

## Relationship between Pupil Size in Different Degrees of Myopia in Young Adults in a University Community

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### Abstract

**Purpose:** To evaluate the relationship between pupil size in different degrees of myopia.

**Method:** This was investigated in 100 randomly selected young myopes of both sexes, aged 18 - 25 years and selected from Abia State University community. The subjects were examined in the university clinic using standard optometric procedures. The degrees of myopia were in the ranges of -0.25 to -1.00DS, -1.25 to -3.00DS, -3.25 to -6.00DS, -6.25 to -10.00DS and > -10.00DS. The pupil diameter was measured monocularly using the Pupillary Distant Rule in the clinic under room illumination and values were recorded to the nearest 0.5 mm.

**Results:** The mean pupil size for the myopes in this study was  $4.33 \pm 1.12$  mm and mean pupil size for each degree of myopia was 3.03 mm, 3.79 mm, 4.60 mm, 5.71 mm and 7.00 mm respectively. Using the  $X^2$  statistical analysis at 0.05 level of significance ( $\alpha$ ), critical or cut off value 12.59158724, df 6 and  $X^2 = 104.51$ .  $X^2$  was greater than the cut off or critical value, therefore a relationship exists between the degree of myopia and pupil sizes. They are dependent. It was found that there was significant increase in pupil size with increase in degree of myopia. The contingency value (C) of 0.71486 indicates a strong association exists between degree of Myopia and pupil sizes (P-value). The mean pupil size of the females was also significantly greater than that of the males. P-value is  $2.8629 \times 10^{-20}$ . P-value is less than significance level (0.05). Therefore, the result is statistically significant - A significant relationship exists between the two attributes, pupil sizes and degree of myopia. The contingency value (C) of 0.71486 indicates a strong association exists between degree of Myopia and pupil sizes.

**Conclusion:** The pupil size increased with increase in degree of myopia, therefore the size of the pupil could give one an idea of the degree of myopia and the presence of a relationship between pupil size and degree of myopia. Female myopes had greater mean pupil size than the males showing that variation in pupil size with degree of myopia is gender related.

**Keywords:** Gender; Myopia; Pupil Size; Young Adults; Relationship

### Introduction

The human eye is an optical medium through which light passes and undergoes series of refraction within different media and converges on the retina [1]. This involves five different stages which are: the transmission of light rays through the transparent media, the refraction of these rays by the refractive media of the eye, accommodation to focus the light rays, constriction of the pupil to regulate the

amount of light reaching the retina and convergence of the eye to maintain visual acuity. The regulation of light rays coming from either a near or far object plays an essential role in the clarity of the images formed on the photographic plate of the retina [2].

The pupil is the opening in the center of the iris about 3 mm behind the anterior surface of the cornea before the anterior surface of the lens. It appears black because most light entering it is absorbed by the tissues of the inner eye. The margin of the pupil is formed by the smooth sphincter muscles of the iris; it is located along the optical axis and is controlled by the involuntary contraction and dilation of the iris [2].

The colour and shape of the pupil varies between same species and among different species. Different colours like brown, black, blue etc. exist and are distributed according to race. Black though appears to be more common. This is mainly due to the layers of chromatophore which are deeply embedded in the posterior surface of the iris [3].

Pupil size therefore is the measurement of the physiological diameter of the pupil which is done monocularly under room illumination [4]. The measurement is done using instruments like the pupillometer, pupillary distant rule or Rosenbaum card. The pupil size can increase or decrease according to intensity of light entering the eye - pupillary light reflex. The pupil diameter can range from 1.5 mm or 2 mm to more than 8 mm in the bright and dim illuminations, respectively. The pupil size also controls the number of blur circles around an image formed [5]. The response of the pupil is an involuntary reflex. This pupillary reflex is very important in determining the integrity of the pupillary pathways. It usually gives the first sign of any disease occurring behind the eye and other neuro-ophthalmic conditions.

Pupil size at infancy is small but increases with age until 18 years when it begins to reduce [6]. It is often affected by emotion, medications, sleep, psychological and mental state [7]. It serves as a determining factor in the diagnosis of several abnormalities of pupil, eye and other health conditions. Such abnormalities like unequal pupil reactions may be seen in conditions like: Amaurotic pupil, Marcus Gunn pupil, Argyll Robertson pupil, Adies tonic pupil, efferent pathway defect, Wernicke's hemianopic pupil [8].

In emmetropia, with accommodation relaxed, parallel rays of light are brought to a focus on the retina. The pupil size of the emmetropic eye in room illumination ranges from 2 mm - 6 mm. In ametropic condition, it may differ depending on the refractive errors. In hyperopic and astigmatic eyes, pupil sizes are smaller while in the myopic eye it is often large. Rays of light coming from optical infinity are focused in front of the retina when accommodation is at rest for myopia. This makes it difficult for the individual to make out distant objects, thereby blurred vision at distance. One of the clinical signs of detecting myopia apart from its significantly reduced visual acuity at far is its dilated pupil [9].

Myopia or short sightedness is an increasingly common vision problem affecting up to 1.4 billion people worldwide [10]. This has different types [11], causes [12] and different causation theories [13]. However, it was found that for a certain amount of uncorrected myopia visual acuity may vary from one individual to another and this is caused by differences in pupil size and illumination. Thus, the tendency of some myopes to squint converting the pupil into a slit and possibly changing the curvature of the cornea as well as differences in aberration of the eye and retinal gradients [9]. From the foregoing therefore, one could question whether measuring the pupil size in myopia may give an idea of the amount of myopia present.

Research show that certain factors like axial length in relation to the focal length of the eye, genetics, including the most recent- breathing pattern are the major causes of myopia [11]. The presence of myopia causes dilated pupils because of less effort to accommodate. One of the signs of diagnosing myopia is by dilated pupils and the action of squinting which the myope employs to produce a pinhole effect thereby improving his acuity at far [14].

In a myopic eye, the character of the image shows that it is large with many blur edges. This is due to the induced aberrational effect of a dilated pupil, if we assume the pupil size to be constant, then the size of the blur circle formed by the myopic eye for a distant object

with accommodation relaxed will only depend on the amount of myopia. Visual acuity therefore will be a function of amount of myopia [3]. From the above laid fact, pupil size may also be a function of amount of myopia. It therefore became necessary to ascertain if the size of the pupil may give an idea of the amount of myopia present. The various degrees of myopia as given by Borish [3] are: Very low myopia (-0.25 to - 1.00DS), Low (-1.25 to - 3.00DS), Medium (-3.25 to - 6.00DS), High (-6.25 to -10.00DS) and Very high (above - 10.00DS).

This research investigated the relationship and variation in pupil size in these various degrees of myopia and if this variation is gender related. The variation in unaided visual acuity with degree of myopia was also evaluated.

### Materials and Methods

The study sample for this research was one hundred (100) myopic young adults (40 males and 60 females) from the Abia State University community. The age range of the subjects was 18 - 25 years. The subjects selected passed through clinical screening tests, which involved: case history which was used to determine the age, health and ocular history of the patient. External examination and ophthalmoscopy were done using the penlight and ophthalmoscope, respectively to rule out any presence of pathology.

### Instrumentation

The instruments for data collection involved; the Snellen’s Visual Acuity Chart to determine the unaided visual acuity and provide the uniform field for the tests, the Inter-Pupillary Distance Rule for measurement of the pupil size and the Trial Lens Case and its accessories for refraction to determine the degree of myopia.

### Data analysis technique

Data collected was analyzed using the following statistical techniques: calculation of the arithmetic mean and standard mean deviation, frequency distribution, bar charts and chi-square.

### Results

Out of the 100 students (40 males and 60 females); 17 (17%) had very low degree of myopia, 38 (38%) low degree, 22 (22%) medium degree, 19 (19%) high degree and 4 (4%) had very high degree of myopia (Figure 1). The degree of myopia with the highest frequency of occurrence was low myopia (38%) and the least frequency was very high myopia (4%). For degree of myopia according to gender, low amount of myopia (-0.25 to -3.00) was approximately equal among both genders whereas the moderate to high degrees (-3.25 to  $\geq$  -10.00) was higher in the female population (Figure 2).

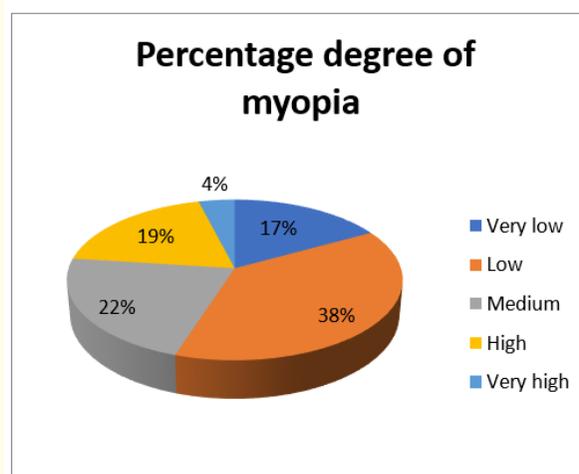


Figure 1: Percentage distribution of degree of myopia.

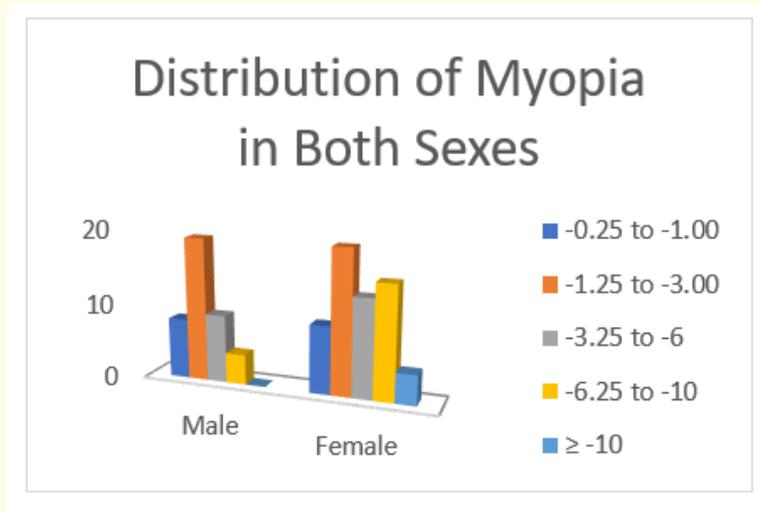


Figure 2: Distribution of myopia according to degree of myopia among both sexes.

The mean pupil size for myopes in the study was  $4.33 \pm 1.12$  mm. Mean pupil size varied from 2.5 mm to 7 mm for the different degrees of myopia; for very low degree of myopia, it was 3.03 mm; for low myopia, it was 3.82 mm; for medium degree, it was 4.55 mm; for high degree, it was 5.71 mm while for very high degree, it was 7.00 mm (Figure 3). Mean pupil size varied for the different sexes. Females had larger pupils than males. The mean pupil size of females was  $4.50 \pm 1.20$  mm, while that of males was  $4.09 \pm 0.93$  mm.

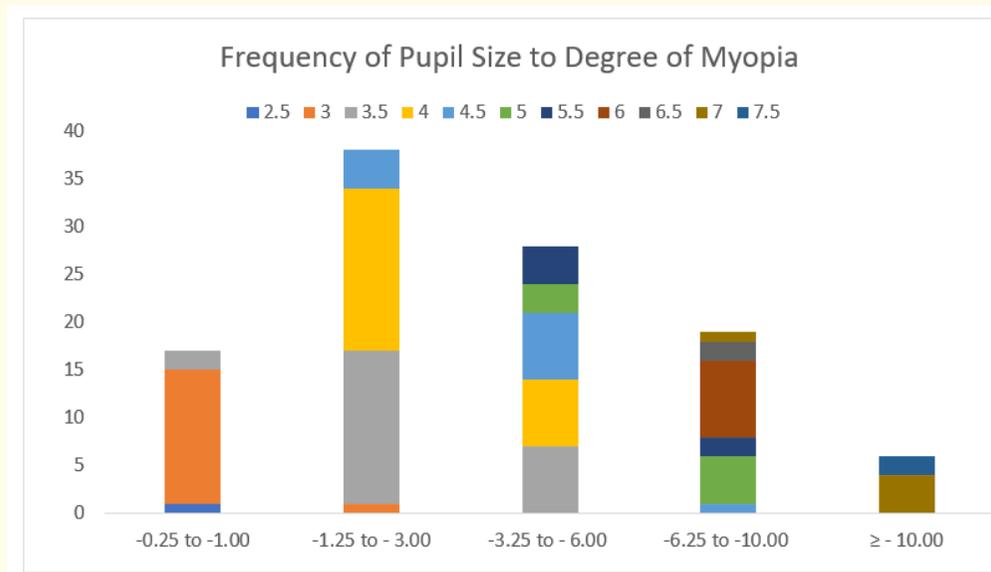


Figure 3: Frequency of pupil size according to the degree of myopia.

The null hypothesis (Ho) which states that the pupil size did not vary with the degree of myopia was tested using Chi-square ( $X^2$  Tab = 12.6 and  $X^2$  Cal = 108.8). The  $X^2$  Tab, 12.6 was greater than the  $X^2$  Cal, 108.77, the Ho was therefore rejected which led to the conclusion that the pupil size varied with the degree of myopia.

Using the  $X^2$  statistical analysis at 0.05 level of significance ( $\alpha$ ), critical or cut off value 12.59158724, df 6 and  $X^2 = 104.51$ .  $X^2$  was greater than the cut off or critical value, therefore a relationship exists between the degree of myopia and pupil sizes. They are dependent. It was found that there was significant increase in pupil size with increase in degree of myopia. The contingency value (C) of 0.71486 indicates a strong association exists between degree of Myopia and pupil sizes (P-value).

The variation in pupil size with degree of myopia was gender related. In males, the variation is shown in figure 4. The mean pupil size for males was  $4.09 \pm 0.93$  mm.

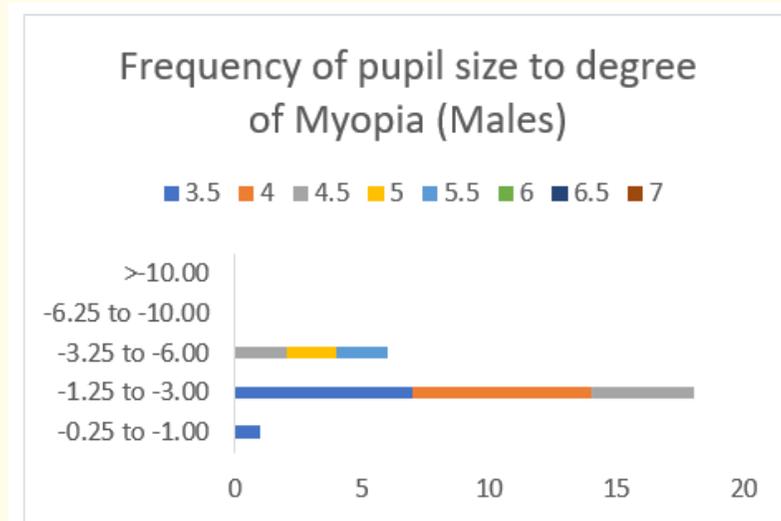


Figure 4: Frequency of pupil size according to degree of myopia in males.

The frequency of pupil size according to degree of myopia in females also varied (Figure 5). The mean pupil size of females was  $4.50 \pm 1.20$  mm.

The degree of myopia varied considerably in both sexes, being higher in females for all the different degrees except for low myopia which was about the same (Figure 6).

The null hypothesis which stated that the variation in pupil size with degree of myopia was not gender related was also tested. The  $X^2$  tabulated, 5.90 was lesser than the  $X^2$  calculated, 7.12; the null hypothesis was therefore rejected which shows that the variation in pupil size with degree of myopia was gender related.

The different degrees of myopia presented with varied visual acuities (Table 1).

This range of visual acuity presenting was highest in the  $> 6/18 - 6/60$  with 48%. The VA progressively reduced as the degree of myopia increased.

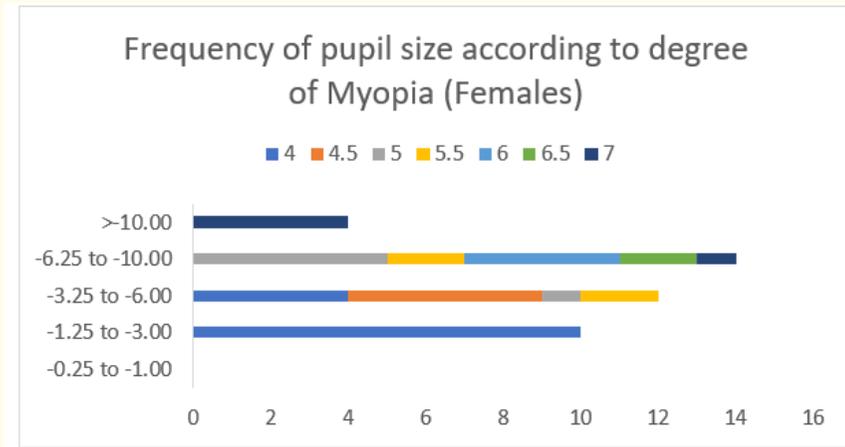


Figure 5: The frequency of pupil size according to the degree of myopia in females.

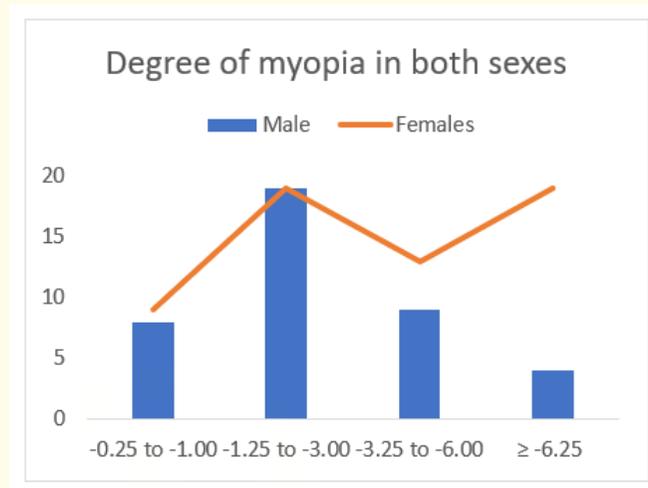


Figure 6: The distribution of myopia among both sexes.

Degree of myopia (ds)	Ranges and percentages in visual acuity				
	< 6/9 - 6/18	> 6/18 - 6/60	> 6/60 - 3/24	> 3/24 - 3/60	≥ 3/60
Very Low	15 (15%)	1 (1%)			
Low	8 (8%)	30 (30%)	1 (1%)		
Medium		14 (14%)	7 (7%)	1 (1%)	
≥ High		3 (3%)	8 (8%)	5 (5%)	7 (7%)

Table 1: Ranges and percentages of visual acuity according to degree of myopia.

### Discussion

This research study investigated the relationship and variation in pupil size in degrees of myopia among 100 myopic young adults of age range, 18 - 30 years. Figure 1 shows the percentage frequency of the degrees of myopia (-0.25 to  $\geq -10.00$ DS). Seventeen subjects (17%) had very low degree of myopia, 38 (38%) low degree, 22 (22%) medium degree, 19 (19%) high degree and 4 (4%) had very high degree of myopia. Very low myopia had the highest percentage frequency (38%) while very high myopia had the lowest frequency (4%). A similar study carried out by Shiferaw, *et al.* in a tertiary institution showed that low degrees of myopia was higher compared to the high degrees of myopia [15].

The range of pupil size among myopes was 2.5 mm to 7 mm with a mean pupil size of  $4.33 \pm 1.12$  mm. Mean pupil size varied for the different degrees of myopia: for very low degree of myopia, it was 3.03 mm; for low myopia, it was 3.82 mm; for medium degree, it was 4.55 mm; for high degree, it was 5.71 mm while for very high degree, it was 7.00 mm. The pupil size increased as the degree of myopia increased (Figure 2). This agrees with the study carried out by Paquin, *et al.* [14], on objective measurement of optical aberrations in myopic eye during which the researchers concluded that optical quality decreases as myopia increases and as pupil size gets larger. This invariably indicates that the degree of myopia is responsible for the variation of pupil diameter among myopes. This as explained by Borish [16] could be attributed to the fact that myopes especially (medium, high and very high) show poor or slow accommodative ability and due to this under accommodation, the diameter of pupil may be increased.

Mean pupil size varied for the different sexes. With respect to gender, females had larger mean pupil size (4.50 mm) than that of the males (4.09 mm). This affirms what was stated by Williams J Benjamin (as cited by Borish) that under ordinary circumstances that the female pupil may be larger than that of the males [3].

The frequency distribution of the different degrees of myopia for both sexes shows that myopia was found more in females than males. Low amount of myopia (-0.25 to -3.00) was approximately equal among both genders whereas the moderate to high (-3.25 to  $\geq -10.00$ ) was higher in the female population (Figure 3-6). This affirms what Kempen, *et al.* said that myopia is found more in females than males, probably due to the early maturation [17].

Since there is a significant relationship between pupil size and different degrees of myopia, one could estimate the degree of myopia by measuring pupil size and vice versa. This means that each degree of myopia may have a particular range of pupil diameters. There is also a direct relationship between the visual acuity and the degree of myopia present. Denton [16] suggested that a possible function of the pupil light reflex might be to provide aperture, optimum for visual acuity at different light intensity levels and which is directly affected by the different degrees of myopia. The visual acuity results obtained from table 1 indicates that the magnitude or degree of myopia coupled with large pupil size reduced visual acuity. The table showed that visual acuity of  $\leq 6/9 - 6/18$  occurred most in very low myopia,  $\geq 6/60 - 3/24$  (medium) and  $\geq 3/24 - 3/60$  (high and very high) myopia.

### Conclusion

Based on the findings of this study the following conclusions are made: that pupil size varied in direct proportion with different degrees of myopia; that pupil size and degree of myopia were affected by gender where female myopes had higher mean pupil size than males; that measuring pupil size could give an idea of degree of myopia as pupil size and degrees of myopia are interdependent and finally that each degree of myopia had an approximate range in visual acuity.

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