A COMPARISON OF MOTOR AND VISUAL SKILLS IN YOUNG CHILDREN: AUTISM SPECTRUM DISORDER AND DEVELOPMENTAL DELAY

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Abstract

Autism spectrum disorder (ASD) causes limitations in a child's development especially language skills and social interaction skills. However, deficits in other developmental domains are often present and common across children of different ages. This study aimed to explore the relationships of motor, visual and cognitive domains with ASD severity and the differences between children with ASD and those with developmental delay without ASD (DD). The study uses the Schedule of Growing Skills II, specifically the locomotor, manipulative, visual domains using developmental quotient scores, to explore motor, visual and cognitive delay in young children aged 24 to 60 months. One hundred and ninety-nine (199) children were divided into two groups: children with ASD, and children with DD. There was a high prevalence of delay in cognitive (94%) and manipulative skills (87%) in both ASD and DD groups. Children with ASD had higher locomotor scores (DQ = 83.27) compared to children with DD (DQ = 67.13). In ASD children, motor skills were poorer for those diagnosed at an older age and in boys ($p < 0.05$). Children with more severe ASD were found to have poorer manipulative, visual and cognitive skills ($p < 0.01$). The study highlighted weaknesses of non-language components in children with severe ASD and the strength of locomotor skills in children with ASD compared to children with DD. However, the limitation of a single-centred study means the findings are not representative of the population of children with ASD and those with DD in Malaysia. In the care of children with ASD in clinical practice, development assessment of every domain is important to ascertain areas of limitations in non-language domains, especially in severe ASD. Future longitudinal research on children with ASD on a larger sample size will allow a better understanding of the trajectory of development in relation to ASD severity.

Keywords**:** Developmental Delay, Autism Spectrum Disorder, Visual Skills, Motor Skills, Malaysia

Introduction

Autism spectrum disorder (ASD) is a lifelong neurodevelopmental disorder defined by the presence of persistent deficits in social communication and interaction, and repetitive or restricted patterns of behaviour of varying severity (1). The disorder affects one's speech and language, social-emotional reciprocity, nonverbal communication and relationships. Persons with ASD also display stereotypic behaviour, insistence on routines and rituals, restricted interests and sensory problems.

ASD is an increasingly common disorder with a worldwide prevalence of 1 in 100 (2). Data from the Unites States show an increase in prevalence, from 1 in 110 in 2006 to 1 in 36 in 2021 (3). In Asia, a meta-analysis in 2020 showed that 1 in 278 children in the region have autism (4). In Malaysia, ASD is categorised under 'Learning Disability' and there is no official data on ASD prevalence on its own (5). Data from the Ministry of Health in Malaysia revealed 589 children were newly diagnosed with autism in 2021, up five percent from 562 children in 2020 (6). The lack of a population-level study on ASD prevalence in Malaysia is a major contributory factor to under-reporting of prevalence in the country. Additionally, lack of access to timely diagnostic services is another factor, given the limited number of healthcare professionals who can provide a confirmatory diagnosis in the country. Differences in screening processes and reporting, as well as limited access may be the cause for the lower reported prevalence in low-middle income countries worldwide.

Children with ASD are often found to have developmental delays in multiple domains (7). It is important to ascertain their overall developmental levels and understand how

they differ from both neurotypical children and children with developmental delay without ASD (8). Review of their developmental profiles will also facilitate the institution of early and appropriate therapy.

There is increasing recognition of the association between ASD and delays in gross and fine motor skills. A study by Mohd Nordin et al. in 2021 found delays in gross and motor skills in children with ASD compared to neurotypical children, with delays more prominent in the older age group (9). Gross motor delays include delayed walking, specific motor difficulties such as hypotonia, apraxia, toe-walking and reduced ankle mobility in children with ASD (10-13). However, some research indicate that motor deficits may be comparable between children with ASD and those with developmental delay without ASD (10). Children with ASD also have poor fine motor control including manual dexterity, handwriting object control, and visuo-motor integration (14). A systematic review on reaching and grasping in ASD showed impairments in reaching and grasping are present early in life (15). This in turn affects planning and execution of motor movements (15). This emphasises the importance of evaluating the motor skills of any child referred for a suspicion of ASD. Additionally, Landa et al.'s (2013) longitudinal study have found that motor developmental trajectories slow down with age (16). Problems with motor praxis, a common comorbidity in ASD, may also contribute to motor delays as higher levels of motor skills involve more complex motor planning and sequencing (17).

For visuospatial skills, evidence shows inconsistent results with some studies reporting superior or intact visuospatial cognition (18, 19) while others have found inferior visuospatial processing (20, 21). Visuospatial processing may be fragmented in persons with ASD, by having more locally or detail oriented perception at the expense of other aspects of visuospatial processing (22). Locally oriented visual perception is important for detailed perception, sharp edges and fine perceptual detail, whereas global visual perception gives information about the general shape, proportions, and large contours of objects (22). Children with ASD as early as ages 3 to 4 years old have been shown to exhibit more detailed perception compared to global patterns (21).

In assessing different developmental domains in ASD, the developmental relationship and interaction between a person and the environment is also an important consideration (23). Exploration promotes learning as new skills emerge from earlier-developing ones and accumulate over time to influence multiple domains of development (24, 25). Motor skills enable exploration, creation of learning opportunities and development of visuospatial cognition (23, 26). Fine motor skills also predict language development, and language development in turn is dependent upon adequate exploration of objects and space, together with social interaction (27). Children with ASD have been found to have abnormal exploration skills, displaying more rotating, spinning, unusual visual exploration, stereotyped, repetitive, restricted use of objects, as well as slower acquisition of skills (28-31). This demonstrates the importance of taking a broader approach in order to understand the association and relationship between different developmental domains.

In summary, studies suggest that children with ASD often have difficulties with gross and fine motor development. Study results for visual abilities in ASD are inconsistent, with some suggesting superior function and others reporting inferior function. In comparison with neurotypical children and children with developmental delay without ASD, children with ASD differ in their motor and visual skills (32). A comparative study on these domains will shed light on the extent of delay in these domains and how they compare with children with DD without ASD. There is also limited research on ASD conducted in the regional context since most studies on ASD have been performed in developed countries (33). Data about this clinical population would be useful in planning of tailored healthcare needs.

This study aimed to explore the difference in visual, locomotor and manipulative skills in children with ASD compared to children with DD without ASD. The objectives were to examine: (i) locomotor, manipulative and visual skills in children with ASD according to their age, sex, ASD severity and cognitive scores, (34) the relationship of these developmental domains with ASD severity, (iii) the differences in visual scores of children with ASD compared to children with DD without ASD, (iv) the differences in motor scores of children with ASD compared to children with DD without ASD.

Methods

Study population

This retrospective study was conducted at University of Malaya Medical Centre (UMMC) in Kuala Lumpur, a tertiary hospital which receives referrals of children with developmental concerns. The centre received approximately 1,500 referrals from January 2017 to August 2020. All children were evaluated at the Developmental Paediatrics Clinic.

The study included all children with a diagnosis of ASD, and children diagnosed with global developmental delay in the absence of ASD, between ages of 24 months to 60 months, from January 2017 to August 2020. The sample was obtained using convenient sampling of all children with the above diagnoses, both new and follow-up cases, that presented to the clinic within the study period and their records reviewed. Diagnosis of ASD was previously confirmed with reference to the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5) criteria through clinical evaluation (including a thorough medical history and physical examination) by either one of the two developmental paediatricians, or developmental paediatrics clinical fellows (paediatricians). ASD severity was obtained from the medical records, as documented by the attending doctors mentioned, at the time of assessment. Children diagnosed with global developmental

delay, in the absence of ASD, will be referred to as the DD group, for brevity. The DD group included children with delays in two or more domains of development, defined as at least two standard deviations (SD) below the mean, and who did not fulfil the criteria of ASD (35, 36).

Exclusion criteria were: (i) age less than 24 months, or more than 60 months, (34) absence of detailed or complete records of the SGS II, and/or (iii) unclear diagnosis. To prevent repetition of cases, children who were evaluated more than once were entered only once and SGS II scores at the earliest assessment date were recorded.

Measures

The Schedule of Growing Skills II (SGS II) is a screening tool used in the Developmental Paediatrics clinic to assess the development of all children under the age of 5 years referred for developmental delay. In Malaysia, the SGS II has been used in studies within the healthcare clinic setting to glean useful information on the development of children with disability (9, 37). The SGS II measures a child's development, from birth to five years old, across ten skill areas, namely: passive posture, active posture, locomotor, manipulative, visual, hearing and language, speech and language, interactive social, self-care social, and cognitive skills. The administration takes around 20 minutes and uses a set of standard stimulus material. The score in each skill area is the sum of the scores of the single most advanced item in each skill set (38). The exception is the cognitive domain, for which a cumulative score is obtained. A study by Williams et al. in 2013 showed that the SGS II has good concurrent validity when compared to the Griffiths Mental Developmental Scales (39). The study used a new scoring method which scores the number of successfully completed items in a domain, as compared to scoring based on the highest item completed, to obtain a developmental quotient (DQ) (39).

Data was extracted from reviewing the patient's medical records. Variables recorded were demographic data (age at diagnosis and gender), diagnosis of ASD (including severity) or DD and SGS II scores. SGS II records included the domains of interest for this study, i.e. locomotor, manipulative, visual and cognitive scores. Raw scores and the corresponding developmental age for the said domains were recorded. All raw scores were converted into DQ scores. DQ was calculated by dividing the developmental age of each domain with chronological age, multiplied by 100. According to the pilot study by Williams et al. (39) of an alternative scoring method of SGS II, a cut-off score to define developmental delay was DQ < 80 for 0-24 month old children and DQ < 85 for children older than 24 month. This study excluded children ages < 24 months, so developmental delay was defined as DQ < 85.

Data analysis

Data was analysed using the Statistical Package for Social Sciences (SPSS) software program. Descriptive analysis with frequencies was used to report demographic data, diagnoses and SGS II scores. To compare means for variables of age, gender and ASD severity for each developmental domain, T-test and one way ANOVA were used. Linear regression was used to compare the difference of visual, manipulative and locomotor domains between 2 groups – ASD and DD. A p-value of less than 0.05 were considered statistically significant.

Results

Study population

Within the study period, a total of 354 records of children diagnosed with either ASD or DD were reviewed. Twenty-nine (29) were excluded due to incomplete SGS II data, 99 were excluded due to ages > 60 months or < 24 months, 27 were excluded due to the presence of only a single developmental domain delay. Referring to Table 1, majority of children presented after age 3 years (81.4%). There was a male preponderance of 75.4% in the total sample and in the ASD group (75.4% and 79.3% respectively). Moderate ASD (Level 2 SCI, Level 2 RRB) had the highest frequency (n = 62, 31.2%).

Table 1: Demographic characteristics of the study population

Groups studied		ASD (n = 150)	*DD (n = 49)	Total (n = 199)
Age at assessment	**Units**			
All ages	Mean [SD]	45.4 [9.0]	43.8 [8.4]	45.0 [8.9]
24-36	N (%)	28 (18.7)	9 (18.4)	37 (18.6)
37-48	N (%)	59 (39.3)	25 (51.0)	84 (42.2)
49-60	N (%)	63 (42.0)	15 (30.6)	78 (39.2)
Gender	Male	119 (79.3)	31 (63.3)	150 (75.4)
	Female	31 (20.7)	18 (36.7)	49 (24.6)
ASD severity	†SCI 1, ‡RRB 1	26 (17.3)		
	SCI 1, RRB 2	6 (4.0)	NA	NA
	SCI 1, RRB 3	0		
	SCI 2, RRB 1	23 (15.3)		
	SCI 2, RRB 2	62 (31.2)		
	SCI 2, RRB 3	1 (0.7)		
	SCI 3, RRB 1	1 (0.7)		
	SCI 3, RRB 2	15 (10.0)		
	SCI 3, RRB 3	16 (10.7)		

*DD represents the developmental delay without ASD group
†SCI = social-communication and interaction deficits
‡RRB = restricted, repetitive patterns of behaviour, interests and/or activities
NA = not applicable

DQ scores within the ASD group

Comparisons of DQ scores were made between age groups, sex and ASD severity for all domains (Table 2). DQ scores across all domains were lower in older age groups. Children in the 24-35 months age group had significantly

higher locomotor and manipulative DQ scores than those in the 36-47 months and 48-60 months age groups. For the manipulative domain, girls had significantly higher DQ scores than boys. Therefore, girls were less delayed in this domain.

Table 2: Comparison of DQ scores between age groups, sex and ASD severity for Locomotor, Manipulative, Visual and Cognitive domains (n = 150)

		Mean DQ scores (SD)							
		Locomotor	**p value**	**Manipulative**	**p value**	**Visual**	**p value**	**Cognitive**	**p value**
Age at assessment (months)	24-35	99.29 (17.07)	**< 0.05**	72.26 (17.25) 63.61 (15.06)	**< 0.05**	87.82 (39.43)	0.059	56.60 (17.64)	0.333
	36-47	84.97 (17.31)		59.89 (21.95)		86.81 (32.72)		52.79 (16.86)	
	48-60	74.56 (19.24)				74.55 (26.62)		50.16 (21.84)	
Sex*	Male	82.52 (18.99)	0.441	61.44 (17.51) 72.18 (22.37)	**< 0.05**	79.94 (32.39)	0.146	50.79 (18.05)	0.084
	Female	86.16 (24.12)				89.16 (30.52)		58.57 (22.61)	
ASD severity	SCI 1, RRB 1	88.37 (19.51)	0.483	77.38 (17.36) 80.71 (24.27)	**< 0.05**	100.52 (21.21)	**< 0.05**	72.86 (16.10)	**< 0.05**
	SCI 1, RRB 2	78.59 (24.82)		- 69.10 (17.13)		96.22 (18.62)		76.84 (17.60)	
	SCI 1, RRB 3	-		62.07 (16.15)		-		-	
	SCI 2, RRB 1	83.48 (19.73)		- -		90.11 (31.37)		57.38 (13.69)	
	SCI 2, RRB 2	83.94 (19.07)		52.00 (15.59) 45.66 (13.75)		83.76 (31.23)		49.09 (14.15)	
	SCI 2, RRB 3	-				-		-	
	SCI 3, RRB 1	83.65				61.79		39.04	
	SCI 3, RRB 2	(23.44) 75.42				(29.69) 50.35		(13.29) 30.45	
	SCI 3, RRB 3	(21.07)				(25.71)		(10.19)	

One-way ANOVA was used for comparison unless stated otherwise.
*Student T-test was used to compare gender differences.

When considering ASD severity, DQ scores were significantly lower for children with more severe ASD in manipulative, visual and cognitive domains, which was an expected finding. There was no difference for the locomotor domain. Chi-square test was performed to look for an association between ASD severity and sex, however there was no significant difference ($p > 0.05$).

Comparison of DQ scores between ASD group and DD group

Table 3 summarises the mean age-adjusted DQ scores for each domain for both groups. Cognitive DQ scores were the lowest, followed by manipulative DQ scores, indicating more severe developmental delays in these two domains. DQ scores were lower in all domains in the DD group compared to the ASD group, with the exception of cognitive scores. Visual DQ scores were the highest among all domains examined, with no statistically significant difference between the two groups. Linear regression analysis revealed that between groups, only the locomotor mean score was significant with a p-value of < 0.05. A multivariate test using multiple linear regression was done, adjusting for age, gender and cognitive scores for the locomotor group to test the difference between groups. The ASD group had a higher mean locomotor score (DQ = 83.27) than the DD group (DQ = 67.13), adjusted for age, gender and cognitive scores.

Prevalence of developmental delay

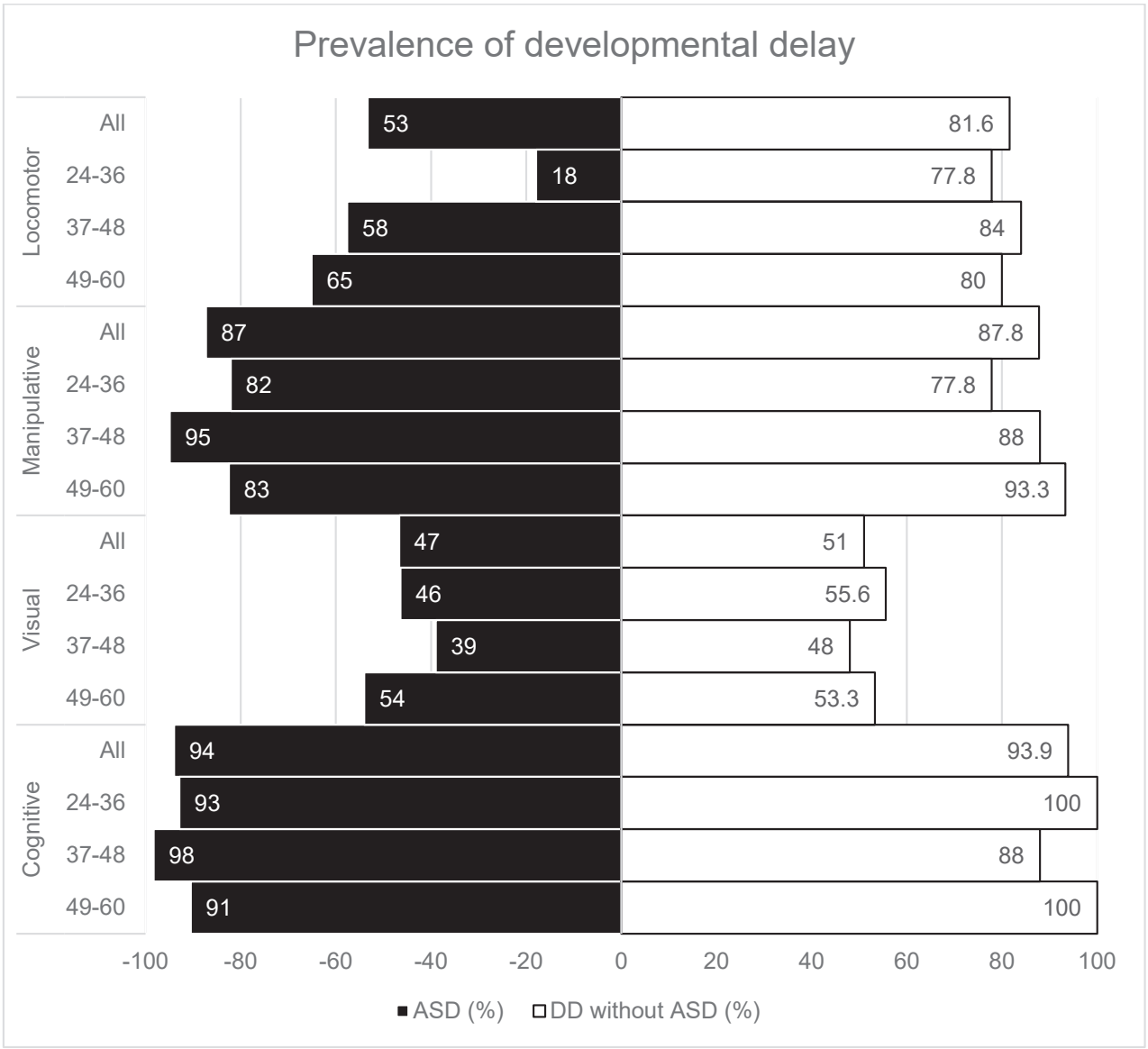
The overall prevalence and the breakdown according to age group are presented in Figure 1. The cut-off point of DQ less than 85 (DQ < 85) was used to define developmental delay for each domain. The cognitive domain had the highest prevalence of delay for both ASD and DD groups, followed by manipulative, locomotor and visual domains. More than half (53%) of the ASD group and 81.6% of the DD group had delays in the locomotor domain. In the manipulative, visual and cognitive domains, there was no statistically significant difference between the two groups. This result is expected because children with ASD also had developmental delays in multiple domains.

Table 3: Descriptive statistics and the SGS II Developmental Quotient (DQ) scores for all patients, the ASD group and the DD without ASD group

Domains	All (N = 199)		ASD (N = 150)		DD* (N = 49)	
	Mean	SD	Mean	SD	Mean	SD
Locomotor[§]	79.30	21.99	83.27	20.12	67.13	23.16
Manipulative	62.71	19.59	63.66	19.04	59.79	21.10
Visual	80.29	32.35	81.85	32.13	75.52	32.90
Cognitive	52.71	19.93	52.39	19.26	53.69	22.05

*DD represents the developmental delay without ASD group
[§]Locomotor mean score was significant with a p-value of < 0.05, using student T-test and multiple linear regression, adjusted for age, gender and cognitive score.

Figure 1: Prevalence of developmental delay according to diagnosis, age group and developmental domain



ASD = autism spectrum disorder
DD = developmental delay without ASD

Discussion

This was a retrospective study exploring different developmental domains in children with ASD and DD without ASD from 24 to 60 months of age. The aims were firstly to explore the non-language developmental domains in children with ASD and examine them according to their severity of ASD. Secondly, the difference in said development between children with ASD and those with DD were explored.

Severity of motor delay with age in ASD

In children with ASD, DQ scores for locomotor and manipulative skills decreased with increasing age, indicating that those who were diagnosed at an older age had more motor delays compared to children who were diagnosed when they were younger. It is possible that those who presented later had not received therapy and intervention during early childhood, resulting in more delays as they grow older. The findings of increased motor delays in older aged children were similar in Mohd Nordin et al.'s study (9). Other studies revealed slowing of motor developmental trajectories with a wider gap between chronological age and developmental performance at older ages (16, 40). Higher levels of motor skills would involve complex motor planning and sequencing, motor organisation, mechanics of movement, in which failure to attain these abilities result in motor delays (17).

Relationship between ASD severity and cognitive delay

When comparing DQ scores within the ASD group, those with more severe ASD had lower manipulative, visual and cognitive scores. Children with more severe ASD commonly have poorer communication skills and more behavioural manifestations, in terms of rigidity, stereotypies and sensory difficulties (1). Their abnormal exploration skills result in slower acquisition of skills (27, 28). Lower cognitive scores on the more severe end of the spectrum are reflected by low manipulative and visual scores that make up most of the 'cognitive score' in the SGS II. Even though a direct comparison cannot be made with other longitudinal studies, similar conclusions could be drawn, whereby more severely affected children with ASD had poorer developmental trajectories (41-43). Szatmari et al.'s study which compared ASD severity with adaptive function found that adaptive function of children with more severe ASD worsened over time (41).

Gender and manipulative scores in ASD

In our study, boys had lower manipulative scores compared to girls ($p < 0.05$). Szatmari et al.'s study in 2015 found that males were more likely to have more severe symptoms of ASD compared to girls (41). Other studies however, did not find any gender differences in visual, fine motor, language or cognitive skills (44, 45). This discrepancy of results may be due to differences in sampling and test tools.

Visual delay in both groups

Among all developmental domains, visual delay had the lowest prevalence for both ASD and DD groups, indicating a relative strength compared to other domains. The relative strength in visual skills is in line with studies which concluded that people with ASD may have superior visual perceptual functioning when processing of details is involved (18, 19, 46). However, other studies found poorer visuospatial processing especially when global visual perception is involved (20, 21). Study by Landa and Garrett-Mayer found that by 24 months, ASD children had delays in all domains, including visual reception, even though there was no delay in visual reception at 14 months (47). One possible explanation for the relatively better visual skills in our ASD cohort was the younger age of children in our study. It is possible that when followed up longitudinally, visual preferences and deficits in visual reception skills may be more apparent. Between groups, ASD had a lower prevalence of visual delay for all ages compared to the DD group, but this difference was not statistically significant. This finding defers from Barbaro and Dissanayake which found poorer visual skills in ASD children when compared to children with learning disability, developmental delay and typically developing children (48).

Locomotor delay in both groups

We found that locomotor scores were significantly lower in the DD group compared to the ASD group. The prevalence of locomotor delay was also higher in the DD group. In the DD group, locomotor delay presented earlier at age 24 to 36 months. This may be due to the cohort of patients in the DD group, with diagnoses including prematurity, cerebral palsy, genetic syndromes, global developmental delay and hearing impairment, that typically presents with early motor delay, with the exception of hearing impairment. This finding differs from Provost et al.'s study in 2007, which found no difference in motor delays in both children with ASD and children without ASD with developmental delay (10). Secondly, the lower prevalence of locomotor delay in the ASD group may be due to limitations of locomotor testing using the SGS II. The SGS II quantifies locomotor delay by assessing important gross motor milestones but does not record qualitative abnormalities. Apart from delay in motor development, motor problems in ASD can manifest as abnormalities of motor function, including stereotypic movements such as rocking, spinning and unusual gait patterns (e.g. walking on tiptoes) and poor motor imitation. Ming et al. (11) described the presence of hypotonia and apraxia in a large proportion of an ASD cohort. These motor function abnormalities are not components of the SGS II assessment. Other studies, however, found no significant difference in motor skills between these groups (10, 16, 49).

Limitations

The findings of this study need to be interpreted in light of its limitations. Firstly, this is a single-centre study that may not represent the population of children with ASD

and those with DD in Malaysia. Secondly, measures of development and severity of ASD are not fully comparable to other studies that used standardised diagnostic tools such as the Bayley Scales of Infant and Toddler Development for developmental scores and the Autism Diagnostic Observation Schedule, 2nd Edition (ADOS-2) for ASD severity. Limitations in the Malaysian setting, such as lack of persons trained in these assessment tools, lack of resources to purchase the tools, and time constraints in the outpatient clinic setting to utilise these tools contribute to the difficulties of using such standardised materials. In addition, key findings were limited in timeline due to the retrospective study design. Thus, the findings cannot be directly compared to the results of longitudinal studies. Finally, developmental age (DA) scores in this study are expected to be an overestimation of scores as compared to the Williams et al.'s study in 2013 (39). The study described a new scoring method whereby the number of successfully completed items were added and converted into a developmental age (DA) score (39). This study followed the recommended guidelines from the manual where the score of the highest item completed was added and converted into a DA score for each domain. Furthermore, our findings require replication on a larger scale. If studied longitudinally, it will allow a better understanding of the trajectory of development in relation to ASD severity.

Nonetheless, this study does inform practice as the findings reveal new information in a Malaysian context that motor delays, while present in children with ASD, are present to a lesser extent than in children with only DD. This contributes to the limited available information on the ASD and DD cohorts in the country and region.

Conclusion

In conclusion, results from this study identified the strength of locomotor skills in children with ASD compared to DD without ASD. Children with more severe ASD were found to be delayed in cognitive, manipulative and visual skills. Thus, for children with milder features of ASD, the relatively stronger locomotor skills may mask the emergence of developmental red flags that would otherwise be detected during developmental screening. Additionally, the less delayed development in the mild ASD group for the other domains (cognitive, manipulative and visual skills) may further delay the age of presentation with broader developmental concerns in ASD. Therefore, clinicians must be particularly vigilant for ASD features, as diagnosis may be missed if the focus is only on overall delayed development. Girls appeared to have stronger manipulative skills compared to boys. The reason for this is unclear. The current findings contribute to the larger body of literature on the non-language components of the developmental profiles of young children with ASD and DD.

Competing interests

The authors declare that they have no competing interests.

Ethical clearance

We obtained approval from The University of Malaya Medical Centre Research Ethics Committee, registered under MREC ID No.: 202093-9039.

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