Original Article

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Influence of Age on the Visual Fields of Normal Subjects: A Clinical Study

Nazia Farah[1], **Syamala Devi Moparthi**[2]

[1]Assistant Professor of Physiology, Government Medical College, Nellore, Andhra Pradesh, India, [2]Associate Professor of Physiology, Andhra Medical College, Visakhapatnam, Andhra Pradesh, India

Abstract

Background: Age-related eye diseases are becoming the leading cause of visual impairment, which causes tremendous impact on their mental and social health and affects the overall quality of life. Precise quantification of the relationship between age and the visual function would enable a correct estimate of the level of visual performance expected in a normal subject of a specific age.

Aim: This study aims to examine the rate of decline in retinal sensitivity with respect to ageing using visual field to determine the pattern of decline in relation to age.

Method: A sample of 72 subjects aged between 15 and 74 years were divided into four incremental age-groups with each group having a maximum age variation of 15 years. Visual fields of all the subjects were assessed using Humphrey Field Analyzer Model-720 devised by Allergan Medical Corporation, California. The test strategy adopted was Swedish Interactive Threshold Algorithm and 30-2 program. P value was calculated using *t*-test for equality of means using a significant two-tailed test. Linear regression analysis with Analysis of Variance was applied to determine the pattern of relationship between age and point-wise retinal sensitivity.

Results: The results show an average loss of sensitivity of 0.7 dB/decade up to 60 years of age and profound loss of 1.8 dB/decade after 60 years of age. The decline was greater in the superior field. The pattern of decline was found to be linearly correlated up to 60 years($r = -0.656$, $R = 42\%$). The decline has been found to be statistically significant ($P = 0.001$).

Conclusion: The study revealed a gradual decline in the retinal sensitivity as the age advances, with a slow decline up to the age of 60 years and an accelerated loss after 60 years. The decline was more marked in males after the age of 60 years.

Key words: Corneal opacity, Intraocular pressure, Manometry, Visual field tests

INTRODUCTION

With an increasing elderly population, age-related eye diseases are becoming the leading cause of visual impairment in the developing world. Many elderly patients are afflicted by more than one aging eye condition, and these have a tremendous impact on their mental and social health and overall quality of life. Enormous strides are being made in understanding and preventing eye diseases. The clinical aim of a psychophysical test, such as the computerized visual field, is to find or exclude pathological alterations. A prerequisite to recognize pathological changes, therefore, is knowledge on normal patterns. As results of psychophysical tests vary for a single normal subject and also among normal subjects, normal values may only be established based on statistical calculations, which represent sample values in healthy populations being demonstrated by means of averages and standard deviations.[1]

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Considering the fact that the detection of early injuries is particularly important in glaucomatous eyes, one should be cautious about minor changes in normal values.[2] Computerized perimetry enables more sensitive and reproducible ways of measuring the visual field. The natural quality of vision gradually declines with anatomical and physiological processes that occur with ageing of the human eyes and visual system. This study was focused on findings regarding alterations of visual field sensitivity during the normal aging process. The purpose of this study is to re-examine the effect of age on visual field sensitivity

Corresponding Author: Dr. M Syamala Devi, # 55-26-15, HB Colony, Visakhapatnam - 530 022, Andhra Pradesh, India. Phone: +91-9849800436. E-mail: syamala.amc@gmail.com

of clinically normal subjects examined with Full Threshold Standard Automated Perimetry. In this study, patients of different ages had visual fields measured with the Humphrey Field Analyzer (HFA) in order to ascertain the appearance of the normal visual field. Precise quantification of the relationship between age and visual function is valuable as it provides an estimate of the level of visual performance expected for a normal subject of a known age. This information may be used by clinicians as a guide to determine whether a subject's function is above or below that expected for an average age-matched, normal control.

MATERIALS AND METHODS

The present study "Influence of age on the visual fields of normal subjects" was conducted at the Government Regional Eye Hospital, Visakhapatnam, from November, 2009 to June, 2010. The study was undertaken with the due clearance of the Institutional Ethical Committee. This study included a total of 72 subjects consisting of 41 females and 31 males ranging in age between 15 years and 74 years who gave their consent for voluntary participation. After careful clinical examination, only those, who satisfied the inclusion criteria, were chosen for the study. 72 subjects were divided into four incremental age-groups with a maximum age variation of 15 years within the group. The first group consisted of 18 subjects in the range of 15-29 years of age. The second group consisted of 20 subjects in the range of 30-44 years of age. The third group consisted of 18 subjects in the range of 45-59 years of age. And the fourth group consisted of 16 subjects in the range of 60-74 years of age.

Visual fields of all the subjects who satisfied the inclusion criteria were assessed using HFA Model 720 using program 30-2 and the test strategy adopted was Swedish Interactive Threshold Algorithm and 30-2 program. Stimulus chosen was Size-III and of white color normal pupil size for all the subjects. Visual field testing in clinical setting typically does not control for pupil size. This study aims at examining the characteristics of ageing under standard test conditions.[3] The 56 locations common to both examination program (24-2), (30-2) were included in the further analysis except for two locations likely to fall within the physiological blind spot which were excluded. The matrix of 56 point is examined in an area of the field of vision extending 30° in all directions from the fixation point. Points are separated by 6° in the horizontal and vertical direction. No points are measured on the horizontal or vertical axes, points are placed three degrees on either side of these axes. The background illumination was 31.5 apostilbs, testing distance 33 cm and stimulus diameter 0.43°. Retinal sensitivity was measured in decibels (dB); 1 dB corresponding to a step of 0.1 log unit of stimulus luminance. Test is considered unreliable if the fixation losses are >20%; false negative error >20%; false positive error>20%. Unreliable tests are not taken into consideration for study, and the test is again repeated. Subject is also allowed to pause whenever required, during the test to eliminate the effect of fatigue. Point-wise threshold data were collected and analyzed. Figure 1 below shows the 30-2 central threshold test pattern.

Figure 1: 30-2 central threshold test pattern.

Data of each subject were analyzed for the following aspects:

a. Mean sensitivity of all the threshold sensitivity (56 points in 24-2 program) points in the whole field excluding the blind spot.
b. Mean sensitivity of the threshold sensitivity of central 20° (16 point around the center of the field).
c. Mean sensitivity of superior and inferior quadrants of the field in the central is 20°.
d. Foveal sensitivity.

Statistical Tools used for Analysis of the data:

a. *t*-test for equality of means is applied to compare the averages of sensitivity between different age groups.
b. *t*-test to compare the averages of sensitivity in all quadrants of the field within central 10° with respect to age and gender.
c. *P* value using *t*-test for equality of means using a significant two-tailed test to determine any significant difference in variation sensitivity with respect to age and gender.
d. Linear Regression Analysis with Analysis of Variance to find any pattern of relationship between age and point-wise retinal sensitivity.

Inclusion Criteria

1. Normal anterior segment (slitlamp) and posterior segment (direct or indirect ophthalmoscopic) examinations. Intraocular pressure of <20 mmHg in both eyes with a difference <3 mmHg as measured by Goldmann Applanation Tonometry.
2. Negative family history of glaucoma.

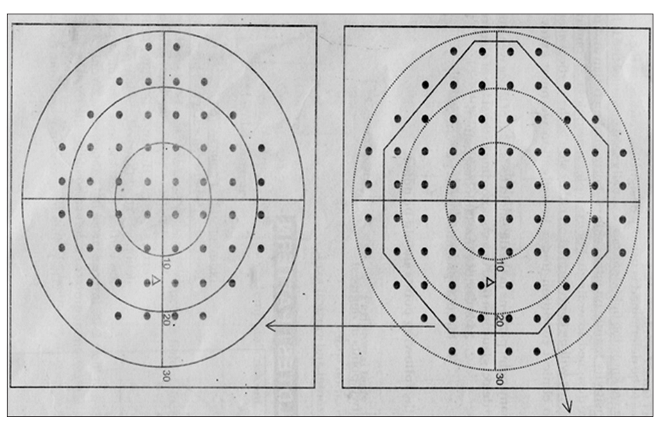

Figure 1: 30-2 central threshold test pattern

Exclusion Criteria

1. History of ocular abnormality. For example Ptosis cataract, corneal opacity, injury, ocular surgery, family history of glaucoma, systemic diseases affecting vision such as diabetes, hypertension.
2. Visual acuity worse than 20/30 (6/9), intraocular pressure >22 mmHg, spectacle refraction > ±5.00 DS and >±2.00 DC, and unreliable visual field test results.
3. History of drug intake, beta-blocks, Phenobarbital, etc.

OBSERVATION AND RESULTS

Totally 72 subjects were divided into four age-groups as shown below:

Group-I	:	15-29 years
Group-II	:	30-44 years
Group-III	:	45-59 years
Group-IV	:	60-74 years

Group-I

18 subjects with an average age of 21.56 ± 2.91 years. The group comprised of 14 female subjects with an average age of 21.29 ± 2.87 years and 4 male subjects with an average age of 22.5 ± 3.32 years. Table 1 shows the average sensitivities of the subjects in Group-I.

Group-II

A total of 20 subjects with a mean age of 37.45 ± 4.29 years, of which 14 female subjects had an average age of 36.57 ± 4.45 years and 6 male subjects had an average of 39.50 ± 3.33 years. Table 2 shows the average sensitivities of Group-II

Group-III

18 subjects with an average age of 51.56 ± 5.11 years, of which 8 female subjects had an average age of 51.50 ± 4.11 years and 10 male subjects had an average 51.60 ± 6.02. Table 3 shows the average sensitivities of Group-III.

Group-IV

Sixteen subjects with an average age of 66.38 ± 5.25 years, of which 5 female subjects had an average of 64.80 ± 4.44 years and 11 male subjects had an average ig 67.09 ± 5.63 years. Table 4 shows the average sensitivities of Group-IV.

Table 5 shows the regression analysis of the total sensitivity of the field.

The present study showed that there was a gradual decline in the retinal sensitivity as the age advances. There was a slow decline up to the age of 60 years and accelerated dB loss after 60 years. The decline was more marked for males after the age of 60 years when compared with females. The decline was greater in the superior field when compared with all the other quadrants in the whole field. Table 6 shows the mean rate of loss in retinal sensitivity.

Figure 2 shows the mean rate of loss per decade in retinal sensitivity in the visual field for each group.

The rate of loss calculated in this study was found to be 0.4 dB/decade in Group–II and the mean rate of loss found

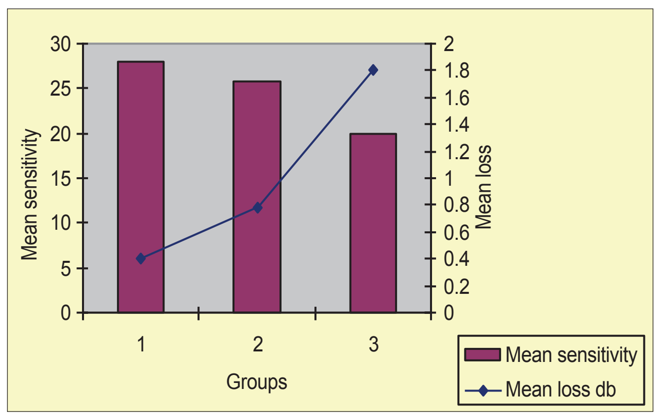

Figure 2: Graph showing the mean rate of loss per decade in retinal sensitivity in the visual field for each age group

Table 1: Average sensitivities of Group-I

Gender	Foveal sensitivity (dB)	Average sensitivity of central field (dB)	Mean±SD sensitivity total field (dB)	Mean±SD sensitivity superior field (dB)	Mean±SD sensitivity inferior field (dB)
Female (*n*=14)	37.64±1.906	28.232±1.99	28.297±2.086	27.308±3.171	29.761±2.314
Male (*n*=4)	36.00±1.83	27.46±3.19	27.77±3.110	25.775±3.70	29.213±2.947
Total group	37.28±1.96	28.059±2.218	28.180±2.254	26.967±3.246	29.639±2.384

SD: Standard deviation

Table 2: Average sensitivities of Group-II

Gender	Foveal sensitivity (dB)	Average sensitivity of central field (dB)	Average sensitivity total field (dB)	Average sensitivity superior field (dB)	Average sensitivity inferior field (dB)
Female (*n*=14)	31.93±4.53	27.834±3.39	26.83±4.31	26.29±6.08	29.66±3.56
Male (*n*=6)	31.83±2.14	28.34±1.13	27.50±2.67	26.44±3.57	30.42±0.83
Total	32.39±2.38	25.726±2.401	26.01±3.02	26.34±5.36	29.887±2.95

dB: Decibels

Table 3: Average sensitivities of Group-III

Gender	Foveal sensitivity (dB)	Average sensitivity of central field (dB)	Average sensitivity total field (dB)	Average sensitivity superior field (dB)	Average sensitivity inferior field (dB)
Female (*n*=14)	33±2.07	25.708±2.218	26.58±2.66	24.76±2.45	28.41±2.72
Male (*n*=6)	31.90±2.60	25.742±2.66	25.56±3.35	26.50±1.44	25.89±4.49
Total	32.39±2.38	25.727±2.40	26.01±3.02	25.727±2.09	27.01±3.93

dB: Decibels

Table 4: Average sensitivities of Group-IV

Gender	Foveal sensitivity (dB)	Average sensitivity of central field (dB)	Average sensitivity total field (dB)	Average sensitivity superior field (dB)	Average sensitivity inferior field (dB)
Female (*n*=14)	23.0±6.89	24.71±3.21	23.57±4.61	23.95±3.68	27.58±2.187
Male (*n*=6)	24.64±6.13	17.72±4.87	16.18±4.57	13.66±7.54	23.09±3.53
Total	24.12±6.19	19.90±5.46	18.49±5.66	16.87±8.11	24.49±3.77

dB: Decibels

Table 5: Regression analysis for total sensitivity of the field model summary

Model	R	R square	Adjusted R square	Standard error of the estimate
1	0.656 *	0.430	0.422	3.99412

*Predictors (Constant), age, *Predictors in the Model: (Constant), age, †Dependent Variable: Total

Table 6: Mean rate of loss in retinal sensitivity

Group	Mean age (years)	Mean sensitivity (decibels)	Mean rate of loss (dB/Decade)
I (15-29 years)	21.56	28.0593	-
II (30-44 years)	37.45	27.986	0.4
III (45-59 years)	51.56	25.7267	0.78
IV (60-74 years)	66.38	19.9081	1.8

to be 0.78 dB/decade in Group-III and 1.8 dB/decade in Group-IV.

DISCUSSION

No human physiological function lasts forever. Normal ageing produces characteristic changes in anatomy and physiology of the visual system and also degrades a number of visual functions. Knowledge of physiological ageing effect on visual function is a pre-requisite of any clinical visual function test designed to distinguish between normal subjects and those with pathology. Precise quantification of the relationship between age and visual function is valuable because it provides an estimate of the level of visual performance expected of a normal subject of a known age. The visual sensitivity is known to shrink with age. The decrease in sensitivity may be due to pre-retinal factors namely increased optical density of the ocular media and position of upper eyelid and globe, a smaller pupil size may contribute to a reduction in retinal image quality and therefore sensitivity.[4]

A second theory states that increased neural loss in the afferent visual pathway may contribute to loss of sensitivity. Further possibility is that an accelerated loss of sensitivity in older age groups may reflect on an increased proportion of sub-clinical pathology among the presumed normal population.

Until date, there are only a few established studies that assess the influence of ageing on visual field data (retinal sensitivity). More than 20 years ago, Haas *et al* reported differential light sensitivity begins to decline in youth, continues to gradually decrease throughout the life at a rate of 0.58 dB per decade. Spry and Johnson from Denver Institute, Portland studied the senescent changes of the normal visual field using HFA retrospectively using the data from 562 normal eyes and found that a significant negative relationship existed between age and mean sensitivity within cross-sectional population data.[5] The mean loss was found to be 0.43 dB/decade for age group <53.4 years and means loss was 1.02 dB/decade for age group more than 53.4 years. Paul GD Spry and Chris A Johnson proposed that non-linear function provided the best fit to cross-sectional population data.

A study in the University of New South Wales by H. Barry Collins Christine Han and Phaik Chin Khor using HFA with 45 subjects selected randomly revealed that there was a slight overall decrease in the sensitivity in the 40 year old age group and a greater decrease in 60 year age group.[6] Between 20 and 40 years, the mean rate of loss of sensitivity for each point was 1.01 dB/decade and between 40 and 60 years it was 1.72 dB/decade. In the present study, mean rate of loss of sensitivity was found to be 0.7 dB/decade before the age of 60 years and 1.8 dB/decade after 60 years which is in agreement with the previous studies. Investigations by H. Barry Collins, Jaffe and Alvarado have found lower sensitivity related to age in superior region of visual field when compared to inferior one, which is also in agreement with the result of the present study.[7] Whereas in another study conducted by Glen J Jaffe and Jorge A Alvarado used Octopus and claimed that age loss was linear and measured a linear decline with age in the threshold sensitivity, volume and surface area of the visual field.

In the present study, the correlation between age and retinal sensitivity was assessed using linear regression. A coefficient describing the relationship between age and the point-wise sensitivity is used routinely in statistical analysis methodologies to adjust patient data for statistical comparison with age-matched normative distribution. It is, therefore, critical that this coefficient is representative of the effect of age on visual field sensitivity present within the population at large.

The model showed R value of 43 %, adjusted R value of 42 % and $r = -0.656$. In a study conducted by Nassim Calixto, Roberto Marcio, Sebastiao Cronemberg assessed the ratio between age and retinal sensitivity by linear regression.[8] This model shows R value of 16.5 per cent and $r = -0.41$. To date, no consensus appears to exist between reports of a specific nature of the relationship between the age and visual field sensitivity. Some investigations have reported a linear relationship although others have found that the relationship is better described bilinear or exponential function. In most studies, the effect of age on sensitivity appears to be a constant steady decline in all decades beyond the age of 20 years.[9] However, others argue that there is a steeper loss after the 6th decade. The pattern of decline in sensitivity in the present study was found to be linearly correlated up to 60 years.

There are four main reasons for decline in luminous sensitivity with age: (1) Changes in the ocular media. (2) Linear reduction in pupil diameter.[10] (3) Decrease in absorbance efficiency of photo-pigments. (4) Neural losses in both retina and retino-geniculostiate pathways. Some investigators have minimized the impact of the ocular media and pupil by using yellow targets, brighter backgrounds, and mydriatic drops in all subjects.[11] They still found decline of about 0.8 dB/decade which were, therefore, attributed to neuronal losses. High resolution perimetry which was thought to more accurately assess elements at or above the retinal ganglion cell level has estimated the loss of neural channels funneling information from the retina to cortex at about 9000/year or about 1/h, which is in fact a thought of concern.

Limitations of the study

One important limitation to the present study is the difficulty in determining whether or not worsening of the visual field sensitivity is due to advancing age or sub-clinical ocular disease progression or a combination of both. Further study is needed using larger groups to establish the rate of decline in sensitivity with ageing.

CONCLUSION

The present study is done on seventy-two normal subjects, divided into 4 homogenous groups. There was a general decline in retinal sensitivity in the entire visual field with respect to ageing in the study sample, and it was found to be statistically significant ($P = 0.001$). The average loss of sensitivity was 0.7dB/decade before 60 years and 1.8 dB/decade after 60 years. Males in the age-group >60 years showed marked loss in sensitivity compared to females. The pattern of decline in sensitivity was found to be linearly correlated up to 60 years. The reduction in sensitivity was greater in the superior region of the visual field when compared to other regions with respect to age.

The present study helps to depict the normal pattern of the visual field retinal sensitivity with respect to age and gender and therefore establishes normal values at different ages. This information is expected to be of some use to clinicians as a guide to estimate the level of visual performance expected of a normal subject of a known age to determine the visual function expected for an average age matched normal control.

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