Relationship between Refractive Errors and Ocular Biometry Components in Carpet Weavers

AbbasAli Yekta, PhD[1] • Akbar Fotouhi, MD, PhD[2] • Hassan Hashemi, MD[3,4]
Hadi Ostadi Moghaddam, PhD[1] • Javad Heravian, PhD[1] • Samira Heydarian, MSc[5]
Reihaneh Yekta, MD[6] • Akbar Derakhshan, MD[7] • Farhad Rezvan, MD[3]
Mehdi Behnia, MD[3] • Soheil Aliakbari, MD[3] • Mehdi Khabazkhoob, MSc[3]

Abstract

***Purpose*:** To determine the relationship between refractive errors and ocular components values in carpet weavers

***Methods*:** Refractive errors and ocular components values were investigated in carpet weavers at Mashhad city in Iran. After selection of samples, the individuals who had ophthalmic and systemic disease effective on the refractive errors were excluded from the study. Refractive errors and ocular components were measured by autorefractometry, A-Scan ultrasonography and, keratometery, respectively.

***Results*:** 269 carpet weavers including 191 male (71.9%) and 78 female cases (28.1%) with the mean age of 41.30±6.5 years and range of 21 to 60 years were investigated in this study. The average of spherical equivalent (SE) refraction of the subjects was -1.7±1.8 diopters (D). SE has a significant relation to axial length (AL) (r=-0.564), anterior chamber depth (ACD) (r=-0.301), vitreous chamber depth (VCD) (r=-0.557), lens thickness (LT) (r=0.170), and corneal curvature radius (CR) (r=0.170). AL and VCD had the most relationship to myopia. The average values of the AL, ACD, VCD, and LT of the subjects were 23.6, 3.2, 16.6 and 3.9 mm respectively. The average of CR was 7.6 mm. Except LT, other optical components were significantly different in both genders. ACD, VCD, and CR had an inverse relation to age and LT had a direct relation to age.

***Conclusion*:** SE refraction in carpet weavers had a significant relation to the ocular components and variation in SE refraction may be due to the changes of these elements.

***Keywords*:** Ocular Biometry, Refractive Error, Carpet Weavers

Iranian Journal of Ophthalmology 2010;22(2):45-54 © 2010 by the Iranian Society of Ophthalmology

1. Associate Professor of Optometry, Department of Optometry, Mashhad University of Medical Sciences
2. Associate Professor of Epidemiology, Department of Epidemiology and Biostatistics, School of Public Health, Tehran University of Medical Sciences
3. Noor Ophthalmology Research Center, Noor Eye Hospital
4. Associate Professor of Ophthalmology, Eye Research Center, Farabi Eye Hospital, Tehran University of Medical Sciences
5. Department of Optometry, Mashhad University of Medical Sciences
6. Emam Khomeini Hospital, Mashhad University of Medical Sciences
7. Ophthalmologist, Department of Ophthalmology, Mashhad University of Medical Sciences

Received: January 27, 2010
Accepted: April 22, 2010

Correspondence to: *Hassan Hashemi, MD*
Noor Ophthalmology Research Center, Noor Eye Hospital, Tehran, Iran, Tel: +98 21 88651515, Email: hhashemi@noorvision.com
Eye Research Center, Farabi Eye Hospital, Tehran, Iran, Tel: +98 21 55414941-6

Introduction

Epidemiological studies indicated that uncorrected refractive errors are accounted to be among the important risk factors for visual impairments in the world.[1] Although genetic, racial, and environmental risk factors were identified as some factors influential on refractive errors.[2,3] The most important factor in the refractive errors is relationship to the ocular components.[4-6] Numerous studies showed that the ocular components are depended on age and perhaps the variation of refractive errors with age may be due to changes in the ocular components.[7] Wong reported that the most important relative predictors of refraction are axial length (AL) and vitreous chamber depth (VCD).[6] He suggested that some factors such as level of education and near work activity affect AL and VCD.[6] McBrien and Adams reported that near work activity in clinical microscopists aged 21 to 63 years causes the myopic shift and VCD is the most ocular component which varies with increasing near work. It has been suggested that ocular biometrical variations in animals are important causes of refractive errors. In an another report,[8] McBrien and Ostadi Moghaddam announced that the major structural cause of the experimentally induced myopia is vitreous chamber elongation.

The art of carpet weaving in Iran is becoming more industrialized and in many parts of Iran; it is done by individuals in their homes or workshops. Important body organs such as spinal cord are involved in this job. In addition, high visual accuracy and involvement in near work for long hours, which cause visual fatigue for weavers, is needed. A carpet weaver works for 8 hours a day on average. Considering the theories on close work and its effects on ocular biometry changes, the current study is carried out in an attempt to determine the relationship between ocular biometry and refractive errors in carpet weavers. To our knowledge this is the first study of ocular biometry and refractive errors in carpet weavers in Iran.

Methods

This cross sectional study is based on the carpet weaving population of Mashhad, the second most populous city in Iran. Six workshops were randomly selected from among the carpet weaving workshops. The manager of one workshop did not agree to the performance of this study and samples were collected from the other five workshops. In each workshop, all carpet weavers were taken under investigation. The inclusion criteria were at least seven hours of carpet weaving per day for a time period of at least two years, lack of ophthalmic disease, amblyopia, aphakia, strabismus, refractive surgery, diabetes, and systemic diseases effective on refractive errors. After obtaining written informed consent from the carpet-weavers, they were interviewed. Demographic information, carpet weaving background, age of starting carpet weaving, and they were investigated during the interviews.

Refractive errors of each eye were measured by autorefractometer (mean of six measurements by Topcon Autorefractometer, model KM 8000, Japan), The autorefraction results were checked using the HEINE BETA 200 retinoscope (HEINE Optotechnic, Germany). Refraction results were evaluated using an autorefractometer. The best corrected visual acuity (BCVA) was determined using a Snellen chart after subjective refraction at a distance of 4 meters. Afterwards, keratometry (mean of three measurements by Javal-Schiotz keratometer, HAAG-STREIT, Swiss), ophthalmoscopy (Ophthalmoscope: HEINE BETA 200, Germany), cover test, and biometry (mean of five measurements) were done for both eyes. For measurement of ocular components (AL, anterior camber and VCDs, lens thickness(LT)), the Sonomed biometer (model 300AP, USA) was used following corneal anesthesia with two drops of 0.5% tetracaine HCL into each eye. The subjects were asked to lying in a supine position and look at a distance object. The lids were held apart with the fingers taking great care to avoid excessive pressure on the globe. The probe tip then applied to touch the cornea to obtain the measurements.

Myopia was defined as a spherical equivalent (SE) refraction of -0.50 diopter (D) or less and hyperopia as an SE refraction of +0.50 D or more. Emmetropia was defined as an SE between +0.50 and -0.50 D. The study protocol was approved by the Ethical Committee of Mashhad University of Medical

Sciences. Written informed consent was also obtained from the carpet weavers for all steps of the study before examinations. We studied the SE, AL, anterior chamber depth (ACD), VCD, LT and CR values, in the studied population. Their averages and standard deviation in terms of age in both genders were presented in this study. Correlation coefficient was used for correlating the ocular components and the refractive errors and reported r and r^2 finally. Linear regression was used for determination of relation among the ocular components values, age, and gender. Analysis of variance was used for comparison of ocular components values in the different types of refractive errors. P-value less than 0.05 is statically significant. Analyses were done with the SPSS version 11.5 software.

Results

In this study, 269 carpet weavers were investigated of which 71.9% (191 subjects) were males and 28.1% (78 subjects) were females. The mean age of the participants was 41.30±6.50 years (range=21-60 years). The mean of working years in carpet weaving was 25.70 years with the standard deviation of 9.20 years (range=2-50 years).

Refractive errors

The mean SE refraction of the subjects was -1.70±1.80 D (range=-10.25 to +2.40 D). The SE refraction values of the age and gender groups are shown in Table 1; there was no significant difference between males and females (P=0.760). The prevalence of myopia and hyperopia were 67.0% and 3.0%, respectively. The relationship between SE refraction and ocular components is shown in Table 2. As is noted in this table, AL, ACD, and VCD have an inverse and significant relation to SE refraction. LT and corneal curvature have a significant and direct relation to SE refraction. The most correlation of SE refraction is to VCD. Figure 1 shows the correlation between SE refraction and AL and figure 2 shows the correlation between SE refraction and VCD. The values of ocular components in the different types of refractive errors are shown in Table 3. Analysis of variance showed that AL, ACD, VCD, and LT are significantly different in different types of refractive errors. Corneal curvature was not significantly different in various types of refractive errors. Figure 3 shows the values of VCD in different types of refractive errors in terms of intensity. As it is seen in the figure, the least value corresponds to the hyperopes and the most intensive value is observed to be in the myopes.

The relationship between ocular components and refractive errors is shown in Table 3. As this table shows, the AL, VCD, and ACD had the most relationship to myopia and LT and corneal curvature were not significantly different in the myopes compared to the nonmyopes.

Table1. Ocular component in carpet weavers

		SE (D)	AL (mm)	ACD (mm)	VCD (mm)	LT (mm)	RC (mm)
Age (Year)	20-30	-2.7±2.5	24.2±1.6	3.5±0.4	17.2±1.4	3.5±0.2	7.7±0.2
	31-40	-1.8±1.8	23.7±1.0	3.2±0.3	16.7±1.0	3.8±0.3	7.6±0.3
	41-50	-1.6±1.8	23.6±0.9	3.2±0.3	16.5±0.8	3.9±0.3	7.5±0.3
	51-60	-1.0±1.3	23.6±1.2	3.1±0.4	16.5±1.0	4.0±0.4	7.5±0.2
Gender	Male	-1.7±1.7	23.8±1.0	3.3±0.3	16.7±1.0	3.9±0.3	7.6±0.3
	Female	-1.7±2.0	23.2±0.8	3.1±0.3	16.3±0.8	3.8±0.4	7.5±0.3
Total		-1.7±1.8	23.6±1.0	3.2±0.3	16.6±0.9	3.9±0.3	7.6±0.3

SE: Spherical equivalent
AL: Axial length
ACD: Anterior chamber depth
VCD: Vitreous chamber depth
LT: Lens thickness
CR: Corneal curvature radius
D: Diopter

Table 2. Correlation between ocular components in carpet weavers

	SE (D)	AL (mm)	ACD (mm)	VCD (mm)	LT (mm)	RC (mm)
SE						
AL	-0.564 (0.318)					
ACD	-0.301 (0.091)	0.544 (0.296)				
VCD	-0.557 (0.31)	0.916 (0.84)	0.316 (0.1)			
LT	0.170 (0.029)	-0.110 (0.012)	-0.275 (0.075)	-0.367 (0.135)		
RC	0.171 (0.029)	0.498 (0.248)	0.082 (0.007)	0.499 (0.249)	0.019 (0)	
Age (Year)	0.132 (0.017)	-0.100 (0.01)	-0.201 (0.04)	-0.161 (0.026)	0.362 (0.131)	-0.195 (0.038)

SE: Spherical equivalent
AL: Axial length
ACD: Anterior chamber depth
VCD: Vitreous chamber depth
LT: Lens thickness
CR: Corneal curvature radius
D: Diopter

Table 3. Correlation between ocular component carpet weavers

	AL (mm)	ACD (mm)	VCD (mm)	LT (mm)	RC (mm)
Myopia	23.9±1.0	3.3±0.3	16.8±0.9	3.8±0.3	7.5±0.3
Emmetropia	23.1±0.8	3.1±0.3	16.1±0.7	3.9±0.3	7.5±0.2
Hyperopia	22.5±0.8	2.8±0.3	15.5±0.7	4.1±0.2	7.5±0.3
P value	<0.001	<0.001	<0.001	0.029	0.996

AL: Axial length
ACD: Anterior chamber depth
VCD: Vitreous chamber depth
LT: Lens thickness
CR: Corneal curvature radius

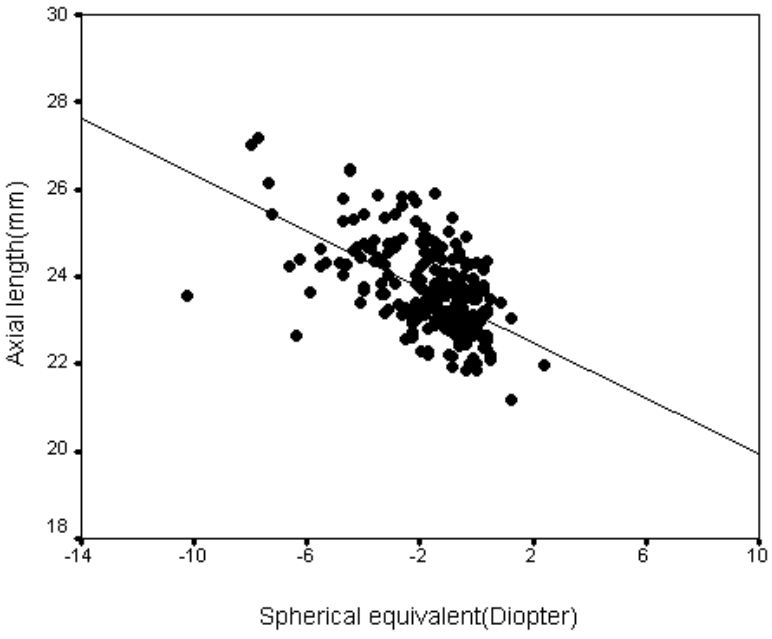

Figure 1. The correlation between axial length and Spherical equivalent

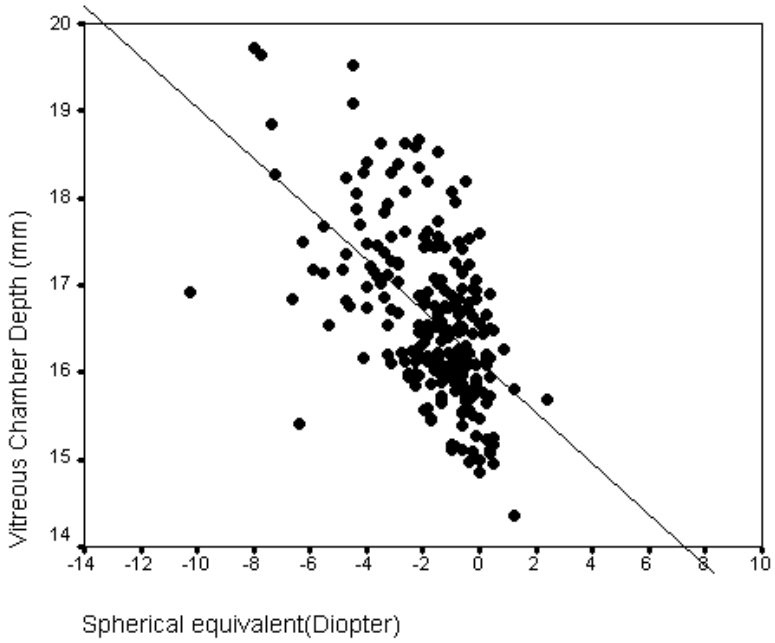

Figure 2. The correlation between vitreous chamber depth and spherical equivalent

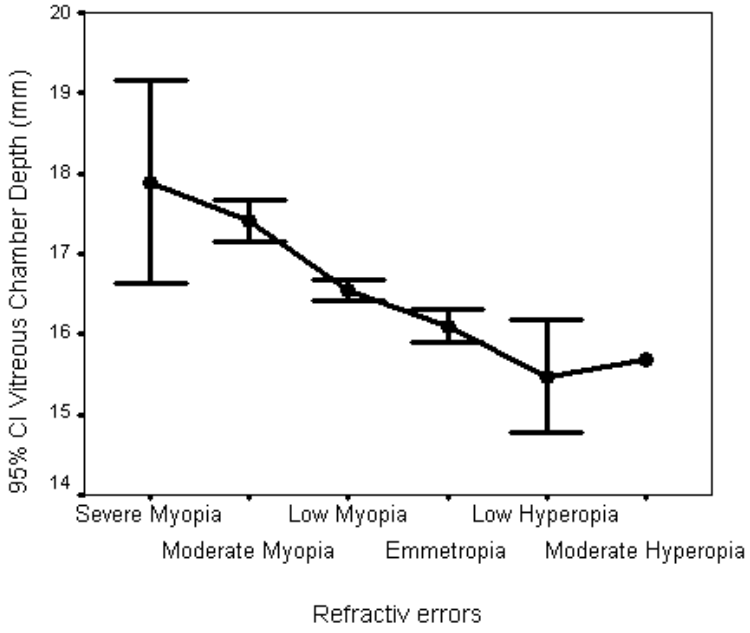

Figure 3. Mean vitreous chamber depth in refractive errors group

Axial length

The mean AL was 23.60 mm (range= 21.13 to 27.17 mm) which was more in males than females (P<0.001). The AL had not significant relationship to age (P=0.012). After elimination of the gender effect, the AL in the males had a significant direct relation to age (P<0.001). According to the results of this study, AL had a direct and significant relation to ACD and VCD; also, corneal curvature had an inverse relation to AL. Values of correlation coefficients of AL to the variables are shown in Table 2.

Anterior chamber depth

The mean ACD in the subjects was 3.20 mm with the standard deviation of 0.30 mm (range=2.30-4.20 mm). The means ACD in males and females were 3.30 and 3.10 mm respectively which were significantly different (P<0.001). With increasing age, ACD significantly decreased (P<0.001) such that this depth gets 0.09 millimeter shorter per year rise in age. After elimination of gender effect, the relationship of age to ACD in males was stronger such that this depth got 0.10 millimeter shorter per year rise in age in the males and it got 0.08 millimeter shorter per year rise in age in the females.

As it is shown in Table 2, ACD has a direct and significant relation to AL and this depth has an inverse relation to the LT.

Vitreous chamber depth

The mean VCD in subjects was 16.60±0.90 mm (range=14.40-19.70 mm) which are shown in Table 1. The means VCD in the males and females were 16.70 and 16.30 mm respectively and were significantly different (P=0.002); values of vitreous chamber decrease 0.2 millimeter per year rise in age (P<0.001). VCD had a significant relation to all ocular components. This factor had an inverse relation to LT and SE refraction and it had a direct relation to ACD and corneal curvature.

Lens thickness

The mean LT was 3.90 mm with the standard deviation of 0.30 millimeter (from 2.4 to 4.8 mm) which are shown in Table 1. The values of LT in the males and females were not significantly different (P=0.273). As it is shown in Table 1, values of LT significantly increased from 20-30 to the 50-60 years. Linear regression test showed that LT increased 0.160 millimeter per 10 years rise in age (P<0.001). LT had an inverse relation to anterior chamber and VCDs (Table 2).

Corneal curvature

The mean corneal curvature in subjects was 7.60 mm with the standard deviation of 0.3 millimeter (range=6.4-8.2 mm). Even though the values of corneal curvature in the males and females were very somehow to each other, but the males significantly had more corneal curvature (P=0.007). Corneal curvature significantly decreased with increasing age (P=0.007). Corneal curvature had a significant relationship to SE refraction, VCD, and AL. Multiple regression test showed that SE refraction, AL and LT had a direct and significant relation to corneal curvature (r^2=0.527). Correlation of VCD and corneal curvature is shown in Figure 4.

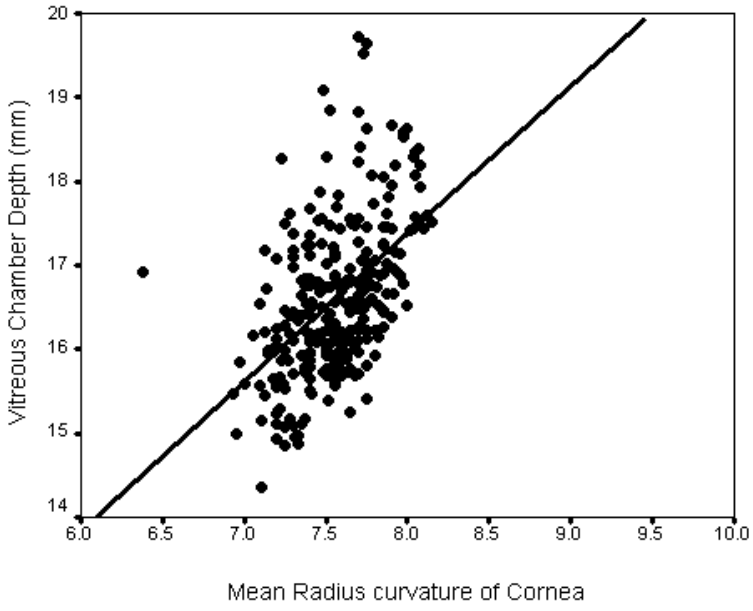

Figure 4. The correlation between vitreous chamber depth and radius curvature of cornea

Discussion

The relationship between the ocular components and refractive errors in the normal populations has previously been investigated.[4-6,9] The purpose of this study was to investigate these elements in carpet weavers who do daily near work each day for a long time. Even though this is a cross sectional study and do not directly show the effect of near work on the refractive errors, but a statistical relationship between refractive errors and ocular biometry can be found. This study is divided into two sections and the results will be discussed. In the first section in respect of the relation between refractive errors and ocular biometry, our results will be compared with the other studies. In the second section, the relationship between the ocular components will be investigated.

As the results of this study showed, 67% of the carpet weavers had myopia and only 3% of them were hyperopes. A high proportion of our subjects were myopic which is accounted to be among the results expected from this investigation. Generally, comparison of this finding with the results of the previous studies which have been accomplished in Iran shows that the occurrence of myopia is high in the carpet weaving population. In a study performed based on cycloplegic and noncycloplegic refractions in Tehran, Iran, the incidence of myopia was 17.20% and 21.80% respectively.[10] Also, in a report concerning the elderly population in Mashhad, the incidence of myopia has been shown to be 27.2%.[11] Investigation of these studies shows that the occurrence of myopia is high in carpet weavers population. Comparing this result with the incidence of myopia in the healthy population of other studies, we see that the prevalence of myopia in the carpet weavers is more than that in many of other studies.[12-14]

The previous studies reported that near work is the reason for myopia progression.[8,15] Refractive errors have previously been investigated in some occupations such as computer operators, typists, and microscopists who have near work activities. In addition to near work, other factors such as environmental and genetic factors play a role in progression of myopia.[2,11,16] Anatomical reason of myopia is not completely known yet and it must be noted that the investigation of factors effective on refractive errors should be accompanied with the measurement of ocular components. Growth of the AL in the childhood period is accompanied with some variation in the corneal power so that ametropia is created. When ametropia is induced, AL is usually abnormal but it does not always affects alone, and imbalance among the refractive elements of the eye is accounted to be the principal factor for inducing refractive errors.

As our results showed, SE refraction has an indirect relation to AL, ACD, and VCD and a direct relation to LT and corneal curvature. In the investigation of these elements in different types of refractive errors, it was noted that AL, ACD, and VCD are higher in the myopes. Even though it was expected that corneal curvature to be also different in the various types of refractive errors, the results of our study did not show any relationship and the reason for this may be the high ages of the carpet weavers. The results of this study indicated that the highest difference between myopic and nonmyopic eyes was in the VCD and AL and the reason for this is perhaps the extended looking of carpet weavers to near objects (carpet gallows) and increase of inter ocular pressure accompanied with lengthening of vitreous chamber that is in agreement with the theory of Young and Leary (1987) who reported that vitreous pressure in monkeys increases with looking from distant to near objects. The previous studies also showed that VCD and AL are the most important ocular components that increase in the myopes.[8,17-20]

In respect of LT, it must also be pointed out that some studies showed that lens is thinner in the myopes. There was no significant difference between the myopes and nonmyopes in LT, but myopes had thinner lens in comparison with the hyperopes in our study.[6,9,17,21,22] McBrien and Adams reported that the myopes have deeper anterior chamber, longer AL, thinner lens, and deeper vitreous chamber than the nonmyopes. They did not find any significant difference in the corneal curvature between the myopes and nonmyopes and reported increase of VCD as the most important factor effective on refractive errors that confirms our results.[8] Even though in our study, AL had a stronger relation than VCD to myopia, on the whole our

findings approve the results of McBrien and Adams.[8] Other studies such as the report of Wong, Tang, Zadnic, Fan, and Garner also like our study recognized increase of VCD and AL as the factors influential on inducing myopia.[6,17-19] One of the probable reasons for myopia and its relationship to VCD and AL may be excessive accommodation culminates in scleral tension and consequently increase of VCD. As our results showed, corneal curvature is not different in myopes and nonmyopes and some studies have also approved it. Perhaps the reason for this may be that cornea grows in the initial years of living whereas the development continues, therefore AL plays more roles in the creation of refractive errors and we may attribute any kind of in coordination among ocular components and causes of the spherical refractive errors to AL of the eye.

The results obtained from this study are compared with several other studies in table 4. As this table shows, values of AL and VCD in our study is relatively more than those in some of the other studies; with regard to the relationship of myopia to these factors, perhaps its reason may be the high incidence of myopia in our population.

In respect of other ocular components, except LT, our results show that the other ocular components had a significant difference between both genders and the values for the males were more than females which agrees with the results of Warrier.[23] In the study of Wong, all of these ocular components in males and females had a significant difference. Also Shufelt showed that there is difference between both genders in all these components.[4,6,23]

The results of our study showed that VCD decreased with increase of age and AL had no relationship to age. Wong[6] showed that AL reduced with increasing age which was also approved by Grosvenor et al and Lighton et al.[24,25] Carly et al reported that with increase of age, little variation is observed in ACD and corneal curvature, but AL and VCD decreased.[26] Malen et al suggested that AL and VCD decreased with increasing age, but these variations are not considerable.[9] Taft reported that there is a very low indirect relationship between AL and age.

Our results indicated that with the rise in age because of growth, LT increases and subsequently ACD decreases which approved the results of Wong et al study.[6] These results were also confirmed by Cook,[27] and Malen.[9] The results of our study showed that corneal curvature reduced considerably with increasing age which is in contrast with the results of the other investigators and its reason may be steepening of the cornea due to eyelid pressure on cornea as a result of extended near work activity.

Table 4. Comparison between this study and other study

	Age (Year)	SE (D)	AL (mm)	ACD (mm)	VCD (mm)	LT (mm)	RC (mm)
Wong (6)	40 to 81	-0.49	23.23	2.9	15.58	4.75	7.65
Wickremasinghe (5)	40+		23.13				
Warrier (23)	40+	-1.22	22.76	2.82	15.43	4.51	7.71
Logan	17-30	-1.01	23.91	3.62			7.74
Logan	17-30	-1.40	24.09	3.55			7.77
Shufelt (4)	40+	0.11	23.38	3.41	15.04	4.38	
Mallen (9)	17-40	-0.87	23.13	3.19	16.04	3.85	7.71
This study	21-60	-1.7	23.6	3.2	16.6	3.9	7.6

SE: Spherical equivalent
AL: Axial length
ACD: Anterior chamber depth
VCD: Vitreous chamber depth
LT: Lens thickness
CR: Corneal curvature radius

The study provided valuable information on ocular biometry of carpet weavers. However, it had some strengths and weaknesses that must be taken into account. The most important strength of the study was its extended examinations among carpet weaving population of Iran. Considering the traditional nature of the profession in the country, the resulted data are important. But, the study had some weaknesses too. Assumptions can be made after forestalling the weaknesses. Since there was no control group in the study, the hypothesis could not be confidently confirmed. In addition, because the study was carried out in one city, certain variables such as environmental factors and living conditions can also act as confounding factors. It is suggested, hence, that future studies be carried out in different cities of Iran among different ethnic groups with control group inclusion. Having no case history of ocular biometry of carpet weavers, Cohort studies will provide better understanding on factors related to carpet weaving and ocular biometry parameters.

Conclusion

SE refraction in myopic individuals (carpet weavers) has a significant relation to the ocular components and variation in SE refraction may be due to the changes in these elements.

Acknowledgments

This study was supported by vice chancellor of Mashhad University of Medical Sciences (code: 86200), Iran.

References

1. Dandona L, Dandona R. Estimation of global visual impairment due to uncorrected refractive error. Bull World Health Organ 2008;86(8):B-C.
2. Ip JM, Huynh SC, Robaei D, et al. Ethnic differences in refraction and ocular biometry in a population-based sample of 11-15-year-old Australian children. Eye (Lond) 2008;22(5):649-56.
3. Saw SM, Goh PP, Cheng A, et al. Ethnicity-specific prevalences of refractive errors vary in Asian children in neighbouring Malaysia and Singapore. Br J Ophthalmol 2006;90(10):1230-5.
4. Shufelt C, Fraser-Bell S, Ying-Lai M, et al. Refractive error, ocular biometry, and lens opalescence in an adult population: the Los Angeles Latino Eye Study. Invest Ophthalmol Vis Sci 2005;46(12):4450-60.
5. Wickremasinghe S, Foster PJ, Uranchimeg D, et al. Ocular biometry and refraction in Mongolian adults. Invest Ophthalmol Vis Sci 2004;45(3):776-83.
6. Wong TY, Foster PJ, Ng TP, et al. Variations in ocular biometry in an adult Chinese population in Singapore: the Tanjong Pagar Survey. Invest Ophthalmol Vis Sci 2001;42(1):73-80.
7. Sorsby A, Benjamin B, Sheridan M, et al. Refraction and its components during the growth of the eye from the age of three. Memo Med Res Counc 1961;301(Special):1-67.
8. McBrien NA, Adams DW. A longitudinal investigation of adult-onset and adult-progression of myopia in an occupational group. Refractive and biometric findings. Invest Ophthalmol Vis Sci 1997;38(2):321-33.
9. Mallen EA, Gammoh Y, Al-Bdour M, Sayegh FN. Refractive error and ocular biometry in Jordanian adults. Ophthalmic Physiol Opt 2005;25(4):302-9.
10. Hashemi H, Fotouhi A, Mohammad K. The age- and gender-specific prevalences of refractive errors in Tehran: the Tehran Eye Study. Ophthalmic Epidemiol 2004;11(3):213-25.
11. Yekta AA, Fotouhi A, Khabazkhoob M, et al. The prevalence of refractive errors and its determinants in the elderly population of Mashhad, Iran. Ophthalmic Epidemiol 2009;16(3):198-203.
12. Saw SM, Gazzard G, Koh D, et al. Prevalence rates of refractive errors in Sumatra, Indonesia. Invest Ophthalmol Vis Sci 2002;43(10):3174-80.
13. Saw SM, Chan YH, Wong WL, et al. Prevalence and risk factors for refractive errors in the Singapore Malay Eye Survey. Ophthalmology 2008;115(10):1713-9.
14. Wang Q, Klein BE, Klein R, Moss SE. Refractive status in the Beaver Dam Eye Study. Invest Ophthalmol Vis Sci 1994;35(13):4344-7.

15. Ip JM, Saw SM, Rose KA, et al. Role of near work in myopia: findings in a sample of Australian school children. Invest Ophthalmol Vis Sci 2008;49(7):2903-10.
16. Jiménez JR, Bermúdez J, Rubiño M, et al. Prevalence of myopia in an adult population of two different ethnic groups in the Ecuadorian Amazon. Jpn J Ophthalmol 2004;48(2):163-5.
17. Zadnik K, Manny RE, Yu JA, et al. Ocular component data in schoolchildren as a function of age and gender. Optom Vis Sci 2003;80(3):226-36.
18. Garner LF, Stewart AW, Kinnear RF, Frith MJ. The Nepal longitudinal study: predicting myopia from the rate of increase in vitreous chamber depth. Optom Vis Sci 2004;81(1):44-8.
19. Fan DS, Lam DS, Wong TY, et al. The effect of parental history of myopia on eye size of pre-school children: a pilot study. Acta Ophthalmol Scand 2005;83(4):492-6.
20. Jiang BC, Woessner WM. Vitreous chamber elongation is responsible for myopia development in a young adult. Optom Vis Sci 1996;73(4):231-4.
21. Olsen T, Arnarsson A, Sasaki H, et al. On the ocular refractive components: the Reykjavik Eye Study. Acta Ophthalmol Scand 2007;85(4):361-6.
22. Shih YF, Chiang TH, Lin LL. Lens thickness changes among schoolchildren in Taiwan. Invest Ophthalmol Vis Sci 2009;50(6):2637-44.
23. Warrier S, Wu HM, Newland HS, et al. Ocular biometry and determinants of refractive error in rural Myanmar: the Meiktila Eye Study. Br J Ophthalmol 2008;92(12):1591-4.
24. Grosvenor T. Reduction in axial length with age: an emmetropizing mechanism for the adult eye? Am J Optom Physiol Opt 1987;64(9):657-63.
25. Leighton DA, Tomlinson A. Changes in axial length and other dimensions of the eyeball with increasing age. Acta Ophthalmol (Copenh) 1972;50(6):815-26.
26. Lam CS, Goh WS, Tang YK, et al. Changes in refractive trends and optical components of Hong Kong Chinese aged over 40 years. Ophthalmic Physiol Opt 1994;14(4):383-8.
27. Cook CA, Koretz JF, Pfahnl A, et al. Aging of the human crystalline lens and anterior segment. Vision Res 1994;34(22):2945-54.