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ORIGINAL ARTICLE

The effect of Under and over Refractive correction of myopia on Binocular Visual acuity and Heterophoria

[1]**Chiranjib Majumder**, [2]**Lee Kar Ling**
[1]M.Optom, ORBIS fellow in Pediatric Optometry and Orthoptics, Twintech International University College of Technology, Kuala Lumpur, Malaysia
[2]B.Optom, Twintech International University College of Technology, Kuala Lumpur, Malaysia
Email address: chiranjib_optm@yahoo.co.in

ABSTRACT
The purpose of the study isto know the effect of the type of refractive correction on binocular visual acuity and heterophoria.Convenient sampling method was used. The subjects comprised of 20 Malaysians ages 18-30. This research was done by using a crossed sectional method.Relevant demographic and clinical data were obtained. Data were analysed by using Friedman test to investigate the effect of under and over correction of refractive error on binocular visual acuity and heterophoria. Post hoc analysis was carried out to observe the differences among groups. Influence over binocular VA (p<0.001) and near phoria (p=0.029) were significant, for under corrected subjects. There is mean reduction in binocular visual acuity of 0.75 log unit for under corrected subjects.Over correction had no significant effect on Binocular visual acuity (p=0.157) but had significant effect on near phoria (p<0.001).On the other hand under correction of refractive error had significant effect on the binocular visual acuity and near phoria but no effect over distance phoria. Furthermore Under correction of myopia patient will create a deviation towards exophoric direction whereas overcorrection of myopia will create a deviation toward esophoric direction.
Key words: *Binocular visual acuity, heterophoria, under correction, overcorrection, myopia*

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INTRODUCTION

Uncorrected and under corrected refractive errors are the leading causes of visual impairment worldwide [1]. Uncorrected refractive error refers to individuals with refractive errors who do not use any form of optical correction (i.e., spectacles or contact lenses) to correct their refractive errors. Under corrected refractive errors include individuals with uncorrected refractive errors and individuals with refractive errors that are under corrected by their prescriptions [2].

A total of 153 million people are estimated to be visually impaired by uncorrected refractive error.1 It is estimated that 59% to 83% of adults with visual impairment in Australia and the United States have under corrected refractive error [3-5. More women (21.8%) have under corrected refractive error than men (18.8%).2 Under corrected refractive error is also more common in subjects older than 50 years compared with subjects aged 40 to 49 years [2]. Ssubjects with under corrected refractive error are more likely to report difficulties with their activities of daily living [6]. Uncorrected refractive errors also can hamper performance at school, reduce employability and productivity, and generally impair quality of life through the survey of Global magnitude of visual impairment caused by uncorrected refractive errors in 2004 [1]. Over-minus correction may cause eye strain and ocular fatigue especially in younger patients who spend most of the day on a computer or engaging in reading activities. Atchison et al showed that there are no significant effects of small prescription errors upon the stereo acuity and heterophoria of subjects [7].

Studies had proven that people are sensitive to the prescription error like 0.25D in both sphere and cylinder correction.However, the +0.25D prescription errors didn't show significant effects on visual acuity, letter contrast and contrast sensitivity but +0.50D sphere and cylinder errors had a significant effect on that. Moreover binocular vision problem, asthenopic symptoms, perceptual changes or mobility problems may occurs if the errors were same or different for both eyes [7]. On the contrary, study has shown that subjects are not sensitive to small prescription errors which indicate that patients are readily accepting small prescription errors [8]. Under corrected refractive error is a significant problem among adults that can results an impairment of vision [9].Ssubject's with under corrected refractive error are more likely to report difficulties with their activities of daily living [6].The purpose of this research is to investigate the effect of overcorrection and under correction on binocular visual acuity and heterophoria.

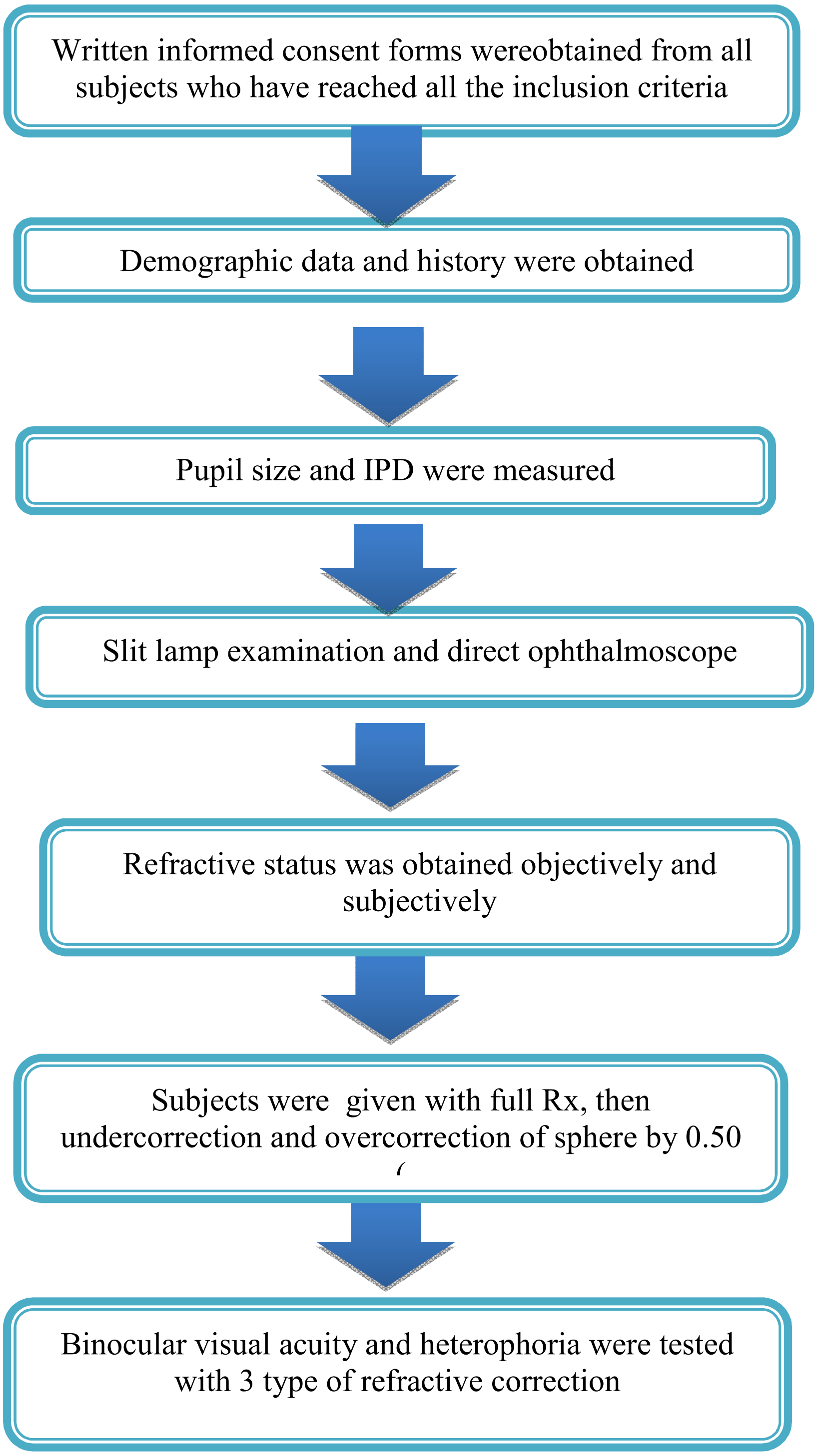
MATERIALS AND METHODS

A cross sectional study was conducted by including 20 Malaysian subjects aged 18-30 years, regardless of gender, from both east and westMalaysia within a period of one year (April 2012 to March 2013) at Twintech vision centre. A convenience sampling method was used. Written informed consent was obtained from all the subjects who were included in the study. Subjects that had best corrected visual acuity of 6/6 in both eyes and myopia of ≥0.75DS to ≤ 6.00DS were included for this study. Subjects having any binocular vision disorder, ocular pathology, eye movement disorder, contact lens wearer, systemic problem were excluded. Permission to conduct the study was obtained from the institute and all procedures were carried out after obtaining the approval from the ethical committee.Detailed history was obtained followed by the measurement of visual acuity, objective and subjective refraction, pupillary evaluation, phoria measurements, measurements of other accommodative and vergence parameters, slit lamp examination and fundus examination. After successful completion of initial assessments, those who passed the inclusion criteria were included in the study.The refractive status was obtained objectively by using Riesterretinoscope (Riester Instruments Inc., USA) and subjectively by using trial lens set (American Opticals). The correction was considered optimal, under corrected and overcorrected based on the findings of the duochrome test. An optimal correction was considered when the subjects didn't appreciate any difference between the visibility and prominence of the letters on the red and green backgrounds. An under corrected eye which is residually myopic by 0.50D, appreciates the letter on a red background clearer and darker than letters on green background. Letters on the green background appear slightly fuzzy and less dark, with less defined borders. On the other hand an eye which is overcorrected by 0.50DS appreciates the letters on the green background to be clearer, darker and more defined in compare to the red background. The chromatic aberration is involved in the visibility of red and green backgrounds. During optimal correction the focus should be halfway between red and green. Whereas slightly fogged subjects initially report that the letters are more visible or prominent on the red background and then switch to the green background with one or two increments of minus power in -0.25D step. Often, a spherical power increment between the "last red" report and the "first green" report, the subject notes no difference between visibility and prominence of the letters on the red and green backgrounds. Subjective tests for spherical or cylindrical correction, accommodation are controlled by moving toward the endpoint from a slightly fogged initial state of the eye. Log MAR visual acuity charts were used to measure the visual acuity. Each letter was scored as either correct or incorrect, and the total numbers of correctly identified letter was calculated to produce a log MAR score.

The horizontal deviation of the eyes (phoria) with the fusion breaks will be measured by Maddox rod for distance and Maddox wing for near. The reason for choosing Maddox wing for near phoria is because of the difference in light source which is not standardized while using Maddox rod to measure near phoria. The room should be in dimly to moderately illuminate. While measuring distance phoria, put a bright spot of light at the opposite end of the examination room from the patient. An actual bright light, a penlight is best but a small round spot of light can be projected onto a screen. Horizontal deviation was measured by placing the Maddox rod in front of either eye, oriented horizontally to create a vertical streak and horizontal dissociation. Patient will be informed that there are two images to be seen: one spot light and the vertical line. Patient will be told to report the position of the light and streak when the prism is placed in the other eye until patient reports the superimposition of the light onto the streak and come back from the opposite direction for another measurement. Maddox wing is used to test for the near phoria in which one eye sees calibrated horizontal and vertical scales and the other eye sees a vertical and a horizontal arrow. The patient reads off the position of each arrow on the appropriate scale to indicate horizontal phoria. Measurement of binocular visual acuity and heterophoria was done first with undercorrection followed by over correction for every subject.

The data was entered in MS Excel 2007 and the statistical analyses were performed using SPSS for Windows version 16.0 software (SPSS Inc., Chicago, IL, USA). The normality of the data was checked by using Shapiro-Wilk test. The Friedman test was performed to assess the variation in visual acuity and Phoria with three different refractive conditions. Post- hoc analysis was carried out to observe the differences among groups. To avoid the type 1 error the banferroni correction was considered while performing post hoc analysis.We performed Spearman non-parametric correlation analysis to find out if there was any significant relationship exists or not between visual acuity and heterophoria based on different refractive correction. Results were expressed as mean±standard deviation. A p value of ≤ 0.05 wasconsidered significant.

DATA COLLECTION PROCEDURE



RESULTS

This study had a total of 20 subjects out of which 10 subjects were male (50%) and 10 subjects were female (50%). These subjects were within the age group of 18 to 30.The study subjects comprises of 100% Chinese. When the changes in visual acuity and phoria were observed for different mode of refractive correction, a significant difference were observed for binocular visual acuity ($p<0.001$) and near phoria ($p<0.001$) but no significant difference observed for distance phoria ($p>0.05$) as shown in table 1, 2 and 3 respectively. Post hoc test for binocular visual acuity showed, a significant difference exists between under correction and optimal correction (p<0.001) as shown in table 4. On the other hand for near phoria the difference was more significant between optimal and overcorrection correction (p<0.001) in compare to optimal and under correction (p<0.05) as shown in table 5. A significant correlation was observed between distance and near phoria when under corrected as shown in table 6. No such correlation exists for visual acuity, distance and near phoria while optimal and overcorrection was used as shown in table 7and 8.

Table 1: Comparison of binocular visual acuity amongdifferent refractive corrections

Refractive correction	BVA(Mean ± SD)	P value
Optimum correction	-0.990 ± 0.00447	
Under correction	-0.240 ± 0.05295	0.000
Over correction	-0.960 ± 0.01046	

*Friedman test
*p<0.05 is considered significant

Table 2: Comparison of near phoria with different refractive corrections

Refractive correction	Near phoria (mean±SD)	P value
Optimum correction	-0.350 ± 1.7252	
Under correction	-1.125 ± 2.3835	0.000
Over correction	0.850 ± 2.0072	

*Friedman test
*p<0.05 is considered significant

Table 3. Comparison of distance phoria among different refractive corrections

Refractive correction	Distance phoria(Mean ±SD)	P value
Optimum correction	-0.125 ± 1.3753	
Under correction	-0.075 ± 1.4892	0.185
Over correction	0.200 ± 1.9426	

*Friedman test
*p<0.05 is considered significant

Table 4.Comparison of binocular visual acuity between groups

Refractive correction	VA (Mean ± SD)	P value
Optimum correction	-0.0990 ± 0.00447	
Under correction	-0.0240 ± 0.05295	0.000
Optimum correction	-0.0990 ± 0.00447	
Over correction	-0.0960 ± 0.01046	0.157

*Post hoc analysis
*p<0.05 is considered significant

Table 5: Comparison of near phoria between groups

Refractive correction	Near phoria(mean±SD)	P value
Optimum correction	-0.350 ± 1.7252	
Under correction	-1.125 ± 2.3835	0.029
Optimum correction	-0.350 ± 1.7252	
Over correction	0.850 ± 2.0072	0.000

*Post hoc analysis
*p<0.05 is considered significant

Table 6: Correlation between VA, distance and near phoria with under refractive correction

Spearman's rho		Under corrected VA	Undercorrected distance phoria	Undercorrected near phoria
Undercorrected VA	Correlation coefficient	1.000	-0.335	-0.220
	Sig(2-tailed)	----	0.149	0.352
Undercorrected distance phoria	Correlation coefficient	-0.335	1.000	0.679
	Sig(2-tailed)	0.149	----	0.001
Undercorrected near phoria	Correlation coefficient	-0.220	0.679	1.000
	Sig(2-tailed)	0.352	0.001	----

*Spearman's correlation
*p<0.05 is considered significant

Table 7: Correlation between VA, distance phoria, and near phoria for optimum refractive correction

Spearman's rho		Optimum VA	Optimum distance phoria	Optimum near phoria
Optimum VA	Correlation coefficient	1.000	0.347	0.202
	Sig(2-tailed)	----	0.134	0.392
Optimum distance phoria	Correlation coefficient	0.347	1.000	0.400
	Sig(2-tailed)	0.134	----	0.081
Optimum near phoria	Correlation coefficient	0.202	0.400	1.000
	Sig(2-tailed)	0.392	0.081	----

*Spearman's correlation
*p<0.05 is considered significant

Table 8: Correlation between VA, distance and near phoria with over refractive correction

Spearman's rho		Over corrected VA	Overcorrected distance phoria	Over corrected near phoria
Overcorrected VA	Correlation coefficient	1.000	-0.154	0.071
	Sig(2-tailed)	----	0.518	0.765
Overcorrected distance phoria	Correlation coefficient	-0.154	1.000	0.351
	Sig(2-tailed)	0.518	----	0.129
Overcorrected near phoria	Correlation coefficient	0.071	0.351	1.000
	Sig(2-tailed)	0.765	0.129	----

*Spearman's correlation
*p<0.05 is considered significant

Table 9. Changes of VA based on under and over refractive correction

Study Name	Optimum (Mean)	Under correction (Mean)	Over correction (Mean)	P value
Atchison et al. (2001)	----	0.013 log unit reduction	----	P=0.001
Miller et al. (1997)	----	0.08 log unit reduction	----	----
This study	-0.990 log unit	0.075 log unit reduction	0.030 log unit reduction	P<0.001

Table 10. Changes of distance phoria based on under and over refractive correction

Study Name	Optimum (Mean)	Under correction (Mean)	Over correction (Mean)	P value
Atchison et al. (2001)	**----**	----	**----**	P=0.906
This study	-0.125	-0.075	0.200	P=0.185

Table 11.Changes of near phoria based on under and over refractive correction

Study Name	Optimum (Mean)	Under correction (Mean)	Over correction (Mean)	P value
Atchison et al. (2001)	**----**	**----**	**----**	P=0.757
This study	-0.350	-1.125	0.850	P<0.001

DISCUSSION

The purpose of this study is to know the effect of different refractive correction on binocular visual acuity and heterophoria. We tried to see if the under or over refraction correction has a significant effect on binocular visual acuity, distance and near phoria. Besides that, the correlation of the binocular visual acuity, distance and near phoria with difference refraction correction will be discussed.

This study showed there is a significant difference in binocular visual acuity within three different refractive corrections ($p<0.001$). Post-hoc analysis showed there is a significant difference between optimum and under correction ($p<0.001$), whereas there is no significant difference observed between optimum and overcorrection ($p=0.157$). There is no significant difference in binocular visual acuity for over correction because subjects were accommodating for the induced hypermetropia. Under and over refractive correction by 0.50DS reduced visual acuity but the effect of over correction was not significant as compared to under correction. In this study, we found out that the 0.50D of under correction showed a mean reduction of 0.75 log unit. This result is almost similar to the study of Miller et al and Atchison et al, where they found out reduction of 0.08 log units and 0.13 log units in binocular visual acuity while using 0.50D under correction [10, 7].

Another important factor which is affect by under and over correction is phoria. This study showed there is no statistically significant difference exists for phoria measurements between optimum and under correction of refractive error ($p=0.593$) and between optimum and over correction of refractive error ($p=0.366$). Atchison et al. in their study showed that the prescription errors did not have significant effects on distance heterophoria ($p=0.906$). There was a trend for the -0.50DS condition to shift distance phoria towards the esophoric direction but the effect was not significant and this finding supports the findings of this study.[7]When near phoria was compared with different refractive correction, it was found that there is a significant difference in near phoria within three different refractive correction ($p<0.001$). Post-hoc analysis showed that the under and over correction of refractive error has significant effect on near phoria ($p=0.029$, $p=0.000$) which cause the near phoria to shift towards exophoric direction and esophoric direction respectively. Atchison et al showed no significant difference in near phoria ($p=0.757$) which contradict this study result. The discrepancy could be possible to exist because of the use of different measuring technique for near phoria [7].When we tried to find out the correlation between visual acuity, distance phoria and near phoria based on optimum correction, under correction, and over correction, there was no significant correlation established between visual acuity with distance phoria ($p=0.134$, $p=0.149$, $p=0.518$) and near phoria ($p=0.392$, $p=0.352$, $p=0.765$) while using three different refractive correction. When an attempt was made to establish a correlation between distance phoria and near phoria, no significant relation was observed for optimum and over corrected subjects ($p=0.081$, $p=0.129$). But a significant correlation exists between distance and near phoria ($p=0.001$) for under corrected subjects. The smaller sample size and ethnicity are the limitations of the study.The comparison of this study result with other study result were shown in table no. 9, 10 and 11.

As a conclusion we can say that under correction of refractive error have significant effect on the binocular visual acuity and near phoria but no effect for distance phoria whereas over correction have significant effect on near phoria only. Furthermore under correction of myopia patient will create a deviation towards exophoric direction whereas overcorrection of myopia will create a deviation toward esophoric direction.

It is our recommendation for researchers interested in this study to have few different approaches to conduct the research. First of all, this study was mostly concentrated on the effect of under and over correction of refractive error on binocular visual acuity, distance phoria, and near phoria. We did not include the age and gender in the analysis. Therefore it is recommended that future studies should include these two factors in the analysis. Secondly, in the clinical aspect we will recommend the clinicians to use different measurement techniques of phoria to find out the differences.

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