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Comparison of the long-term effects of high and low altitude on the choroidal thickness

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Abstract

The aim is to evaluate the long-term effects of high and low altitudes on the choroid. This study was a cross-sectional retrospective study. The individuals were divided into two groups according to the altitude where those lived. Those living at low altitude (Sakarya) were included in the low altitude group (LAG), and those living at high altitude (Ağrı) were included in the high altitude group (HAG). Sub-foveal choroidal thicknesses of both groups were compared. Spectral domain optical coherence tomography (SD-OCT) was used to measure the subfoveal choroidal thickness. The average of subfoveal CT in LAG was 270.3±22.2µm, whereas it was 275.1±21.0 µm in HAG. No significant difference in choroid thickness was observed in between the groups (P= 0.334).The choroid may have the ability to autoregulate and maintain a constant blood flow to the retina under different conditions.

Keywords: Choroid, choroid thickness, high altitude, low altitude

Introduction

Retina is a very active metabolic tissue and demands high amounts of oxygen [1]. Choroidal circulation and autoregulation play an important role in providing sufficient oxygen to retina when systemic blood pressure and oxygen saturation were altered in various conditions [2,3]. The change in choroidal blood flow also affects the choroidal thickness [4,5]. Optical coherence tomography (OCT) provides noninvasively visualization and measurement of the choroid, including its thickness.

The effect of altitude changes on peripheric oxygen saturation, heart rate, systemic blood pressure, blood volume and erythropoiesis is a well-documented fact [6]. Accordingly, one expects that altitude change should also alter the choroidal morphology including choroidal blood flow and choroidal thickness. In this study, it was aimed to investigate the long-term effect of altitude difference on choroidal thickness. This will be the first study to evaluate the long-term relationship between altitude and choroid.

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Materials and Methods

The study was planned retrospectively. Forty healthy subjects who applied to the Ağrı Training and Research Hospital between 2015-2016 and 40 healthy subjects who applied to the Sakarya Training and Research Hospital between 2017-2020 were included in the study. The study conformed the tenets of the Declaration of Helsinki and was approved by ethics committee of the Ağrı Training and Research Hospital.

Subjects were selected from the patient records. Those, whose demographic data and examination data were recorded well on their files, were included in the study. The exclusion criteria were; as follows: history of smoking habit, history of any ocular disorder; having body mass index between 20-25 having a refractive disorder spherical equivalent ≥ ±3D and media opacity that can attenuate signal strength in OCT, having any chronic disease and having low quality OCT scans. In addition, subjects whose OCT examination were performed in the afternoon were excluded from the study. In substance, it was aimed to form the groups from healthy subjects.

The subjects underwent a detailed ophthalmologic examination, including the measurement of best corrected visual acuity on Snellen, Ishihara color test, slit-lamp bio-microscopy, applanation tonometry, indirect ophthalmoscopy, optic disc photography, and SD-OCT.

The sub-foveal choroidal thickness was measured using the 3D OCT 2000 FA Plus Spectral Domain (Topcon Medical Systems, Inc. Tokyo, Japan) device as previously described by Ozdemir I et al. [7].

Forty subjects were found from the records at the hospital in Ağrı. Ağrı where is at 1600-2000 m higher than sea level is a city in Turkey. This group was named the high attitude group (HAG). Forty subjects from Sakarya formed the second group. Sakarya where has 100-150 m altitude, is a city in Turkey. This group was named the low attitude group (LAG). Both groups were age and gender matched.

Data was statistically analyzed of using the SPSS statistical package version 20.0 (SPSS Inc., Chicago, IL, USA). The Kolmogorov–Smirnov test was used to assess the normal distribution of the age and subfoveal CT. Levene's test was used to assess variance homogeneity of the variables. Independent samples t test was used to evaluate the significance of differences between the two groups. The value of statistical significance was set at $P < 0.05$.

Results

This study consists of 40 subjects in LAG (male, 25; female, 15) and 40 subjects in HAG (male, 25; female, 15). The age range and mean age ± SD of subjects in LAG was 19–40 years and 27.2 ± 6.7 years, respectively, whereas that in HAG was 19–41 years and 27.6 ± 7.0 years, respectively. The average of subfoveal CT in LAG was 270.3±22.2µm , whereas it was 275.1±21.0 µm in HAG. Subfoveal CT was higher in HAG than LAG, but it was not significant (P= 0.334, respectively) [Table 1].

Table 1. Demographics of subjects and distribution of subfoveal choroidal thickness by groups

	Izmir	Agri	Total	P value
Male (n) %	25 62.5%	25 62.5%	80	= 1
Age (y) ±Std Range	27.2±6.7 19-40	27.6±7.0 19-41	27.3±6.8 19-41	=0.795
CT (µm) ±Std Range	270.3±22.2. 238-320	275.1±21.0 242-347	272.7±21.6 238-347	=0.334

Discussion

In this study, we assessed the relationship between altitude difference and the choroidal thickness and found that there was no statistically significant difference in choroidal thickness between the population living in high and low altitude. In MM Bosch et al.'s study; mean systemic blood pressure, and hematocrit increased whereas oxygen saturation decreased in high altitude changes . They demonstrated that choroidal blood velocity did not significantly increased up to altitude of 5533-meter, during hypoxic conditions [8]. They stated that result may be due to choroidal oxygen delivery, which was found to be less sensitive to lower partial arterial oxygen pressure in early studies [8,9]. On the other hand, it was determined that choroidal blood flow and choroidal thickness increased after acute exposure to 4459 meters, and then these parameters decreased to their initial values when descending to low altitudes. [10]. They suggested that decreased peripheral oxygen saturation resulted in increased choroidal blood flow and, accordingly, increased choroidal thickness.

The above-mentioned studies evaluated only the effect of short-term hypoxic conditions on the choroidal structure. The research assessing the relationship between obstructive sleep apnea disorder (OSAS) and choroidal morphology would be expected to reveal more hint regarding to address the effects of chronic hypoxia on choroid. While some studies indicate that there was no relation between OSAS and choroidal thickness [11,12], other studies demonstrated alterations in choroidal morphology [13,14]. Although there is significant evidence that moderate to severe OSAS lead to choroidal thickness decrease compared to healthy controls, mild OSAS patients seems to have no change in choroidal structures [15,16].

We suggest that our cohort living in high altitude may represent the similar characteristics with the mild OSAS patients. Systemic and choroidal adaptations to chronic hypoxic conditions may ensure sufficient amount of oxygen delivery to retina. Elevated hematocrit levels in high altitudes seems to be an essential chronic systemic adaptation to hypoxia. Locally, choroidal autoregulation may be sufficient to maintain a balance between sympathetic and parasympathetic signals in mild hypoxia, which is thought to be disturbed in severe hypoxia and leading to decrease in choroidal blood flow and choroidal thickness [17].

In conclusion, we revealed that high altitude difference between 1500-2000 meters did not cause any difference in choroidal thickness in the long-term. Similar studies including larger number of cases are needed to support our result.

Conflict of interests
The authors declare that they have no competing interests.

Financial Disclosure
All authors declare no financial support.

Ethical approval
It was a retrospective study and was approved by ethics committee of the Agri Training and Research Hospital).

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