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Kaur Anujot
Assistant Professor, MPT (Neurology), Lovely Professional University, Jalandhar, Punjab, India.

Vij Jaspreet Singh
Associate Professor, University College of Physiotherapy, Baba Farid University of Health Sciences, Faridkot, Punjab India.

Kaur Sumandeep
MPT Neurology, Physiotherapist, Lovely Professional University, Consult Physiotherapy, Jalandhar, Punjab, India.

Correspondence:
Jaspreet Singh Vij
(PhD in Physiotherapy)
Associate Professor, University College of Physiotherapy, Baba Farid University of Health Sciences, Faridkot, Punjab India.

Analysis of certain quantitative gait parameters in children with autism spectrum disorders

Kaur Anujot, Vij Jaspreet Singh, Kaur Sumandeep

Abstract
No doubt Autism spectrum disorders is a disorder of neuronal development characterized by impaired social interaction and communication and by restricted and repetitive behavior, previous studies have documented a definite link of autism with motor impairment. The fact that most of the previous studies on children with ASD have been focused on their social and behavioral problems, it has diluted the focus and attention of rehabilitation community on physical functioning of these children especially gait performances. A total of forty five children with ASD (34 males and 11 females) with an average age of 8.47 years (range 4-14 years) were included in the study another forty five typically developing asymptomatic children (32 males and 13 females) with an average age 8.87 years (range 4-14 years) were selected as a control group for comparison of gait parameters. Step length (Right and Left), stride length, cadence and gait velocity were measured using footprints method of gait analysis. It was found that there was a significant difference between step length (left and right) and stride length children with ASD and asymptomatic children. But there was no significant difference between cadence and gait velocity of both the groups.

Keywords: ASD, Gait, step length, Gait velocity, cadence

1. Introduction

1.1. Background of the Study

Autism spectrum disorder (ASD) is a group of neurodevelopmental disorders comprising autistic disorder and two related but less severe disorders: Asperger disorder and pervasive developmental disorder not otherwise specified (PDD-NOS). Children who have ASD exhibit characteristic impairments in social interactions and communication and restricted, repetitive, and stereotyped patterns of behavior [1]. According to The Center of Disease Control (CDC) about 1 in 88 or 11.3 per 1,000 (range 4.8-21.2 per 1000) children has been identified with an ASD in United States of America based on data collected from health and special education records of children living in USA in 2008. Estimated prevalence of boys were 1 in 54 and girls 1 in 252. The average prevalence of ASD before 1980 was around 1.9/10,000 while it was 14.8/10,000 from 1980 to 2010 [2]. Numerous studies have suggested that the prevalence of diagnosed ASD, in the United States and elsewhere, has increased dramatically in the past decades [3-8]. As far as India is concerned, there is paucity of published literature related to prevalence of ASD in children.

Previous studies have documented a high level of functional limitations and poor health status in children with autism [9] an accompanying high level of health care use [9, 10] and unmet health needs [10], and increased parenting stress and family burden [10, 11]. But majority of these studies have been conducted in developed countries targeting the population group residing in them. No doubt Autism is a disorder of neuronal development characterized by impaired social interaction and communication and by restricted and repetitive behavior, previous studies have documented a definite link of autism with motor impairment [12]. The fact that most of the previous studies on children with ASD have been focused on their social and behavioral problems, it has diluted the focus and attention of rehabilitation community on physical functioning of these children especially gait performances.

Interestingly previous researchers have noted difference of gross and fine motor skills in school aged children with ASD [13], Lopez *et al.* also revealed that all children with ASD have delays in gross motor skills and fine motor skills or both, but the motor scores of young

children with ASD did not differ significantly on motor skills measures when compared to young children with Pervasive Developmental Disorders [14]. More specifically few researchers had highlighted the presence of gait abnormalities in children with ASD [15]. Thus there is lack of substantial and whole hearted effort focusing these areas. A considerable difference in gait in terms of reduced stride lengths and increased stance times have been revealed in children with autism in comparison to normal children. The literature related to gait in autism concentrate more on gait abnormalities such as toe walking [15, 16]. There is limited work exploring the quantitative gait parameters such as step length, stride length, cadence and gait velocity in these children.

Moreover motor deficits along with gait abnormalities further add to children's other handicaps, Therefore, there is a urgent and desired need to investigate and document gait parameters in these children so that timely intervention strategies can be planned and executed at appropriate time.

2. Materials and Methods

The study was conducted during the period of October 2012 and March 2013. Children pre diagnosed with Autism Spectrum Disorders were recruited from the special schools and institutions spanned across the various districts of Punjab. A total of forty five children with ASD (34 males and 11 females) with an average age of 8.47 years (range 4-14 years) were included in the study another forty five typically developing asymptomatic children (32 males and 13 females) with an average age 8.87 years (range 4-14 years) were selected as a control group for comparison of gait parameters. The ASD subjects who met the following criteria were selected; (1) children pre diagnosed with Autism Spectrum Disorders (2) able to walk and ambulate independently without any orthosis or gait aid (3) able to follow commands and complaint in gait analysis (4) birth > 36 weeks of gestation (5) birth weight over 2500 g (6) absence of known or suspected genetic disorders causally linked to autism or that might affect neurological or muscular function (7) no history of meningitis, encephalitis, brain injury, or other potentially encephalopathic illness (8) no report of clinical seizures (9) absence of congenital malformations and disorders along with leg length discrepancy. The study was approved by the ethical committee. The informed written consent to participate in the study was undertaken from the parents and care takers of the children as applicable. The gait assessment comprised of right and left step lengths, stride length, cadence and gait velocity. For assessing these gait parameters the subjects were made to walk on a leveled surface in a linear progression. They were made to walk bare feet after application of foot ink and hence foot prints were obtained on the floor. The step length was measured by calculating the distance from the point of heel strike of one extremity to the point of heel strike of opposite extremity. Both left and right step lengths were measured. Stride length was measured from the line of linear progression between the heel strikes of two consecutive footprints of the same foot. Only the middle steps were evaluated to avoid the variable steps associated with initiation and termination of gait. The cadence was calculated by asking the subject to walk for one minute through a straight pathway with self-selected speed and then calculating the number of steps taken during one minute. The gait velocity was calculated after dividing the required (10 m) distance by ambulation time. Three trials were under taken for assessment of these gait parameters for each subject. The average of three trials were calculated and considered for analysis.

3. Statistical analysis

The statistical analysis was performed by using SPSS (version 16). An independent t test was performed to analyze the gait parameters for the two groups.

4. Results

The quantitative gait parameters namely left and right step length, stride length, cadence and gait velocity were assessed and compared in children with ASD and typically developing children. The parameters assessed have been shown in table 1.

Table 1: Gait parameters in children with ASD (Group A) and Typically Developing Children (Group B)

Parameter	ASD Children	Typically Developing Children	t value	p value
Step length Left (cm)	31.55± 5.61	35.40± 6.00	-3.13	<0.05
Step length Right (cm)	31.60± 5.64	35.35± 6.04	-3.04	<0.05
Stride length (cm)	63.15 ±11.24	70.75± 12.04	-3.09	<0.05
Cadence (steps/minute)	121.0± 19.89	124.3± 12.68	-0.960	>0.05
Gait velocity (cm/s)	141.9± 16.21	143.2± 14.59	-0.396	>0.05

The left step length, the right step length as well as stride length were reduced in ASD children (step length left =31.55±5.61, step length right = 31.60± 5.64, stride length =63.15 ±11.24) as compared with Typically Developing Children (step length left=35.40± 6.00, step length right=35.35± 6.04, stride length=70.75± 12.04). The cadence (121.0± 19.89) and gait velocity (141.9± 16.21) of ASD children when compared with Typically Developing Children (cadence=124.3± 12.68, gait velocity=143.2± 14.59) was found to be having statistically non- significant difference.

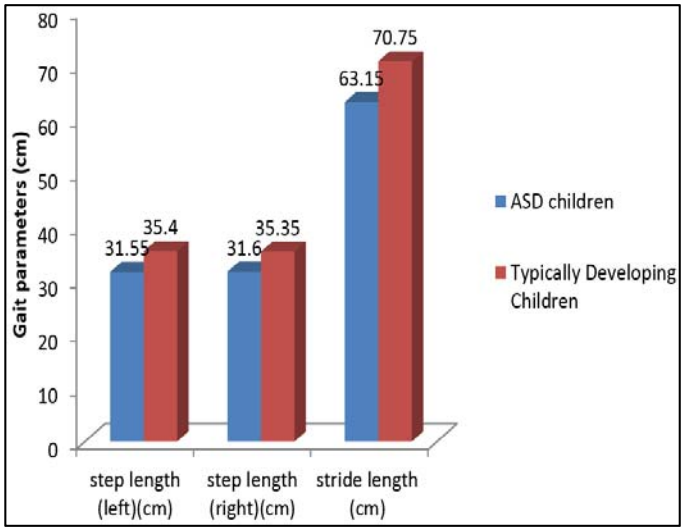

Fig 1: Graphical representation of left and right step length and stride length of ASD children And Typically Developing Children

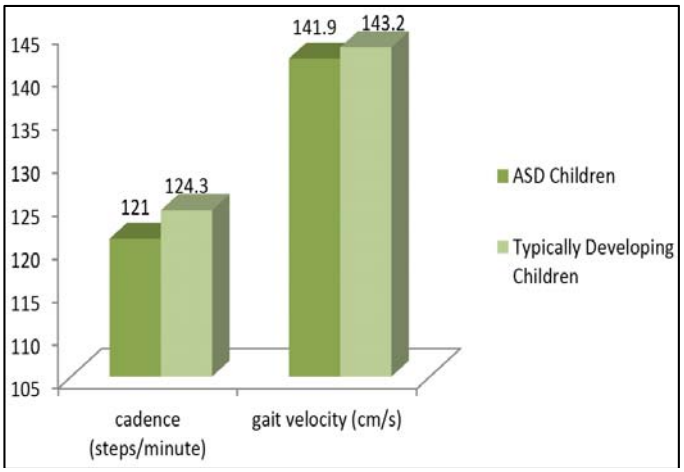

Fig 2: Graphical representation of cadence and gait velocity of ASD children and Typically Developing Children

5. Discussion

The present study has highlighted that in comparison to Typically Developing Children the children with ASD have reduced left and right step length as well as stride length. These findings are in agreement with the observation made by other authors [17, 18, 19].

Martin *et al*. and Damasio & Maurer (1981) also documented reduced step length in children with ASD indicating the presence of short steps in these children. Further a comparison of left and right step length in the ASD children suggested the presence of marked symmetry there by revealing that these children, although having short steps and reduced step length in comparison to Typically developing children, were having almost similar left and right step lengths. Literature has demonstrated that presence of any pain and weakness in hip, knee or ankle joints leads to short steps. It has been especially noticed that if the control of plantar flexors and hip extensors are inefficient it reduces the swing time which causes quicker landing, thus reducing the step length [17].

It also has been evidenced that hypotonia is one the key existing elements foreseen in children with ASD [15, 16]. Klein *et al.* (2012) [15] has stated the presence of hypotonia and increased passive joint mobility in ASD children. The tonal abnormality could be one of the precipitating factor which results in gait dysfunction in children with ASD. This tonal abnormality could be one of the reasons of weakness in lower limb muscles and muscle imbalance leading to short steps. But still too less work has been done linking abnormal gait in these children with measurable quantitative gait parameters.

The present study also suggests that there has been no significant difference in cadence and gait velocity of Typically Developing Children and children with ASD [18, 19]. Previous studies have also shown similar results but were unable to explain the exact reason behind this fact. One of the reasons of non-significant difference in cadence and gait velocity in Typically Developing Children and children with ASD could be cadence has been related to length of the lower limbs. Longer legs depict slower cadence [20]. In this present study length of the lower limbs were not taken into consideration which could be one of the reasons of non-significant results.

This study was a pioneer step to analyze objective gait parameters in children with ASD clinically. The limitation of the study was because of the fact that very less number of parents allowed their children to participate in the study so the age range chosen for the present sample was large (4-14 years).In future the results of this study could be used for more detailed analysis of gait parameters in children with ASD. For this purpose apart from the temporal gait variables used in this study stride duration, swing time, stance time double support period could also be studied.

6. Conclusion

The findings of this study concluded that there exists a significant difference in right and left step length and stride length of typically developing Children and children with ASD. The children with ASD have shown significantly reduced right and left step length and stride length as compared to Typically Developing Children. But there exists a non-significant difference in cadence and gait velocity of typically developing Children and children with ASD.

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