

Research Article

# Body Mass Index and Interocular Asymmetry of Retinal and Choroidal Thickness in Emmetropic and Ametropic Subjects

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## Abstract

**Objective:** To assess the normal range of interocular asymmetry in retinal and choroidal thickness in healthy emmetropic (as a control group) and ametropic subjects and to describe its relationship with anthropometric attributes.

**Methods:** A Spectral-Domain Optical Coherence Tomography (SD-OCT) was performed on 586 patients to measure the thickness of the retina and choroid at the fovea as well as at 1, 2 and 3 mm nasally, temporally, superiorly, and inferiorly. In 95% confidence intervals, absolute interocular differences were calculated to determine the normal range of asymmetry and its relationship to Body Mass Index (BMI).

**Results:** There was a statistically significant interocular difference in the choroidal thickness at 3 mm distance from the center inferiorly (Standardized Mean Difference (SMD): -17.33, 95% Confidence Interval (CI): -29.60 to -5.07  $\mu\text{m}$ ,  $P < 0.001$ ) in the control group, and in the macular thickness at 2 mm distance from the center superiorly (SMD: -9.76, CI: -17.40 to 2.13  $\mu\text{m}$ ,  $P = 0.01$ ) in the myopic group between underweight and overweight individuals.

**Conclusion:** The expanded range of retinal and choroidal thickness asymmetry found in subjects with different BMI grades in the absence of disease is of relevance when exploring these patients for early signs of ocular pathology.

**Keywords:** Anthropometry; Ametropia; Body Mass Index; Choroidal Thickness; Interocular Asymmetry; Retinal Thickness

## Introduction

Anthropometry is a non-invasive way of assessing body dimensions [1]. Anthropometric measurements are observed affecting body organs like the heart, liver, eyes, etc. Taller people have longer eyeball axial lengths, which lead to changes in the eyeball's refractive state [2,3].

Increased axial length affects other eye structures, stretching the retinal and choroidal layers. The retina is the eye's light-sensitive region where visual sensations are felt, while the choroid supplies the retina with oxygen from blood vessels [4-6]. Increased axial length stretches the retina, causing degenerative changes that distort vision. Several studies show that myopia decreases choroid thickness more than hypermetropia, especially in the fovea [4,7,8].

In light of the importance of detecting pathological changes associated with refractive error and the fact that structural changes in the retina and choroid precede visual manifestations, previous studies have sought to determine the normal thresholds of interocular asymmetry. Differences beyond these thresholds may indicate early stages of ocular disease [5,7,9-14].

Obesity is associated with eye problems such as early cataract, glaucoma and diabetic retinopathy. Assessment of Retinal Nerve Fiber Layer Thickness (RNFL) with Spectral Domain Optical Coherence Tomography (SD-OCT) in morbidly obese individuals demonstrated that obesity thins the RNFL and Ganglion Cell Layer of the retina, which is a risk factor for many ocular disorders. Compared to a healthy control group, obese children had thinner RNFL. Increased BMI accelerates refractive error development in children [3,15-26].

Obese anthropometry measurements were correlated with refractive error, retinal layer thinning and choroidal thinning. Increased BMI causes retinal and choroidal thinning. Thus, anthropometry aids in early diagnosis of risk factors for ocular disorders, including refractive error, RNFL thinning and choroidal thinning [7,8,19-26].

While much research is available on the association between RNFL and anthropometric measurements, comparatively less exists on macular thickness profile and anthropometric parameters. This study aimed to examine interocular asymmetry in macular and central choroidal thickness in people with and without refractive error and to define their relationship with anthropometric attributes.

## **Material and Methods**

### *Subjects*

This cross-sectional study included 586 participants. Patients were recruited from visitors to Opticalia Eye Clinic, Olot, Spain, for routine ocular examinations between October 2018 and April 2022. Among 200 emmetropic, 198 myopic and 188 hypermetropic patients, those with a spherical equivalent between +0.50D and -0.50D were considered emmetropes. Patients with a refractive error of  $\geq -0.50$ D were considered myopic, while individuals with that of  $\geq +0.50$ D were considered hypermetropic. Patients with anisometropia of  $\geq 0.50$  were excluded. Patients were included if they had a Distance-Corrected Visual Acuity (CDVA) of 0.0 logMAR (20/20) or better, and intraocular pressure  $<21$  mmHg.

Patients with a history of trauma, ocular pathology and any ocular fundus abnormality such as, but not limited to, choroidal neovascularization, foveoschisis, macular hole, diabetic retinopathy, posterior uveitis, drusen, or age-related macular degeneration were excluded. Additionally, all individuals with histories of glaucoma, amblyopia and refractive surgery were excluded. All patients without clear ocular media or central fixation were excluded, as were those failing to understand or cooperate during OCT and/or anthropometric measurements.

All patients were provided with information regarding the procedures and aim of the study. Informed consent was obtained from all participants or a parent/legal guardian for participants below 18 years.

The study followed the 1975 Helsinki Declaration (as revised in Tokyo in 2004). Hospital Universitari de Girona Doctor Josep Trueta Ethics Review Board approved this investigation.

### *Retinal and Choroidal Thickness*

A spectral-domain 3D OCT-1 Maestro System (Topcon Corporation, Tokyo, Japan) with enhanced depth imaging was used to assess retinal and choroidal thickness at 1 mm, 2 mm and 3 mm from the fovea nasally, temporally, superiorly and inferiorly.

Choroidal thickness was described as the distance between the retinal pigment epithelium and the sclera's inner margin (choroidal-scleral interface), which was observed as a hyperreflective line behind the choroid's large vessel layer. A caliper was used to measure this manually. Two experienced examiners (ZA and MF) performed all measurements, with the average used for statistical analysis. Measurements were repeated by a third examiner (AZ) if the difference surpassed 15%.

### *Anthropometric Measurements*

Height was measured in meters using a Seohnle electronic height altimeter, in which a tilt sensor was used to monitor the horizontal alignment and make necessary corrections. Patients stood tall, barefoot, with their shoulders on the wall and looked straight ahead.

Weight was measured in kilograms using the Soehnle digital scale 7830. BMI measurements were calculated using Dietowin software version 8.0. All equipment was calibrated before measuring each subject.

### Data Collection Procedure

After a comprehensive case history, patients underwent a complete optometric examination, including noncontact air-puff tonometry. Noncycloplegic refraction was performed and monocular distance-corrected visual acuity was assessed with the retro-illuminated ETDRS chart (Lighthouse International, NY). The chart was presented from 4 m and visual acuity values were recorded in logMAR units. Ocular fundus and cross-sectional macular images were captured with the OCT device and sent to retinal experts (OPTretina S.L., Barcelona, Spain) to identify and exclude patients with retinal pathologies, as per the predefined inclusion and exclusion criteria.

During each procedure, eyes were examined in random order. To avoid the possible effect of changes in choroidal thickness throughout the day, all measurements were done around the same time.

### Data Analysis

For statistical analysis, IBM SPSS V.24 for Windows was used. Data was evaluated for normality with the Kolmogorov-Smirnov test, revealing that all variables under examination followed a normal distribution. Descriptive statistics are reported as mean  $\pm$  standard deviation. The 95% confidence interval was used to define normal interocular asymmetry for anatomical and functional measures. Instead of relative values, absolute interocular asymmetry values were used.

When comparing data from the Right (RE) and Left (LE) eyes, the student t-test for matched pairs was used and the student t-test for unmatched pairs was used when data came from different study groups such as control, myopic and hypermetropic.

Multiple comparisons were made for the analysis of anthropometric measurements in relation to retinal and choroidal thicknesses through the Tukey's Test for Post-Hoc Analysis. A 5% confidence level was used to determine statistical significance for statistical tests.

## Results

### *Demographic Characteristics*

The sample contains more females ( $n = 366$ , 62.46%) than males ( $n = 220$ , 37.54%) (Table 1). Mean age (years) for control (range = 6-95), myopia (range = 9-69) and hypermetropia (range = 7-86) groups was  $39.93 \pm 17.43$ ,  $33.02 \pm 14.28$  and  $54.74 \pm 14.19$  respectively. Mean refractive error (diopters) in control was very low at  $-0.004 \pm 0.29$  and  $-0.003 \pm 0.28$  in RE and LE respectively. Contrarily, participants with myopia averaged  $-1.92 \pm 1.42$  (range =  $-0.50 - -7.75$ ) in RE and  $-1.90 \pm 1.45$  (range =  $-0.50 - -7.75$ ) in LE. Furthermore, the mean hypermetropia magnitude for hypermetropia was  $1.41 \pm 0.85$  in RE and  $1.50 \pm 0.89$  in LE, with a range of  $+0.50$  to  $4.38$  and  $+0.50$  to  $+5.13$  in RE and LE, respectively (Table 2).

### *Anthropometric Characteristics*

In the control group, average height and weight were  $1.65 \pm 0.10$  meters and  $66.08 \pm 16.63$  kg, respectively. The individuals' mean weight was higher in both the myopic ( $68.66 \pm 13.40$  kg) and hypermetropic ( $71.71 \pm 15.25$  kg) groups. Similarly, height data also showed a higher mean in myopic ( $1.69 \pm 0.09$ ) and hypermetropic ( $1.66 \pm 0.08$ ) groups compared to control (Table 2).

In total, 59.56% of patients had a normal BMI, whereas 3.4% were underweight. The hypermetropic group had the most obese participants ( $n = 36$ , 19.1%), while the other groups had similar proportions (9.1% in myopia versus 6.5% in the control). The control group had the greatest mean BMI ( $36.18 \pm 7.99$ ) for obesity, while myopic participants had the lowest ( $32.59 \pm 2.59$ ) (Table 3).

### *Retinal Thickness Profile*

For the RE, the central macular thickness ( $\mu\text{m}$ ) was highest for the hypermetropic group ( $181.30 \pm 22.17$ ) which was followed by myopic ( $179.34 \pm 15.85$ ) and emmetropic ( $176.26 \pm 17.78$ ) groups, respectively. The myopic retinal thickness profile showed the

lowest average value in all macular quadrants, while the hypermetropic group had the highest average value. At one millimeter distance from the temporal quadrant's center, the mean value in the control, myopic and hypermetropic groups was  $288.38 \pm 17.34 \mu\text{m}$ ,  $289.61 \pm 15.26 \mu\text{m}$  and  $291.54 \pm 17.52 \mu\text{m}$ , respectively. For the 2 mm distance in the nasal quadrant, hypermetropic individuals had an average thickness of  $288.53 \pm 20.49 \mu\text{m}$ , while it was reduced subsequently in control ( $287.74 \pm 18.93 \mu\text{m}$ ) and myopic ( $282.74 \pm 15.79 \mu\text{m}$ ) participants. In the superior quadrant, values for the point at 3 mm distance were  $244.73 \pm 23.94 \mu\text{m}$ ,  $244.15 \pm 17.01 \mu\text{m}$ ,  $250.12 \pm 20.00 \mu\text{m}$  for the control, myopic and hypermetropic groups, respectively. Lastly, the mean for the average values obtained for three distances in the inferior quadrant were lowest for myopic ( $264.52 \pm 12.83 \mu\text{m}$ ) and highest for hypermetropic participants ( $273.40 \pm 17.90 \mu\text{m}$ ). Similar results for all quadrants were seen in the LE as well. Table 4 provides further details.

#### *Choroidal Thickness Profile*

In the LE, central choroidal thickness was higher in the emmetropic control group ( $252.74 \pm 51.64 \mu\text{m}$ ) compared to myopic ( $245.19 \pm 46.75 \mu\text{m}$ ) and hypermetropic ( $228.51 \pm 41.93 \mu\text{m}$ ) participants. In the nasal quadrant, a similar trend was observed with the control ( $181.53 \pm 32.68 \mu\text{m}$ ) depicting the highest average value, and the lowest value was observed in hypermetropic cases ( $165.73 \pm 27.44 \mu\text{m}$ ). At 1 mm distance from the center temporally, the mean value for choroidal thickness in myopia was  $231.42 \pm 60.45 \mu\text{m}$  while the values were  $223.26 \pm 47.17 \mu\text{m}$  and  $201.20 \pm 36.96 \mu\text{m}$  for the control and hypermetropic groups, respectively. For 2 mm distance in the superior quadrant, the mean value was highest for myopia ( $240.89 \pm 54.17 \mu\text{m}$ ) and lowest for hypermetropia ( $206.82 \pm 37.04 \mu\text{m}$ ). The mean values at 3 mm distance from the inferior quadrant's center were  $222.40 \pm 44.76 \mu\text{m}$ ,  $242.95 \pm 48.99 \mu\text{m}$  and  $211.21 \pm 42.14 \mu\text{m}$  for the control, myopic and hypermetropic groups, respectively. A similar pattern of choroidal thickness was also present in RE (Table 4).

#### *Interocular Asymmetry in Retinal and Choroidal Thickness*

Interocular differences in retinal and choroidal thickness are seen in Table 5. In the retinal thickness profile, the nasal macular quadrant thickness' mean value was statistically significant across all groups ( $P < 0.05$ ). The inferior quadrant's mean retinal thickness was statistically significant for both control ( $P < 0.001$ ) and hypermetropic ( $P = 0.02$ ). In the hypermetropics, the temporal and superior retina thickness profile did not show statistical significance at any distance.

For the choroidal thickness data, the myopic and control groups showed statistical significance for the central choroidal thickness ( $P < 0.05$ ). In the superior quadrant, statistical significance was observed at all distances from the center for the control ( $P < 0.001$ ).

The analysis of interocular asymmetry between the three groups showed that there was no statistical significance for the central values of retinal ( $P = 0.18$ ) and choroidal thickness ( $P = 0.39$ ). In the retinal thickness data, intergroup comparison showed statistical significance for average values in the nasal ( $P < 0.001$ ), temporal ( $P = 0.03$ ) and inferior quadrant ( $P < 0.001$ ). On the other hand, the choroidal thickness profile showed a significant statistical difference between mean values in nasal ( $P < 0.001$ ), temporal ( $P < 0.001$ ) and superior ( $P = 0.02$ ) quadrants for the comparison of the main groups.

#### *Choroidal and Retinal Thickness Profiles and BMI Grades*

Tables 6 and 7 show the macular and choroidal thickness' mean values for each category of BMI in the three study groups. A statistically significant difference in choroidal thickness at 3 mm from the center inferiorly was seen between underweight and overweight individuals in the control group (SMD:  $-17.33$ , CI:  $-29.60$  to  $-5.07 \mu\text{m}$ ,  $P < 0.001$ ). However, a statistically significant difference in macular volume was observed in the myopic participants between underweight and overweight participants (SMD:  $-0.144$ , CI:  $-0.252$  to  $-0.037 \mu\text{m}$ ,  $P < 0.001$ ) (Table 8).

| Control Group (N = 200)       |           |      |
|-------------------------------|-----------|------|
|                               | Frequency | %    |
| Female                        | 138       | 69   |
| Male                          | 62        | 31   |
| Myopia Group (N = 198)        |           |      |
|                               | Frequency | %    |
| Female                        | 116       | 58.6 |
| Male                          | 82        | 41.4 |
| Hypermetropia Group (N = 188) |           |      |
|                               | Frequency | %    |
| Female                        | 112       | 59.6 |
| Male                          | 76        | 40.4 |

**Table 1:** Descriptive statistics of the demographic distribution.

| Control Group (N = 200)                                                                                      |        |       |         |         |
|--------------------------------------------------------------------------------------------------------------|--------|-------|---------|---------|
|                                                                                                              | Mean   | SD    | Minimum | Maximum |
| Age (Years)                                                                                                  | 39.93  | 17.43 | 6       | 95      |
| Height (Meters)                                                                                              | 1.65   | 0.1   | 1.27    | 1.87    |
| Weight (Kg)                                                                                                  | 66.08  | 16.63 | 25      | 185     |
| BMI                                                                                                          | 24.05  | 4.76  | 14.35   | 60.41   |
| SEQ RE (Diopters)                                                                                            | -0.004 | 0.29  | -0.375  | 0.375   |
| SEQ LE (Diopters)                                                                                            | -0.003 | 0.28  | -0.375  | 0.375   |
| Myopia Group (N = 198)                                                                                       |        |       |         |         |
|                                                                                                              | Mean   | SD    | Minimum | Maximum |
| Age (Years)                                                                                                  | 33.02  | 14.28 | 9       | 69      |
| Height (Meters)                                                                                              | 1.69   | 0.09  | 1.44    | 1.93    |
| Weight (Kg)                                                                                                  | 68.66  | 13.4  | 27      | 110     |
| BMI                                                                                                          | 24.03  | 3.92  | 12.84   | 39.44   |
| SEQ RE (Diopters)                                                                                            | -1.92  | 1.42  | -0.5    | -7.75   |
| SEQ LE (Diopters)                                                                                            | -1.9   | 1.45  | -0.5    | -7.75   |
| Hypermetropia Group (N = 188)                                                                                |        |       |         |         |
|                                                                                                              | Mean   | SD    | Minimum | Maximum |
| Age (Years)                                                                                                  | 54.74  | 14.19 | 7       | 86      |
| Height (Meters)                                                                                              | 1.66   | 0.08  | 1.3     | 1.89    |
| Weight (Kg)                                                                                                  | 71.71  | 15.25 | 25      | 118     |
| BMI                                                                                                          | 25.99  | 4.79  | 13.57   | 40.83   |
| SEQ RE (Diopters)                                                                                            | 1.41   | 0.85  | 0.5     | 4.38    |
| SEQ LE (Diopters)                                                                                            | 1.5    | 0.89  | 0.5     | 5.13    |
| Results are presented as mean $\pm$ SD, minimum and maximum; BMI: Body Mass Index; SEQ: Spherical Equivalent |        |       |         |         |

**Table 2:** Descriptive statistics of the three groups of study.

| Control Group (N = 200)                                                                                                                                                                                |           |      |       |      |         |         |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|------|-------|------|---------|---------|
|                                                                                                                                                                                                        | Frequency | %    | Mean  | SD   | Minimum | Maximum |
| Underweight                                                                                                                                                                                            | 6         | 3    | 16.31 | 1.35 | 14.35   | 17.93   |
| Normal Weight                                                                                                                                                                                          | 130       | 65   | 22.06 | 1.83 | 18.22   | 24.92   |
| Overweight                                                                                                                                                                                             | 51        | 25.5 | 26.92 | 1.34 | 24.96   | 29.73   |
| Obesity                                                                                                                                                                                                | 13        | 6.5  | 36.18 | 7.99 | 30.11   | 60.41   |
| Myopia Group (N = 198)                                                                                                                                                                                 |           |      |       |      |         |         |
|                                                                                                                                                                                                        | Frequency | %    | Mean  | SD   | Minimum | Maximum |
| Underweight                                                                                                                                                                                            | 9         | 4.5  | 16.85 | 1.73 | 12.84   | 18.36   |
| Normal Weight                                                                                                                                                                                          | 131       | 66.2 | 22.39 | 1.48 | 18.52   | 24.81   |
| Overweight                                                                                                                                                                                             | 40        | 20.2 | 27.17 | 1.37 | 24.97   | 29.41   |
| Obesity                                                                                                                                                                                                | 18        | 9.1  | 32.59 | 2.59 | 30.07   | 39.44   |
| Hypermetropia Group (N = 188)                                                                                                                                                                          |           |      |       |      |         |         |
|                                                                                                                                                                                                        | Frequency | %    | Mean  | SD   | Minimum | Maximum |
| Underweight                                                                                                                                                                                            | 5         | 2.7  | 15.16 | 1.32 | 13.57   | 17.1    |
| Normal Weight                                                                                                                                                                                          | 88        | 46.8 | 22.73 | 1.74 | 18.65   | 27.4    |
| Overweight                                                                                                                                                                                             | 59        | 31.4 | 27.37 | 1.31 | 25.26   | 29.78   |
| Obesity                                                                                                                                                                                                | 36        | 19.1 | 33.39 | 3.27 | 30.08   | 40.83   |
| Results are presented as frequency, percentage, mean $\pm$ SD, minimum and maximum. Underweight (BMI < 18.50); Normal Weight (BMI 18.50-24.99); Overweight (BMI 25-29.99) and Obesity (BMI $\geq$ 30). |           |      |       |      |         |         |

**Table 3:** Descriptive statistics of the Body Mass Index (BMI).

|                            | Control Group (N = 200) |       |        |       | Myopia Group (N = 198) |       |        |       | Hypermetropia Group (N = 188) |       |        |       |
|----------------------------|-------------------------|-------|--------|-------|------------------------|-------|--------|-------|-------------------------------|-------|--------|-------|
|                            | RE                      |       | LE     |       | RE                     |       | LE     |       | RE                            |       | LE     |       |
| Retinal Thickness, $\mu$ m | Mean                    | SD    | Mean   | SD    | Mean                   | SD    | Mean   | SD    | Mean                          | SD    | Mean   | SD    |
| Central                    | 176.26                  | 17.78 | 178.59 | 19.79 | 179.34                 | 15.85 | 179.64 | 19.17 | 181.3                         | 22.17 | 183.15 | 20.41 |
| Macular Thickness N1       | 306.53                  | 19.33 | 307.49 | 17.94 | 307.46                 | 15.95 | 309.29 | 15.74 | 311.2                         | 20.69 | 310.97 | 21.59 |
| Macular Thickness N2       | 287.74                  | 18.93 | 288.57 | 18.13 | 282.47                 | 15.79 | 281.8  | 14.62 | 288.53                        | 20.49 | 289.84 | 20.13 |
| Macular Thickness N3       | 262.63                  | 20.03 | 265.1  | 18.36 | 256.97                 | 26.66 | 264.01 | 16.05 | 263.36                        | 21.48 | 266.07 | 22.05 |
| Mean of N quadrant         | 285.63                  | 16.64 | 287.05 | 15.38 | 282.3                  | 16.17 | 285.04 | 12.89 | 287.69                        | 19.29 | 288.96 | 19.65 |
| Macular Thickness T1       | 288.38                  | 17.34 | 287.18 | 17.27 | 289.61                 | 15.26 | 288.65 | 14.78 | 291.54                        | 17.52 | 293.05 | 17.57 |
| Macular Thickness T2       | 258.75                  | 14.75 | 258.43 | 15.74 | 252.92                 | 13.96 | 249.69 | 19.4  | 262.3                         | 17.45 | 261.38 | 18.05 |
| Macular Thickness T3       | 223.28                  | 12.52 | 225.26 | 14.5  | 218.98                 | 13.26 | 219.39 | 12.11 | 226.7                         | 19    | 227.72 | 15.6  |
| Mean of T quadrant         | 256.81                  | 13.24 | 256.95 | 14.13 | 253.83                 | 12.49 | 252.57 | 12.41 | 260.18                        | 14.65 | 260.72 | 15.35 |
| Macular Thickness S1       | 310.45                  | 17.01 | 306.89 | 24.13 | 308.31                 | 18.29 | 310.61 | 14.76 | 308.22                        | 21.6  | 307.37 | 24.46 |

|                                                      |        |       |        |       |        |       |        |       |        |       |        |       |
|------------------------------------------------------|--------|-------|--------|-------|--------|-------|--------|-------|--------|-------|--------|-------|
| Macular Thickness S2                                 | 276.67 | 18.36 | 277.72 | 16.86 | 272.53 | 14.16 | 273.4  | 15.12 | 277.52 | 19.73 | 279.55 | 17.24 |
| Macular Thickness S3                                 | 244.73 | 23.94 | 249.38 | 16.27 | 244.15 | 17.01 | 245.28 | 12.73 | 250.12 | 20    | 251.03 | 19.01 |
| Mean of S quadrant                                   | 277.28 | 16.15 | 278.28 | 14.52 | 274.99 | 13.34 | 276.43 | 11.98 | 278.62 | 15.52 | 279.32 | 16.44 |
| Macular Thickness I1                                 | 306.2  | 20.19 | 305.5  | 19.63 | 305.15 | 17.45 | 305.89 | 15.08 | 309.35 | 19.35 | 309.06 | 18.41 |
| Macular Thickness I2                                 | 267.09 | 19.87 | 261.53 | 17.99 | 256.34 | 17.67 | 254.91 | 16.44 | 267.58 | 24.07 | 266.67 | 19.82 |
| Macular Thickness I3                                 | 237.71 | 15.19 | 236.32 | 15.33 | 232.08 | 15.27 | 231.29 | 16.49 | 243.24 | 22.3  | 238.38 | 17.58 |
| Mean of I quadrant                                   | 270.34 | 15.15 | 267.79 | 14.15 | 264.52 | 12.83 | 264.03 | 12.59 | 273.4  | 17.9  | 271.37 | 14.76 |
| Total volume (mm3)                                   | 7.64   | 0.36  | 7.63   | 0.34  | 7.49   | 0.35  | 7.53   | 0.3   | 7.71   | 0.49  | 7.69   | 0.39  |
| <b>Choroidal Thickness, <math>\mu\text{m}</math></b> |        |       |        |       |        |       |        |       |        |       |        |       |
| Central                                              | 243.29 | 52.41 | 252.74 | 51.64 | 232.63 | 44.71 | 245.19 | 46.75 | 229.46 | 40.86 | 228.51 | 41.93 |
| Choroidal Thickness N1                               | 207.37 | 44.73 | 215.81 | 42.28 | 210.32 | 37.04 | 208.9  | 45.13 | 191.54 | 32.28 | 191.23 | 32.84 |
| Choroidal Thickness N2                               | 177.57 | 38.5  | 181.56 | 34.85 | 180.21 | 34.4  | 179.39 | 35.24 | 168.2  | 30.06 | 162.25 | 29.98 |
| Choroidal Thickness N3                               | 148.49 | 34.87 | 147.21 | 28.03 | 150.06 | 32.23 | 150.98 | 33.8  | 146.62 | 28.2  | 143.7  | 28.48 |
| Mean of N quadrant                                   | 177.81 | 36.87 | 181.53 | 32.68 | 180.2  | 31.22 | 179.76 | 35.06 | 168.79 | 27.55 | 165.73 | 27.44 |
| Choroidal Thickness T1                               | 208.97 | 48.23 | 223.26 | 47.17 | 222.28 | 45.82 | 231.42 | 60.45 | 203.93 | 40.51 | 201.2  | 36.96 |
| Choroidal Thickness T2                               | 188.3  | 44.41 | 200.24 | 47.53 | 206.93 | 48.56 | 215.78 | 59.79 | 184.62 | 36.49 | 182.68 | 37.29 |
| Choroidal Thickness T3                               | 173.52 | 41.73 | 174.42 | 42.63 | 189.52 | 44.45 | 196.28 | 57.68 | 170.86 | 40.98 | 166.56 | 35.65 |
| Mean of T quadrant                                   | 190.26 | 42.86 | 199.31 | 43.34 | 206.24 | 44.21 | 214.49 | 57.44 | 186.47 | 37.29 | 183.48 | 34.41 |
| Choroidal Thickness S1                               | 232.49 | 44.22 | 243.31 | 50.57 | 239.74 | 42.18 | 243.16 | 57.44 | 206.13 | 36.95 | 209.58 | 38.46 |
| Choroidal Thickness S2                               | 227.85 | 43.7  | 238.83 | 45.88 | 234.83 | 49.97 | 240.89 | 54.17 | 201.06 | 34.77 | 206.82 | 37.04 |
| Choroidal Thickness S3                               | 229.52 | 42.55 | 238.65 | 45.3  | 241.19 | 46.62 | 241.78 | 53.58 | 209.13 | 44.05 | 207.38 | 45.5  |
| Mean of S quadrant                                   | 229.96 | 40.15 | 240.26 | 44.16 | 238.58 | 43.17 | 241.95 | 50.91 | 205.44 | 33.95 | 207.93 | 36.58 |
| Choroidal Thickness I1                               | 226.82 | 44.29 | 231.9  | 45.78 | 245.18 | 46.7  | 244.89 | 55.18 | 214.65 | 36.54 | 212.75 | 44.23 |
| Choroidal Thickness I2                               | 224.46 | 38.88 | 228.41 | 41.73 | 242.51 | 47.05 | 242.35 | 49.72 | 205.71 | 39.41 | 207.13 | 36.52 |
| Choroidal Thickness I3                               | 222.57 | 45.03 | 222.4  | 44.76 | 239.89 | 45.38 | 242.95 | 48.99 | 212.04 | 43.1  | 211.21 | 42.14 |

|                                                                                                                                                    |        |       |        |       |        |       |       |       |       |       |        |       |
|----------------------------------------------------------------------------------------------------------------------------------------------------|--------|-------|--------|-------|--------|-------|-------|-------|-------|-------|--------|-------|
| Mean of I quadrant                                                                                                                                 | 224.62 | 39.12 | 227.57 | 40.17 | 242.53 | 41.92 | 243.4 | 46.45 | 210.8 | 36.46 | 210.36 | 36.41 |
| Results are presented as mean $\pm$ Standard Deviation (SD) for RE and LE; N: nasal; T: temporal; S: superior; I: inferior (at 1mm, 2mm and 3 mm). |        |       |        |       |        |       |       |       |       |       |        |       |

**Table 4:** Mean retinal and choroidal thickness at each of the locations and quadrants under examination for control, myopia, and hypermetropia groups.

|                                                                       | Control Group |       |        |       |        | Myopia Group (N = 198) |       |        |       |        | Hypermetropia Group |       |        |       |        |        |  |
|-----------------------------------------------------------------------|---------------|-------|--------|-------|--------|------------------------|-------|--------|-------|--------|---------------------|-------|--------|-------|--------|--------|--|
| Absolute Interocular Difference (RE-LE) in Retinal and Thickness (um) | Mean          | SD    | 95% CI |       | P      | Mean                   | SD    | 95% CI |       | P      | Mean                | SD    | 95% CI |       | P      | P*     |  |
| Central                                                               | -2.32         | 15.14 | -4.44  | -0.21 | 0.03   | -0.29                  | 14.24 | -2.29  | 1.69  | 0.77   | -1.85               | 10.68 | -3.38  | -0.31 | 0.09   | 0.18   |  |
| Macular Thickness N1                                                  | -0.96         | 9.77  | -2.33  | 0.40  | 0.16   | -1.84                  | 9.53  | -3.17  | -0.50 | 0.01   | 0.23                | 8.76  | -1.03  | 1.48  | 0.23   | 0.37   |  |
| Macular Thickness N2                                                  | -0.83         | 10.71 | -2.33  | 0.66  | 0.27   | 0.67                   | 9.51  | -0.66  | 1.99  | 0.35   | -1.31               | 9.29  | -2.65  | 0.02  | 0.05   | 0.13   |  |
| Macular Thickness N3                                                  | -2.47         | 13.98 | -4.42  | -0.52 | 0.01   | -7.04                  | 26.49 | -10.75 | -3.33 | <0.001 | -2.72               | 12.92 | -4.60  | -0.86 | <0.001 | 0.04   |  |
| Mean of N quadrant                                                    | -1.42         | 8.53  | -2.61  | -0.23 | 0.02   | -2.73                  | 11.36 | -4.32  | -1.14 | <0.001 | -1.27               | 7.95  | -2.41  | -0.12 | 0.03   | <0.001 |  |
| Macular Thickness T1                                                  | 1.20          | 6.82  | 0.25   | 2.16  | 0.01   | 0.96                   | 7.72  | -0.12  | 2.04  | 0.08   | -1.51               | 16.32 | -3.85  | 0.83  | 0.21   | 0.75   |  |
| Macular Thickness T2                                                  | 0.33          | 8.51  | -0.87  | 1.52  | 0.58   | 3.23                   | 18.31 | 0.66   | 5.80  | 0.01   | 0.91                | 10.45 | -0.59  | 2.42  | 0.23   | 0.04   |  |
| Macular Thickness T3                                                  | -1.98         | 11.61 | -3.60  | -0.36 | 0.02   | -0.41                  | 11.41 | -2.01  | 1.18  | 0.61   | -1.02               | 13.52 | -2.96  | 0.92  | 0.30   | 0.20   |  |
| Mean of T quadrant                                                    | -0.15         | 6.30  | -1.03  | 0.73  | 0.74   | 1.26                   | 9.01  | -0.01  | 2.50  | 0.05   | -0.54               | 9.34  | -1.88  | 0.80  | 0.43   | 0.03   |  |
| Macular Thickness S1                                                  | 3.56          | 20.18 | 0.75   | 6.38  | 0.01   | -2.30                  | 14.33 | -4.30  | -0.29 | 0.02   | 0.84                | 25.19 | -2.78  | 4.47  | 0.65   | <0.001 |  |
| Macular Thickness S2                                                  | -1.05         | 14.92 | -3.13  | 1.02  | 0.31   | -0.87                  | 10.66 | -2.36  | 0.63  | 0.25   | -2.03               | 15.57 | -4.27  | 0.21  | 0.07   | 0.81   |  |
| Macular Thickness S3                                                  | -4.65         | 22.46 | -7.79  | -1.52 | <0.001 | -6.10                  | 42.45 | -3.03  | 0.76  | 0.23   | -0.91               | 17.82 | -3.47  | 1.65  | 0.48   | 0.06   |  |
| Mean of S quadrant                                                    | -0.71         | 9.69  | -2.06  | 0.64  | 0.30   | -1.43                  | 7.97  | -2.55  | -0.32 | 0.01   | -0.70               | 11.31 | -2.32  | 0.93  | 0.40   | 0.41   |  |
| Macular Thickness I1                                                  | 0.70          | 17.60 | -1.75  | 3.16  | 0.57   | -0.74                  | 12.83 | -2.55  | 1.05  | 0.41   | 0.29                | 12.85 | -1.56  | 2.14  | 0.76   | 0.35   |  |
| Macular Thickness I2                                                  | 5.55          | 15.47 | 3.40   | 7.71  | <0.001 | 1.43                   | 14.92 | -0.66  | 3.53  | 0.18   | 0.91                | 23.80 | -2.51  | 4.33  | 0.60   | <0.001 |  |
| Macular Thickness I3                                                  | 1.39          | 14.68 | -0.66  | 3.44  | 0.18   | 0.79                   | 14.19 | -1.19  | 2.78  | 0.43   | 4.86                | 18.43 | 2.20   | 7.51  | <0.001 | 0.64   |  |
| Mean of I quadrant                                                    | 2.55          | 9.93  | 1.16   | 3.93  | <0.001 | 0.49                   | 9.23  | -0.80  | 1.79  | 0.45   | 2.02                | 12.05 | 0.28   | 3.75  | 0.02   | <0.001 |  |
| Total Volume (mm³)                                                    | 0.01          | 0.16  | -0.01  | 0.03  | 0.41   | -0.04                  | 0.22  | -0.07  | -0.01 | 0.01   | 0.01                | 0.29  | -0.33  | 0.05  | 0.70   | <0.001 |  |
| Absolute Interocular Difference (RE-LE) in Choroidal Thickness (um)   |               |       |        |       |        |                        |       |        |       |        |                     |       |        |       |        |        |  |
| Central                                                               | -9.45         | 36.71 | -14.57 | -4.33 | <0.001 | -12.56                 | 29.60 | -16.71 | -8.41 | <0.001 | 0.96                | 27.02 | -2.93  | 4.84  | 0.63   | 0.39   |  |
| Choroidal Thickness N1                                                | -8.44         | 33.74 | -13.15 | -3.74 | <0.001 | 1.41                   | 37.77 | -3.87  | 6.71  | 0.59   | 0.32                | 30.13 | -4.02  | 4.65  | 0.88   | <0.001 |  |
| Choroidal Thickness N2                                                | -3.99         | 28.01 | -7.90  | -0.09 | 0.04   | 0.82                   | 33.82 | -3.92  | 5.56  | 0.73   | 5.95                | 28.81 | 1.80   | 10.10 | <0.001 | 0.09   |  |
| Choroidal Thickness N3                                                | 1.28          | 30.64 | -2.99  | 5.55  | 0.55   | -0.93                  | 33.11 | -5.57  | 3.71  | 0.69   | 3.06                | 25.47 | -1.55  | 7.38  | 0.20   | 0.5    |  |
| Mean of N quadrant                                                    | -3.72         | 26.33 | -7.39  | -0.05 | 0.05   | 0.44                   | 30.17 | -3.79  | 4.66  | 0.84   | 2.73                | 39.14 | -0.60  | 6.73  | 0.10   | <0.001 |  |
| Choroidal Thickness T1                                                | -14.29        | 41.63 | -20.09 | -8.48 | <0.001 | -9.14                  | 47.76 | -15.83 | -2.45 | 0.01   | 1.94                | 41.21 | -2.90  | 8.36  | 0.34   | 0.23   |  |
| Choroidal Thickness T2                                                | -11.93        | 45.76 | -18.31 | -5.55 | <0.001 | -8.85                  | 47.83 | -15.56 | -2.15 | 0.01   | 4.30                | 43.27 | -3.98  | 7.87  | 0.52   | 0.49   |  |
| Choroidal Thickness T3                                                | -0.90         | 45.64 | -7.27  | 5.46  | 0.78   | -6.76                  | 48.64 | -13.58 | 0.05  | 0.05   | 2.99                | 37.93 | -1.92  | 10.53 | 0.17   | 0.21   |  |
| Mean of T quadrant                                                    | -9.04         | 40.25 | -14.65 | -3.43 | <0.001 | -8.25                  | 44.20 | -14.44 | -2.06 | 0.01   | -3.45               | 34.98 | -2.47  | 8.45  | 0.28   | <0.001 |  |
| Choroidal Thickness S1                                                | -10.82        | 40.09 | -16.41 | -5.23 | <0.001 | -3.42                  | 41.63 | -9.25  | 2.41  | 0.25   | -5.76               | 36.21 | -8.49  | 1.58  | 0.18   | 0.13   |  |
| Choroidal Thickness S2                                                | -10.97        | 39.93 | -16.54 | -5.41 | <0.001 | -6.07                  | 42.45 | -12.02 | -0.12 | 0.04   | 1.75                | 41.20 | -10.97 | -0.55 | 0.03   | 0.18   |  |
| Choroidal Thickness S3                                                | -9.12         | 42.88 | -15.10 | -3.14 | <0.001 | -0.59                  | 38.04 | -5.92  | 4.73  | 0.82   | -2.48               | 29.44 | -4.17  | 7.68  | 0.56   | 0.04   |  |
| Mean of S quadrant                                                    | -10.31        | 31.87 | -14.75 | -5.86 | <0.001 | -3.36                  | 30.68 | -7.66  | 0.94  | 0.12   | 1.90                | 42.20 | -6.72  | 1.75  | 0.25   | 0.02   |  |
| Choroidal Thickness I1                                                | -5.07         | 39.87 | -10.63 | 0.48  | 0.07   | 0.29                   | 44.76 | -5.97  | 6.57  | 0.92   | -1.42               | 36.55 | -4.16  | 7.97  | 0.54   | 0.23   |  |
| Choroidal Thickness I2                                                | -3.95         | 32.08 | 2.27   | -8.42 | 0.08   | 0.16                   | 40.31 | -5.49  | 5.80  | 0.95   | 0.83                | 50.91 | -6.68  | 3.84  | 0.59   | 0.25   |  |
| Choroidal Thickness I3                                                | 0.16          | 34.55 | -4.65  | 4.98  | 0.95   | -3.06                  | 41.08 | -8.82  | 2.96  | 0.29   | 0.44                | 34.43 | -6.49  | 8.15  | 0.82   | 0.36   |  |
| Mean of I quadrant                                                    | -2.95         | 25.47 | -6.50  | 0.60  | 0.10   | -0.87                  | 31.02 | -5.21  | 3.47  | 0.69   |                     |       | -4.50  | 5.40  | 0.86   | <0.001 |  |

The results of the matched (P) and nonmatched (P\*) pairs Student t test are shown. P and P\* values in bold denote statistically significant differences between the control, myopia, and hypermetropia groups in terms of absolute interocular differences. CI, confidence interval; N, nasal; T, temporal; S, superior; I, inferior (at 1mm, 2mm, and 3 mm).

**Table 5:** Absolute interocular differences in retinal and choroidal thickness in Mean  $\pm$  Standard Deviation (SD) (95% CI) at each of the locations and quadrants under examination for control, myopia, and hypermetropia groups.

| Retinal Thickness, $\mu\text{m}$     | Control Group (N = 200) |                    |                    |                    | Myopia Group (N = 198) |                    |                    |                    | Hypermetropia Group (N = 188) |                    |                    |                    |
|--------------------------------------|-------------------------|--------------------|--------------------|--------------------|------------------------|--------------------|--------------------|--------------------|-------------------------------|--------------------|--------------------|--------------------|
|                                      | Underweight             | Normal Weight      | Overweight         | Obesity            | Underweight            | Normal Weight      | Overweight         | Obesity            | Underweight                   | Normal Weight      | Overweight         | Obesity            |
| Central (RE)                         | 171.33 $\pm$ 12.21      | 175.81 $\pm$ 17.54 | 178.20 $\pm$ 19.24 | 175.46 $\pm$ 17.35 | 184.67 $\pm$ 19.77     | 178.28 $\pm$ 14.52 | 176.97 $\pm$ 15.35 | 189.61 $\pm$ 20.64 | 164.80 $\pm$ 17.15            | 177.90 $\pm$ 19.79 | 182.75 $\pm$ 23.09 | 189.73 $\pm$ 24.36 |
| Central (LE)                         | 171.17 $\pm$ 11.20      | 179.01 $\pm$ 18.74 | 177.82 $\pm$ 17.25 | 180.77 $\pm$ 24.56 | 181.78 $\pm$ 15.57     | 179.48 $\pm$ 19.89 | 175.50 $\pm$ 15.76 | 188.89 $\pm$ 20.37 | 168.80 $\pm$ 8.67             | 188.65 $\pm$ 19.44 | 185.32 $\pm$ 20.86 | 187.78 $\pm$ 21.97 |
| Macular Thickness N1 (RE)            | 317.17 $\pm$ 18.46      | 307.45 $\pm$ 18.33 | 305.59 $\pm$ 19.75 | 296.00 $\pm$ 25.02 | 310.67 $\pm$ 13.15     | 307.58 $\pm$ 16.67 | 305.60 $\pm$ 15.04 | 309.11 $\pm$ 14.36 | 324.20 $\pm$ 6.09             | 310.15 $\pm$ 21.87 | 311.72 $\pm$ 19.09 | 311.08 $\pm$ 21.56 |
| Macular Thickness N1 (LE)            | 319.83 $\pm$ 22.97      | 308.61 $\pm$ 16.64 | 305.72 $\pm$ 18.89 | 297.46 $\pm$ 21.03 | 310.22 $\pm$ 11.15     | 309.47 $\pm$ 16.83 | 306.92 $\pm$ 13.63 | 312.83 $\pm$ 13.92 | 317.60 $\pm$ 5.85             | 310.77 $\pm$ 23.39 | 310.68 $\pm$ 20.82 | 311.00 $\pm$ 19.97 |
| Macular Thickness N2 (RE)            | 294.00 $\pm$ 16.39      | 287.91 $\pm$ 18.74 | 288.16 $\pm$ 18.87 | 281.54 $\pm$ 22.48 | 281.67 $\pm$ 8.38      | 283.38 $\pm$ 15.47 | 281.82 $\pm$ 16.92 | 277.67 $\pm$ 18.30 | 298.80 $\pm$ 5.97             | 289.79 $\pm$ 22.04 | 286.50 $\pm$ 20.75 | 287.34 $\pm$ 19.97 |
| Macular Thickness N2 (LE)            | 291.50 $\pm$ 19.50      | 288.85 $\pm$ 18.19 | 288.90 $\pm$ 18.05 | 283.15 $\pm$ 18.50 | 278.11 $\pm$ 9.27      | 282.87 $\pm$ 15.31 | 280.07 $\pm$ 14.34 | 279.72 $\pm$ 12.07 | 302.60 $\pm$ 4.93             | 290.37 $\pm$ 21.47 | 288.82 $\pm$ 20.08 | 288.43 $\pm$ 17.83 |
| Macular Thickness N3 (RE)            | 268.16 $\pm$ 22.39      | 262.98 $\pm$ 20.78 | 262.67 $\pm$ 18.87 | 256.38 $\pm$ 16.04 | 245.89 $\pm$ 45.75     | 259.34 $\pm$ 25.98 | 255.62 $\pm$ 15.36 | 248.33 $\pm$ 36.87 | 271.00 $\pm$ 6.63             | 264.96 $\pm$ 22.12 | 261.62 $\pm$ 23.21 | 261.20 $\pm$ 17.93 |
| Macular Thickness N3 (LE)            | 261.00 $\pm$ 19.10      | 267.20 $\pm$ 17.99 | 262.47 $\pm$ 18.80 | 256.31 $\pm$ 17.85 | 266.78 $\pm$ 9.11      | 265.85 $\pm$ 16.54 | 258.40 $\pm$ 14.39 | 261.72 $\pm$ 16.38 | 270.00 $\pm$ 7.18             | 266.59 $\pm$ 23.23 | 265.68 $\pm$ 21.82 | 264.88 $\pm$ 21.40 |
| Mean of N quadrant (RE)              | 293.11 $\pm$ 18.33      | 286.11 $\pm$ 16.40 | 285.47 $\pm$ 16.50 | 277.97 $\pm$ 18.14 | 279.41 $\pm$ 18.44     | 283.45 $\pm$ 16.06 | 281.02 $\pm$ 14.40 | 278.37 $\pm$ 19.71 | 298.00 $\pm$ 4.93             | 288.30 $\pm$ 20.54 | 286.61 $\pm$ 19.43 | 286.54 $\pm$ 16.99 |
| Mean of N quadrant (LE)              | 290.78 $\pm$ 19.35      | 288.22 $\pm$ 15.02 | 285.70 $\pm$ 15.34 | 278.97 $\pm$ 16.20 | 285.04 $\pm$ 7.35      | 286.07 $\pm$ 13.28 | 281.80 $\pm$ 12.36 | 284.76 $\pm$ 13.01 | 296.73 $\pm$ 1.92             | 289.24 $\pm$ 21.29 | 288.39 $\pm$ 19.17 | 288.10 $\pm$ 17.76 |
| Macular Thickness T1 (RE)            | 297.00 $\pm$ 14.78      | 288.94 $\pm$ 16.82 | 287.47 $\pm$ 19.88 | 282.46 $\pm$ 11.28 | 290.78 $\pm$ 8.42      | 289.93 $\pm$ 16.27 | 287.27 $\pm$ 14.54 | 291.83 $\pm$ 11.75 | 293.20 $\pm$ 4.96             | 291.98 $\pm$ 17.71 | 292.75 $\pm$ 18.76 | 288.08 $\pm$ 16.00 |
| Macular Thickness T1 (LE)            | 296.50 $\pm$ 15.29      | 287.68 $\pm$ 16.43 | 286.84 $\pm$ 19.84 | 279.23 $\pm$ 13.90 | 290.22 $\pm$ 10.11     | 289.43 $\pm$ 15.69 | 285.90 $\pm$ 12.58 | 288.28 $\pm$ 14.61 | 293.80 $\pm$ 8.70             | 292.23 $\pm$ 18.11 | 293.77 $\pm$ 19.34 | 293.77 $\pm$ 14.01 |
| Macular Thickness T2 (RE)            | 260.83 $\pm$ 13.56      | 258.83 $\pm$ 14.85 | 259.23 $\pm$ 15.30 | 255.15 $\pm$ 12.95 | 256.33 $\pm$ 9.72      | 253.59 $\pm$ 14.91 | 250.22 $\pm$ 12.31 | 252.28 $\pm$ 11.81 | 265.80 $\pm$ 11.61            | 262.21 $\pm$ 17.46 | 261.70 $\pm$ 17.97 | 263.03 $\pm$ 17.76 |
| Macular Thickness T2 (LE)            | 257.83 $\pm$ 12.22      | 259.31 $\pm$ 15.90 | 257.88 $\pm$ 16.61 | 252.00 $\pm$ 11.18 | 254.89 $\pm$ 13.47     | 251.22 $\pm$ 18.04 | 242.82 $\pm$ 25.00 | 251.17 $\pm$ 14.53 | 258.00 $\pm$ 14.35            | 260.69 $\pm$ 16.07 | 262.08 $\pm$ 20.69 | 262.40 $\pm$ 18.92 |
| Macular Thickness T3 (RE)            | 227.00 $\pm$ 10.73      | 223.17 $\pm$ 12.36 | 224.41 $\pm$ 13.11 | 218.15 $\pm$ 12.27 | 224.89 $\pm$ 8.74      | 219.76 $\pm$ 13.57 | 214.72 $\pm$ 11.37 | 219.78 $\pm$ 15.14 | 230.80 $\pm$ 9.12             | 227.31 $\pm$ 19.54 | 224.17 $\pm$ 17.86 | 228.91 $\pm$ 20.65 |
| Macular Thickness T3 (LE)            | 228.33 $\pm$ 10.07      | 225.92 $\pm$ 14.58 | 224.92 $\pm$ 15.50 | 218.54 $\pm$ 9.99  | 223.22 $\pm$ 10.13     | 219.54 $\pm$ 13.03 | 217.82 $\pm$ 10.36 | 219.89 $\pm$ 9.70  | 228.20 $\pm$ 12.69            | 227.98 $\pm$ 14.61 | 227 $\pm$ 17.73    | 228.20 $\pm$ 15.02 |
| Mean of T quadrant (RE)              | 261.61 $\pm$ 11.68      | 256.98 $\pm$ 12.92 | 257.04 $\pm$ 14.74 | 251.92 $\pm$ 10.56 | 257.33 $\pm$ 7.19      | 254.43 $\pm$ 13.39 | 250.74 $\pm$ 10.28 | 254.63 $\pm$ 11.75 | 263.26 $\pm$ 6.94             | 260.50 $\pm$ 15.39 | 259.53 $\pm$ 14.99 | 260.01 $\pm$ 13.31 |
| Mean of T quadrant (LE)              | 260.89 $\pm$ 11.97      | 257.64 $\pm$ 13.67 | 256.54 $\pm$ 16.03 | 249.92 $\pm$ 10.31 | 256.11 $\pm$ 7.93      | 253.40 $\pm$ 13.13 | 248.85 $\pm$ 10.94 | 253.11 $\pm$ 10.75 | 260.00 $\pm$ 11.1             | 260.30 $\pm$ 14.48 | 260.95 $\pm$ 17.61 | 261.45 $\pm$ 14.33 |
| Macular Thickness S1 (RE)            | 315.33 $\pm$ 13.54      | 311.00 $\pm$ 16.87 | 310.80 $\pm$ 18.37 | 301.38 $\pm$ 12.26 | 309.11 $\pm$ 11.30     | 308.22 $\pm$ 19.91 | 307.52 $\pm$ 16.62 | 310.28 $\pm$ 12.10 | 305.80 $\pm$ 14.02            | 310.29 $\pm$ 21.69 | 308.87 $\pm$ 20.48 | 302.23 $\pm$ 23.73 |
| Macular Thickness S1 (LE)            | 309.00 $\pm$ 18.65      | 307.28 $\pm$ 23.78 | 306.47 $\pm$ 28.12 | 303.69 $\pm$ 11.02 | 312.56 $\pm$ 9.08      | 311.27 $\pm$ 15.86 | 308.25 $\pm$ 13.45 | 310.00 $\pm$ 11.23 | 288.20 $\pm$ 42.80            | 308.43 $\pm$ 25.32 | 308.48 $\pm$ 22.16 | 305.54 $\pm$ 22.78 |
| Macular Thickness S2 (RE)            | 277.33 $\pm$ 10.03      | 277.56 $\pm$ 19.15 | 275.67 $\pm$ 17.54 | 271.38 $\pm$ 16.77 | 277.56 $\pm$ 15.02     | 274.13 $\pm$ 14.84 | 268.02 $\pm$ 10.47 | 268.33 $\pm$ 13.45 | 282.80 $\pm$ 18.17            | 277.36 $\pm$ 20.49 | 278.17 $\pm$ 18.43 | 276.06 $\pm$ 20.74 |
| Macular Thickness S2 (LE)            | 278.33 $\pm$ 24.25      | 278.25 $\pm$ 16.30 | 277.76 $\pm$ 18.16 | 270.44 $\pm$ 14.19 | 270.44 $\pm$ 13.82     | 274.43 $\pm$ 12.60 | 273.33 $\pm$ 17.93 | 273.40 $\pm$ 21.33 | 292.23 $\pm$ 17.23            | 293.70 $\pm$ 17.59 | 279.17 $\pm$ 16.66 |                    |
| Macular Thickness S3 (RE)            | 240.50 $\pm$ 10.75      | 245.04 $\pm$ 23.94 | 245.16 $\pm$ 23.55 | 241.92 $\pm$ 31.14 | 249.33 $\pm$ 10.85     | 246.31 $\pm$ 17.10 | 238.35 $\pm$ 13.72 | 238.67 $\pm$ 21.62 | 248.40 $\pm$ 11.54            | 250.54 $\pm$ 20.06 | 248.72 $\pm$ 16.75 | 251.71 $\pm$ 25.73 |
| Macular Thickness S3 (LE)            | 245.00 $\pm$ 14.13      | 249.08 $\pm$ 16.02 | 250.84 $\pm$ 18.02 | 248.77 $\pm$ 13.25 | 252.33 $\pm$ 11.67     | 246.21 $\pm$ 13.14 | 240.45 $\pm$ 10.69 | 245.72 $\pm$ 11.92 | 256.20 $\pm$ 31.17            | 249.72 $\pm$ 16.33 | 254.17 $\pm$ 22.02 | 248.23 $\pm$ 17.74 |
| Mean of S quadrant (RE)              | 277.72 $\pm$ 10.84      | 277.87 $\pm$ 16.02 | 277.21 $\pm$ 15.68 | 271.56 $\pm$ 13.54 | 278.67 $\pm$ 11.36     | 276.22 $\pm$ 13.76 | 271.30 $\pm$ 11.40 | 272.42 $\pm$ 14.02 | 279.00 $\pm$ 12.13            | 279.60 $\pm$ 16.19 | 278.58 $\pm$ 15.44 | 276.67 $\pm$ 19.59 |
| Mean of S quadrant (LE)              | 277.44 $\pm$ 15.84      | 278.20 $\pm$ 14.16 | 278.35 $\pm$ 16.21 | 274.82 $\pm$ 11.32 | 278.44 $\pm$ 10.48     | 277.31 $\pm$ 12.49 | 273.12 $\pm$ 10.23 | 276.35 $\pm$ 12.26 | 272.60 $\pm$ 25.22            | 279.46 $\pm$ 16.56 | 280.65 $\pm$ 16.26 | 277.65 $\pm$ 15.41 |
| Macular Thickness I1 (RE)            | 305.33 $\pm$ 14.39      | 306.36 $\pm$ 20.30 | 308.37 $\pm$ 19.48 | 296.53 $\pm$ 23.29 | 306.78 $\pm$ 10.46     | 305.37 $\pm$ 18.16 | 305.85 $\pm$ 17.47 | 301.11 $\pm$ 15.03 | 306.20 $\pm$ 17.79            | 313.31 $\pm$ 19.15 | 308.45 $\pm$ 20.08 | 301.37 $\pm$ 16.56 |
| Macular Thickness I1 (LE)            | 306.33 $\pm$ 8.45       | 306.53 $\pm$ 19.09 | 305.31 $\pm$ 20.55 | 295.54 $\pm$ 23.69 | 305.89 $\pm$ 7.41      | 306.32 $\pm$ 16.05 | 305.97 $\pm$ 14.35 | 305.61 $\pm$ 12.46 | 305.40 $\pm$ 17.79            | 311.93 $\pm$ 18.30 | 307 $\pm$ 19.83    | 305.23 $\pm$ 15.59 |
| Macular Thickness I2 (RE)            | 268.33 $\pm$ 12.66      | 267.90 $\pm$ 19.75 | 267.12 $\pm$ 21.48 | 258.31 $\pm$ 16.49 | 253.22 $\pm$ 12.94     | 258.96 $\pm$ 18.31 | 250.37 $\pm$ 13.70 | 252.11 $\pm$ 19.60 | 261.40 $\pm$ 22.33            | 272.87 $\pm$ 22.83 | 263.87 $\pm$ 24.94 | 261.54 $\pm$ 23.99 |
| Macular Thickness I2 (LE)            | 276.00 $\pm$ 16.88      | 262.28 $\pm$ 17.47 | 260.18 $\pm$ 18.58 | 252.77 $\pm$ 18.25 | 254.78 $\pm$ 12.83     | 257.01 $\pm$ 15.91 | 247.67 $\pm$ 15.51 | 255.78 $\pm$ 20.21 | 275.80 $\pm$ 20.80            | 266.87 $\pm$ 19.64 | 266.87 $\pm$ 20.38 | 264.54 $\pm$ 19.59 |
| Macular Thickness I3 (RE)            | 241.00 $\pm$ 17.72      | 237.50 $\pm$ 14.73 | 239.16 $\pm$ 16.35 | 232.69 $\pm$ 14.39 | 238.67 $\pm$ 10.57     | 234.09 $\pm$ 15.24 | 224.32 $\pm$ 11.78 | 231.44 $\pm$ 18.63 | 247.00 $\pm$ 20.94            | 247.04 $\pm$ 20.56 | 239.35 $\pm$ 21.24 | 239.80 $\pm$ 27.23 |
| Macular Thickness I3 (LE)            | 252.67 $\pm$ 12.45      | 236.83 $\pm$ 15.77 | 233.49 $\pm$ 17.13 | 234.85 $\pm$ 16.18 | 234.78 $\pm$ 7.82      | 233.70 $\pm$ 16.85 | 224.95 $\pm$ 15.43 | 226.11 $\pm$ 15.24 | 240.20 $\pm$ 10.33            | 241.77 $\pm$ 16.67 | 235.03 $\pm$ 17.15 | 235.34 $\pm$ 20.17 |
| Mean of I quadrant (RE)              | 271.56 $\pm$ 11.62      | 270.59 $\pm$ 15.07 | 271.54 $\pm$ 15.77 | 262.51 $\pm$ 14.07 | 266.22 $\pm$ 6.29      | 266.14 $\pm$ 13.28 | 260.18 $\pm$ 10.91 | 261.56 $\pm$ 13.81 | 271.53 $\pm$ 18.31            | 277.74 $\pm$ 15.63 | 270.56 $\pm$ 19.33 | 267.57 $\pm$ 18.75 |
| Mean of I quadrant (LE)              | 278.33 $\pm$ 9.92       | 268.55 $\pm$ 14.41 | 266.33 $\pm$ 13.87 | 261.05 $\pm$ 17.10 | 265.15 $\pm$ 8.17      | 265.67 $\pm$ 12.81 | 259.53 $\pm$ 11.57 | 261.50 $\pm$ 12.91 | 273.80 $\pm$ 14.49            | 273.53 $\pm$ 14.50 | 269.76 $\pm$ 15.44 | 268.37 $\pm$ 13.95 |
| Total Volume (mm <sup>3</sup> ) (RE) | 7.71 $\pm$ 0.18         | 7.63 $\pm$ 0.34    | 7.63 $\pm$ 0.34    | 7.69 $\pm$ 0.36    | 7.59 $\pm$ 0.28        | 7.53 $\pm$ 0.36    | 7.39 $\pm$ 0.33    | 7.33 $\pm$ 0.33    | 7.74 $\pm$ 0.73               | 7.79 $\pm$ 0.48    | 7.64 $\pm$ 0.52    | 7.60 $\pm$ 0.45    |
| Total Volume (mm <sup>3</sup> ) (LE) | 7.72 $\pm$ 0.24         | 7.63 $\pm$ 0.33    | 7.60 $\pm$ 0.38    | 7.63 $\pm$ 0.38    | 7.57 $\pm$ 0.24        | 7.56 $\pm$ 0.31    | 7.41 $\pm$ 0.27    | 7.53 $\pm$ 0.33    | 7.92 $\pm$ 0.36               | 7.72 $\pm$ 0.42    | 7.67 $\pm$ 0.39    | 7.65 $\pm$ 0.32    |

N, nasal; T, temporal; S, superior; I, inferior (at 1mm, 2mm, and 3 mm)

**Table 6:** Mean  $\pm$  Standard Deviation (SD) of retinal thickness with the four BMI Categories at each of the locations and quadrants under examination for control, myopia, and hypermetropia groups.

| Choroidal Thickness, $\mu\text{m}$ | Control Group (N = 200) |                    |                    |                    | Myopia Group (N = 198) |                    |                    |                    | Hypermetropia Group (N = 188) |                    |                    |                    |                    |
|------------------------------------|-------------------------|--------------------|--------------------|--------------------|------------------------|--------------------|--------------------|--------------------|-------------------------------|--------------------|--------------------|--------------------|--------------------|
|                                    | Underweight             | Normal Weight      | Overweight         | Obesity            | Underweight            | Normal Weight      | Overweight         | Obesity            | Underweight                   | Normal Weight      | Overweight         | Obesity            |                    |
| Central (RE)                       | 197.83 $\pm$ 33.04      | 249.39 $\pm$ 51.76 | 238.22 $\pm$ 52.93 | 223.15 $\pm$ 51.28 | 214.44 $\pm$ 56.77     | 238.00 $\pm$ 45.47 | 224.15 $\pm$ 34.98 | 221.50 $\pm$ 48.29 | 212.60 $\pm$ 46.42            | 232.21 $\pm$ 46.92 | 224.75 $\pm$ 36.85 | 233.03 $\pm$ 28.73 |                    |
| Central (LE)                       | 227.17 $\pm$ 61.19      | 258.12 $\pm$ 50.22 | 250.88 $\pm$ 51.41 | 218.00 $\pm$ 50.72 | 226.11 $\pm$ 53.91     | 251.24 $\pm$ 46.63 | 235.00 $\pm$ 40.99 | 233.39 $\pm$ 51.01 | 192.60 $\pm$ 44.01            | 231.89 $\pm$ 44.16 | 226.45 $\pm$ 38.79 | 228.63 $\pm$ 40.16 |                    |
| Choroidal Thickness N1 (RE)        | 196.67 $\pm$ 29.70      | 209.83 $\pm$ 44.20 | 207.12 $\pm$ 45.60 | 188.09 $\pm$ 21.48 | 198.78 $\pm$ 21.53     | 214.14 $\pm$ 36.11 | 206.02 $\pm$ 53.61 | 200.74 $\pm$ 52.67 | 189.80 $\pm$ 14.91            | 192.70 $\pm$ 24.57 | 187.70 $\pm$ 26.89 | 197.08 $\pm$ 35.41 |                    |
| Choroidal Thickness N1 (LE)        | 197.17 $\pm$ 39.53      | 215.00 $\pm$ 49.39 | 210.60 $\pm$ 47.07 | 195.69 $\pm$ 54.94 | 210.47 $\pm$ 44.53     | 219.47 $\pm$ 47.52 | 189.44 $\pm$ 54.56 | 185.44 $\pm$ 27.78 | 159.40 $\pm$ 26.18            | 195.40 $\pm$ 25.65 | 190.40 $\pm$ 22.62 | 200.80 $\pm$ 32.10 |                    |
| Choroidal Thickness N2 (RE)        | 168.67 $\pm$ 31.83      | 178.86 $\pm$ 38.10 | 176.31 $\pm$ 39.15 | 166.89 $\pm$ 43.40 | 161.32 $\pm$ 27.39     | 181.27 $\pm$ 35.01 | 176.55 $\pm$ 30.93 | 173.39 $\pm$ 37.85 | 157.00 $\pm$ 38.73            | 169.52 $\pm$ 32.73 | 168.22 $\pm$ 30.73 | 166.46 $\pm$ 30.80 |                    |
| Choroidal Thickness N2 (LE)        | 173.00 $\pm$ 24.21      | 182.83 $\pm$ 54.14 | 182.49 $\pm$ 55.92 | 169.35 $\pm$ 42.05 | 163.78 $\pm$ 28.34     | 181.32 $\pm$ 36.2  | 178.92 $\pm$ 30.35 | 174.22 $\pm$ 30.38 | 135.00 $\pm$ 20.39            | 161.06 $\pm$ 32.64 | 162.43 $\pm$ 26.03 | 168.86 $\pm$ 27.94 |                    |
| Choroidal Thickness N3 (RE)        | 153.30 $\pm$ 30.70      | 149.76 $\pm$ 34.75 | 147.74 $\pm$ 36.66 | 136.38 $\pm$ 31.51 | 126.56 $\pm$ 11.74     | 153.23 $\pm$ 32.62 | 145.57 $\pm$ 29.04 | 148.72 $\pm$ 37.44 | 143.60 $\pm$ 8.53             | 148.12 $\pm$ 28.70 | 146.07 $\pm$ 29.47 | 144.20 $\pm$ 37.11 |                    |
| Choroidal Thickness N3 (LE)        | 152.33 $\pm$ 14.77      | 147.68 $\pm$ 28.31 | 147.84 $\pm$ 28.62 | 137.69 $\pm$ 28.22 | 132.32 $\pm$ 30.90     | 152.57 $\pm$ 33.91 | 150.70 $\pm$ 36.36 | 149.50 $\pm$ 27.42 | 121.40 $\pm$ 13.96            | 145.98 $\pm$ 29.45 | 142.45 $\pm$ 27.99 | 143.28 $\pm$ 27.71 |                    |
| Mean of N quadrant (RE)            | 172.94 $\pm$ 27.65      | 178.83 $\pm$ 36.42 | 177.06 $\pm$ 37.83 | 162.92 $\pm$ 40.72 | 160.18 $\pm$ 17.23     | 183.65 $\pm$ 31.27 | 176.06 $\pm$ 28.84 | 174.30 $\pm$ 37.90 | 156.80 $\pm$ 8.31             | 170.28 $\pm$ 29.16 | 167.33 $\pm$ 25.27 | 169.25 $\pm$ 29.17 |                    |
| Mean of N quadrant (LE)            | 174.17 $\pm$ 23.60      | 182.83 $\pm$ 52.10 | 181.81 $\pm$ 33.82 | 170.87 $\pm$ 38.40 | 165.37 $\pm$ 29.34     | 182.14 $\pm$ 35.99 | 178.21 $\pm$ 36.48 | 173.06 $\pm$ 25.99 | 138.60 $\pm$ 20.08            | 165.46 $\pm$ 29.21 | 165.12 $\pm$ 24.57 | 171.31 $\pm$ 26.86 |                    |
| Choroidal Thickness T1 (RE)        | 181.83 $\pm$ 51.85      | 214.08 $\pm$ 49.01 | 203.59 $\pm$ 46.20 | 191.54 $\pm$ 40.42 | 211.31 $\pm$ 54.73     | 224.53 $\pm$ 45.99 | 218.60 $\pm$ 46.32 | 212.72 $\pm$ 44.39 | 210.40 $\pm$ 42.10            | 204.65 $\pm$ 41.78 | 203.45 $\pm$ 40.69 | 202.03 $\pm$ 38.25 |                    |
| Choroidal Thickness T1 (LE)        | 199.67 $\pm$ 53.27      | 227.59 $\pm$ 46.86 | 220.60 $\pm$ 45.74 | 201.23 $\pm$ 48.45 | 236.32 $\pm$ 73.05     | 235.34 $\pm$ 61.61 | 232.22 $\pm$ 57.83 | 221.00 $\pm$ 51.81 | 175.20 $\pm$ 36.20            | 202.59 $\pm$ 36.44 | 199.55 $\pm$ 35.73 | 204.34 $\pm$ 33.17 |                    |
| Choroidal Thickness T2 (RE)        | 177.50 $\pm$ 49.30      | 192.32 $\pm$ 46.74 | 182.88 $\pm$ 40.44 | 174.38 $\pm$ 28.81 | 189.78 $\pm$ 68.98     | 208.58 $\pm$ 50.07 | 204.00 $\pm$ 45.69 | 200.00 $\pm$ 34.05 | 187.28 $\pm$ 29.54            | 186.62 $\pm$ 38.33 | 181.68 $\pm$ 36.44 | 184.26 $\pm$ 33.59 |                    |
| Choroidal Thickness T2 (LE)        | 180.83 $\pm$ 53.73      | 201.41 $\pm$ 49.10 | 201.18 $\pm$ 45.73 | 179.85 $\pm$ 40.84 | 233.56 $\pm$ 77.53     | 218.94 $\pm$ 60.75 | 205.40 $\pm$ 55.56 | 200.00 $\pm$ 52.11 | 149.40 $\pm$ 29.33            | 186.84 $\pm$ 38.59 | 177.55 $\pm$ 37.53 | 185.77 $\pm$ 32.45 |                    |
| Choroidal Thickness T3 (RE)        | 162.00 $\pm$ 41.83      | 177.04 $\pm$ 44.56 | 169.53 $\pm$ 35.85 | 159.31 $\pm$ 31.01 | 197.56 $\pm$ 67.09     | 188.75 $\pm$ 44.92 | 188.72 $\pm$ 40.86 | 181.14 $\pm$ 37.40 | 167.60 $\pm$ 42.40            | 173.75 $\pm$ 44.48 | 167.25 $\pm$ 38.27 | 170.26 $\pm$ 37.05 |                    |
| Choroidal Thickness T3 (LE)        | 172.17 $\pm$ 51.07      | 174.86 $\pm$ 44.14 | 175.59 $\pm$ 40.10 | 166.54 $\pm$ 36.53 | 228.22 $\pm$ 82.20     | 197.37 $\pm$ 57.06 | 190.20 $\pm$ 56.61 | 185.89 $\pm$ 48.71 | 156.00 $\pm$ 41.48            | 170.63 $\pm$ 35.88 | 159.38 $\pm$ 35.06 | 169.77 $\pm$ 34.72 |                    |
| Mean of T quadrant (RE)            | 173.78 $\pm$ 45.46      | 194.48 $\pm$ 44.80 | 185.33 $\pm$ 39.05 | 175.08 $\pm$ 31.47 | 206.81 $\pm$ 62.29     | 207.22 $\pm$ 49.92 | 203.77 $\pm$ 42.03 | 212.28 $\pm$ 36.14 | 188.40 $\pm$ 34.35            | 188.34 $\pm$ 39.32 | 184.13 $\pm$ 36.62 | 185.51 $\pm$ 34.72 |                    |
| Mean of T quadrant (LE)            | 184.22 $\pm$ 50.56      | 201.62 $\pm$ 49.21 | 199.46 $\pm$ 49.09 | 182.54 $\pm$ 39.48 | 232.67 $\pm$ 76.50     | 217.21 $\pm$ 58.05 | 205.94 $\pm$ 54.73 | 204.63 $\pm$ 48.28 | 160.20 $\pm$ 30.87            | 186.69 $\pm$ 34.91 | 178.88 $\pm$ 35.27 | 186.63 $\pm$ 31.11 |                    |
| Choroidal Thickness S1 (RE)        | 230.83 $\pm$ 54.08      | 237.58 $\pm$ 43.08 | 232.20 $\pm$ 45.61 | 227.71 $\pm$ 41.88 | 235.56 $\pm$ 61.25     | 241.37 $\pm$ 42.47 | 234.70 $\pm$ 43.41 | 241.22 $\pm$ 40.10 | 190.80 $\pm$ 33.65            | 210.35 $\pm$ 39.01 | 205.53 $\pm$ 35.10 | 198.74 $\pm$ 34.71 |                    |
| Choroidal Thickness S1 (LE)        | 244.67 $\pm$ 60.55      | 248.43 $\pm$ 49.06 | 232.08 $\pm$ 51.59 | 233.61 $\pm$ 54.99 | 252.89 $\pm$ 63.94     | 245.62 $\pm$ 57.47 | 235.27 $\pm$ 57.77 | 239.59 $\pm$ 55.88 | 191.80 $\pm$ 39.26            | 211.53 $\pm$ 43.64 | 211.03 $\pm$ 39.94 | 204.74 $\pm$ 40.34 |                    |
| Choroidal Thickness S2 (RE)        | 242.50 $\pm$ 56.39      | 230.98 $\pm$ 44.30 | 219.37 $\pm$ 40.82 | 220.08 $\pm$ 41.98 | 237.44 $\pm$ 56.85     | 236.81 $\pm$ 49.02 | 239.25 $\pm$ 50.94 | 231.50 $\pm$ 54.49 | 200.00 $\pm$ 40.24            | 198.26 $\pm$ 37.05 | 205.80 $\pm$ 29.53 | 200.00 $\pm$ 37.03 |                    |
| Choroidal Thickness S2 (LE)        | 247.83 $\pm$ 62.81      | 244.37 $\pm$ 45.05 | 209.89 $\pm$ 41.27 | 211.74 $\pm$ 54.55 | 255.71                 | 234.56 $\pm$ 51.61 | 233.71 $\pm$ 54.15 | 230.00 $\pm$ 51.97 | 228.33 $\pm$ 43.73            | 191.00 $\pm$ 17.39 | 208.42 $\pm$ 36.54 | 208.97 $\pm$ 39.01 | 201.40 $\pm$ 37.01 |
| Choroidal Thickness S3 (RE)        | 226.67 $\pm$ 35.68      | 230.82 $\pm$ 44.49 | 228.27 $\pm$ 40.39 | 227.17 $\pm$ 36.75 | 246.67 $\pm$ 49.82     | 242.56 $\pm$ 45.06 | 238.27 $\pm$ 45.53 | 234.54 $\pm$ 60.35 | 197.20 $\pm$ 49.32            | 209.17 $\pm$ 47.94 | 210.48 $\pm$ 37.97 | 208.43 $\pm$ 44.51 |                    |
| Choroidal Thickness S3 (LE)        | 248.83 $\pm$ 51.86      | 240.04 $\pm$ 45.17 | 228.94 $\pm$ 44.04 | 221.77 $\pm$ 42.53 | 248.56 $\pm$ 50.25     | 245.87 $\pm$ 45.94 | 235.05 $\pm$ 53.92 | 225.83 $\pm$ 50.91 | 187.00 $\pm$ 54.17            | 208.67 $\pm$ 45.64 | 208.46 $\pm$ 46.62 | 208.68 $\pm$ 43.25 |                    |
| Mean of S quadrant (RE)            | 233.33 $\pm$ 46.30      | 233.13 $\pm$ 40.77 | 223.28 $\pm$ 38.62 | 222.87 $\pm$ 37.40 | 239.89 $\pm$ 48.52     | 240.24 $\pm$ 42.24 | 234.07 $\pm$ 43.57 | 235.89 $\pm$ 49.17 | 196.33 $\pm$ 37.27            | 205.93 $\pm$ 36.64 | 207.27 $\pm$ 28.84 | 202.39 $\pm$ 35.92 |                    |
| Mean of S quadrant (LE)            | 249.11 $\pm$ 56.12      | 245.40 $\pm$ 43.57 | 230.03 $\pm$ 41.65 | 224.97 $\pm$ 43.76 | 258.33 $\pm$ 58.23     | 245.07 $\pm$ 50.80 | 233.11 $\pm$ 50.90 | 230.70 $\pm$ 47.21 | 189.93 $\pm$ 37.67            | 209.54 $\pm$ 36.21 | 208.81 $\pm$ 37.88 | 204.94 $\pm$ 36.29 |                    |
| Choroidal Thickness I1 (RE)        | 259.83 $\pm$ 32.17      | 229.99 $\pm$ 43.91 | 220.74 $\pm$ 40.37 | 217.37 $\pm$ 25.74 | 232.00 $\pm$ 53.17     | 247.30 $\pm$ 47.84 | 246.80 $\pm$ 40.28 | 232.78 $\pm$ 49.26 | 208.40 $\pm$ 37.35            | 209.89 $\pm$ 38.92 | 222.37 $\pm$ 35.20 | 214.31 $\pm$ 31.65 |                    |
| Choroidal Thickness I1 (LE)        | 262.50 $\pm$ 55.19      | 233.51 $\pm$ 45.00 | 226.33 $\pm$ 46.23 | 223.46 $\pm$ 45.87 | 240.56 $\pm$ 51.12     | 249.26 $\pm$ 55.91 | 241.27 $\pm$ 56.18 | 238.28 $\pm$ 47.13 | 219.80 $\pm$ 34.32            | 221.19 $\pm$ 43.95 | 216.17 $\pm$ 44.15 | 207.38 $\pm$ 47.41 |                    |
| Choroidal Thickness I2 (RE)        | 253.33 $\pm$ 27.80      | 226.20 $\pm$ 30.10 | 210.72 $\pm$ 39.43 | 212.31 $\pm$ 33.61 | 237.00 $\pm$ 45.81     | 246.91 $\pm$ 49.06 | 239.15 $\pm$ 43.16 | 232.70 $\pm$ 35.95 | 196.20 $\pm$ 20.09            | 199.78 $\pm$ 37.15 | 215.92 $\pm$ 45.78 | 204.48 $\pm$ 32.23 |                    |
| Choroidal Thickness I2 (LE)        | 266.67 $\pm$ 39.78      | 229.04 $\pm$ 42.11 | 226.76 $\pm$ 41.90 | 211.15 $\pm$ 35.93 | 235.57 $\pm$ 51.94     | 244.78 $\pm$ 52.62 | 239.45 $\pm$ 45.42 | 234.56 $\pm$ 45.95 | 189.20 $\pm$ 31.63            | 208.87 $\pm$ 40.08 | 208.53 $\pm$ 34.05 | 202.91 $\pm$ 31.86 |                    |
| Choroidal Thickness I3 (RE)        | 250.17 $\pm$ 33.28      | 224.42 $\pm$ 45.75 | 219.45 $\pm$ 45.04 | 205.34 $\pm$ 36.76 | 223.44 $\pm$ 43.41     | 243.61 $\pm$ 47.17 | 237.62 $\pm$ 42.12 | 226.06 $\pm$ 37.75 | 188.60 $\pm$ 44.64            | 206.62 $\pm$ 43.89 | 220.47 $\pm$ 45.74 | 210.26 $\pm$ 34.74 |                    |
| Choroidal Thickness I3 (LE)        | 248.50 $\pm$ 30.92      | 222.50 $\pm$ 45.67 | 215.72 $\pm$ 41.88 | 208.61 $\pm$ 44.88 | 229.67 $\pm$ 55.55     | 246.14 $\pm$ 49.36 | 230.97 $\pm$ 46.30 | 225.00 $\pm$ 45.52 | 219.20 $\pm$ 29.99            | 208.57 $\pm$ 39.41 | 212.87 $\pm$ 42.81 | 213.88 $\pm$ 49.67 |                    |
| Mean of I quadrant (RE)            | 254.44 $\pm$ 28.84      | 226.87 $\pm$ 39.43 | 219.97 $\pm$ 39.81 | 206.54 $\pm$ 27.77 | 230.81 $\pm$ 39.76     | 245.94 $\pm$ 44.02 | 241.19 $\pm$ 37.37 | 226.52 $\pm$ 34.00 | 207.73 $\pm$ 36.23            | 205.43 $\pm$ 37.15 | 219.58 $\pm$ 38.88 | 209.68 $\pm$ 28.55 |                    |
| Mean of I quadrant (LE)            | 259.22 $\pm$ 42.81      | 229.25 $\pm$ 40.20 | 222.92 $\pm$ 38.44 | 214.41 $\pm$ 40.66 | 235.73 $\pm$ 40.24     | 247.33 $\pm$ 44.20 | 237.23 $\pm$ 43.24 | 236.94 $\pm$ 37.03 | 209.40 $\pm$ 29.33            | 209.87 $\pm$ 36.70 | 212.52 $\pm$ 35.78 | 208.03 $\pm$ 38.85 |                    |

|                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                                                                                                              |                                                                                                             |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------|
| Macular Thickness I3, $\mu\text{m}$<br>LE: Obesity and Underweight: $p = 0.01$ ; CI: 3.12 to 32.52. Overweight and Underweight: $p = <0.001$ ; CI: 6.33 to 32.03. Normal Weight and Underweight: $p = 0.01$ ; CI: 3.40 to 28.27.                                                           | Macular Thickness S2, $\mu\text{m}$ : Absolute Interocular Differences<br>Obesity and Underweight: $p = <0.001$ ; SMD = -12.111; CI: -20.56 to -3.67 Normal Weight and Underweight: $p = 0.04$ ; SMD = -7.42; CI: -14.54 to -0.29. Underweight and Overweight: $p = 0.01$ ; SMD = -9.76; CI: -17.40 to 2.13. | Mean of Macular I quadrant, $\mu\text{m}$<br>RE: Obesity and Normal Weight: $p = 0.02$ ; CI: 1.08 to 19.26. |
| Mean of Macular I quadrant, $\mu\text{m}$<br>LE: Obesity and Underweight: $p = 0.01$ ; CI: 3.31 to 31.26.                                                                                                                                                                                  | Macular Thickness I2, $\mu\text{m}$<br>RE: Normal Weight and Overweight: $p = < 0.001$ ; CI: 2.39 to 14.79.<br>LE: Normal Weight and Overweight: $p = <0.001$ ; CI: 3.58 to 15.08.                                                                                                                           |                                                                                                             |
| Central Choroidal Thickness, $\mu\text{m}$<br>RE: Normal Weight and Underweight: $p = 0.02$ ; CI: 9.03 to 94.09.<br>LE: Normal Weight and Obesity: $p = 0.01$ ; CI: 10.94 to 69.30. Overweight and Obesity: $p = 0.04$ ; CI: 1.71 to 64.05.                                                | Macular Thickness I3, $\mu\text{m}$<br>RE: Normal Weight and Overweight: $p = < 0.001$ ; CI: 4.48 to 15.05.<br>LE: Normal Weight and Overweight: $p = < 0.001$ ; CI: 2.10 to 14.51.                                                                                                                          |                                                                                                             |
| Choroidal Thickness I1, $\mu\text{m}$<br>RE: Underweight and Overweight: $p = 0.04$ ; CI: 1.92 to 76.26. Underweight and Obesity: $p = 0.01$ ; CI: 13.56 to 98.57. Normal Weight and Obesity: $p = 0.04$ ; CI: 1.17 to 51.27.                                                              | Mean of Macular I quadrant, $\mu\text{m}$<br>RE: Normal Weight and Overweight: $p = 0.01$ ; CI: 1.44 to 10.47.<br>LE: Normal Weight and Overweight: $p = < 0.001$ ; CI: 1.72 to 10.57.                                                                                                                       |                                                                                                             |
| Choroidal Thickness I2, $\mu\text{m}$<br>RE: Overweight and Underweight: $p = 0.04$ ; CI: 0.73 to 66.49. Obesity and Underweight: $p = 0.03$ ; CI: 3.43 to 78.62.                                                                                                                          | Total Macular Volume ( $\text{mm}^3$ ): Absolute Interocular Differences<br>Underweight and Overweight: $p = <0.001$ ; SMD = -0.144; CI: -0.252 to -0.037.                                                                                                                                                   |                                                                                                             |
| LE: Underweight and Obesity: $p = 0.01$ ; CI: 15.35 to 95.67. Underweight and Overweight: $p = 0.03$ ; CI: 4.84 to 75.08. Underweight and Normal Weight: $p = 0.03$ ; CI: 3.65 to 71.61.                                                                                                   |                                                                                                                                                                                                                                                                                                              |                                                                                                             |
| Choroidal Thickness I3, $\mu\text{m}$ : Absolute Interocular Differences<br>Underweight and Overweight: $p = <0.001$ ; SMD = -17.33; CI: -29.60 to -5.07.                                                                                                                                  | Choroidal Thickness I3, $\mu\text{m}$ : Absolute Interocular Differences<br>Normal Weight and Obesity: $p = 0.02$ ; SMD = -24.21; CI: -44.49 to -4.33 (Between the two eyes). Overweight and Obesity: $p = <0.001$ ; SMD = -33.59; CI: -56.27 to -10.92 (absolute interocular differences).                  |                                                                                                             |
| Mean of I quadrant, $\mu\text{m}$<br>RE: Underweight and Overweight: $p = 0.04$ ; CI: 1.55 to 67.39. Underweight and Obesity: $p = 0.01$ ; CI: 10.26 to 85.55.<br>LE: Underweight and Overweight: $p = 0.04$ ; CI: 2.38 to 70.22. Underweight and Obesity: $p = 0.02$ ; CI: 6.02 to 83.61. |                                                                                                                                                                                                                                                                                                              |                                                                                                             |
| Results are presented as Post-Hoc Tukey Test for RE and LE for each group shown. CI, confidence interval; N, nasal; T, temporal; S, superior; I, inferior (at 1mm, 2mm, and 3 mm). Only statistically significant interocular differences P values at alpha level of 0.05 are shown.       |                                                                                                                                                                                                                                                                                                              |                                                                                                             |

**Table 8:** Multiple Comparisons Analysis (P-value of Tukey's Test for Post-Hoc Analysis; Standard Mean Difference (SMD); (95% CI)) in retinal and choroidal thickness with the categories of Body Mass Index at Each of the locations and quadrants under examination for control, myopia, and hypermetropia Groups.

## Discussion

The results indicate that the study demonstrates the normal thresholds of interocular asymmetry in retinal and choroidal thickness, in emmetropic, myopic and hypermetropic individuals and analyzed their relationships with anthropometric parameters. While much work targets on interocular asymmetry for macular and optic nerve head thickness, very limited work assesses macular and choroidal thickness profiles in different refractive errors with respect to BMI grades, to the best of our knowledge.

In our study there was a statistically significant difference in macular thickness in both eyes among the BMI categories, irrespective of the study group (control, myopic and hypermetropic). However, central choroidal thickness had a statistically significant difference between different BMI grades for both eyes only in the control group. Interocular asymmetry with a significant statistical difference was also observed in different quadrants of the retina and choroid for all study groups.

The nasal macular quadrant was the only section of the macula showing statistically significant interocular difference for its mean value across all study groups. The highest of the differences was observed in the myopic group (RE-LE =  $-2.73 \mu\text{m}$ ). Mahmudi et al. published a study in which they provided a layer-wise interocular comparison. They reported similar results, with the LE's nasal macula having a higher value, but statistical significance was not achieved. Besides, they have not provided the distance from the center at which they measured thickness, which might be very close to the center [11]. In our study, the greatest difference between the eyes was at 3 mm distance from the center.

The hypermetropia group had the weakest relationship between anthropometric features and choroidal and retinal thickness profiles. None of the areas of choroid showed any difference in thickness between BMI categories.

Nevertheless, it can be logically concluded that retinal thickness in hypermetropia is least affected by anthropometric measurements compared to emmetropic and myopic individuals. Although a weak relationship was observed within the hypermetropic group and BMI with respect to choroidal thickness, intergroup comparison showed statistically significant difference in choroidal thickness in all quadrants as hypermetropic participants had the lowest thickness ( $P < 0.05$ ).

Several animal-based studies found that choroidal thickness relates to refractive error-based defocus. As hypermetropia creates a defocus where images from behind the retina, this subsequently leads to choroidal thinning, resulting in a posterior shift in the retina so the image can focus correctly [15,27]. While statistically significant differences in the central choroid have been reported, this was not observed in our study [25].

These findings are not in general agreement with published literature documenting that no significant differences in hypermetropic eyes' symmetry were observed and in effect, retinal and choroidal thickness are equal regardless of the refractive status' magnitude [8].

For retinal thickness, only RE showed a statistically significant difference between normal weight and obese participants in the central macular region (CI:  $0.58\text{--}23.10 \mu\text{m}$ ) and a mean value in the inferior macula (CI =  $1.08\text{--}19.26 \mu\text{m}$ ). The central thickness was higher in obese ( $189.73 \pm 24.36 \mu\text{m}$ ) compared to normal weight participants ( $177.90 \pm 19.79 \mu\text{m}$ ). Contrarily, the normal weight group ( $277.74 \pm 15.63 \mu\text{m}$ ) had a higher mean value in the inferior macular region compared to the obese group ( $267.57 \pm 18.75 \mu\text{m}$ ).

Multiple studies have investigated macular thickness and BMI, but results have failed to reach consensus because a particular direction of relationship cannot be established [21,22,28]. This can be one likely explanation for the relationship's variable direction between these groups. The current findings, on the other hand, are in agreement with previous reports that showed people with a higher BMI had thinner retinas and choroids [22].

In the myopia group, statistically significant difference was observed in the central macular thickness for normal weight ( $P = 0.02$ ) and overweight participants ( $P = 0.02$ ). The foveal thickness was higher among obese ( $189.61 \pm 20.64 \mu\text{m}$ ) compared to

overweight ( $176.97 \pm 15.35 \mu\text{m}$ ) and normal weight participants ( $178.28 \pm 14.52 \mu\text{m}$ ). Contrasting reports exist regarding the relationship's direction between BMI and macular thickness [26,28]. This might be because no study, to the best of our knowledge, has conducted a stratified analysis for different refractive error groups to study this relationship.

Generally, myopia is associated with higher foveal thickness [29,30]. However, the central foveal thickness in obese groups was comparable in myopic and hypermetropic cases for RE ( $189.61 \pm 20.64 \mu\text{m}$  vs  $189.73 \pm 24.36 \mu\text{m}$ ) and LE ( $188.89 \pm 20.37 \mu\text{m}$  vs  $187.78 \pm 21.97 \mu\text{m}$ ). This suggests that the link between BMI and refractive error is more complicated and more research is needed. Interocular asymmetry has been described by several posterior segment parameters such as choroidal thickness, RNFL, blood vessel diameter, retinal sensitivity and foveal avascular zone morphology [9,10,12-14,18]. Interestingly, no study in the literature studied anthropometric differences in interocular asymmetry in macular and choroidal thickness, especially in different refractive errors, to the best of our knowledge [13]. In line with the hypothesis, the results might suggest that further research is required to investigate whether the interocular asymmetry is affected by the laterality, like preferential use of one side of the human body, in order to understand the mechanisms pertaining to these findings.

Our study has limitations. First, multivariate analysis ruled out variables like age, gender and medical history. This is because interocular asymmetry is similar in both eyes. Future research should use multivariate analysis to investigate the combined effect of refraction and BMI while adjusting for covariates. A manual caliper was used to measure choroidal thickness. Although inter-observer agreement was ensured, automated measurement methods can offer more accuracy.

Lastly, it cannot be ruled out that interocular asymmetry is not an early sign of ocular pathologies because of this study's cross-sectional nature. Therefore, cases with asymmetry in choroidal and macular thickness should be followed up to understand the prospective changes with respect to asymmetry and if alterations in BMI have reversible consequences. It can be concluded that some retinal and choroidal layers are thinner in obese people than in normal weight people. These SD-OCT readings may be predictive of adverse events associated with increased body weight and have prognostic abilities.

### Conflict of Interest

The authors have no conflict of interest to declare.

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