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Visual Functional Assessment in Children and Young Adults with Refractive Errors

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Abstract

Background: Normal visual functioning depends not only on patient's visual acuity but also on many other parameters, such as the visual fields, perception of colour, contrast and visual skills. Clinically, objective measurements, such as those of acuity or the visual fields, provide an assessment of a patient's visual status but do not reflect the degree of visual impairment that the patient experiences in his or her daily activities sufficiently. Impairment of vision affects the quality of life which is related to health, and affects the daily activities of life, including social activities. The efficacy of interventions should be validated by patient's visual functions and by assessing visual or impact of visual impairment on daily activities. *Aim:* To evaluate visual functions and performance among children and young adults with refractive errors and to assess the effectiveness of ophthalmological interventions on visual functional improvement. *Materials and Methods:* The participants in this study comprised children and young adults with refractive errors, aged 5-30 years, attending the low Vision and paediatric ophthalmology department at Institute of Ophthalmology, Joseph Eye Hospital, Tiruchirappalli. Data relating to distant visual acuity, near visual acuity, ocular examination, refraction after cycloplegia, near vision, contrast sensitivity; colour vision, field of vision and functional visual assessment were collected and reviewed after refractive correction. *Results:* The comparison of visual functions and functional skills in children and young adults with refractive errors showed that individuals in low vision groups had reduced visual functions even with best corrected visual acuity than the individuals in normal vision group. There was a statistically significant difference in uncorrected visual acuity, best corrected visual acuity, colour vision, contrast sensitivity, stereopsis, near point of accommodation, near point of convergence etc. between Group 1(patients with vision $\geq 6/18$) and Group II(patients with vision<6/18). Functional skills like reading speed, writing speed and mobility were also reduced in low vision groups that shows statistically significant difference between Group 1 and II and also had significant difference among subgroups of Group 1 and II. None of the patients had age appropriate functional skills in Group 1 and Group II. After using interventions (like optical and non-optical aids) for 6 months, there was a statistically significant improvement in BCDV, functional skills between first visit and follow-up visit and had significant differences among subgroups. But none of the individuals in Group 1and II had age appropriate functional skills. *Conclusion:* The present study had shown that in spite of improved clinical and functional vision with interventions, at short term follow-up, the visual skills required, were not age appropriate, both at initial and at also follow-up visit. Hence, functional vision parameters should be monitored as a criterion to determine the quality of vision in those with refractive errors especially in the paediatric age group.

Keywords: Refractive Error; Visual Function; Paediatric and Young Adults.

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Introduction

The World Health Organisation (WHO) and VISION 2020 report states that uncorrected refractive errors (43%), unoperated cataract (33%), and glaucoma (2%), are the important causes of blindness and low vision globally. Of these, refractive errors has been identified as one of the main cause of visual impairment in children and young adults, leading to drastically reduced productivity, educational opportunities and quality of life. According to the WHO (2011), Low Vision is defined as the best corrected visual acuity (BCDV) less than 6/18 to light perception or visual field of less than 10 degree in the better eye after the best possible correction [1].

According to WHO (2012) estimates, approximately 285 million people across the world live with low vision and blindness. Out of this estimation, 39 million people are blind and 246 million live with moderate to severe visual impairment. Of the latter, 145 million of the visually impaired people suffer from uncorrected refractive errors, where restoration of normal vision can be done with the help of optical devices such as spectacles [2].

Normal visual functioning depends not only on patient's visual acuity but also on many other parameters, such as the visual fields, perception of colour, contrast and visual skills [3]. Clinically, objective measurements, such as those of acuity or the visual fields, provide an assessment of a patient's visual status but do not reflect the degree of visual impairment that the patient experiences in his or her daily activities sufficiently [4].

Low vision is characterised by changes in visual functions such as decreased visual acuity, stereo acuity, contrast sensitivity, brightness perception, abnormal contour interaction. These visual functions can be reduced even in people with normal vision and are highly compromised in low vision.These visual parameters determine the quality of vision that are used in daily tasks such as reading and writing, especially in the school and college years [5].

Amblyopia is one of the preventable causes of low vision. In amblyopia, the visual acuity is reduced. Interestingly, patients with amblyopia have improvement in the visual acuity by one or two lines when examined through a neutral density filter but patients with organic lesions have further worsening of visual acuity. Second, patients with amblyopia have reduced visual acuity when examined with multiple letters in the charts than by using single letter charts and this is named as crowding phenomenon [8].

It has been documented that there is no correlation between subjective complaints and objective measurements of difficulty in patients with visual impairmentThere is a paucity of literature on how functional visual performance improves with correction of refractive errors. The improvement of visual functions after correction of refractive error has been inferred based on improvement in visual acuity only [7].

In general, visual impairment and low vision affects the visual functioning of a person in areas like orientation and mobility, in day-to-day communication skills, with the daily living activities and prolonged near tasks such as reading. The effect on these four areas depends on the type and degree of impairment [9]. Visual impairment also affects various aspects of life which include a person's educational status, occupation and leisure activities.

Impairment of vision affects the quality of life which is related to health, and affects the daily activities of life, including social activities. The efficacy of interventions should be validated by patient's visual functions and by assessing visual or impact of visual impairment on daily activities [9].

Children and young adults with low vision have different needs from that of their peers, necessitating residual vision enhancement. Residual vision can be enhanced by thorough clinical assessment and correction of refractive errors by glasses or contact lenses. These patients should also be trained to use optical and non-optical aids if needed, through adaptation of environment and teaching methods. This is very important especially in children, because any delay in development of visual skills will affect their education. Early referral and intervention have great potential to impact on visual outcome as well as on participation in family, school and community life [10].

As of today most of the studies done on refractive errors was on assessing the prevalence of the problem and its associated illness only very few studies had been done on assessing the visual function among the refractive error children so this study was done to identify the differences in visual funcions like visual acuity, contrast sensitivity, colour vision, stereopsis, visual fields etc in patients with refractive errors between individuals with normal best corrected visual acuity and individuals suffering from visual impairment.

Aim

To assess the visual functions among children and young adults with refractive errors and to evaluate the interventions made on them.

Materials and Methods

A prospective comparative study was conducted at the out-patient department of Institute of Ophthalmology, Joseph Eye Hospital, Tiruchirappallifor a period of one year after getting the clearance from the institutional ethical committee. All patients aged 5-30 years presenting with refractive error were included for the study. Patients with features of strabismus/anisometropic amblyopia; refractive errors <0.5 D (sphere/ cylinder); nystagmus; any previous ocular surgeries or pathology were excluded from the study. The patients were divided into two groups. Group 1, were those with best corrected visual acuity (BCVA) > 6/18 (in both eyes) (50 patients), Group1 subgroup A consisted of those presenting for the first time while subgroup B consisted of those already using interventions. Group 2, were those with (BCVA) <6/18(in both eyes) (50 patients); Group 2 subgroup A consisted of those presenting for the first time while Group 2 subgroup B consisted of those already using interventions. All eligible patients underwent a complete clinical and visual function assessment and were prescribed interventions. Clinical and visual function assessment include examination of the anterior segment by slit-lamp biomicroscopy and posterior segment by fundus examination, presenting and best corrected visual acuity testing by log MAR charts for both distance and near vision; refraction; contrast sensitivity testing by Lea's low contrast numbers; visual field testing by Bjerrums; colour vision by Farnsworth D 15; testing of visual skills such as reading and writing speed, stereopsis by TNO cards and binocular single vision parameters by synoptophore, near-point of accommodation and near-point of convergence by RAF ruler.

Interventions prescribed included; prescription of distance and near correction; optical and non-optical devices; and environmental modifications. All cases were reviewed after 6 months and their visual skills like reading and writing speed were evaluated at follow up. The data were entered and analysed by using SPSS version 21. Mean and standard deviation were derived for all the parametric variables. Chi-square test with Yates correction and Mann-Whitney U test and Wilcoxon sign rank test was applied for assessing the statistical significance between the groups.

Results

Table 1 shows the age wise distribution of the study population. The minimum age of the study subjects was 6 years and the maximum age was 30 years. Majority of the study subjects were in the age group between 10–20 years and the mean age ranges between 10–15 years. In the intra-group comparison there is a statistically significant difference between group 2A and 2B among the age group distribution. Females were found to be more in number than males in group I whereas males were more among group II and the difference was found to be statistically significant. Among the intra-group comparison there was almost equal distribution between males and females (Table 2).

Among the various refractive errors which were presented between the two groups, myopia was found to be more common among group I (52%) and compound myopic astigmatism (52%) was found to be more common in group II patients and the difference between the two groups was found to be statistically significant ($p<.05$) (Table 3). The mean spherical equivalent was found to be of high dioptres in group II when compared to group I and the difference was found to be statistically significant and among the intra-group comparison between group I, it was high in group IB when compared to group IA and the difference was statistically significant, whereas intra-group comparison among group II did not show a statistically significant difference (Table 4).

The various interventions prescribed to the patients enrolled in the study was tabulated in table 5. Prescription of new glasses was the most common intervention done for most of the patients in group I, whereas in group II few patients were prescribed magnifiers, lamp, telescope and bifocals. No statistical significant difference was observed in the type of intervention between inter-group and intra-group (Table 5). Table 6 shows the various clinical parameters related to refractive errors and colour vision measured among the two groups. All the parameters showed a statistically significant difference between the two groups, whereas between the intragroup comparisons there was no statistical significant difference among any of the parameters.

Table 7 shows the functional vision assessment among the study subjects. It is inferred from the table that mean reading speed and mean writing speed were better among group I patients when compared to group II and the difference was statistically significant ($p<.05$). The comparison of the clinical and functional visual parameters between the initial and follow-up (after 6 months) visit among the intra and inter group shows that there is no statistically significant difference in the clinical parameters (p>.05), whereas among the functional parameters there is a statistically significant difference (p<.05) in the initial and follow-up visit among both inter and intra group (Table 8).

Table 1: Age wise distribution of the study population

Age Group	Group I A (n=25)	Group I B (n=25)	Group II A (n=25)	Group II B (n=25)
<10	6 (24%)	4 (16%)	13 (52%)	6 (24%)
10 – 20	14 (56%)	15 (60%)	10 (40%)	15 (60%)
21 – 30	5 (20%)	6 (24%)	2 (8%)	4 (16%)
Mean ± SD	15.8 ± 7.1	16.2 ± 5.8	10.0 ± 5.9	15.0 ± 6.7
P value (Mann-Whitney U test)	Group 1A vs 1B U=292, P=0.690		Group 2A vs 2B U=170, **P=0.006**	

Table 2: Gender wise distribution of the study population

Study group	Males	Females	P value (Chi-square test)	P value (between group I and group II)
Group I A (n = 25)	11 (44%)	14 (56%)	1.000	**<.01**
Group I B (n = 25)	11 (44%)	14 (56%)		
Group II A (n = 25)	19 (76%)	6 (24%)	0.538	
Group II B (n = 25)	17 (68%)	8 (32%)		

Table 3: Refractive errors presented between the two groups

Refractive Errors	Group I (n=50)	Group II (n=50)	P value (Chi-square test)
Myopia	26 (52%)	10 (20%)	**<.01**
Hypermetropia	1 (2%)	4 (8%)	**0.0318**
Myopic astigmatism	12 (24%)	8 (16%)	**0.0281**
Compound myopic astigmatism	9 (18%)	26 (52%)	**<.01**
Compound hypermetropic astigmatism	2 (4%)	1 (2%)	0.319
Mixed astigmatism	0	1 (2%)	0.182

Table 4: Mean spherical equivalent in both eyes of the individuals enrolled in the current study

Groups (no.of individuals)	Mean Spherical Equivalent (dioptres)	Statistical analysis (Mann-Whitney 'U' test)	Subgroups (no.of individuals)	Mean Spherical Equivalent(dioptres)	Statistical analysis (Mann-Whitney 'U' test)
Group 1 (50)	-1.85±1.94	U=679, **P<0.000**	1A(25)	-1.2±2.85	U=173.5, **P=0.007**
			1B(25)	-2.50±2.75	
Group 2 (50)	-5.9±7.85		2A(25)	-5.9±7.8	U=279.5, P=0.5.
			2B(25)	-5.9±8.5	

Table 5: Interventions prescribed to the individuals enrolled in the study

Interventions	Group 1 1A	Group 1 1B	Statistical analysis	Group 2 2A	Group 2 2B	Statistical analysis(Chi-square test)
Glasses	25	22	Yates'=1.42,P=0.23.	25	24	{x^2 [d.f=1]=1.020, P=0.312}
Same glasses	0	3		0	1	
			Low Vision Aids			
CCTV	0	0	No significant difference.	0	2	(x^2 (d.f=4)=7.754, P=0.2
Magnifiers	0	0		1	1	
Lamp	0	0		2	1	
Telescope	0	0		2	0	
Bifocals + Lamp	0	0		3	0	

Table 6: Evaluation of clinical parameters in both eyes of the individuals between the two groups

Clinical parameters (In both eyes)	Group I	Group II	P value
BCNV (logMAR units)	0.63±0.00	1.22 ±0.73	**<.0001**
BCDV (logMAR units)	0.03 ± 0.09	0.61 ± 0.13	**<.0001**
Confusion angle (degrees)	69.04± 7.30	21.13±60.16	**<.0001**
Contrast sensitivity	18.50±4.50	7.00±5.43	**<.0001**
Stereopsis (arc secs)	76.80±34.37	195.6±137.04	**<.0001**
Fusional range (degrees)	14.78±2.45	15.82±3.53	**<.0001**
NPC (cms)	11.18±2.00	9.82±2.33	**<.0001**
NPA (D)	11.18±2.00	9.52±2.53	**<.0001**

BCNV – Best corrected near vision
BCDV – Best corrected distant vision
NPC – Near point of convergence
NPA – Near point of accommodation

Table 7: Assessment of functional vision among the study subjects

Functional Parameter	Group I	Group II	P value	Intra Group Comparison		P value
No. of individuals with dependent mobility in unfamiliar places	0	26	<.0001	IA	0	0
				IB	0	
				II A	14	0.571
				II B	12	
Mean reading speed(words/min)	86.22±20.03	29.06±20.34	<.001	IA	83.40 ± 21.80	0.484
				IB	89.04 ± 18.10	
				II A	21.12 ± 16.05	**0.005**
				II B	37.00 ± 21.35	
Mean writing speed(words/min)	36.38±7.02	13.82±7.79	<.0001	IA	35.00 ± 8.11	0.321
				IB	37.76 ± 5.56	
				II A	9.92 ± 7.29	**<.0001**
				II B	17.72 ± 6.25	
Mean number of words omitted while reading	Nil	0.76±0.52	<.0001	IA	Nil	---
				IB	Nil	
				II A	0.67 ± 0.34	**0.034**
				II B	0.60 ± 0.32	

P value derived by using Mann-Whitney U test

Table 8: Comparison of visual parameters between the initial and follow-up visit among the study subjects

Visual Parameter	Study Groups	Initial	Follow-up	P value
BCDV (log MAR units)	Group I	0.026±.09	0.022±0.08	0.57
	Group II	0.614±0.13	0.608±0.13	0.180
	IA	0.05±0.12	0.04±0.10	0.157
	IB	0.00±0.0	0.00±0.0	1.000
	II A	0.65±0.15	0.65±0.14	0.317
	II B	0.57±0.09	0.56±0.09	0.317
BCNV (log MAR units)	Group I	0.63±0.0	0.63±0.0	1.000
	Group II	1.22±0.727	1.24±0.73	0.317
	IA	0.63±0.0	0.63±0.0	1.000
	IB	0.63±0.0	0.63±0.0	1.000
	II A	1.33±0.93	1.33±0.93	1.000
	II B	1.11±0.43	1.16±0.46	1.000
Mean reading speed (words/min)	Group I	86.22±20.03	96.14±21.27	<.0001
	Group II	29.06±20.34	33.84±20.44	<.0001
	IA	83.40±21.80	93.48±23.61	<.0001
	IB	89.04±18.10	98.8±18.7	<.0001
	II A	21.12±16.05	25.04±15.7	<.0001
	II B	37.00±21.35	42.68±20.97	<.0001
Mean writing speed (words/min)	Group I	36.38±7.02	42.10±8.90	<.0001
	Group II	13.82±7.79	16.02±8.24	<.0001
	IA	35.00±8.11	40.00±9.72	<.0001
	IB	37.76±5.56	44.2±7.63	<.0001
	II A	9.92±7.29	30.0±11.9	<.0001
	II B	17.72±6.25	20.12±6.71	<.0001

P value derived by using Wilcoxon sign rank test

Discussions

In the present study, the overall study population comprised 58% males and 42% females with refractive errors. In Group I, (50 patients with refractive errors) 44% were males and 56% were females (mean age of 15.96 years). In group II, 72% were males and 28% were females (mean age was 12.78 years). The prevalence of refractive errors in Group 1 individuals was myopia in 26(52%) and in Group II it was compound myopic astigmatism. A study done by Sethietal found that myopia to be the most common refractive error among 417 school children aged 12-17 years [11]. This is further affirmed by Karkietal, in their study on prevalence of amblyopia in ametropes, myopic astigmatism (55.36%) was found to the most common refractive error followed by hypermetropic astigmatism [9]. This underlines the importance of identifying and managing astigmatism effectively at the earliest in such a way to prevent amblyopia. Interestingly, 57.14% of amblyopic patients in the study done by Karki et al [9] were male, similar to the preponderance of male patients in group II noted in our study. Whether this reflects the gender predilection or health seeking behaviour of parents depending on the gender of the child has to be studied separately.

Colour vision was found to be affected in high axial myopia as studied by Rutar Tetal, with tritan defect being the most common anomaly noticed [12]. In our study, protan defect (42%) was the most commonly encountered colour vision abnormality among those with low vision due to ametropic amblyopia. Our study used a computerised version of a similar test used in the said study. The difference in the colour vision could be because patients with various refractive errors have been grouped together in group II. Whether this anomaly in the colour vision perception will affect their activities of daily living has to be studied.

Martin-Boglindetal, found that an error as little as 1D can significantly influence the visual fields [13]. Performance of visual field testing without spectacles resulted in reduced peripheral visual field as well as reduction in contrast sensitivity. Another study by Ohno-Matsui etal found that visual field defects were significantly higher in myopic eyes [14]. They conducted visual field examinations by Goldman kinetic perimetry for 492 eyes of 308 patients with high myopia (myopic refractive error >8D or axial length >26.5 mm). Significant visual field defects developed in 13.2% of highly myopic eye. In the current study, visual fields were examined by Bjerrum's screen, 97% of the patients with refractive errors had normal visual field except 3 patients in Group II had peripheral constriction of visual field.

Li S and Zou H conducted a study on stereoscopic visual acuity among ametropic amblyopia; it proved that children with astigmatism had the worst stereo-acuity in case of mild and moderate amblyopia [15]. In present study, the mean value of stereopsis in Group 1 was 76.80 arc secs and 195.6 arc secs in Group II and the difference was statistically significant. It could be because 52% of patients in low vision group had compound myopic astigmatism with ametropic amblyopia.

Manny etal conducted a study on changes in fusionalvergence, phoria and near point of convergence among myopic children aged 7-13 years and followed up annually for 10 years [16]. During follow-up, measurements like refractive error for distance and near, prism bar fusionalvergence range, near point of convergence were measured. After 10 years, the distance and near base out was decreased from 20 pd and 30 pd to 5.6 pd and 9.4 pd. This study concluded that for myopic children, the near point of convergence decreases for both distant and near vision viewing, as near phoria becomes more exophoric. In the current study, the mean near point of convergence was 11.18 cms in group 1 and 9.82 cms in group II as most of the patients in the study group were myopic.

A relationship between writing skills and visual-motor control was assessed in 42 students with low vision and 26 normal -sighted students by Atasavum Uysal et al [17]. Significant differences were found between the groups in writing speed, legibility, and visual motor control. Visual motor control was correlated with both writing speed and legibility. Students with low vision had poorer handwriting performance, with lower legibility and slower writing speed. Writing performance time was related to visual motor control in students with low vision. In the current study, the mean writing speed was 36.3 words/ min in group 1, 13.8 words/min in group II and16.02 words /min in group 2 during the follow-up visit. All the patients in group II had poorer writing speed when compared with patients in normal group.

In this study there were significant differences between clinical, orthoptic and functional vision parameters between low vision and normal vision groups. There were significant differences in functional visual skills within subgroups in low vision groups, but none of the patients in both groups had age appropriate functional skills, despite of improvement in visual acuity and functional skills at follow-up. The comparison within subgroups proved that functional skills were better in patients, those who were already using interventions (Group 1B & 2B) than from the patients presenting for the first time (Group 1A &2A). The present study reports that regular follow-up with evaluation and correction of refractive error by glasses or contact lenses is necessary in children and young adults.

Conclusion

Refractive errors, with or without associated amblyopia, can lead to reduced visual functions like contrast sensitivity, stereopsis, colour vision, visual fields and reduced functional skills such as reading and writing.The present study had shown that in spite of improved clinical and functional vision with interventions, at short term follow-up, the visual skills required, were not age appropriate, both at initial and at also follow-up visit. Hence, functional vision parameters should be monitored as a criterion to determine the quality of vision in those with refractive errors especially in the paediatric age group.

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