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A retrospective analysis of heterophoria values in a clinical population aged 18 to 30 years

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Abstract

Information on heterophoria values in South Africans is scanty. The purpose of this paper therefore, is to present information on the distribution of heterophoria in a clinical population aged 18 to 30 years, which hitherto is not available. The data presented here was obtained from the record cards of 475 black South African patients examined at the Optometry clinic, University of Limpopo (Turfloop campus) between 2000 and 2005. The patients were examined by final year students under the supervision of qualified optometrists. Heterophoria was measured for each patient using the von Graefe method. The horizontal heterophoria for distance vision (6 m) ranged from 16 prism diopters (pd) esophoria to 12 pd exophoria with a mean of 0.74 pd exophoria (SD = ± 2.84 pd). For distance vision, esophoria ranged from 0.5 to 16 pd with a mean of 3.08 pd (SD = ± 3.09), while exophoria ranged from 0.5 pd to 12 pd with a mean of 2.21 pd (SD = 1.82 pd). For near vision (0.4 m), the horizontal phorias ranged from 17 pd esophoria to 15 pd exophoria with a mean of 3.84 pd exophoria (SD = ± 4.80 pd). The near esophorias ranged from 0.5 to 17 pd with a mean 4.88 pd (SD = ± 3.41), while the exophorias ranged from 1.0 to 15 pd with a mean of 6.30 pd (SD = ± 2.58). Vertical heterophoria for distance vision ranged from 5 to 3 pd right hyperphoria with a mean of 0.05 pd right hyperphoria (SD = ± 0.76) whereas at near it ranged from 4 to 6 pd right hyperphoria with a mean of 0.08 pd right hypophoria (SD = ± 0.96). The distributions of heterophoria at distance and near were non-normal. There was no significant gender variation in the horizontal values for distance vision and the vertical (distance and near) ones. However, there was a statistically significant gender variation in the near horizontal values ($p > 0.05$). There was no significant variation in heterophoria values with age. The data presented here will be useful for comparison with similar data from South Africa or other countries.

Keywords: Heterophoria, horizontal phoria, vertical phoria, esophoria, exophoria.

Introduction

Heterophoria often simply called phoria has been defined in many ways by researchers. Carey[1] has discussed the issue of definition adequately, and hence will not be discussed here any further. An interesting definition of this condition is that of Kommerel and Kromeier[2] who defined it as a non-primarily existing ocular deviation but a reaction to an interruption of the sensory-motor-feedback control system. This definition agrees with the claim by Von Noorden[3] that ocular misalignment in heterophoria is held in check by the fusion mechanism. According to this author[3], in patients with heterophoria, motor fusion is adequate to provide

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proper alignment of the eyes; this, however, does not mean that the patient with heterophoria necessarily has normal sensory fusion. When there is a high degree of heterophoria, there may be suppression and a high stereoscopic threshold, but motor responses are sufficient to keep the eyes aligned[2]. Heterophoria measurements are very vital during binocular vision assessment as its values are used in the diagnosis of binocular vision anomalies such as divergence excess and convergence insufficiency.

There are several methods used clinically to evaluate heterophorias. In all of these methods fusion must first be broken to achieve dissociation of the eyes, allowing evaluation of heterophoria[4]. The methods may differ in the ability to control accommodation adequately in the level of proximal convergence induced and in the method by which heterophoria is quantified. The duration and the degree of dissociation when fusion is disrupted will also affect the measurements in that a longer duration of dissociation will increase vergence adaptation[5]. Therefore heterophoria values may vary from one procedure to another.

Heterophoria has been attributed to four main categories of etiologies namely: anatomical, refractive, uniocular activity and trauma[6, 7]. The anatomical causes include abnormal interpupillary distance, exophthalmos and/or endophthalmos. Also, an abnormality of the fascia or ligaments of extraocular muscles may be a cause of an imbalance. Refractive causes relate to the relationship between accommodation and vergence. For example, an uncorrected hyperopia has a tendency to induce a shift towards esophoria. The repeated use of one eye (for example, watchmakers) has also been suggested as a possible cause of heterophoria[6, 7]. Von Noorden[3] also reported that innervational factors which comprise of nervous impulses reaching the eyes can result in heterophoria. This implies that all these ocular and visual abnormalities have the ability to interrupt fusional innervation thereby precipitating heterophoria.

Heterophoria can be vertical, horizontal or oblique (cyclophoria). A small heterophoria is present in 70-80% of the population[2]. Bennett and Rabbetts[8] reported that people are exophoric both at distance and near or esophoric in both and also, the angle of deviation might differ in both distances. According to these authors[8], vertical heterophoria is less likely to alter between distance and near vision. Slight incomitancy and relative vertical prism in anisometropia may, however, cause differences in the angle of a vertical heterophoria as gaze depresses for close work. This view differs from those of Schor and Ciuffreda[9] and Dowley[10] who reported that there is a high prevalence of distance orthophoria in the population despite a large number of mechanical, neural and sensory variables.

Decompensated heterophoria is associated with several symptoms[11-17] such as photophobia, eyestrain, headaches, decreased stereopsis, pain in the eyes, diplopia, poor visual performance[11-17] and dizziness is associated with vertical heterophoria[18]. Diagnosis such as convergence insufficiency characterized by an exophoria which is greater at near than at distance, or divergence excess, characterized by exophoria greater at distance than at near are associated with many symptoms[19]. Decompensated heterophorias may become significant after a working day and they can result in ocular symptoms and visual discomfort[20]. Jaschinski-Kruza and Schweflinghaus[21] found a relationship between tonic convergence and psychosomatic symptoms. Also, Hasebe *et al*.[22] found that fatigue reduces tonic accommodation. These studies imply that after a working day there is high incidence of visual and psychosomatic symptoms.

Fixation disparity and associated phoria (the degree of prism required to eliminate fixation disparity) have been thought to be an indicator of a decompensated phoria which give rise to symptoms[19]. Yekta *et al*.[20] found a statistically significant increased dissociated exophoria and associated exophoria after the normal close working day. They[20] also found that at the end of the working day 63 of the 84 subjects complained of visual symptoms. They, therefore, concluded that there is fixation disparity and symptoms associated with close work which is more likely to be related to binocular stress and decompensated heterophoria. Also, Hasebe *et al*.[22] reported that fatigue reduces tonic accommodation, therefore individuals such as students who are exposed to a lot of near work are likely to have decompensated phorias which may result in symptoms. There are reports that age influences heterophoria[23-26]. According to

Kephart and Oliver[23], distance heterophoria has a slight tendency towards greater esophoria with age. The validity of this claim has been questioned because accommodation decreases with age which may lead to greater divergence and hence an increase in exophoria[25, 26]. This view agrees with the reports by Freier and Pickwell[25] that exophoria increases with age. Also, Yekta *et al*. [26] reported an increase in exophoria, associated phoria and fixation disparity with age. An increase in exophoria for near vision with age has been reported[24, 25]. Although Waline *et al*.[11] however, found no significant changes of distance heterophoria with age. There is a general consensus that age has an effect on heterophoria. Although heterophoria has been studied in South African children[27], but no information could be found in the literature on heterophoria in South African adults. It was, therefore decided to examine the distribution of this condition in adults in a clinical setting.

Method

Record cards of 475 (277 males and 198 females) black South African patients who had a comprehensive eye examination at the Optometry clinic, University of Limpopo (Turfloop campus) between 2000 and 2005 were reviewed. Only record cards containing required information for this study were reviewed. The patients were examined by final year students under supervision of qualified optometrists. A large proportion of the patients between 18 and 30 years were students and thus a decision was made to include only students in the study. The Von Graefe method of heterophoria measurement was used to obtain heterophoria values. Data on heterophoria and related values such as age and gender were recorded. Record cards which did not include information on heterophoria or other relevant information were excluded from the study. The data was analyzed with a personal computer using the Statistical Package for Social Science (SPSS) programme. For the purpose of analysis, exophoria and right hyperphoria values were designated as positive, esophoria and right hypophoria as negative and orthophoria as zero. All values presented in the results therefore, follow the above mentioned pattern.

Results

The subjects included 277 males and 198 females. Their ages ranged from 18 to 30 years with a mean of 21.44 (SD = ± 2.75). Four hundred and seventy four (474) record cards contained horizontal heterophoria values of which, 200 contained vertical heterophoria values and only one record card contained information on vertical heterophoria only. All the patients included are students. For easy reference, a summary of the different heterophoria values is presented in Table 1 and the gender related values are summarized in Table 2. At distance (6 m), horizontal heterophoria ranged from 16 pd esophoria to 12 pd exophoria with a mean of 0.74 pd exophoria (SD = ± 0.74). The distribution of horizontal heterophoria for distance vision is shown in Figure 1. For distance vision exophoria was more common (N = 287), followed by orthophoria (*N* = 95) and esophoria (*N* = 90). For distance vision, esophoria ranged from 0.5 to 16 pd with a mean of

Table 1. A summary of heterophoria measurements. Positive values refer to exophoria and right hyperphoria while negative refer to esophoria and right hypophoria. The units are in prism diopters (pd).

Heterophoria	Range (pd)	Mean (pd)	Standard Deviation (pd)
Horizontal at far	-6 to 12	0.74	2.87
Exophoria	0.5 to 12	2.21	1.82
Esophoria	-16 to -0.5	-3.08	3.09
Vertical at far	-5 to 3	0.05	0.76
Right hyperphoria	0.5 to 3	0.22	0.5
Right hypophoria	-5 to -1	-1.30	0.99
Horizontal at near	-17 to 15	3.84	4.80
Exophoria	1 to 15	6.30	2.58
Esophoria	-0.5 to -17	4.88	3.41
Vertical at near	-4 to 6	-0.08	0.96
Right hyperphoria	0.5 to 6	0.19	6.51
Right hypophoria	-4 to -1	-1.61	0.95

Table 2. A summary of heterophoria values according to gender for distance and near vision. Positive values refer to exophoria and right hyperphoria while negative refer to esophoria and right hypophoria. The units are in prism diopters (pd).

Gender	Range of horizontal heterophoria (pd)		Range of vertical heterophoria (pd)	
	Far	Near	Far	Near
Females	-13 to 12	-17 to 15	-2 to 2	-3 to 3
Males	-16 to 12	-11 to 15	-5 to 3	-4 to 6

3.08 pd (SD = ± 3.09) while exophoria ranged from 0.5 to 12 pd with a mean of 2.21 pd (SD = ± 1.82). Horizontal heterophoria for near vision (0.4 m) ranged from 17 pd esophoria to 15 pd exophoria with a mean of 3.84 (SD = ± 4.80). The distribution is shown in Figure 2.

Esophoria at near ranged from 0.50 to 17 pd with a mean of 4.88 pd (SD = ± 3.41) while exophoria ranged from 1 to 15 pd with a mean of 6.30 pd (SD = ± 2.58) as shown in Table 1. Vertical heterophoria at distance ranged from 5 pd right hypophoria to 3 pd right hyperphoria with a mean of 0.05 pd right hyperphoria (SD = ± 0.76). The distribution is shown in Figure 3. Near vertical heterophoria ranged from 4 pd right hypophoria to 6 pd right hyperphoria with a mean of 0.08 pd (SD = ± 0.96). The distribution of the near vertical heterophoria is shown in Figure 4.

The results were subsequently divided in to males and females categories. Among the females, horizontal heterophoria for distance vision ranged from 13 pd esophoria to 12 pd exophoria with a mean of 0.77 pd (SD = ± 2.81). The distribution of horizontal heterophoria for distance vision is shown in Figure 5. Near horizontal heterophoria in females ranged from 17 pd esophoria to 15 pd exophoria with a mean of 3.56 pd exophoria (SD = ± 4.99). The distribution is shown in Figure 6. Vertical heterophoria for distance vision in females ranged from 2 pd right hypophoria to 2 pd right hyperphoria with a mean of 0.03 pd right hyperphoria (SD = ± 0.55). The distribution of vertical heterophoria at far among females is shown in Figure 7. Near vertical heterophoria among females ranged from 3 pd right hypophoria to 3 pd right hyperphoria with a mean of 0.06 pd right hypophoria (SD = ± 0.78). The distribution of near vertical heterophoria among females is shown in Figure 8.

Distance horizontal heterophoria for males ranged from 16 pd esophoria to 12 pd exophoria with a mean of 0.74 pd exophoria (SD = ± 2.88). Figure 5 shows the distribution of distance horizontal heterophoria in males. Near horizontal heterophoria in males ranged from 11 pd esophoria to 15 pd exophoria with a mean of 4.28 pd exophoria (SD = ± 4.46). The distribution is shown in Figure 6. Distance vertical heterophoria in males ranged from 5 pd right hypophoria to 3 pd right hyperphoria with a mean of 0.05 pd

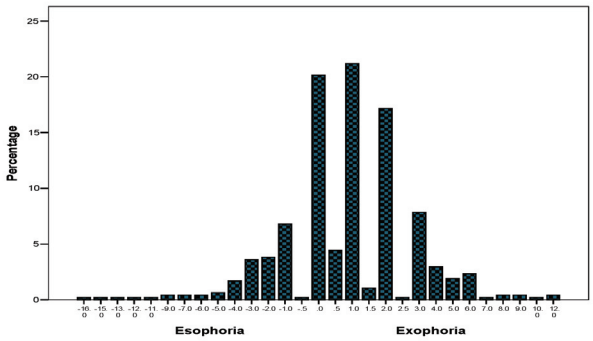

Figure 1 Distribution of horizontal heterophoria for distance vision for the total sample. A large proportion of the sample is exophoric and the peak is at 1 pd exophoria.

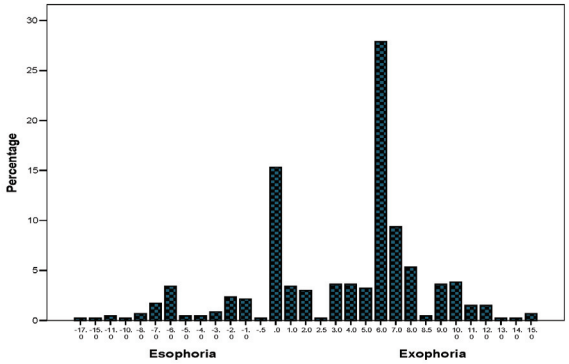

Figure 2 Distribution of horizontal heterophoria for near vision for the total sample, showing greater proportion of exophoria and the peak is at 6 pd exophoria.

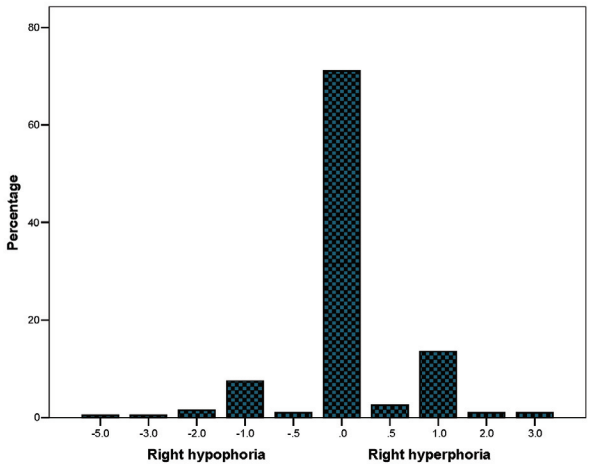

Figure 3 Distribution of vertical heterophoria for distance vision (total sample), showing a greater proportion of orthophoria. Also, the peak is at orthophoria.

right hyperphoria (SD = ± 0.76). Figure 7 shows the distribution of vertical heterophoria for distance vision among males. Near vertical heterophoria ranged from 4 pd right hypophoria to 6 pd right hyperphoria with a mean of 0.11 pd right hypophoria (SD = ± 1.14). The distribution of near vertical heterophoria is shown in Figure 8.

Analysis of variance (ANOVA) indicated that there was no statistically significant gender variation in vertical (distance and near) and distance horizontal heterophoria values ($p > 0.05$). However, there was a statistically significant gender variation in near horizontal heterophoria values ($p < 0.05$). Also, ANOVA indicated that there was no correlation ($p < 0.05$) between both horizontal and vertical heterophoria and age at distance and near.

Discussion

Generally optometrists measure heterophoria routinely in a clinical practice and this might help in the diagnosis of binocular conditions. Researchers have found that there is a high prevalence of orthophoria for distance vision[9, 10]. From a sample of 925 asymptomatic subjects, Dowley[10] found that a vast majority were orthophoric at distance, followed by esophoria and then exophoria. These findings agree with the findings by Schor and Ciuffreda[9] who also found that orthophoria was prevalent for distance vision as compared to orthophoria and esophoria. Both the researchers did not indicate the age groups of their subjects. Findings in the present study, however, differ from those of Dowley[10] who found orthophoria to be prevalent at far. In this study exophoria (61%) was more common at distance followed by orthophoria (20%) and then esophoria (19%).

Letourneau and Giroux[28] found that distance horizontal heterophoria in children aged between 6 and 13 years ranged from 10 pd exophoria to 10 pd esophoria with a mean of 0.75 pd exophoria (SD = ± 2.52). The range of 16 pd esophoria to 12 pd exophoria with a mean of 0.74 pd exophoria (SD = ± 2.84) at far in the present study are wider than those found by Letourneau and Giroux[28]. This may be due to age differences and different dissociation techniques used as the authors[28] used the Maddox rod technique for phoria measurements.

Also, using the Maddox rod technique, Mathebula *et al*.[27] found that in 900 South

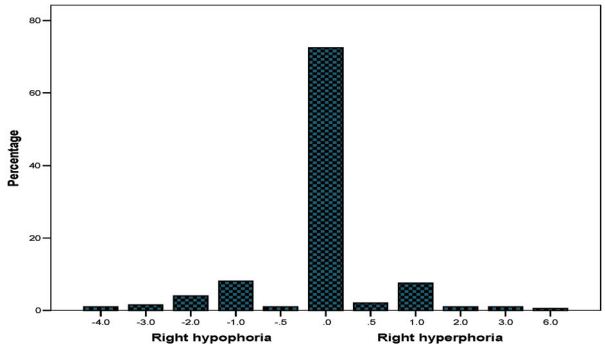

Figure 4 Distribution of vertical heterophoria for near vision (total sample). A large proportion of the values are orthophoria and the peak is also at orthophoria.

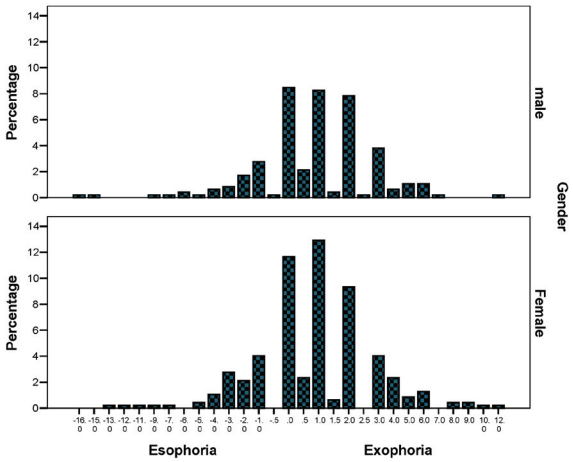

Figure 5 Distribution of distance horizontal heterophoria according to gender. A large proportion (both males and females) is exophoric with a peak at orthophoria (males) and 1 pd exophoria (females)

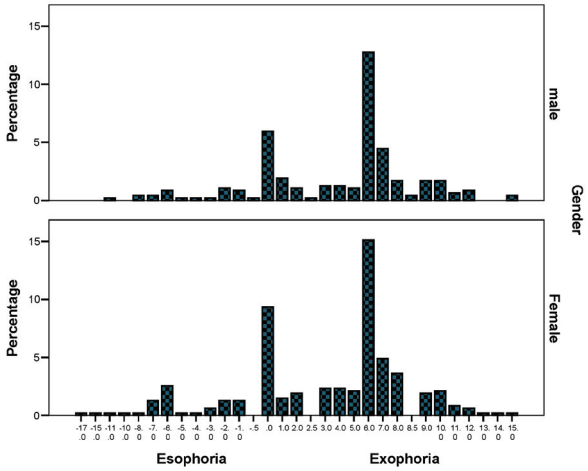

Figure 6 Distribution of near horizontal heterophoria according to gender. A large proportion (both males and females) is exophoric with a peak at 6 pd exophoria.

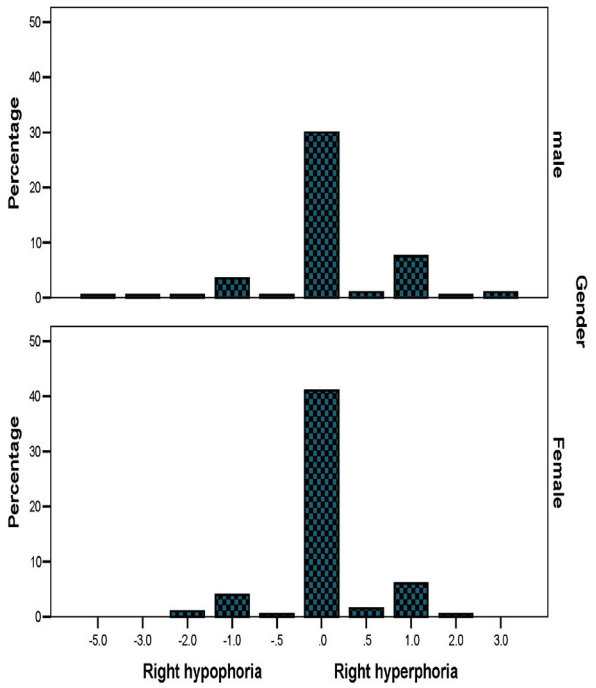

Figure 7 Distribution of distance vertical heterophoria according to gender, showing greater orthophoria for both male and female.

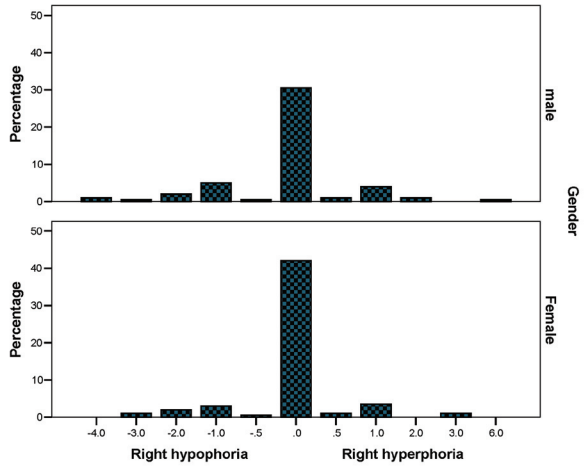

Figure 8 Distribution of near vertical heterophoria according to gender, showing greater orthophoria for both male and female.

African children aged 6 to 13 years, distance horizontal heterophorias ranged from 4 pd esophoria to 6 pd exophoria with a mean of 0.20 pd exophoria (SD = ± 1.17). This range is also narrower than the present study. Again, this might be due to differences in age and dissociation techniques. There is however, a possibility that adults exhibit a wider range of horizontal heterophoria as compared to children.

There is a general agreement that there is a much wider distribution of horizontal heterophoria for distance vision than for near, which was attributed to accommodation and proximal convergence that play a part at near vision. It may also be a result of input from slow vergence mechanisms that are changeable overtime[29]. The findings in the present study agree with this view.

In the present study, at near most of the subjects had exophoria (*N* = 336), followed by orthophoria (*N* = 72) and then esophoria (N = 62). The findings are in agreement with the findings by several researchers who reported that there is a high prevalence of near exophoria[3, 27, 28]. Mathebula *et al*.[27] found that near horizontal heterophorias ranged from 6 pd esophoria to 1.7 pd exophoria with a mean of 2.5 pd exophoria (SD = ± 2.37) among children. In the present study, the ranges of 17 pd esophoria to 15 pd exophoria with a mean of 0.74 pd exophoria (SD = ±2.84) at near are larger than those by Mathebula *et al*.[27]. Again, this may be due to differences in age and dissociation techniques.

Letourneau and Giroux[28] found a range of 2 pd right hypophoria to 2 pd right hyperphoria with a mean of 0.07 pd (SD = ± 0.69) at far. Also, Mathebula *et al*.[27] found that vertical heterophoria ranged from 1.8 pd right hypophoria to 2 pd right hyperphoria with a mean of 0.01 pd right hyperphoria (SD = ± 0.22). These differ with the ranges of 5 pd right hypophoria to 3 pd hyperphoria with a mean of 0.05 pd right hyperphoria (SD = ± 0.76) found in the present study. The differences in range, means and standard deviations may be due to age differences, sample size and also the dissociation techniques used. Mathebula *et al*.[27] found that near vertical heterophoria ranged from 2 pd right hypophoria to 2 pd right hyperphoria with a mean of 0.01 pd right hyperphoria (SD = ± 0.22). This is different from the ranges of 4 pd right hypophoria to 6 pd right hyperphoria with a mean of 0.08 pd right hypophoria (SD = ± 0.96) found in the present study.

Several studies indicated that there is a relationship between heterophoria and age[23-26]. The findings in the present study, however, indicated that there was no correlation between heterophoria (vertical and horizontal) at distance and near and age. This may be due to the somewhat

limited age range in the present study. A major limitation in the present study is that the values were obtained by several students therefore, there may be inter-examiner differences. In spite of this limitation, the values presented here are of value in adding to available knowledge of heterophoria values amongst black South Africans.

Conclusion

There is a non-normal distribution of both the vertical and the horizontal phorias at distance and near. A vast majority of the subjects were exophoric at distance and near and in terms of vertical heterophoria the majority were orthophoric at distance and near. Due to the high prevalence of heterophoria at distance (exophoria / esophoria) in this study, there is a great likelihood that some of these subjects have decompensated phorias which can lead to ocular symptoms. Therefore there is a need to perform heterophoria measurements on each and every patient (symptomatic or asymptomatic) because in some asymptomatic patients, symptoms may occur after extended near work especially if the relevant compensatory mechanism is not very high.

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