ORIGINAL ARTICLE

Measurements of Peripheral Refraction in Malay and Chinese Myopic Children in Kuala Lumpur: A Pilot Study

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ABSTRACT

Introduction: Retinal shape varies between ethnicities and may contribute to myopia development. This study investigated the peripheral refraction (PR) in Malay and Chinese myopic children living in Kuala Lumpur. **Materials and Methods**: This is a retrospective study involving data from 96 participants (40 Malays, 56 Chinese). Subjects were myopes from -0.50D to -5.00D, with visual acuity (VA) of 0.00 log MAR in each eye. Cycloplegic refraction was conducted using an autorefractometer across the horizontal meridian, out to 30° at 10° intervals in the nasal (N) and temporal (T) of the retina. Axial length (AL) measurements were taken using A-scan and optical biometry. The results were analysed using SPSS. **Results**: The mean age of subjects was 9.55 ± 1.51 years (Malays) and 8.34 ± 0.48 years (Chinese) ($p<0.05$). Mean SER and AL for the Malays and Chinese were -2.97±1.26D and -3.06 ± 1.10D ($p>0.05$) and 24.74± 0.90mm and 24.50 ± 0.86mm ($p<0.05$) respectively. Higher hyperopic shift was observed in the Chinese than Malays but was only significant at 300 N ($p=0.003$). Greater RPR was noted at all eccentricities in the Chinese than the Malays ($p<0.0001$). No significant differences were noted in J0 and J45 between both ethnicities ($p>0.05$) and AL was shown to have significant influence in the changes of PR for both groups ($p<0.05$). **Conclusion**: Chinese children have greater horizontal hyperopic PR and RPR than the Malays of similar refractive error, indicating a more prolate ocular shape. Nevertheless, more data is needed to confirm these findings.
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INTRODUCTION

The prevalence of myopia is increasing drastically worldwide, particularly in East Asian countries. It is estimated that 1.4 billion people were myopic in 2000 and it is predicted to increase to 4.8 billion by 2050 (1). In addition myopia has been diagnosed at younger age and progressing to higher degrees (2). Implications of high myopia include vision threatening ocular diseases such as glaucoma, cataract and retinal detachment (3). Nevertheless, few studies have demonstrated the efficacy of optical interventions in controlling myopia progression such as contact lens and the new generation myopia control spectacle lens (4, 5). This approach is widely accepted since it is non-invasive and has shown clinically significant treatment effects in children.

Peripheral refraction (PR) refers to the distribution of refractive power across the peripheral visual field and is commonly used to infer retinal shape. Previous studies have shown that the relative peripheral myopia in hyperopic eyes indicated an oblate shape while relative peripheral hyperope in myopic eyes indicated a less oblate or more prolate shape (6, 7). However it is still unclear whether these differences are the cause for myopia development or progression. Nevertheless, there is increasing suggestions that myopic defocus that extends to the periphery of the retina while a clear image is focused on the fovea (typically during overnight orthokeratology or while wearing myopia control spectacle lens) may inhibit axial length growth in humans (5, 8). Thus, measuring PR has now gained interest in myopia research.

There are suggestions in the literature that retinal shape varies between ethnicities. Mutti et al (9) demonstrated differences in PR in myopes between Asian Americans, African Americans, Hispanic and white Americans, and their results showed that the highest degree of relative peripheral hyperopia was in Asian American compared to other ethnicities. Higher relative peripheral hyperopia was also found in myopic East Asians than Caucasians with similar central refraction, implying a more prolate shape in the former (10). In another study, Verkicharla et al (11) investigated whether the retinal shape is different between East Asian and Caucasian young adults using partial coherence interferometer. Their results showed that the Caucasian young adults had flatter retina in both emmetropes and myopes, than the East Asian subjects. Considering the high prevalence of myopia in the East Asian populations, the investigators proposed that retinal shape may play a role in myopia development. Apart from ethnicity, there are other confounding factors that may influence retinal shape including age, degree of myopia and parental myopia (12). However, this study focuses on ethnicity due to the difference in myopia prevalence found between ethnicities in Malaysia (13, 14). The prevalence study in Kuala Lumpur, Malaysia reported that the prevalence of myopia among local school children was the highest among the Chinese, followed by Malays and Indians (13, 14). It is possible that the differences in retinal shape between ethnicities influence the prevalence of myopia. Therefore this study investigated and compared the PR in myopic Malays and Chinese primary school children living in Kuala Lumpur.

MATERIALS AND METHOD

Subjects

This is a retrospective study and the subjects were participants from Myopia Control Study in Kuala Lumpur (MyCOSKL). The research ethics approval of this study (UKM PPI/111/8/JEP-2020-667) was obtained from the UKM research ethics committee and this study adhered to the tenets of the Declaration of Helsinki for the use of human subjects in research study. Informed consent from parents and children were obtained prior to data collection. Eligible subjects had best corrected distance visual acuity (VA) of 0.00 log MAR or better in each eye and spherical equivalent refraction (SER) ranged from -0.50D to -5.00D by cycloplegic refraction. Subjects with astigmatism and anisometropia of more than 1.50D were excluded from this study. Subjects were also screened to be free from any ocular or systemic diseases. Data presented in this study was collected prior to any myopia intervention, prescribed in MyCOSKL. All subjects were wearing single vision spectacles and were not prescribed with any type of myopia intervention prior to data collection.

Measurement Techniques

Cycloplegic refractions were determined on both eyes. Left eye was occluded when measurement of the right eye was conducted, and vice versa. Axial length (AL) was measured using two different instruments, ultrasound A-scan (PacScan Plus; Sonomed Escalon, New Hyde Park, NY, USA) for the Chinese children and optical biometry (Lenstar 900, Haag-Streit, USA) for the Malays. This is because optical biometry was unavailable in the clinic during data collection for the Chinese children. The central and peripheral refraction was measured using an autorefractometer (Grand Seiko WAM-5100, Hiroshima, Japan). The measurements were conducted across the horizontal meridian out to 30° at 10° intervals in the nasal (N) and temporal (T) side of the retina in all subjects. Prior to the autorefractor measurement, two drops of cyclopentolate hydrochloride 1%, (Cyclogyl, Alcon) were instilled at five-minute intervals between each drop to achieve the cycloplegic effect. The RAF ruler was used to measure amplitude of accommodation to ensure that accommodation was paralyzed and the cycloplegic refraction was conducted when pupil size achieves ≥ 5mm. In addition, anterior segment biomicroscopy and fundus examination were also conducted to rule out any ocular pathology.

During the peripheral measurement using autorefractometer, subjects were requested to focus on the high contrast target of 0.3 logMAR size located 4m away and turning the eyes instead of the head for the subsequent angle, even though study has already shown turning eyes and turning head has no significant difference (15). Five readings were taken at each eccentricity and readings were averaged. The spherical (S), cylindrical power (C) and cylindrical axis (Θ) of the spherocylindrical refractive error measured by the autorefractor were converted into vector components of spherical equivalent M, with/against the rule astigmatism, J0; and oblique astigmatism, J45 following equations derived by Thibos et al (16). PR was later converted into RPR for further analysis. RPR was calculated by subtracting central M values obtained in primary gaze from M values measured at each respective eccentric fixation point. Formula for both calculations is as below.

$$\mathbf{M = S + \frac{C}{2}}$$

$$\mathbf{RPR = M\ (\theta) - M\ (\theta = 0)]}$$

Data Analysis

Statistical analyses were conducted using a commercial software (SPSS version 21.0; SPSS, Inc., Chicago, IL). The distribution of the measured variables was estimated by the Shapiro-Wilk test. All data were normally distributed and only data from the right eye was used for further analyses. An independent sample t-test was employed to compare the measured peripheral refraction at each eccentricity between both groups. To facilitate comparison with other similar studies from other ethnicities conducted elsewhere, polynomial fit trend lines were employed. Multiple linear regression was implemented to analyse the association between the M component in PR and axial length, age, and gender. A p-value of <0.05 was considered statistically significant.

The adjusted significance level was set to 0.008 as the refraction was measured at six retinal eccentricities along the horizontal meridian for each subject.

RESULTS

Data from 96 myopic school children from around Kuala Lumpur (40 Malays and 56 Chinese) were analysed in this study. The mean age was 9.55 ± 1.51 years old for Malays and 8.34 ± 0.48 years old for Chinese. There were no statistically significant differences (p>0.05) between data from two eyes, therefore, only data of right eyes were used for further analyses. The mean cycloplegic SER for Malay was -2.97 ± 1.26D (range -0.63D to -5.50D) and for Chinese was -3.06 ± 1.10D (range -1.22D to 5.33D). Details on patients' demographic profile (in mean (SD) is shown in Table 1.

Table I: Patient demographic profile

Parameter	Malay (n=40)	Chinese (n=56)	p-value
Age (years)	9.55 (1.51)	8.34 (0.48)	<0.001*
Male: Female	15:25	30:26	
Refraction in spherical equivalent (SER) (D)	-2.97 (1.26)	-3.06 (1.10)	0.713
Axial length (mm)	24.74 (0.90)	24.50 (0.86)	<0.05*
Corneal Curvature (D)	44.46 (1.44)	43.45 (1.24)	<0.001*

* p<0.05 is considered statistically significant

Figure 1 shows the horizontal PR for all subjects. Both Malay and Chinese children showed a similar pattern, a hyperopic PR shift with the increasing field towards nasal and temporal side of the retina. Myopic Chinese school children showed more hyperopic shifts than the Malays at all eccentricities, however the higher value of the hyperopic shift was only statistically significant at 300 N (p=0.003). Comparison of RPR between both groups showed that the Chinese myopic school children had significantly greater hyperopic RPR than the Malays at all eccentricities (p<0.0001) as shown in Figure 2. Statistical analysis also showed no significant differences in J0 and J45 between both ethnicities (p>0.05) at all eccentricities (Table 2). Linear regression was implemented to analyse the association between the M component in PR with AL, age, and gender. The overall model was significant with p < 0.05 for all eccentricity measured with the highest variation of the PR (M-component) being found at 10T with R2 of 39.2% while lowest variation was found at 30T, R2 of 14.0%. Among AL, age, and gender, analysis showed only AL has a significant influence (p<0.05) in the changes of PR (M-component) for both groups, β = [30N = -0.458, 20N -0.536, 10N = -0.577, 10T = -0.625, 20T = -0.540, 30T = -0.343]. In contrast, age and gender were not significant influence in the changes of PR (M-component), indicating that they did not meaningfully contribute to the model

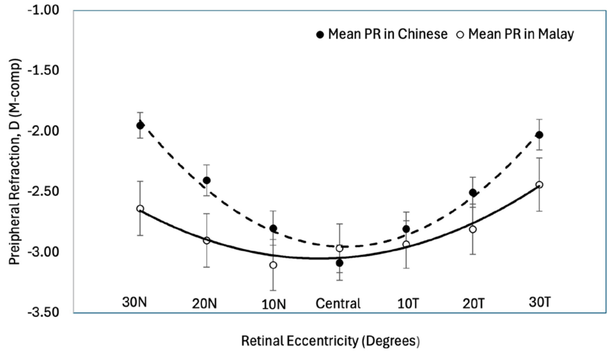

Figure 1: Mean horizontal peripheral refraction (PR) for the Malay and Chinese children. Error bars denote the SEM.

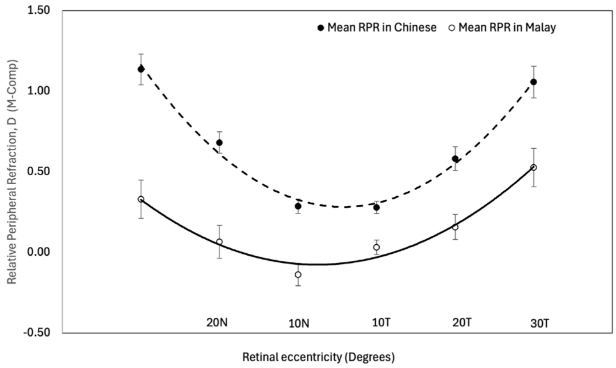

Figure 2: Mean relative peripheral refraction (RPR) for the Malay and Chinese children. Error bars denote the SEM.

Table II: Mean (SD) of J_0 and J_{45} for all subjects

J_0 (Dioptre)							
Group	**30N**	**20N**	**10N**	**0**	**10T**	**20T**	**30T**
Malay	-0.18 (0.34)	0.02 (0.40)	-4.10 (0.80)	0.31 (0.26)	0.14 (0.36)	-0.13 (0.48)	-0.52 (0.57)
Chinese	-0.19 (0.24)	0.02 (0.31)	0.21 (0.23)	0.22 (0.26)	0.18 (0.26)	-0.17 (0.37)	-0.51 (0.43)
P value	0.91	0.98	0.22	0.89	0.59	0.68	0.89
J_{45} (Dioptre)							
Group	**30N**	**20N**	**10N**	**0**	**10T**	**20T**	**30T**
Malay	-0.03 (0.27)	-0.06 (0.25)	0.04 (0.19)	0.05 (0.12)	0.06 (0.20)	0.11 (0.24)	0.18 (0.25)
Chinese	-0.07 (0.13)	-0.09 (0.11)	0.03 (0.14)	0.05 (0.11)	0.02 (0.19)	0.06 (0.19)	0.11 (0.19)
P value	0.84	0.48	0.97	0.92	0.22	0.24	0.17

*** p<0.05 is considered statistically significant**

DISCUSSION

The PR refers to the distribution of refractive power across the peripheral visual field. It can differ from the central refraction, which is the refractive power of the centre of the visual field. The interest in PR has increased in the last decade because of the hypothesis that the periphery of the retina might influence myopia development and progression. This is acceptable because the sizes of retinal dendritic cells increase with eccentricities, indicating that the area that receives information directly or indirectly on the retina increases as well (10). Therefore, it is possible that the summation of information from the peripheral retina dominates over that from the fovea (10). Moreover, there is evidence demonstrated in several animal and human studies which concurred with the hypothesis (11, 12, 13).

This study measured and compared horizontal PR in Malays and Chinese myopic school children living in Kuala Lumpur. In general, all myopic children in this study have hyperopic PR, which is consistent with previous investigations (9, 17, 18). However, the myopic Chinese school children had significantly greater hyperopic PR than the Malays, suggesting a more prolate retinal shape. Mutti et al (19) demonstrated that Asians children were evident to have hyperopic RPR three years earlier than Caucasians before the myopia onset and remained to be greater hyperopic up to five years after the myopia onset. Their findings suggested that hyperopic defocus may trigger and stimulate the axial growth and therefore proposed that hyperopic PR contributes to the development of myopia rather than being the consequences of it.

It is widely accepted that axial length is highly correlated with spherical refraction (20). Previous prevalence studies in Malaysia showed higher levels of myopia and longer AL in Chinese school children compared to the Malays or Indians (13, 14). It is therefore possible that the greater hyperopic defocus at the peripheral retina of the Chinese children, stimulates faster AL growth compared to other ethnicities. Nevertheless, the results of this study demonstrated that the Malays had longer AL than the Chinese with similar refractive error, which could be due to the difference in the measurement techniques. Due to logistics, two different methods were employed to measure the AL. The AL of the Malays was measured using optical biometry while ultrasound biometry was used to measure the AL of the Chinese children. Optical biometry uses contactless operation which eliminates the confounding of corneal applanation and measures the distance from the tear layer to the retinal pigment epithelium whereas ultrasound biometry applanate the cornea and measures the distance from the cornea to the vitreoretinal interface, thus creating differences in measurements even though the central refraction is similar between both groups. To confirm this hypothesis, a comparison study was conducted between both instruments on 90 young myopic adults (14 males and 76 females) with mean age of 22.03 ± 1.14 years and mean refraction of -3.04 ± 1.61 D (ranged from -0.50 to -6.75DS). The mean AL found using optical biometry was significantly longer (24.75±1.19 mm) than ultrasound A-scan (24.54±0.85 mm) ($p<0.05$), which confirms our hypothesis that the difference in results was due to different measurement techniques. Therefore, it is safe to infer that the AL in both groups in this study are comparable due to similar refractive error and that the difference in PR between both ethnicities was not influenced by the difference in AL measurements.

Analysis of the relationship between the M-component (spherical equivalent) in PR with AL, corneal curvature, age, and gender using generalized linear model demonstrated that only AL has significant influence on the M-component at all eccentricities ($p<0.05$). This indicates that the PR becomes more hyperopic as the AL elongates. As this was a cross- sectional study, we were not able to confirm whether hyperopic PR was the consequence or cause of myopia. However, Mutti et al (19) investigated children from six different ethnicities and reported that myopia progression was greater per dioptre of more hyperopic relative PR, but only by a small amount, and that AL elongation was unrelated to the average relative PR, regardless of ethnicities. Changes in central and PR in Singapore Chinese children was monitored for 12 months by Sng et al (21), and concluded that PR did not predict myopia onset or influence myopia progression.

The results of this study were also compared with similar studies from other populations (Figure 3). Interestingly, the parabolic PR curve for the Malays was the flattest compared to other populations with similar central refraction while the parabolic PR curve of the Chinese children in Kuala Lumpur is quite similar to those in Japan (17) and China (22). The similarities could be explained by the genetic variance between ethnicity that may alter the signalling cascade on a cellular level. Different genetic backgrounds and the existence of ethnic variations in myopia prevalence are found to be related with the development of myopia-related phenotypes. In a recent review on myopia genetics, Cai et al (23) reported that it is possible that genetics plays a more significant role in myopia development. However, more extensive investigations are needed to confirm these observations.

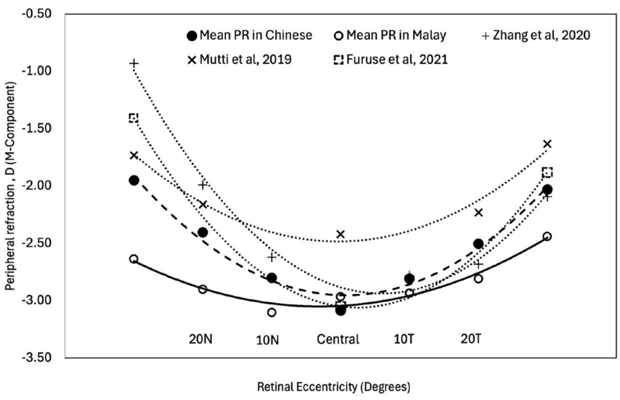

Figure 3: Comparison of peripheral refraction from previous peripheral refraction studies. #Data from Zhang et al. 2020 was extracted from the baseline data from the Single Vision (SV) group.

The effects of age on PR were not observed in this study. The results demonstrated that even though the Chinese children were significantly younger than the Malays, their PR were more hyperopic at all eccentricities. In an earlier study, Li et al (24) found older children had more hyperopic PR than the younger group when comparing between 14 and 7 years old myopic children of similar refractive error. This was probably because as the child grows, the AL elongates creating a more prolate ocular shape, which leads to an overall increase in hyperopic PR error in older children (7). On the contrary, Atchison et al (25) reported that the PR in emmetropes to moderate myopes is relatively unaffected by age for healthy eyes of similar refractive errors, when comparing between young adult and old subjects. It is possible that the effect of age on PR was not detected in this study due to the small age difference between both ethnicities, which was 9.55 ± 1.51 years for the Malays and 8.4 ± 0.48 years for the Chinese.

The results of this study also showed that a more myopic central refraction is associated with greater hyperopic PR. This finding is similar to previously reported studies where higher degrees of central refraction were shown to have more hyperopic RPR (19, 24). Mutti et al (19) suggested that the retinal profile is steeper with increasing myopia and the amount of retinal steepening occurs symmetrically for vertical and horizontal meridians. Nevertheless, many investigators did not measure PR along the vertical meridian, possibly due to its small effect on myopia (26). However few investigators have demonstrated relative peripheral myopia along the vertical meridian of the retina (27). If retinal shape is associated with myopia development, it is possible that the signals triggered along the horizontal are stronger than the vertical meridian of the retina. Nevertheless, the retinal shape of the participants was not known before they developed myopia. Therefore, it is impossible to determine in this study whether the retinal shape triggers myopia development/progression or whether retinal shape changes as myopia develops. This warrants further investigations.

Few limitations were acknowledged in this study such as the lack of overall ocular measurement including the corneal curvature and lens curvature. Thus differences in the PR cannot be fully explained by differences in the anterior optics of the eye. However, even though cornea is the predominant factor in the overall power of the eye, only minimal alteration was noted after reaching early childhood age and demonstrated minimal clinically meaningful variation by ethnicity (27, 28). Apart from that, the number of subjects in this study were not age matched and quite small to be representative of the two main ethnicities in Malaysia. Therefore, a larger age matched sample size is needed in future studies, to confirm our findings.

CONCLUSION

This is the first reported study on the differences of PR between ethnicities in myopic children in Malaysia. Chinese children appear to have a greater hyperopic PR than the Malays of similar refractive error, indicating a more prolate or steeper retinal shape that may contribute to higher prevalence of myopia observed in the population. Future longitudinal studies are needed to verify this finding.

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