulties in tasks involving motor performance (Dziuk, 2007), in the case of ASD the neuromotor compromises deserve attention of the specialists who work with this population (Jeste, 2011). However, the understanding of neuromotor impairments is not well described as well as neurological development, limiting its generalization (Paquet et al., 2016).

In a study that evaluated children with ASD between 7 and 10 years of age, comparing two groups using the MABC-2 scale, individuals with ASD presented deficits in motor performance, evidenced by deficits in balance skills and ball skills. This finding leads to the possibility that motor deficiencies cannot be generalized as suggested by previous research (Whyatt et al., 2012).

The results presented in this study indicate that motor deficits are present in most of the evaluated group, corroborating the data presented in previous studies (Paquet et al., 2016; Bhat et al., 2011; Fournier et al., 2010; Dziuk et al., 2007; Dowell et al., 2009; Van Waelvelde et al., 2010; Mieres et al., 2012; Whyatt et al., 2012; Green et al., 2012; Green et al., 2009), suggesting that motor abnormalities are present in individuals with ASD and can influence global development.

Using the M-ABC scale to assess individuals with ASD, it was observed that 85% of the sample obtained a value of 2 for the standard deviation (SD) of the mean of the scale (Beth, Brian, & Sandra, 2007). This data agrees with the present research, in which it was found that 86% of the individuals with ASD evaluated obtained an overall score below 2 (SD) which is indicative of significant movement difficulty.

Children referred for investigation of ASD showed an average delay of 6 months for gross motor skills, and 8 months for fine motor skills. Were evaluated 56 children were divided into three groups: a) ASD group, b) children with developmental delay, and c) children at risk of developmental delay, and the groups were assessed using two motor assessment instruments. The first was performed using the Bayley Scales of Infant Development - II, and the mean score for children with ASD was 57.1, with 16% (3) presenting mild delay and 84% (16) significant delay. Using the age scores to calculate the percentage of delay, 12 children with ASD (63%) qualified for the early intervention service, and two children in the ASD group had more than a 50% delay in motor skills (Beth et al., 2007). The second instrument used was the Peabody Developmental Motor Scale, 68% of the ASD group (13) would qualify for early intervention services. A corresponding age-matched control group with typical development could provide evidence about the origin and characteristics of motor deficits and demonstrate if the motor abnormalities could be considered a principal symptom and diagnostic measure of autism (Whyatt & Craig, 2012).

The present study included a control group matched by gender and age for the comparison of motor

performance. This homogeneity of the groups allowed us to compare the motor performance, highlighting even more the impairments of the ASD group.

Motor impairment in ASD is evidenced in the literature but the understanding or nature of these impairments has not yet been explored (Paquet et al., 2016; Rebecca & Mary, 2012). Evidence on intervention with this population remains limited, and research is needed that can more fully describe the limitations of these individuals' motor skills in their daily routines (Rebecca & Mary, 2012). It was evidenced a moderate linear inverse correlation between autistic traits and motor impairments in one of the abilities assessed by the M-ABC2 skills ball skills ($r = -0.311$; $p = 0.278$). Although the p-values are not significant, the size of the effect following Cohen's criteria could demonstrate the relationship between these two variables. Corroborating with one of the hypotheses of the study, ball skills appear to be influenced by the autism trait.

During the development of this work, no study was identified that related the traits or characteristics of autism and motor performance, as proposed in this study. However, motor changes or impairment seem to be present even in individuals with high functioning ASD (Whyatt & Craig, 2012; Green, 2009; Downey & Rapport, 2012; Rinehart & Jennifer, 2010; Provost, Lopez, & Heimerl, 2007; Lane, Harpster, & Heathcock, 2012). Unusual sensory characteristics are present in individuals with ASD, as well as motor difficulties apparently due to voluntary or involuntary disorders ranging widely between individuals (Burns & Matson, 2017).

The results presented here may contribute to the discussion of the role of physical therapy for the development of individuals with ASD, influencing the overall performance of these individuals, assisting their families and care teams.

The limitations of the study are that there is no stratification of the group cases according to the seriousness of the ASD, and the lack of information on the criteria and instruments that led to the diagnosis of autism with the ICD-10 classification (ICD-10, 2016). However, in addition to be a limitation of this study, this is a limitation in the clinic-schools that care for this community, as recognized by the studies' headquarter institution in Brazil. The sample size could be a limitation in relation to the correlations results.

As a pioneering study in Brazil, this research has the potential to contribute to new studies relating to motor performance and ASD, and to how physiotherapy could intervene in these impairments. Research related to motor development interventions with these individuals is necessary in the pursuit of better methodologies that can contribute to the global development in ASD.

It was observed a correlation between the autistic characteristics and the motor performance (ball skills), that is, it is observed that the motor performance in one of the evaluated abilities can be influenced by the characteristic of the ASD, but the instrument used in the present research limits the understanding commitment. In general, the GASD group presented below-expected performance on the M-ABC2 scale and when compared to its typically developing peers this finding is of great clinical relevance.

5. Conclusion

The results indicated that children and adolescents with ASD present deficits in global motor performance including in all the aspects assessed (manual dexterity, ball skills, balance).

A comparison of motor performance of the ASD group with their peers in the control group made the discrepancy in their motor skills even more evident. However, no correlation was observed between motor performance and autistic traits, indicating independence between these characteristics for the studied group, except for a moderate correlation related to ball skills.

The study highlights the need for greater knowledge about motor repercussions in individuals with ASD, giving more attention to motor performance in this group, as well as encouraging discussion about the contribution that physiotherapy professionals integrated into the treatment teams can make.

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6. References

- [1] American Psychiatric Association – APA. Diagnostic and statistical manual of mental disorders (DSM-5). (5th ed.) Arlington, VA: American Psychiatric Publishing, 2013.
- [2] Burns C.O., Matson J.L. An evaluation of the clinical application of the DSM-5 for the diagnosis of Autism Spectrum Disorder. *Expert Review of Neurotherapeutics*, Sep;17(9):909-917, 2017.
- [3] Paquet A., Olliac B., Bouvard M.P., Golse B., Vaivre-Douret L. The Semiology of Motor Disorders in Autism Spectrum Disorders Highlighted from a Standardized Neuro-Psychomotor Assessment. *Frontiers in Psychology*, Volume7, Article:1292, 2016.
- [4] Assumpção Jr. B.F., Matteo D.J., Cucolicchio S., Amorim C.A.L., Rego F., Gomes C., Simone F.M. Escala de Avaliação de Traços Autísticos (ATA): segundo estudo. *Revista de medicina Física e Reabilitação.*; 27(2):41, 2008.
- [5] Myers C.L., Gross A.D., McReynolds B.M. Broadband Behavior Rating Scales as Screeners for Autism?. *Jornal Autism Developmental Disorder*. v44 n6 p1403-1413, 2013.
- [6] Teixeira M.C.T.V., Mecca T.P., Renata L.V., Riviane B.B., Sabrina H.B.R.V., Marcos T.M., Cristiane S.P. Brazilian scientific production about Autism Spectrum Disorders. *Revista da Associação Médica Brasileira*, 56:607-14, 2010.
- [7] Elsabbagh M., Divan G., Koh Y.J., Kim Y.S., Kauchali S., Marcín C., Montiel-Nava C., Patel V., Paula C.S., Wang C., Yasamy M.T., Frombonne E. Global prevalence of autism and other pervasive developmental disorders. *Autism Research.*; Jun;5(3):160-79, 2012.

- [8] Centers for Disease Control and Prevention – CDC (2008). Prevalence of Autism Spectrum Disorders - Autism and Developmental Disabilities Monitoring Network, 14 Sites, United States. *MMWR Surveill Summ*; Mar 30;61(3):1-19, 2012.
- [9] Bhat A.N., Landa R.J., Galloway J.C. Current Perspective on motor functioning in infants, children, and adults with autism spectrum disorders. *Physical Therapy*.; 91(7):1116-29, 2011.
- [10] Rinehart N., Jennifer Mc.G. Is motor dysfunction core to autism spectrum disorder? *Developmental Medicine Child Neurology*. 52: 697. This article is a commentary on van Waelvelde et al., pp e174-e178 of this issue, 2010.
- [11] Fournier K.A., Hass C.J., Naik S.K., Lodha N. Cauraugh J.H. Motor Coordination in Autism Spectrum Disorders: A Synthesis and Meta-Analysis. *Journal Autism Developmental Disorder*, 40:1227–1240, 2010.
- [12] Dziuk M.A., Gidley L.J.C, Apostu A., Mahone E.M., Denckla M.B., Mostofsky S.H. Dyspraxia in autism: association with motor, social, and communicative deficits. *Developmental Medicine & Child Neurology*. 49: 734–739, 2007.
- [13] Dowell L.R., Mahone E.M., Mostofsky S.H. Associations of Postural Knowledge and Basic Motor Skill With Dyspraxia in Autism: Implication for Abnormalities in Distributed Connectivity and Motor Learning. *Neuropsychology*.; 23(5): 563–570, 2009.
- [14] Van Waelvelde H., Oostra A., Dewitte G., Van den B.C. Stability of motor problems in young children with or at risk of autism spectrum disorders, and development coordination disorder. *Developmental Medicine & Child Neurology*, 52:e174–e178, 2010.
- [15] Mieres A.C., Kirby R.S., Armstrong K.H., Murphy T.K., Grossman L. Autism Spectrum Disorder: An emerging opportunity for physical therapy. *Pediatric Physical Therapy*, Spring;24(1):31-7, 2012.
- [16] ICD-10. (2010). International statistical classification of diseases and related health problems. – (10th revision ed., edition). Available at: <http://apps.who.int/classifications/icd10/browse/2010/en#/F84.1>. Accessed May 20, 2016.
- [17] Henderson S.E., Sugden D.A., Barnett A.L. Movement Assessment Battery for Children-2 Examiner’s Manual. Pearson Education, 2007.
- [18] Assumpção Junior F.B., Kuczynski E., Rego M.G.S., Rocca C.C.A. Validade e Confiabilidade de uma escala para a detecção de condutas autísticas. *Arquivos de Neuropsiquiatria*. 57(1):23-29, 1999.

- [19] Whyatt C.P., Craig C.M. Motor Skills in Children Aged 7–10 Years, Diagnosed with Autism Spectrum Disorder. *Journal of Autism Developmental Disorders*,42(9) 1799-809, 2012.
- [20] Green D., Baird G., Barnett A.L., Hendersen L., Huber J., Hendersen S.E. The severity and nature of motor impairment in Asperger’s syndrome: a comparison with specific developmental disorder of motor function. *Journal Childen Psychology Psychiatry.*; 43(5):655-68, 2002.
- [21] Green D., Charman T., Pickles A, Chandler S., Loucas T., Simonoff E., Baird G. Impairment in movement skills of children with autistic spectrum disorders. *Developmental Medicine & Child Neurology*, 51(4):311-6, 2009.
- [22] Mandelbaum D.E., Stevens M., Rosenberg E., Max W., Mitchelli S., Pauline F., Isabelle R. Sensorimotor performance in school-age children with autism, developmental language disorder, or low IQ. *Developmental Medicine & Child Neurology*; 48: 33–39 33, 2006.
- [23] Staples K.L., Reid G. Fundamental movement skills and autism spectrum disorders. *Journal of Autism and Developmental Disorder*, 40,209–217, 2010.
- [24] Cuccolichio S., Di Matteo J., Paicheco R., Gomes C., Falcão M.S., Assumpção Junior F.B. Correlação entre as escalas CARS e ATA no diagnóstico de autismo. *Medicina Reabilitação*. 29(1); 6-8, 2010.
- [25] Harris S.R. Early motor delays as diagnostic clues in autism spectrum Disorder. *European Journal of Pediatrics*, Sep,176(9):1259-126, 2017.
- [26] Jeste S.S. The Neurology of Autism Spectrum Disorders. *Current Opinion Neurology*. April; 24(2): 132–139, 2011.
- [27] Provost B., Lopez B.R., Heimerl S. Comparison of motor delays in young children: autism spectrum disorder, developmental delay, and developmental concerns. *Journal of Autism and Developmental Disorder*; 37:321-328, 2007.
- [28] Sugden D.A, Henderson S.E. *Ecological Intervention for children with Movement Difficulties*, Pearson education Ltda., 2007.
- [29] Downey R., Rapport M.J. Motor Activity in Children with autism: a review of current literature. *Pediatric Physical Therapy*, 24:2-20, 2012.

[30] Lane A., Harpster K., Heathcock J. Motor Characteristics of Young Children referred for possible autism spectrum disorder. *Pediatric Physical Therapy*, 34:21, 2012.

[1] A.B. Smith, C.D. Jones, and E.F. Roberts, "Article Title," *Journal*, Publisher, Location, Date, pp. 1-10.

[2] Jones, C.D., A.B. Smith, and E.F. Roberts, *Book Title*, Publisher, Location, Date pp. 20-30.

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