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MOTOR PERFORMANCE, INTELLIGENCE, AND EXECUTIVE FUNCTIONS IN CHILDREN WITH ASD

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ABSTRACT

Autism spectrum disorder (ASD) is a neurodevelopmental disorder characterized by persistent impairments in communication and social interaction and restricted and repetitive patterns of behavior, interests or activities. Evidence points to a significant increase in the number of cases worldwide. Motor impairments in people with ASD are evidenced in numerous studies, but the real cause of this impairment is still a source of discussion in the literature. The aim of this study was to evaluate and correlate motor, intellectual and executive function performance in children diagnosed with ASD. Eighteen children and adolescents with a medical diagnosis of ASD, aged between 9 and 13 years, were evaluated. For the evaluations, the Movement Assessment Battery for Children (MABC-2) scales were used for motor evaluation, Wechsler Abbreviated Intelligence Scale - WASI, cognitive evaluation, Trail Test: Parts A and B aiming at cognitive flexibility and the Attention Test by Cancellation - TAC. The results indicate that 67% of the studied sample had severe motor difficulties in all studied skills and significant correlations between the intellectual level and executive functions (rho = 0.907; 0.713), suggesting that the greater the impairment of executive functions and capacity the greater the impairment of motor skills.

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INTRODUCTION

Autistic Spectrum Disorder (ASD) is a neurodevelopmental disorder characterized by persistent impairments in communication and social interaction, as well as restricted and repetitive patterns of behavior, interests or activities (APA, 2014). It is estimated that the prevalence of ASD in Brazil is between 70 and 90 cases per 10,000 inhabitants (PAULA *et al*., 2012). A study conducted in the United States shows an estimated prevalence of ASD of 1 in 68 children (CHRISTENSEN *et al*., 2016). In the United States, this prevalence is determined by the Center for Disease Control and Prevention (CDC), which, in its last publication in April 2018, reported a prevalence of 16.8 per 1,000 (1 in 59) children aged 8 years. Published data regarding prevalence show a significant increase in the number of cases in the US in recent decades, representing a 150% increase since 2000, highlighting the urgent need to comprehend and fulfill the behavioral, educational and occupational requirements of these individuals (BAIO *et al*., 2018).

The ASDs affect four times more boys than girls, and in terms of intellectual ability, it has been observed that 31% of children with ASD were classified as having an IQ <70, in the intellectual disability range; 25% in the intermediate range, with IQ between 71 and 85; and the highest percentage, 44%, obtained an IQ >85 and were rated at or above average (BAIO, 2018). According to the Diagnostic and Statistical Manual of Mental Disorders (APA, 2014), in addition to intellectual ability, other skills may be impaired in ASD. One of these is shared attention, where the child expresses difficulty in pointing at or showing objects with the intention of sharing their interest with other people. Although individuals with ASD may learn some functional gestures, their repertoire is limited and, consequently, they fail to use expressive gestures. They can also demonstrate strange language and body postures, due to the difficulty in managing verbal communication and speech. In addition, people with ASD may have motor deficits characterized by poor motor coordination, atypical gait, and other abnormal motor signs such as tiptoe walking (APA, 2014). In fact, according to Caçola, Miller and Williamson (2017), problems of movement accuracy, motor coordination and balance are often observed in children with

ASD. Kanner (1943) also found motor deficiencies to be common symptoms of ASD. One group of researchers concluded, through a systematic literature review and meta-analysis, that motor coordination deficits are present throughout the full spectrum of diagnoses associated with ASD and argue that such deficits should be considered intrinsic symptoms characteristic of ASD and not just a comorbidity (FOURNIER *et al*., 2010). Using the short form of the Bruininks-Oseretsky Test of Motor Proficiency, Dewey, Cantell, and Crawford (2007) evaluated motor skills in 238 children, of whom 49 had ASD, 46 motor coordination disorders, 38 coordination disorders and attention deficit hyperactivity disorder (ADHD), 27 ADHD and 78 typical development. The instrument requires the production of meaningful gestures through verbal commands and imitation. The researchers found that only children with ASD demonstrateda generalized gestural impairment and significantly more gestural orientation and distortion errors to imitation compared to the other groups. According to Ament *et al*. (2015), studies using the Movement Assessment Battery for Children (MABC) show that 79% of children with ASD present severe motor impairments.

The authors also stated that, on the MABC scale, these children present more difficulties in the movements of throwing and catching. In addition, studies by Whyatt and Craig (2012, 2013), using the same instrument, however, in its second edition, found that children with ASD had specific deficits in catching a ball, suggesting that motor skill deficits in Children with ASD may be specific to the perception-action connection or the ability to integrate spatial and temporal-visual information of an action rather than affect general motor skills. The authors suggest that there is also evidence of impaired balance and manual dexterity. In addition to motor impairments, recent studies have highlighted changes in executive functions in children with ASD (MERCHÁN-NARANJO *et al*., 2016, JONES *et al*., 2017). Executive functions (EFs) are a set of cognitive processes related to self-control that underpin various skills crucial for learning and for the development of behaviors adapted to environmental demands. The EFs assists in the self-regulation of behavior and attention for the achievement of specific goals and involve three core skills, these being inhibitory control, cognitive flexibility and working memory (BINDMAN *et al*., 2013; DIAMOND, 2014; SEABRA *et al*., 2014). According to Diamond (2013), inhibitory control is the ability to control attention, behavior, thoughts and/or emotions to replace a prepotent response to accomplish what is most appropriate or necessary. When there is difficulty or failure in this ability, the individual is dependent on their own impulses or habits. In this sense, cognitive flexibility, in turn, has its basis in the capacity for inhibitory control, because it is necessary to inhibit the previous perspective to change to a new perspective to the point of changing the direction of the behavior or thought/emotions (DIAMOND, 2013).

Finally, working memory, another core capability of the EFs, involves the manipulation of simultaneous information, which is no longer perceptually present (DIAMOND, 2013; MIYAKE, 2000). A study by Merchán-Naranjo *et al*.(2016), in which several domains of EFs were evaluated in children with ASD, highlighted that there was an important impairment in the performance of sustained and selective attention, working memory, inhibitory control, cognitive flexibility and also in problem solving. The authors suggested that children with ASD present significant difficulties in inhibiting prepotent responses, consequently taking longer for information processing and task performance. However, despite Diamond's (2013) theoretical proposition relating EFs to intelligence skills, these findings showed no correlation with intelligence levels, suggesting that these skills are relatively dissociated from each other. In addition to these findings, D'Cruz *et al*.(2013) suggested that difficulties related to cognitive flexibility in individuals with ASD can be observed in their restrictive and repetitive behaviors. Accordingly, impairment in the establishment of new behavioral routines over previously preferred alternatives, as well as impairments in motor regulation and modulation may be linked to clinical manifestations of behavioral rigidity in individuals with ASD.
Despite a theoretical relationship between EF deficits and motor alterations, especially in autonomous, planning and goal-directed behaviors, it was observed that the majority of the studies conducted with children with ASD provide information on motor and EF performance in an isolated way. Considering that there is still no clarity regarding the relationship between motor behavior, EFs and intelligence in individuals with ASD, the aim of this study was to evaluate the motor, intellectual and executive function performance in children diagnosed with ASD. In this context, the present study sought to answer the following questions: are motor impairments in children with ASD correlated with their intellectual capacity? Do EFs correlate with motor performance in ASD? The hypotheses of the study are that there is a relationship between motor performance and intellectual performance, as well as between motor performance and executive functions, in children and adolescents with ASD.

MATERIALS AND METHODS

Participants: A total of 23 participants diagnosed by a multidisciplinary team composed of a neurologist/psychiatrist, a speech therapist, a teacher and a psychologist, were invited to attend a referral center for the care of individuals with ASD, in the city of Campinas-SP. The criteria for the initial selection of the participants invited were to have a medical diagnosis of ASD, to be aged between 9 and 13 years (as this is the target age of the applied tests) and to not have uncorrected hearing or a visual impairment (according to the medical records of the institution).Those responsible for the children were sent the terms requesting authorization to participate in the study, as described in the Procedures section. Of these, 23 parents authorized the participation of their children in the study. The collection began, and of the 23 participants, three did not attend on the days the collection was performed and two were excluded due to not understanding the instructions. In all, 18 children participated in the study (one girl and 17 boys), from 09 to 13 years of age, with a mean age of 10.8 years.

Instruments

Movement Assessment Battery for Children - Second Edition (MABC-2): This scale created by Henderson, Sugden, Barnett (2007), allows, through its assessment tests, the motor profile to be traced in three skill areas: manual dexterity, ball skills and static/dynamic balance. It provides qualitative and quantitative information on the individuals' performance in terms of standard scores and percentile in these three areas, as well as an overall performance score. The standard score is a transformation of raw points into a standardized distribution with estimation of mean and standard deviation that allows an individual to be compared with the average population assessed by the scale. In the MABC-2, the normalized scores in the three skill areas are based on a distribution with a mean of 10 and a standard deviation (*SD*) of 3. The individual's overall motor performance is derived from the three areas and is also expressed as a standard score (mean = 10; *SD* = 3) and as a percentile. At the end of the assessment the overall performance is graded on a Traffic light color system that has been developed to make it easy to view and explain the performance results for family and teachers. This system is based on the child's classification from the percentiles and total scores for the scale. The color divisions are defined according to Table 1.

Table 1. Traffic light system for total score of the test

Classification of the Child	Percentile Range	Description
Red Zone	5^{th} percentile or below	Indicates significant movement difficulty.
Amber Zone	Between the 5^{th} and 15^{th} percentiles	Suggests that the child is at risk for movement difficulties, requires monitoring.
Green Zone	Above the 15^{th} percentile	No difficulty in movement detected.

Source: Henderson, Sugden, Barnett (2007).

An important feature of the scale is that it allows the assessment to be discontinued at any time and completed at a more appropriate time, making it an even more useful tool for assessing individuals with ASD. In addition, the scale allows children and adolescents from 03 to 16 years to be evaluated, which increases the possibility of monitoring individuals for a longer period using the same instrument.

Wechsler Abbreviated Scale of Intelligence – WASI: This is a brief intelligence assessment instrument applicable for individuals from 6 to 89 years of age.It provides Total, Execution, and Verbal IQ information from four subtests (Vocabulary, Cubes, Similarities, and Matrix Reasoning) from a relatively short assessment. The scale also provides the possibility of an abbreviated evaluation of Total IQ from only two subtests (Vocabulary and Matrix Reasoning).For the purposes of this study, only the Total IQ from the two subtests was used (TRENTINI, YATES, BATES, 2014).

Trail Making Test: Parts A and B: The Trail Making Test is one of the most widely used instruments for assessing cognitive flexibility worldwide. It is divided into two parts (A and B) which contain numbers and letters (evidence of validity and standards in DIAS and TORTELLA, 2012). Part "A" consists of two sheets, where first the letters must be interconnected in alphabetical order and then the numbers must be linked in ascending order on the second sheet. Part "B" is composed of a single sheet, with letters and numbers, which must be interconnected alternately, that is, a letter and a number successively, with the letters in alphabetical order and numbers in ascending order. The number of correct sequences and the execution time in each part of the test is considered.

Attention by Cancellation Test (*Teste de Atenção por Cancelamento* - TAC): This test was developed by Montiel and Seabra (2012), with evidence of validity and Brazilian standardization, and consists of three stages. The first stage is characterized by a task of canceling a given target stimulus in a printed matrix with six types of stimuli, which aims to evaluate selective attention. The second stage has the same objective as the first one, however, with a higher degree of difficulty, presenting a pair of target stimuli to be canceled. The third part of the instrument assesses alternating attention, as it is necessary to shift the focus of attention on each line presented. The total number of correct responses, the number of errors and the number of omissions are computed.

Procedure

Initial contact was made with a referral center for the care of individuals diagnosed with ASD in the city of Campinas, state of São Paulo. In this first contact the content and objectives of the research were presented to those responsible for the institution, as well as the instruments that would be used for the data collection. After this meeting a formal visit by the researchers to the school was scheduled to select the research participants, based on the criteria described in the Participants section, which characterized a convenience sample. The formal invitation was made through the consent form sent to the parents and/or legal guardians of the participants. The parents and/or guardians were informed that the participants would be free to withdraw from the study without any prejudice and were told about the possible minimal risks (tiredness and agitation) from participating in the study. For the benefit of the institution and the participants, a feedback report was prepared, describing the research results, and a meeting was scheduled between the researchers and the institution's coordinators, teachers and assistants involved in the study, to assist in the elaboration of possible behaviors to be performed according to the institution's requirements.

Data collection was performed in an adequate, spacious, well-ventilated room with appropriate furniture provided by the institution, as recommended by the manuals of the instruments used. The instruments were applied individually, in two sessions lasting approximately 40 and 60 minutes, respectively. First the participant performed the cognitive evaluation and after an interval of at least 30 minutes, performed the motor performance evaluation. The two evaluation sessions were held in separate rooms due to the type of testing. The first session lasted approximately 40 minutes, and the Wechsler Abbreviated Scale of Intelligence - WASI (TRENTINI; YATES; BATES, 2014), Attention by Cancellation Test - TAC (MONTIEL; SEABRA, 2012) and Trail Making Test for Schools were used. (DIAS; TORTELLA, 2012). The instruments were applied by a psychologist of the research team. Motor performance was evaluated in the second session, of approximately 60 minutes, in an appropriate space in the institution. The Movement Assessment Battery for Children- Second Edition - MABC-2 scale (HENDERSON *et al*., 2007) was used and applied by a member of the research team, specialized in physiotherapy and with experience of using the same instrument in other studies.

The data collected through the application of the selected instruments were evaluated according to the guidance manuals used and inputted into a database for analysis using the IBM Statistical Package for Social Sciences Version SPSS 17.0 software. Initially, a descriptive analysis was conducted using measures of central tendency (median), dispersion (minimum and maximum) and coefficient of variation (CV) of the studied group. To verify the normality of the sample, the Kolmogorov-Smirnov test was used for the motor performance (manual dexterity, ball skills, balance, overall performance), intelligence quotient (IQ), attention and executive function variables. For the analysis of correlations between the variables, Spearman's correlation test (rho) was used. The use of non-parametric statistics was justified due to the small sample size and the absence of normal distribution in the variables under analysis. In all analyses, a 5% significance level was considered. The criterion of Bisquerra *et al.* was used to interpret the correlation values (2004).

RESULTS

The final sample consisted of 18 children and adolescents, aged between 9 and 13 years, with multidisciplinary medical diagnoses of ASD. Descriptions of the variables studied and their dispersion measures are presented in Table 2.

However, among them, some obtained better scores in some specific skills, so that they would rank in the green zone if the results were analyzed considering the subtests separately, and not by overall performance. For example, participants 1 and 10 presented 25th and 16th percentiles, respectively, in balance, while participants 08 and 18 obtained 37th and 16th percentiles, respectively, in ball skills. These data are presented in Figure 1. Regarding motor performance, the group presented great variability in all the skills studied (manual dexterity, ball skills, balance, and overall performance).Some participants scored on or above the mean in some subtests, that is, they presented performance within that expected for their age in one or more skills; however overall the group demonstrated poor motor performance. It was concluded that this variability was common in the studied population.

Table 2. Descriptive and dispersion measures related to the variables studied.

Variables	Mean	*Med.(Min.-Max.)	***SD*	****CV* (%)
Manual Dexterity	6.7	2 (0.1-50.0)	12.1	182
Ball Skills	14.5	5 (0.5-84.0)	22.0	152
Balance	14.5	5 (0.1-50.0)	17.4	120
Overall Performance	7.5	1 (0.1-37.0)	11.0	136
IQ - WASI	73.3	80 (56.0-96.0)	15.3	20
TAC 1	80.0	80 (56.0-111.0)	14.4	18
TAC 2	85.7	87 (56.0-113.0)	15.8	18
TAC 3	59.6	61 (22.0-93.0)	21.0	35
TAC TOTAL	67.0	66 (39.0-101.0)	17.2	25
Trail Making A	52.6	47 (4.0-109.0)	44.9	85
Trail Making B	92.3	91 (46.0-151.0)	26.7	28
Age	10.8	10 (9.0-13.0)	1.3	12

*Median (minimum), **Standard deviation, ***Coefficientof Variation

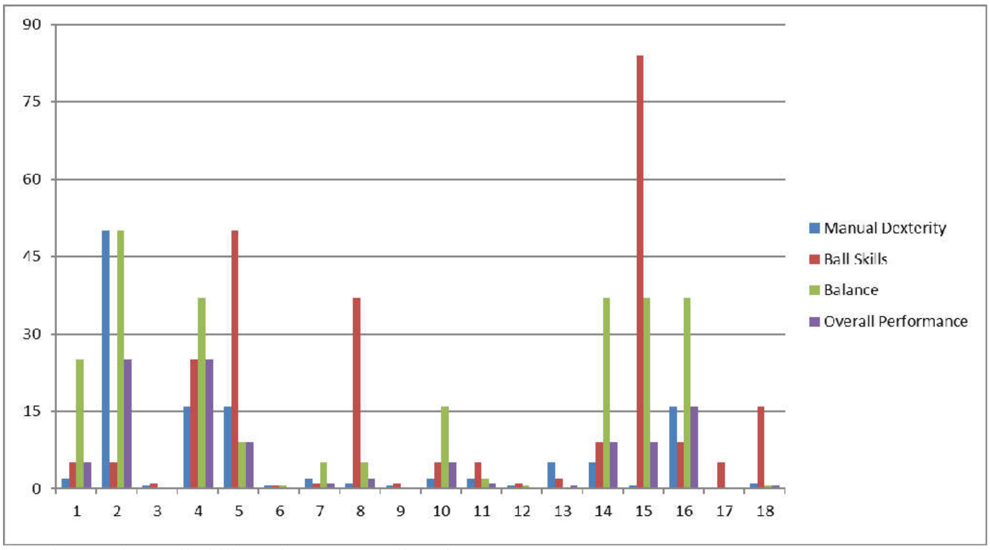
Table 3. Description of MABC-2 results expressed in percentile according to chronological age, sex and motor performance

Part	Age	Sex	Manual dexterity	Ball skills	Balance	Overall performance	Traffic light system[1]
1	10	M	2	5	25	5	Red
2	12	M	50	5	50	25	Green
3	12	M	0.5	1	0.1	0.1	Red
4	13	F	16	25	37	25	Green
5	11	M	16	50	9	37	Green
6	10	M	0.5	0.5	0.5	0.1	Red
7	9	M	2	1	5	1	Red
8	9	M	1	37	5	2	Red
9	13	M	0.5	1	0.1	0.1	Red
10	10	M	2	5	16	5	Red
11	11	M	2	5	2	1	Red
12	10	M	0.5	1	0.5	0.1	Red
13	9	M	5	2	0.1	0.5	Red
14	10	M	5	9	37	9	Amber
15	13	M	0.5	84	37	9	Amber
16	10	M	16	9	37	16	Green
17	12	M	0.1	5	0.1	0.1	Red
18	11	M	1	16	0.5	0.5	Red

[1]Red=motor performance ≤5%; Amber= motor performance 6 - 14%
Green = motor performance ≥15%.

Regarding the variables studied, the means obtained in the motor performance (manual dexterity, ball skills, balance, overall performance) presented greater variation in relation to the means obtained in the IQ, attention tests and executive function tests, as indicated by the coefficient of variation. These variations may be explained by the greater heterogeneity of the motor impairments found in individuals with ASD in relation to the other measures. Table 3 presents the description of the participants' performance in relation to age, sex and their classification resulting from the MABC-2 traffic light system. In relation to the MABC-2 traffic light system, in Table 3 it is possible to observe that 12 of the 18 participants were classified in the red band in terms of overall performance (indicative of motor impairment and the need for intervention).

Table 4 presents the description of the participants and the results obtained (IQ and standard score) in the Wechsler Abbreviated Scale of Intelligence - WASI (IQ), Attention by Cancellation (TAC) and executive function (Trail Making) tests. The measures in all these variables were standardized, with a mean of 100 points and a standard deviation of 15 points. The normality of the distributions of the studied variables was verified, namely motor performance (MABC-2), intelligence quotient (WASI) and executive functions (TAC and Trail Making Test: part A and B) through the Kolmogorov-Smirnov test. Normal distributions were only identified for the variables: IQ, TAC1, TAC2, TAC3 and Trail Making B. For this reason, non-parametric measures were used to analyze the variables studied.



Manual Dexterity, Ball Skills, Balance e Overall Performance.

Figure 1. Comparisonof motor skills performance as measuredbythe MABC-2 scale

Table 4. Description of the evaluated group regarding chronological age, sex and performance in the cognitive assessments

Participant	Age	Sex	IQ*	TAC T	Trail Making-A***	Trail Making-B***
1	10	M	75	65	56	89
2	12	M	83	101	89	94
3	12	M	65	67	72	75
4	13	F	80	92	105	102
5	11	M	95	82	89	110
6	10	M	63	39	4	77
7	9	M	95	81	109	151
8	9	M	77	80	34	101
9	13	M	46	45	10	46
10	10	M	65	52	4	71
11	11	M	52	65	38	73
12	10	M	57	43	4	80
13	9	M	75	65	4	98
14	10	M	88	55	108	137
15	13	M	80	85	105	85
16	10	M	96	68	108	125
17	12	M	53	55	4	55
18	11	M	76	67	4	93

*WASI, **Attention by Cancellation Test (TAC 1, TAC 2, TAC 3), ***Trail Making Test: Parts A and B

Table 5. Description of the correlations of the studied variables

Variables	Manual dexterity	Ball skills	Balance	Overall Performance	IQ
Manual dexterity	__	.367 (.135)	.660** (.003)	.817***(.000)	.685**(.002)
Ball skills	.367 (.135)	__	.578*(.012)	.726**(.001)	.540*(.021)
Balance	.660**(.003)	.578*(.012)	__	.895***(.000)	.703**(.001)
Overall Performance	.817***(.000)	.726**(.001)	.895***(.000)	__	.759**(.000)
TAC-1	.126(.619)	.338(.170)	.209(.404)	.290(.243)	.147(.560)
TAC-2	.501*(.034)	.035(.891)	.318(.199)	.264(.291)	.468*(.050)
TAC-3	.683**(.002)	.613**(.007)	.706**(.001)	.820***(.000)	.848***(.000)
TAC - T	.537* (.022)	.612** (.007)	.563* (.015)	.698** (.001)	.713**(.001)
Trail Making A	.514*(.029)	.354(.150)	.673**(.002)	.657**(.003)	.759**(.000)
Trail Making B	.683**(.002)	.404*(.097)	.541*(.021)	.620**(.006)	.907***(.000)

*Moderate Correlation, **Strong Correlation, ***Very Strong Correlation †Spearman's *rho* Correlation (*p*-value)

Correlation analyses between the variables were conducted using Spearman's test (*rho*) and are presented in Table 5. The values presented indicate a strong positive correlation between IQ scores and the variables manual dexterity, balance, overall performance, TAC-3, TAC-T, Trail Making A and Trail Making B, with *rho* values above 0.70. That is, the higher the IQ, the better the performance tended to be in these skills. The results also show that there was a significant, strong to very strong positive correlation (*rho* values above 0.60) between the executive functions and motor performance tests, except for TAC parts 1 and 2, showing that when the executive function skills were better, the motor performance tended to be better. Significant positive correlations were also found between ball skills and overall performance in attention (TAC total), and moderate positive correlations between manual dexterity and attention skills.

DISCUSSION

The aim of this study was to evaluate the motor, intellectual and executive function performance in children diagnosed with ASD. For this some hypotheses were proposed. The first was

that if children and adolescents have good motor performance, then their intellectual performance will also tend to be good.
The results indicated that of the 18 participants evaluated, 12 presented 5th percentiles or below, classifying their motor performance in the red zone (significant movement difficulties); 2 participants were classified in the Amber zone between the 6th and 14th percentiles (risk of having difficulty in movement and requires monitoring); and only 4 were above the 15th percentile, indicating that no difficulty in movement was detected. Accordingly, 67% of the studied sample presented significant difficulties in relation to their motor skills. The same occurred in a study by Ament *et al.* (2015), which used the MABC-2 scale and demonstrated that 79% of their sample with ASD showed significant motor impairments, thus corroborating the data presented here. In a literature review describing motor deficits in ASD, Wilson and colleagues (2018) highlighted that these could be associated with the first signs of impairment related to ASD, and these abnormalities could be associated with impairments in the communication of these individuals. These hypotheses, combined with the high frequency of motor changes observed in the present study and others (e.g., AMENT *et al*., 2015), corroborate the importance of assessing these aspects in ASD. Associated with motor impairments, the results showed that there was a positive correlation between the intelligence level and motor performance (*rho* = 0.759). This is similar to that described by Yu *et al*. (2018), who evaluated individuals with ASD to compare motor skills and IQ and demonstrated that the higher the IQ, the better the motor performance, highlighting this correlation. These results are also in line with those of the study by Green and collaborators (2008), in which individuals with ASD were evaluated using the MABC scale, with 79.2% of the children evaluated presenting motor deficits that need intervention and most of this group presenting an IQ below 70.
It should be highlighted that it is still necessary to better understand the nature of this correlation, as it may be the result of the application of the motor tests, which require a minimum degree of comprehension for each task from those evaluated. In fact, Green and colleagues (2008) suggest that the participants in their study might not have understood the verbal commands needed for the assessment. In the present study, however, this bias was at least partially eliminated by excluding individuals that did not respond to the commands required for the motor, intellectual, and executive function assessments, which enabled all participants to complete the entire evaluation. It is possible that, despite having responded to all tasks, the participants may have had more subtle difficulties in understanding the instruction, which could have led to worse performance for those with lower IQs.

Bogja Jeoung (2018) assessed motor skills in three groups divided into different degrees of intellectual disability and autism using the Bruininks-Oseretsky Test. According to the results, the individuals presented lower scores in relation to the fine motor coordination skills. Whyatt and Craig (2012, 2013) highlighted evidence that children with ASD had greater difficulties in ball skills, suggesting that motor skill deficits in children with ASD could be specific to one ability. In fact, in the present study, the greatest impairment was in relation to manual dexterity, with participants presenting a lower percentile than expected for their development. Several studies emphasize motor impairment in ASD (BHAT *et al.*2011, AMENT *et al*. 2015), including the present study, however, the relationship of the emergence of these impairments is the subject of little discussion in the literature. This study aimed to advance this understanding by analyzing the relationship with the executive functions. As expected, a positive correlation was observed between motor impairments and executive functions. Although the correlational design does not allow cause and effect relationships to be derived, from the theoretical perspective it can be hypothesized that the impairment in executive functions may be contributing to the motor impairment. This is because motor skills require a sequence of actions and planning in a dynamic system of assessment, reassessment and regulation in relation to the goal. Scientific evidence shows that individuals with frontal injuries and individuals with ASD present similar planning difficulties in relation to their motor skills (MECCA *et al*., 2012). Therefore, it is relevant that evaluation and intervention programs directed toward this population address the cognitive (emphasizing the executive functions) and motor needs. The second study hypothesis was that if children and adolescents perform well in executive functions, then they will present good motor performance. For this hypothesis the results indicate a strong positive correlation between cognitive flexibility, alternating and selective attention (Trail Making B, TAC 3) and overall motor performance (*rho* = 0.620; 0.820 respectively).These findings are corroborated by Merchán-Naranjo *et al*. (2016), who demonstrated that there is an important impairment in selective attention performance, working memory and cognitive flexibility for the population with ASD. The results also indicate that there are significant and positive correlations between the intellectual level and executive functions (*rho* = 0.907; 0.713).

It is possible that the positive correlation between motor skills and executive functions, especially cognitive flexibility, is related to the presence of restricted and repetitive behaviors. D`Cruz *et al*. (2013) suggested that this is due to the compromise in the establishment of new behavioral routines over previously preferred alternatives, as well as impairments of motor regulation and modulation, which are linked to clinical manifestations of behavioral rigidity in individuals with ASD. Therefore, the hypotheses proposed regarding the correlations between motor performance, executive functions and level of intelligence were confirmed, however, the perception of the educators did not correspond to the data of the quantitative evaluation, which is an indication that studies in the motor area are essential for this aspect to be better understood in relation to the population with ASD. This study had some limitations, among them the limited number of participants, with it not being possible to generalize the data to other samples. Also, no different constructs of executive functions, such as inhibitory control and objective measures of working memory, were compared. However, the data presented here show a wide field for scientific research that can contribute to a better understanding and planning of educational and/or therapeutic intervention programs for children and young people with ASD.

Conclusion

The present study sought to identify impairments in ASD in relation to the motor skills, executive functions and intellectual capacity and to correlate them, as well as to verify the teachers' perception regarding the motor impairments. The results show that the impairments in motor skills, executive functions and intellectual capacity present a strong positive correlation between one another, suggesting that the greater the impairment in executive functions and intellectual capacity, the greater the impairment in motor skills. To the authors' knowledge this is the first study that seeks to correlate these skills in ASD. It can be concluded that this study indicates the need for greater knowledge about the motor repercussions and the relationships between executive functions and intellectual capacity in individuals with ASD.

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