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RESEARCH ARTICLE

Evaluation of Visual Acuity (VA) in Children with Autism Spectrum Disorder (ASD): A Comparison of Different Vision Charts

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Abstract:

Background:

Children with autism spectrum disorder (ASD) have a significant risk of vision and eye disorders. Conversely, there is little information available for eye care professionals regarding the best method for assessing visual acuity in autistic children.

Objectives:

The aim of this study was to evaluate the different visual acuity charts in children with ASD.

Methods:

The study was a comparative perspective conducted among children with ASD, in 2022 in the Qassim region, Saudi Arabia, and included thirty children aged 5 to 12 years. Measurement of visual acuity on three charts; Snellen tumbling E, LEA symbols, and pediatric picture-colored were obtained from the children who met the inclusion criteria of the study. Paired t-test analysis was used to compare the mean findings from the three visual acuity charts, and significance levels were established at $p = 0.05$.

Results:

The mean and standard deviation of visual acuity (VA) obtained from children with ASD by the three charts ranged from (0.86 ± 0.19) to (0.72 ± 0.22); the pediatric picture-colored chart had the highest, and the tumbling E chart had the lowest vision score. There was a highly significant difference in VA obtained by three charts, $P \leq 0.05$. Conversely, there was no significant difference in VA obtained while using Lea Symbol and pediatric picture-colored chart, $P = 0.950$. The effective communication levels of children were examined by the tumbling E, Lea symbol, and pediatric picture-colored VA charts, which were 33.3%, 50.0%, and 60%, respectively. The communication level of children with ASD was extremely significantly associated with examination difficulties, $P = 0.0001$.

Conclusion:

There was a highly significant difference in visual acuity obtained from autistic children using three vision charts. Most of the autistic children with effective communication and half of the children with poor communication levels successfully completed the pediatric picture-colored VA charts. Thus, understanding the autistic child's ability to communicate and respond to vision charts is important in selecting and administering visual acuity and other subjective eye examinations.

Keywords: Autism spectrum disorder, Visual acuity charts, Pediatric picture-colored chart, Lea symbol, Autism, Vision.

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1. INTRODUCTION

Autism spectrum disorder (ASD) is a common neurodevelopmental anomaly affecting children, with about 2% occurrence in the populace [1]. The condition is commonly associated with deficits in socialization and communication, as well as uncommon performances or interests [1, 2]. The disorder negatively affects the children and family. Thus, timely diagnosis and intervention could help maximize the quality of life and productivity [2]. The causes of autism remain unidentified, with several studies [3 - 5] highlighting genetic roots and others emphasizing possible epigenetic and ecological factors. Previously published studies [6, 7] reported that ASD is four times or more frequently diagnosed in males. This finding highlights the strong genetic factor of the disorder.

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Grandin [8] reported that there are three visual processing systems in the brain of autistic children. The first is photo-realistic visual thinkers. In this type, all thoughts are expressed in photo-realistic images. While the second type is pattern thinkers, which contain music and the math mind. The final type is the word and fact thinkers, characterized by a strong memory of linguistic facts and a varied range of subjects. Quill [9] reported that visual aids in two or three dimensions can be processed more quickly by autistic children, whereas Grandin [8] showed that it is significantly more difficult for children with ASD to recognize text that does not have an association with pictures. Regarding the above-mentioned information about the visual processing system in children with ASD and their interaction with pictures and color, eye care professionals should assess the communication levels of autistic children with different visual acuity charts that contain pictures and color.

A previously published study on autistic children showed that 40% of autism had ophthalmic disorders, such as refractive error, amblyopia, or strabismus [10]. Another study conducted in Turkey showed that 22% of ASD had a considerable refractive error, and 8.6% had strabismus. The authors recommended that comprehensive eye examination by eye care providers is essential for all children diagnosed with ASD [9]. It is clear from previous studies [10, 11] there was a high prevalence of eye problems among children with ASD. This could be due to poor communication with the ophthalmological investigations, resulting in a lack of eye coverage for autistic children, which can impact their previously impaired social and communication skills.

Visual acuity (VA) test considers the main clinical indicator of how well the visual system can resolve and distinguish a detailed objective [12]. Thus, the prominent level of VA suggests a normal visual pathway from the photoreceptor in the retina to the visual cortex [12 - 14]. Milne *et al*. [12] conducted a study to compare the vision function of autistic and normal children. They reported that the autism group had poorer VA in both eyes compared with the normal children. Children with ASD commonly have difficulties in social interaction and verbal and non-verbal communication. As a result of these difficulties, children with ASD could be unable to cooperate well with VA examinations and other subjective eye tests [15]. Lindly *et al*. [16] reported that children with ASD did not meet the minimal standard guidelines for visual function examination by eye care providers. Autistic Children are considered among the people who need exceptional care in dealing with and coexisting with them, and sight is especially important during this development period [15 - 17]. There is little information available for eye care professionals regarding the best method or modified procedure for VA examination of children with ASD. Therefore, the current study was conducted to assess the VA in children with ASD and to compare the results of three visual acuity charts in children with ASD in the Qassim region of Saudi Arabia.

2. MATERIALS AND METHODS

2.1. Study Design and Setting

The study was a comparative-cross-sectional prospective conducted on children with ASD in autism centers between February and May 2022 in the Qassim region of Saudi Arabia.

2.2. Sample

This study used a non-probability sampling technique, where 30 autistic children were selected from the Qassim region, whose mean age was 8.87 ± 1.79 ranging from 5 to 12 years. Males were 23 and females were 7. Measurement of VA was obtained by three VA charts, Snellen tumbling E, LEA symbols matching cards, and pediatric picture-colored charts, from children with ASD who met the inclusion criteria of the study.

2.3. The Inclusion and Exclusion Criteria

The inclusion criteria for the study were children with ASD aged 5 to 15 years, and their parents agreed to participate in the study. Whereas the exclusion criteria were any other associated disorders with ASD, such as systemic diseases and syndromes.

2.4. Ethics Approval

Ethical approval for the study was obtained from the Qassim University Ethics Committee under approval number (23-30-0), and the study was conducted according to the Declaration of Helsinki guidelines. Inform consent was obtained from all parents of autistic children, and the aim of the study if any associated risks following VA examination were explained to them. The collected information was saved confidentially, and no individual data was obtained. The study sample participated freely; they could retract from the study at any time without giving a reason.

2.5. Data Collection Procedures

After taking the child's visual system and family history, the examiner conducted external examinations, such as red reflex testing to assess the ocular media and strabismus, pupil examination, assessment of the ocular fundus using an ophthalmoscope, and evaluation of visual function. The data were collected by an eye care provider with experience in dealing with children with special needs with the assistance of a teacher who teaches children with ASD. The clinical information was gathered using three VA charts, namely, Snellen tumbling E, LEA symbols matching cards, and pediatric picture-colored charts. The pediatric picture-colored VA chart was designed to check the color vision defect and, at the same time, to assess VA, while the 6/6 line of the test chart contained a black picture with a white background. This VA chart was manufactured by Ennovation, USA [18].

In this study, the VA charts of the three tests were set at 3 meters rather than 6 meters as standard. This testing distance for children is recommended by the American Association of Pediatric Ophthalmology and Strabismus [19]. This study used a distance of 3 meters to enhance interaction between the child with ASD and the examiner. In general, the eye care practitioner assesses the VA charts according to the time taken for each vision chart, the response time of the child during the examination, and the understanding of the tests by the children. During the VA examination process, the examiner assesses the level of child communication on each VA chart and rates it as

good, moderate, and poor. The difficulties facing the eye care practitioner during VA measurement by different vision charts were also recorded as difficult, moderate, and easy.

2.6. Data Analysis

The data entry was done by the principal investigator using an Excel sheet, and analysis was done by Statistical Package for the Social Sciences (SPSS Version 24). The information was corrected for data entry errors and/or missing values before analysis. The data for everyone were analyzed descriptively using standard deviations, mean, variants, and percentages. The relationship between measures was determined using cross-tabulation and chi-squares analysis. Paired t-tests were used to compare the mean findings from the diffident VA charts, and significance levels were established at p = 0.05.

3. RESULTS

3.1. Descriptive Statistics

Of thirty autistic children aged between 5 to 12 years, 23(76.7%) were males, and 7(23.3%) were females with a mean age of 8.87 ± 1.79 years who met the inclusion criteria of this study. The Shapiro–Wilk test showed that the ages of children with ASD were distributed normally with P = 0.245. The mean and standard of the VA measurements by the three charts ranged from (0.86 ± 0.19) to (0.72 ± 0.22); the pediatric picture-colored VA chart gave the highest vision score, while the tumbling vision chart had the lowest score, as shown in Table **1**.

3.2. The Difference in the VA Measurements for the Right Eye between three Different Test Charts

Using the repeated measures test, the findings showed that there was no significant difference in VA obtained from autistic children by using the tumbling E and Lea symbol VA charts, P=0.148. Furthermore, there was a highly significant difference between tumbling E and pediatric colored VA charts, P=0.014. Conversely, there was no significant difference in VA obtained from autistic children when using Lea Symbol and pediatric colored VA charts, P= 0.950, as shown in Table **2**.

Table 1. Descriptive statistics of visual acuity in decimal of autistic children measured by three different vision charts.

Statistics	Tumbling Eye Chart VA (in decimal)		Lea Symbol Chart VA (in decimal)		Pediatric Colour Chart VA (in decimal)	
-	RE	RL	RE	RL	RE	RL
Means	0.72	0.72	0.81	0.82	0.86	0.85
Standard deviations	0.22	0.22	0.21	0.20	0.19	0.19
Skewness	0.33	0.28	0.43	0.43	0.43	0.43
Kurtosis	-1.6	-1.7	-1.6	-1.4	-0.88	-0.50
Variance	0.05	0.05	0.04	0.04	0.03	0.03
Minimums	0.5	0.5	0.5	0.5	0.5	0.4
Maximums	1	1	1	1	1	1

Abbreviations: VA= Visual acuity, RE= Right eye, LE = Left eye

Table 2. Repeated measures to show the difference in the VA measurements for the right eye between three VA charts.

(I) VA Chart	(J) VA Chart	Mean Difference (I-J)	Std. Error Mean	P-value	95% Confidence Interval of the Difference	
					Lower Bound	Upper Bound
Tumbling E	Lea Symbol	-0.087	.042	0.148	-0.194	0.021
	Paediatric Color	-0.137*	.052	0.041	-0.269	-0.005
Lea Symbol	Tumbling E	0.087	.042	0.148	-0.021	0.194
	Paediatric Color	-0.050	.049	0.950	-0.175	0.075
Paediatric Color	Tumbling E	0.137*	.052	0.041	0.005	.0269
	Lea Symbol	0.050	.049	0.950	-0.075	0.175

Table 3. Communication levels of autistic children and VA examination difficulties by tumbling e chart.

Chrematistics		Communication with Tumbling E Chart			P-value	Total N (%)
		Poor N (%)	Moderate N (%)	Good N (%)		
Examination difficulties	Easy	0(0.0)	1(12.5)	7(70)	**0.000**	8(26.7)
	Moderate	0(0.0)	7(87.5)	2(20)		9(30.0)
	Difficult	12(100)	0(0.0)	1(10)		13(43.3)
Total		**12(40.0)**	**8(26.7)**	**10(33.3)**	-	**30(100)**

Table 4. Communication of autistic children and vision examination difficulties by Lea Symbol chart.

Chrematistics		Communication with Lea Symbol VA chart			P-value	Total N (%)
		Poor N (%)	Moderate N (%)	Good N (%)		
Examination difficulties	Easy	1(16.7)	4(44.4)	13(86.7)	**0.000**	18(60.0)
	Moderate	0(0.0)	5(55.6)	1(6.7)		6(20.0)
	Difficult	5(83.3)	0(0.0)	1(6.6)		6(20.0)
Total		**6(20.0)**	**9(30.0)**	**15(50.0)**	-	**30(100)**

Table 5. Communication level of autistic children, VA examination difficulties by Paediatric picture-colored VA chart.

Chrematistics		Communication with Paediatric picture-colored VA chart			P-value	Total N (%)
		Poor N (%)	Moderate N (%)	Good N (%)		
Examination difficulties	Easy	2(50.0)	2(25.0)	17(94.4)	**0.0001**	19(63.3)
	Moderate	2(50.0)	6(75.0)	1(5.6)		9(30.0)
	Difficult	0(50.0)	0(0.0)	0(0.0)		2(6.7)
Total		**4(13.3)**	**8(26.7)**	**18(60.0)**	-	**30(100)**

3.3. Communication Levels of Autistic Children and VA Examination Difficulties by Tumbling E Chart

The VA assessment by Tumbling E chart showed that 12 (40%) of autistic children had poor communication, whereas 10 (33.3%) showed effective communication. All children 12 (100%) with poor communication had difficulties in the VA examination. However, 7 (70%) with effective communication easily completed the vision examination. The communication levels of autistic children were highly significantly associated with examination difficulties, P= 0.0001, as shown in Table **3**.

3.4. Communication of Autistic Children and VA Examination Difficulties by Lea Symbol Chart

Assessment of the VA of autistic children by Lea Symbol chart showed that 15 (50.0%) had effective communication and only 6 (20%) had poor communication. Most children with effective communication 13 (86.6%) easily completed the VA test, while only one child with poor communication easily went through the vision examination. The communication of autistic children was highly significantly associated with examination difficulties, P=0.0001, as shown in Table **4**.

3.5. Communication of Autistic Children and VA Examination Difficulties by Paediatric Picture-colored Chart

Measurement of the VA by the pediatric picture-colored VA chart for children with ASD showed that 18 (60.0%) had effective communication, and most of them, 17 (94.4%), easily completed the vision examination. Whereas only 4 (13.3%) of the children showed poor communication with pediatric picture-colored VA charts, and half of them, 2 (50.0%), had moderate difficulties during vision assessment. The communication level of children with ASD was highly significantly associated with examination difficulties, P= 0.0001, as shown in Table **5**.

4. DISCUSSION

Children with ASD have a considerable risk of vision and eye disorders. Until now, little is known about their eye care, particularly visual function examinations. Despite recommendations for children with ASD to receive routine comprehensive vision examinations by eye care professionals, such as optometrists and ophthalmologists, nowadays, children with autism have many communication barriers to accessing eye care services. From an educational perspective, Quill [9] stated that a normal visual system could help autistic children to learn and communicate more efficiently in their community and environment by taking advantage of their natural ability to study visually. Thus, this study was performed to assess the VA in children with ASD and to compare different vision charts. Our findings showed that the pediatric picture-colored chart had the highest and the tumbling E chart had the lowest vision score obtained from autistic children. There was a highly significant difference in VA obtained from autistic children using three VA charts, P≤0.05. Conversely, there was no significant difference in VA obtained while using Lea Symbol and pediatric picture-colored VA chart, P= 0.950.

In a retrospective chart review study conducted among autistic children, the finding showed that only 40% of children were cooperative for recognition VA testing [8]. Whereas in the current study, the effective communication levels of children while tested by tumbling E, Lea symbol, and pediatric picture-colored VA charts were 33.3%, 50.0%, and 60%, respectively. This means that the autistic children had effective communication and cooperation with pediatric picture-colored VA charts. This finding agrees with Grandin [8], who reported that children with ASD have a visual processing system called photo-realistic visual thinkers; in this type, all thoughts are expressed in photo-realistic images. A previously published study reported that visual learning is responsible for about 83% of accompanying knowledge for typical children [20]. Furthermore, Quill [9] revealed that visual supports in two or three dimensions could be treated more rapidly in children with

ASD than brief information like hearing stimuli. Thus, understanding the autistic child's ability to communicate, attend to, and respond to VA charts is important in selecting and administering VA and other eye subjective examinations.

Furthermore, our findings showed that the communication of children with ASD was highly significantly associated with examination difficulties, P= 0.0001. Our findings agreed with Coulter *et al*., who reported that children with ASD can complete the visual acuity examination, but there were some difficulties, particularly for nonverbal children and children with poor communication [14]. Coulter *et al*. revealed that in assessing VA, all children who were fluent and had effective communication completed the Snellen tumbling E VA chart. However, only half of the children with poor communication or who were nonverbal were able to complete the Snellen tumbling E chart [14]. In our study, only 16.7% of children with poor communication were able to complete the Lea Symbol chart. In comparison, half of the children with poor communication were successfully able to complete the pediatric picture-colored VA charts.

Scharre and Creedon [19] conducted a study to assess VA in children with autism, they showed that binocular VA was measured with the acuity card method, and monocular VA was not assessed. In our study, the VA was measured monocularly with three test charts, and no difference was found between the two eyes. A previously published study used Crowded Log MAR to assess the VA in autistic children. It indicated that for children who were not capable of naming letters, their VA was measured with the Kay picture chart [12]. The findings showed that most autistic children had significantly poorer VA in both eyes compared to the control group [12]. These findings support our results, showing that autistic children preferred the color-picture VA chart more than the tumbling E VA chart. Previously published reports to explain the predictable vision levels for autistic children were compared to a typically developing control group. The findings showed no significant difference in VA between children with and without ASD [21]. These agreed with our findings that most autistics had normal VA, but there was a significant difference in vision obtained by the three visual acuity charts.

5. LIMITATIONS

The current study has some limitations, the sample size included was small, and this is due to the limited for autistic centers in the Qassim region, and only two have cooperated with our research team. During data collection, some children with ASD were uncooperative. Our study used a comparative design. In future studies, it is better to implement the control group. Despite the stated limitations above, the present study assessed VA for children with ASD with three different vision charts and showed the comparison between them.

CONCLUSION

There was a highly significant difference in visual acuity obtained from autistic children using three visual acuity charts. Most of the children with effective communication and half of the children with poor communication were successfully able to complete the pediatric picture-colored VA charts. Thus, understanding the autistic child's ability to communicate and respond to vision charts is important in selecting and administering visual acuity and other eye subjective examinations.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Ethical approval was obtained from the Qassim University Research Ethics Committee (approval no. 23-30-0).

HUMAN AND ANIMAL RIGHTS

No animals were used in this research. All the procedures involving human participants were in accordance with the 1975 Declaration of Helsinki, as revised in 2013.

CONSENT FOR PUBLICATION

Informed consent was obtained from all subjects, and the aim of the study was explained to them. The collected data were saved confidentially, and no individual information was obtained.

STANDARDS OF REPORTING

COREQ guidelines were followed.

AVAILABILITY OF DATA AND MATERIALS

The data and supportive information are available within the article.

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None declared.

CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

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