Original Article

# Physical and Physiological Changes with Presbyopia

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**Purpose:** To estimate the possible physical and physiological changes in the optical system of the eye related to age over 40 years in normal presbyopic persons.

**Material and Methods:** Sample of 20 subjects with presbyopia ages (40 – 45 years) was used as cases and other sample of 20 subjects from university student's ages (20 – 25 years) was used for comparison. Typical measurement procedures for the two groups included: accommodation, pupil size, anterior corneal surface power, and refraction from both eyes in each subject.

**Results:** T-test showed significant difference between the measurements of the two groups. The estimated changes from young age to presbyopic age demonstrated the amplitude of accommodation tends to decrease 0.27 D per year, the pupil size tends to become smaller 0.033 mm per year, the refraction tends to shift toward hypermetropia 0.018 D per year, the corneal astigmatism tends to decrease 0.0083 D per year, and the cylinder of corneal astigmatism was found to change gradually from with-the-rule to against-the-rule.

**Conclusion:** All measurements in this study suggesting significant changes in the optical system of the eye were essentially related to age.

As age advances it is found initially to affect the optical system of the eye in the process of accommodation, hence the presbyopia occurs. Accommodation is reasonably effective by the age of about four months and remains more than adequate for most purposes until the onset of presbyopia at the age of about 40 years[1]. With increasing age, it is generally believed that the crystalline lens progressively loses elasticity, leading to a complete inability to change shape and to loss of accommodation by the mid fifties[2]. Although there appears to be no general agreement on how to define the onset of presbyopia, it is often accepted that this term should be applied when the subjective amplitude of accommodation falls below three dioptres[3]. The changes with age vary very little between individuals and, unlike many aspects of human physiology, do not appear to have been affected by the changes in nutrition[4]. It is found that anterior chamber depth decreases with accommodation and age, and the lens thickness increases with accommodation and age[5]. The cornea as a whole changes its shape with age, becoming flatter, its curvature diminishing particularly in the vertical meridian and there is decrease in the percentage of eyes showing with-the-rule corneal astigmatism and significantly higher potential for against-the-rule astigmatism with age[6,7]. The healthy ageing lens is seen to decrease in power with age due to difference between the refractive indices of cortex and nucleus of the lens[8]. Accommodative miosis varies widely between subjects of the same age and does not appear to change systematically between the ages of 20 and 40 years[9]. Although Sorsby (1958) stated that the pupil becomes smaller and dilates poorly with old age[10]. Therefore, the amount of entrant light may be reduced but provides a pinhole effect and this has advantage if the error is only slight[11].

This study aimed to calculate the effect of age on accommodation, pupil size, corneal power, and refraction.

## MATERIAL AND METHODS

A comparative cross-sectional method was employed, in which two groups of subjects were selected, young adults and presbyopes to achieve the objectives.

A total sample of fourty (40) subjects were recruited for this study, group (A) included twenty (20) subjects with presbyopia ages between (40 – 45 years) and group (B) included twenty (20) subjects of young adults ages between (20 – 25 years). Each group contains equal number of (10) males and (10) females. All subjects were selected according to criteria of admission after consent. The criteria of admission included; (a) each subject should have no history of corrected refractive error, strabismus, eye surgery, and systemic or chronic diseases, (b) each subject have no symptoms of eye discomfort, except the difficulty in reading from presbyopia, (c) distance vision should not be less than 6/6 by Snellen test types in each eye, (d) normal appearance of outer eye (slit lamp examination) and normal appearance of inner eye (direct ophthalmoscopy) should be achieved, (e) each eye pupil appears regularly round and the two pupils should not be different in size.

Four measurements were applied typically in same conditions and parameters for each subject and the data recorded in a data form. Measurement of accommodation was performed by RAF rule and the mean of three readings (in dioptres) were recorded. Measurement of pupil size was done by PD-ruler and horizontal diameters of pupil (in mm) were taken with aid of magnifier under normal room lighting conditions. The autoref – keratometer (Shin – nippon SRK 9000) instrument was used to measure the two principal corneal powers (in dioptres), the average of the two powers, and the cylinder of the corneal astigmatism with its axis (in degrees) was recorded. The autoref – keratometer (Shin – nippon SRK 9000) was also used to measure refraction of the eye. Three readings of each eye were obtained and the mean was selected. All examinations and measurements were done in Alwalidain Eye Hospital.

For analysis the mean and standard deviation of accommodation and pupil size were calculated directly from data. The Keratometry expressed in two sets of data, the average K-reading of principal powers and the cylinder of corneal astigmatism. The refractometry also expressed in two sets of data, the spherical component and the cylinder component of refraction, the minus cylinder axis in this study referred to as being with-the-rule or direct (axis 180° ± 20°); against-the-rule or inverse (axis 90° ± 20°); and oblique (axis 45 / or 135 ± 25°)[12]. T-test was used to determine significant difference among the two groups. Confidence interval at 95% and probability (P) value 0.05 was taken to indicate statistical significance and all results were summarized in four tables.

## RESULTS

The mean age of group (A) was 42.40 years and of group (B) was 22.15 years, the average length of time between the mean of the two groups was 20.25 years (42.40 minus 22.15) which was used for calculations to estimate the changes per year in measurements.

No doubt change in accommodation is highly significant when a person becomes presbyopic. According to this study the difference in accommodation between group (A) and group (B) was calculated 5.66 D, when distributed over 20.25 years the result was 0.27 D decrease in accommodation per year between young age towards presbyopia.

The difference in pupil size between group (A) and group (B) was 0.68 mm, when distributed over 20.25 years the result was 0.033 mm decrease in pupil size each year towards old age.

The mean corneal astigmatism of group (B) was slightly greater than in group (A) of about 0.17 D. However, if this difference distributed over 20.25 years the result was 0.0083 D decrease or flattening in corneal curvature each year due to aging.

The spherical component of refraction in this study demonstrated that group (A) have a mean +0.37D and group (B) have a mean -0.01D, the difference in mean is +0.36D, when distributed over 20.25 years, it turned out to be a change of 0.018D per year on hypermetropic side in presbyopic age.

## DISCUSSION

The results of this study indicated that accommodation, pupil size, corneal astigmatism, and refraction all change with age. The present results are in conformity with extent previous studies. However, there were no clinically significant differences between males and females in each group for any of the measurements except the pupil size and the cylindrical component of refraction in group (B). The significant decrease of accommodation (estimated 0.27D) occurs gradually and is continuous throughout life without any sudden alteration. The statistical analysis presented gender difference (at 0.05) in pupil size for group (B). The data in Table 2 demonstrated that

**Table 1:** Shows the mean, standard deviation (SD), and T-test for (group A)

| | Females | | Males | | T-test | P |
|---|---|---|---|---|---|---|
| | Range | Mean and SD | Range | Mean and SD | | |
| Accommodation | 2.0 - 4.56 D | 3.01 ± 0.68 | 2.53 - 4.76 D | 3.23 ± 0.54 | 1.157 | 0.117 |
| Pupil size | 2.0 - 3.5 mm | 2.56 ± 0.45 | 2.0 - 3.0 mm | 2.57 ± 0.35 | 1.250 | 0.178 |
| Ave K-reading | 39.75 - 46.50 D | 43.61 ± 1.70 | 42.50 - 44.63 D | 43.52 ± 0.77 | 0.210 | 0.347 |
| Corneal asting | 0.00 - 1.50 D | 0.60 ± 0.39 | 0.25 - 1.50 | 0.57 ± 0.32 | 0.270 | 0.341 |
| Sph of refraction | -0.50 +1.25D | +0.36 ± 0.50 | 0.00 +1.00 | +0.38 ± 0.25 | 0.163 | 0.452 |
| Cyl of refraction | 0.00 - 1.25D | 0.42 ± 0.30 | 0.00 - 1.50 | 0.55 ± 0.33 | 1.440 | 0.078 |

**Table 2:** Shows the mean, standard deviation (SD), and T-test for (group B)

| | Females | | Males | | T-test | P |
|---|---|---|---|---|---|---|
| | Range | Mean and SD | Range | Mean and SD | | |
| Accommodation | 5.76 - 11.00 D | 9.12 ± 2.06 | 6.25 - 11.00 D | 8.44 ± 1.56 | 1.192 | 0.113 |
| Pupil size | 2.0 - 4.0 mm | 3.05 ± 0.52 | 2.5 - 4.0 mm | 3.45 ± 0.52 | 2.500 | 0.013 |
| Ave K-reading | 41.25 - 45.25 D | 42.80 ± 1.04 | 40.12 - 47.13 D | 43.32 ± 2.23 | 0.940 | 0.162 |
| Corneal asting | 0.25 - 2.00 D | 0.25 ± 0.44 | 0.25 - 1.25 | 0.76 ± 0.35 | 0.080 | 0.660 |
| Sph of refraction | -0.75 +1.00D | +0.13 ± 0.58 | -0.75 +0.75 | -0.07 ± 0.54 | 0.350 | 0.283 |
| Cyl of refraction | 0.00 - 1.25D | -0.57 ± 0.35 | 0.00 - 1.00 | -0.30 ± 0.33 | 2.700 | 0.011 |

**Table 3:** Shows the mean, standard deviation, and T-test for the two groups

| | Mean and SD of Group (A) | Mean and SD of Group (B) | T-test | P |
|---|---|---|---|---|
| Pupil size | 2.57 ± 0.35 | 3.25 ± 0.62 | 6.18 | 0.000 |
| Average K-reading | 43.57 ± 1.35 | 43 06 ± 1.68 | 0.50 | 0.318 |
| Corneal astig | 0.58 ± 0.36 | 0.75 ± 0.38 | 2.12 | 0.016 |
| Sph of refraction | +0.37 ± 0.41 | -0.01 ± 0.55 | 4.70 | 0.000 |
| Cyl of refraction | 0.48 ± 0.32 | 0.43 ± 0.36 | 0.71 | 0.185 |

**Table 4:** Shows the form of corneal stigmatism in the two groups

| | With-the-Rule n (%) | Oblique Astig n (%) | Against-the-Rule n (%) | No-Astig n (%) |
|---|---|---|---|---|
| Group (A) | 22.5 | 45 | 22.5 | 10 |
| Group (B) | 42.5 | 17.5 | 7.5 | 32.5 |

females have slightly larger pupil size than males of about 0.40 mm; this result was supported by Emsly [13] who stated that the pupil is somewhat larger in myopes and women, smaller in hypermetropes, men, and very old people. Although the average K-reading in this study showed no statistical significant difference between the two groups, but the result of corneal astigmatism has shown significant difference. However, any changes in corneal curvature or axial length are far too small to account for the observed

changes in accommodation although, surprisingly, there is still debate on whether some minor changes in corneal curvature do occur[14-16]. The spherical component of refraction in this study demonstrated that group (A) have a tendency to acquired hypermetropia. Undoubtedly the effects of the changes in the surface curvatures of the lens and those in the index gradients both make important contributions to the overall power changes in the lens during accommodation[17]. The cylinder component of refraction showed no statistical difference between means of cylinder in the two groups. The current study showed a mean cylinder of 0.48 D in group (A) and 0.43 D in group (B), this result agree with Helmholtz[(18)] who stated that the limit of normal astigmatism of the eye given as 0.50D; the direct form (with-the-rule) being more common in youth and the inverse form (against-the-rule) in more advanced life. Although functional near vision can be achieved with simple methods such as spectacles or contact lenses, or more advanced methods such as intraocular lenses, these are not ideal. The ideal method of treating presbyopia would be to restore the dynamic change in power that a young lens can achieve, therefore restoring the full range of near and far vision[19]. Therefore, any explanation of presbyopia that relies on simple changes in the amplitude of accommodation is not reliable.

## CONCLUSION

All measurements in this study suggesting significant changes in the optical system of the eye were essentially related to age.

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