Journal of Physical Education and Sport ® (JPES), Vol.20 (3), Art 205, pp. 1491 - 1496, 2020
online ISSN: 2247 - 806X; p-ISSN: 2247 – 8051; ISSN - L = 2247 - 8051 © JPES

Original Article

Motor proficiency of children with autism spectrum disorder and typically developing children in Portugal

CARLA LOURENÇO[1], DULCE ESTEVES[2], CÉLIA NUNES[3], TING LIU[4]
[1,2,3]University of Beira Interior, Covilhã - PORTUGAL
[4]Texas State University, Texas, USA

Published online: May 30, 2020
(Accepted for publication: May 18, 2020)
DOI:10.7752/jpes.2020.03205

Abstract:
Children experiencing deficits in motor proficiency may have poor communication skills, low physical activity engagement, and difficulties on achieving academic success. Thus, the early assessment of deficits in motor proficiency allows planning an intervention that leads to the minimization of these deficits.Children with autism spectrum disorder (ASD) present severalmotor deficits, such as balance, coordination, or strength combined with developmental delays in fine and gross motor proficiency. However, there are limited research have been conducted to examine motor proficiency in Portuguese children with ASD. This study was aimed to evaluate the motor proficiency of Portuguese children with ASD and comparewith motor proficiency of the typically developing children. The sample consisted of 10 children with ASD and 10 typical developing children with a mean age of 6.9 years. All children were assessed on their fine and gross motor proficiency using the Bruininks-OseretskyTest of Motor Proficiency-Second Edition (BOT-2). A significant difference was found between the groups (p = 0.02) on BOT-2 subtests. Children with ASD scored significantly lower (25.50 ± 14:34) than their typical developing peers (39.50 ± 11.26). Specifically, children with ASD scored poorly on fine motor precision (p=0:00), manual dexterity (p=0.02), balance (p=0.02), speed and agility (p=0.04), and strength (p=0.04) in comparison to the typically developing children. All typical developing children scored average in their motor proficiency performance whereas 80% children with ASD were categorized as below and very below average, with two children were within the average of motor proficiency. These findings suggest that more research is needed on investigation of motor delays in Portuguese children with ASD to develop interventions to improve motor proficiency in children with ASD.
KeyWords*:* Fine and gross motor skills, Autism Spectrum Disorder, Portuguese children

Introduction

Motor development is characterized by the acquisition of fundamental motor skills, allowing different postures, locomotion, and manipulation of objects (Santos, Dantas,& Oliveira, 2004). Researchers suggest that motor skill acquisition accompanies intellectual development and physical fitness which may positively affect the cognitive development in children (Abdelkarima et al., 2017). The development of a child according to the established development stages is referred as typical development, while the presence of changes behind the typical development trajectory are considered early warning signs or red flags for different pathologies (Illingworth, 2013).

One of the pathologies associated with outside typical development trajectory is Autism Spectrum Disorder (ASD), which consists of neurological disorders affecting children's communication, social, and language development (American Psychiatric Association, 2013). Previous studies reported that children with ASD displayed considerable deficits in motor skill proficiency and competence (Fournier, Hass,Naik, Lodha, &Cauraugh, 2010),and difficulties in social functioning (Liu, Kaarengala,&Litchke, 2019). In addition, studies revealed that children with ASD performed poorer when compared to their typically developing peers (Bhat, Landa, & Galloway, 2011) on coordination of the upper and lower limbs in manual dexterity, balance, agility and speed (Brás, Correia,& Silva, 2009; Borremans, Rintala, &McCubbin, 2009),and in praxis/motor planning(Kaur, Srinivasan, &Bath, 2018).

Although this topic has been recurrent in different investigations, an approach focusing on the motor proficiency profile inPortuguese children with ASD has not been sufficiently developed. Understanding motor proficiency in Portuguese children with ASD is necessary in examining their onset of motor skill development and acquisition. Motor proficiency profile is defined as the "index or sum of the best performance or performance observed in a wide variety of situations or motor tasks and which tends to increase with age" (Morato& Rodrigues, 2014, p.10). It is positively associated with physical activity participation and inversely to the children's sedentary lifestyle (Wrotniak, Epstein, Dorn, Jones, &Kondilis, 2006). Evaluating the motor

Corresponding Author: CARLA LOURENÇO, E-mail: ccvl@ubi.pt

proficiency profile in Portuguese children with ASD allows us to better understand motor capacity of each child, as well as to analyze different motor aspects in an isolated manner and a better evaluation of the fundamental fine and gross motor skills (Deitz, Kartin, & Kopp, 2007).

Material &Methods

The objective of this study was to compare Motor Proficiency profiles between children with ASD and their typically developing peers.

Participants

Twenty Portuguese children participated in this study. Ten children were diagnosed with ASD (6.9 ± 1.97 years) and 10 children were typically developing (7 ± 1.83 years). The participants' ages ranged from 4 to 10 years (6.95 ± 1.85 years), with a prevalence of males (60%) participants. Table 1 shows the characterization of the participants for each group.

Table 1 Characterization of the participants

Participant	Gender	Age (Years)	Participant	Gender	Age (Years)
	ASD			Typical Developing	
1	M	8	11	M	4
2	M	7	12	M	7
3	F	4	13	F	8
4	M	6	14	M	8
5	M	9	15	M	10
6	M	8	16	M	7
7	F	6	17	M	6
8	F	7	18	M	5
9	F	4	19	F	9
10	F	10	20	F	6
Mean±SD		6.9±1.97			7±1.83

Procedures

This study was approved by the Scientific Committee of the 3rd cycle of studies in Sports Sciences of the University, and was in compliance with the ethical recommendations with implicit requirements when working with minors. The informed consent was obtained from the children legal guardians prior to their participation of the study. The confidentiality and anonymity, and minimization of risks, and all the principles of the Helsinki Declaration were fulfilled. The participants were recruited from the school community, through Schools of Viseu Portugal. The inclusion criteria were (1) the children's chronological ages were between 4 and 10 years, (2) the children could follow instructions and compete the motor assessments; and (3) the children were either diagnosed with ASD or they were typical developing. Parents/caregivers of children who met the inclusion criteria were contacted and the children whose parents gave permission, participated in the study.

Instruments

Bruninks-OsereteskyTest of Motor Proficiency -2 (BOT-2)

All participants were assessed using the BOT-2 short form (Bruininks&Bruininks, 2005). The short form with knee pushup test was used in this study to assess fine and gross motor proficiency in children with ASD and their typical developing peers. The BOT-2 short form includes eight subtests with scores on four subtests measure fine motor proficiency: 1) fine motor precision, 2) fine motor integration, 3) manual dexterity, and 4) bilateral coordination; and four subtests assess gross motor proficiency: 1) balance, 2) running speed and agility, 3) upper-limb coordination, and 4) strength (Table 2). The raw scores were converted to a point score and total point scores were used to find percentile rank. Children's percentile scores in BOT-2 were used to classify their performance to well-below average (2 or less), below-average (3-17), average (18-83), above average (84-97), and well above average (98 or greater).

Table 2Items and subtests that make up the BOT-2 short form

Subtest 1 - Fine motor precision	Item 1	Drawing lines, through a path
	Item 2	Folding paper
Subtest 2 - Fine motor integration	Item 3	Copying a square
	Item 4	Copying a star
Subtest 3 - Manual Dexterity	Item 5	Transferring pennies
Subtest 4 - Bilateral coordination	Item 6	Jumping in place-same sides synchronized
	Item 7	Tapping feet and fingers-same sides synchronized
Subtest 5 - Balance	Item 8	Walking forward in a line,
Subtest 6 - Speed and agility racing	Item 9	Foot-to-side jumps from one side to the other of a line
Subtest 7 - Coordination of the upper limbs	Item 10	Throwing and catching the ball with one hand
	Item 11	Dribbling the ball by playing alternately in the same
Subtest 8 - Strength	Item 12	Performing push-ups, with or without knee support, on the ground

Statistical analysis

The IBM Statistical Package for the Social Sciences (SPSS), version 24.0, was used to perform the statistical analyses. Descriptive statistical methods (mean and standard-deviation) were used to describe the participant's motor performance in BOT-2. Normality was verified using the Shapiro-Wilk test (n<30) and the independent t-tests were used to analyze the performance differences between children with ASD and the typical developing children.

Effect sizes were calculated using Cohen's d and their interpretation was based on the following criteria: 0.20 = small effect, 0.50 = medium effect, and 0.80 = large effect (Cohen, 1988). The significance level was set at $p < 0.05$.

Results

The results (table 3) revealed that children with ASD scored significantly lower on fine manual precision subtest than the typical developing children ($p<0.05$) and large effect sizes were found ($d > 0.8$). Specifically, children with ASD scored loweron item 1-drawing line through path (1.90±0.87) and item 2–fold paper (4.00±2.30) when compared to their typical developing peers.

Table 3 Mean±SD, independent t test analysis, and effect sizes for all subtest and total percentile score

		ASD	Typically Developoing Children	Independent t test		Cohen´d
Subtest	Variables	Mean±SD	Mean±SD	t	p	
Fine motor precision	Item 1	1.90±0.87	2.70±0.48	-2.530	**0.021***	1.138
	Item 2	4.00±2.30	6.50±0.85	-3.213	**0.005***	1.441
Fine motor integration	Item 3	4.80± 1.81	5.50± 0.70	- 2.530	0.270	0.510
	Item 4	3.10 ± 1.59	4.00± 1.24	- 3.213	0.177	0.631
Manual dexterity	Item 5	2.20±1.61	3.90±1.44	-2.530	**0.024***	1.113
Bilateral coordination	Item 6	2.00± 1.88	2.70 ± 1.49	- 2.530	0.370	0.412
	Item 7	0.90 ± 1.28	1.20± 1.22	- 3.213	0.600	0.239
Balance	Item 8	1.90 ±1.28	3.20 ±1.13	- 2.530	**0.028***	1.076
Speed/agility	Item 9	1.50±1.26	3.00 ±1.76	- 2.530	**0.043***	0.980
Coordination of the upper limbs	Item 10	0.80±1.61	1.60 ±2.36	- 2.530	0.389	0.396
	Item 11	1.30 ±1.49	3.40±2.67	- 3.213	**0.044***	0.971
Strength	Item 12	1.10±1.79	1.80±1.75	- 2.530	0.389	0.395
Percentil score motor proficiency		25.50 ±14.34	39.50 ±11.26	- 3.213	**0.026***	1.085

No statistically significant difference was found between the two groups in fine motor integration subtests ($p> 0.05$). However, effect sizes showed moderate effect ($d > .5$) indicated children with ASD were less proficient on fine motor performance when compared to the typical developing children and suggesting a trend for delays in motor integration tasks. The two items corresponding to bilateral coordination did not show any statistically significant differences, however typical developing displayed higher mean values than the children with ASD. They showed better results in item 6 than the other item in bilateral coordination subtest.

A significant difference was found between children with ASD and the typically developing children on manual dexterity ($p=0.024$) suggesting that children with ASD were delayed on manual dexterity. Alarge effect size was also found ($d=4.467$)= indicating a strong practical effect in the Portuguese children with ASD population.

The coordination of the upper limbs was evaluated through items 10 and 11. No significantly differences between the two groups were found on item 10. However, item 11 registered significant differences ($p=0.044$) and a large effect size ($d=1.664$). Portuguese children with ASD scored lower mean values on both items when compared to their typical developing peers suggesting a delay in coordination of the upper limbs.

In addition, typical developing children presented significantly higher mean values than the children with ASD ($p=0.028$) on balance, and a large effect size was found ($d=4.221$). Children with ASD scoredsignificantly lower on speed and agility when compared to typical developing children with a large effect size ($p=0.043$; $d=2.496$).

Descriptive analysissuggested thatmajority of Portuguese children with ASD (80%) were classified in well below the average or below average category and only 2 children were in the average motor proficiency category. On the other hand, 90% typical developing children's motor proficiency was in the average or above average category.

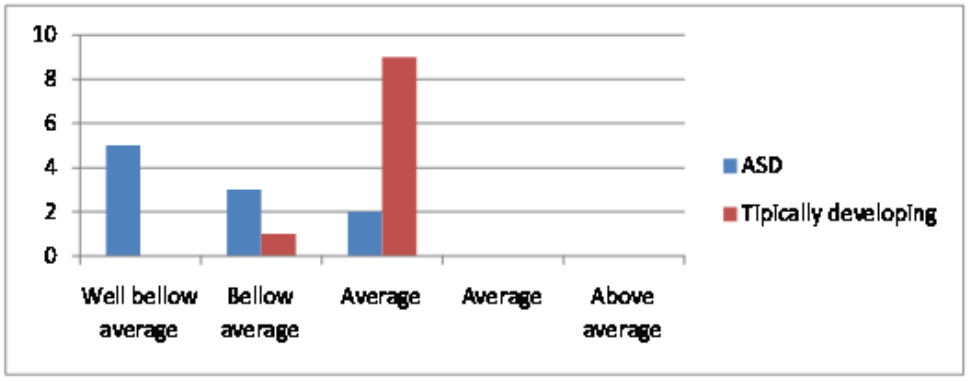

*Figure 1.*Classification of the motor proficiency profile of children with ASD and typically developing

Discussion

The objective of this study was to evaluate differences in Motor Proficiency profiles between children with ASD and their typically developing peers. Motor proficiency evaluation test was used to evaluate both fine and gross motor proficiency and a global classification on this parameter (motor proficiency score).The results showed that Portuguese children with ASD were significantly delayed on manual dexterity. This findingwas consistent with the previous studies suggested that children with ASD were delayed on their fine motor skill performance (Bhat et al.,2011; LeBarton,& Iverson, 2013).Furthermore, Fournier et al. (2010) and Bhat, et al. (2011) reported a lower manual dexterity in children with ASD when compared to those standardized by the typical developmental stages, and their results were in accordance with the findings obtained in this study. The deficits found in fine motor proficiency can lead to delays in the autonomy of day to day tasks, since fine motor proficiency is indispensable for tasks such as feeding themselves, grasping toys, buttoning and zipping clothes, writing, drawing and other self-care, and everyday tasks. Pan,Tsai, and Chu, (2009) and Sacrey, Germani, Bryson, and Zwaigenbaum (2015) emphasize on the importance of training for fine motor skills, stimulating dexterity, strength and manual coordination, especially in children who show low levels in fine motor proficiency.

Furthermore, children with ASD showed significant lower proficiency on balance; speed/agility, and coordination of upper limbs. The findings of study are in agreement with Minshew, Sung, Jones and Furman(2004) and Doumas, McKenna and Murphy (2015), who report deficits in postural control and balance in children with ASD. Delays in speed and agility ($p = 0.04$) in children with ASD were also supported by the previous research (Bhat et al., 2011; Roeber, Gunnar, &Pollak, 2014;VanDamme, Fransen, Simons, van West &Sabbe, 2015), in which children with ASD showed severe deficits in motor speed and agility . Similarly, significant differences between Portuguese children with ASD and typically developing children on coordination of the upper limbs were in concordant with Braddock &Hilton (2015), who reported problems in the coordination of the upper limbs in children with ASD and the need for specific therapy that would allow the development of this coordination.

The finding of no significant differences onstrength (item 12) between the two groups was in contrary to the results obtained by Tyler, MacDonald andMenear (2014), who reported the existence of significant differences in the ability to perform force between individuals with and without ASD. This result suggestedthat children with ASD gross motor proficiency deficitsweremore in coordination than muscular strength.

In our sample, no statistical differences were found on bilateral coordination.With the development of young children, differences in bilateral coordination maybecome apparent, because it greatly increases with age in a typically developing child (Roeberet al., 2014).Santos, Santos, Duncan, Vale andMota (2019) suggest that gross motor coordination is often specified in terms of proficiency in a variety of fundamental motor skills in object control, such as grasping,and striking, and locomotion, such as walking and hopping. Therefore, deficits in gross motor proficiency can hinder children with ASDphysical activity participation, initiation to sport, and the inclusion of these children.

Finally, one of the most important results of this study is the significant motor proficiency impairments in Portuguese children with ASD. These results were similar to those presented by Pan (2014), whereas the author refers to the importance of considering the motor proficiency index in the characterization of the motor profile of children with ASD, quantifying, and categorizing this index.De Meester et al. (2018) suggested a motor proficiency barrier to the physical activity participation. That is, there might be a threshold level of motor proficiency above which child will be more likely to engage in various types of physical activity as they are able to successfully participate. Below this threshold, children areless likely to engage in such activities as they would not have the prerequisite skill level to be successful, and the result, lack the confidence and motivation to engage in physical activities. The evaluation of the motor proficiency score allows a better identification of this

threshold and thus recognizechildren who should be targeted to improve their level of motor proficiency in order to overcome the barrier to participation in physical and sports activities.

Conclusions

Many studies reported significant motor delays in children with ASD (Haywood, Roberton,& Getchell, 2012) onmotor control (Kopp, Beckung,& Gillberg, 2010), coordination (Fournier et al., 2010) and equilibrium (Minshew et. al, 2004). The findings of this study were consistent with previous research.

Portuguese children with ASD showed deficits in both fine and gross motor proficiency as compared to the typical developing children, Children with ASD showed a lower level of motor proficiency, as also observed by Pan (2014) in adolescents with ASD. These findings add value to the ASD literature in identifying motor proficiency deficits and quantifying and categorizing motor delays in Portuguese children with ASD, which supported by Pan (2014), to obtain a quantitative notion of the level of motor proficiency change that each child presents in comparison to typical developing children. This quantification of the level of motor proficiency can be used for designing motor intervention programs to best target the specific motor behavior.In conclusion, Portuguese children with ASD present deficits in motor proficiency. It is suggested for future research to include both fine and gross motor skill training when designing interventions for children with ASD so that their findings can be generalizable to other settings like classroom, playground, and home.

Conflicts of interest - No conflict of interest.

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