EFFECTS OF HIGH ALTITUDE ON COLOUR VISION OF CLIMBERS DURING AN EXPEDITION TO MT. AĞRI

Yüksek İrtifanin Ağrı Dağı'na Tırmanış Yapan Dağcılarda Renkli Görme Üzerine Etkisi

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Abstract

Purpose: *This study was designed to detect any altitude related changes in colour discrimination of climbers and to possibly use this test to detect acute mountain sickness (AMS) in its prodromal period.*

Material and Methods: *Farnsworth-Munsell 100-Hue (FM-100 Hue) test was performed at 1640m and also at 4200m above sea level on 16 middle aged climbers (mean age: 34.12±8.7 yrs) during a climb on Mt. Ağrı. Total and sectorial error scores were compared between these altitudes.*

Results: *The total error score (median±range) was 80 (16-277) at 1640m and 104 (36-216) at 4200m (p= 0.905). However, there was no statistically significant difference between this observed detoriation on FM-100 Hue test scores.*

Conclusion: *Research on the effects of various day light conditions and longer acclimatization in larger groups of climbers from various age groups could make early-monitoring of the prodromal signs of emerging acute mountain sickness possible.*

Key Words: *Acute mountain sickness; Color discrimination; Color vision.*

Özet

Amaç: *Bu çalışma, renkli görmede yüksek irtifaya bağlı herhangi bir değişiklik olup olmadığını belirlemek ve kullanılan testin akut dağ hastalığını önceden belirleyebilme potansiyelini araştırmak amacıyla tasarlanmıştır.*

Gereç ve Yöntem: *Farnsworth-Munsell 100-Hue (FM-100 Hue) testi deniz seviyesinden 1640 m'de ve 4200m'de yukarıda 16 orta yaşlı dağcıya Ağrı Dağı tırmanışı sırasında uygulandı (ortalama yaş: 34.12±8.7 yıl). Bu ik irtifa arasında hem toplam hem sektöriyel skorlar karşılaştırıldı.*

Bulgular: *Toplam hata skoru (ortanca±dağılım aralığı) 1640m'de 80 (16-277) ve 4200m'de 104 olarak hesaplandı ancak FM-100 Hue test skorlarında bu iki irtifa arasında istatistiki açıdan önemli bir fark görülmedi (p= 0.905).*

Sonuç: *Daha geniş serilerde ve farklı yaş gruplarında yapılacak çalışmalarla yüksek irtifanın renkli görme üzerine etkisi ile akut dağ hastalığının erken bulguları arasındaki ilişki kesinlik kazanabilir.*

Anahtar Kelimeler: *Akut dağ hastalığı; Renk ayırımı; Renkli görme bozuklukları.*

Introduction:

Acute mountain sickness (AMS) is a condition encountered particularly by climbers after an unacclimatized exposure above 2500m [1,2] and is very prominent over 3500-4000 [3]. Hypoxia at these altitudes affects various visual functions including colour discrimination, a function which depends on the integrity of the photoreceptors [4, 5]. Various responses of the human body have been investigated as the early signs of AMS however, a reliable indicator of the commencing pathology would be beneficial for climbers at or approaching high altitude. In order to investigate the effects of high altitude (4200m) on colour vision, and to search for an alternative and a practical test to detect AMS at a prodromal level we designed a study where the defects related to colour discrimination of healthy climbers would be investigated.

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Material and Methods:
Sixteen climbers were enrolled in this study. The expedition to Mount Ağrı, Turkey (Peak altitude: 5165m) was officially planned and conducted by the Turkish Alpinism Federation. Consent was obtained from each climber prior to the study. Initial ophthalmologic examination of the climbers was performed in Doğubeyazıt province of city of Ağrı located at 1640m above sea level. Those without any anterior or posterior ocular pathology, without a refraction error over ± 4.50 Diopters, and without any systemic or metabolic disorders were enrolled into the study. Those with a refraction error were requested to wear their spectacles during the test.

Their colour vision was tested with Farnsworth-Munsell 100-Hue (FM-100 Hue) test (Luneau, Paris). One day after the initial baseline tests performed at 1640m, the climbers were transported to Eliköy (2200m) by vehicles. They started climbing from Eliköy around noon time and after a slow ascent with frequent rests over 4 hours, climbers reached the base camp at 3200 m. in the afternoon. After spending one night for acclimatization and rest they started climbing next morning at 9 a.m. over 4 hours to 4200m. At 4200m, after having rest of approximately one hour, FM-100 Hue test was performed on the climbers under bright daylight conditions between 2 am and 5 am. The weather conditions (minimum wind, humidity, clear sky, sun setting time as 8 p.m.) were suitable for climbing as well as easily performing FM-100 Hue test in open air. None of the climbers were allowed to wear any sunglasses during the last two hours of ascent or any phase of testing not to affect test results. They were permitted to wear sunglasses after the test was finished. The next day, early in the morning at 5 a.m., the mountaineers continued their planned climb to the summit of Mt Ağrı (5156m) however, since the weather conditions could be unpredictable and could frequently change, test was performed at 4200m instead of the summit at 5156m.

Each test consisted of 4 sub sectors: sector 1 (caps 76-12), sector 2 (caps 13-33), sector 3 (caps 34-54) and sector 4 (caps 55-75). Median values (with range) of total error scores of 16 climbers in all sectors as well as in each sector were calculated and Wilcoxon test was used for the statistical comparison of error scores between 1640m and 4200m. We performed this study on the largest possible number of subjects at highest possible altitude. Mt. Ağrı is the highest and the longest summit to reach in Turkey; although over 100 climbers attended to the expedition, limited number of participants (16 climbers) could take the test at both altitudes (1640m and 4200m) since it would be difficult to perform the test on a larger group under optimal weather conditions as well as in suitable day light. Because of great variability in total scores and limited number of participants, we used a non-parametric test (Wilcoxon's signed rank test). Statistical significance was set at $p<0.05$ being statistically significant. A statistical software package (SPSS® 11.5 for Windows ®) was used for the statistical analysis of the results.

Results:
Sixteen climbers enrolled in the study. Their average age was 34.13±8.7 years; 13 climbers were male and 3 female. Six of the climbers had a refractive error ranging between +0.75 and –4.50D; the remaining was emmetropic. Total error score (median with range) was 80.0 (16-277) at 1640m and 104.0 (36-216) at 4200m. Sectorial error scores (median with range) were as follows: Sector 1: 19.5 (0.0-71.0) at 1640m and 17.0 (0.0-59.0) at 4200m; Sector 2: 24.0 (4.0-96.0) at 1640m and 18.5 (8.0-54.0) at 4200m; Sector 3: 22.0 (0.0-108.0) at 1640m and 32.5 (5.0-91.0) at 4200m; Sector 4: 17.5 (4.0-72.0) at 1640m and 25.0 (8.0-66.0) at 4200m. There was not a statistically significant difference in total or sectorial error scores between 1640m and 4200m ($Z=0.057$, $p=0.905$). These error scores are summarized on Table I.

Discussion:
Although there are many criteria previously cited in the literature to detect approaching AMS in climbers at high altitude [6], establishment of some new and practical methods could be very useful for climbers. This issue is particularly of importance in decision making as to who should discontinue climbing and require immediate decent instead.

Although at 'extreme altitudes' (over 6000m) more dramatic changes occur which are not hard to detect, at 'high altitudes' (3500m-6000m) early detection of the symptoms may be vague, and unnoticeable which can lead to serious results for climbers leading to AMS. Response of photoreceptors at high altitude is very important. Among other methods to detect colour vision defects, Farnsworth-Munsell 100 Hue (FM-100) test is the preferred method at high altitude or simulating laboratory environments [7, 8]. Error scores by the FM-100 Hue test are reported to increase at moderate altitude (3600m) when compared with sea-level scores; it was suggested that hypoxia at high altitudes can depress retinal ganglion cell activity and can affect photopic as well as scotopic vision [8]. In our study, although there was an increase in total median error scores at 4200m (score=104) when compared to 1640m (score=80), this difference was not statistically significant in our group of healthy middle aged climbers. This could be explained by several factors. Firstly, climbers in our study had a gradual ascent which offered optimum time for acclimatization. More abrupt ascent could have had a more significant and detoriating effect on colour discrimination and affect our data. Secondly, performing tests under frequently changing open air conditions with climbers likely to get exposed to various atmospheric conditions is not an easy task. Accordingly, it is not always possible to recruit desired number of subjects in this kind of environment and obtain better statistical results. Hypoxia at high altitudes may affect special wavelengths. It was reported that at 3600m. blue-yellow loss was more significant on the FM-100 Hue test [9]. In another investigation, 48 people between 20-50 years of age were examined in the altitude simulation chamber at 3500m; reduced light sensitivity in the photopic range was detected [10]. Bouquet et al studied the effects of chronic hypoxia on colour discrimination in 8 subjects during a simulated climb from sea level to 8848m over a period of 31-days in a decompression chamber; defects mainly occurred in the red and blue ranges [11]. Richalet and associates reported that a relative decrease in green, compared to red, sensitivity was observed under hypoxic conditions [12,13]. In our study, we did not find a statistically significant detoriation in neither the blue-yellow nor the green-red axis among the two altitudes. In our group of climbers, testing was done in ideal conditions for photopic vision, both at 1640 and 4200m. However all summit climbs start in the period between twilight and sunrise, which is regarded as mesopic conditions, in order to complete climbing and return to the camping site before sunset. Therefore, it would be interesting to determine colour sensitivity changes under various day light conditions.

In our study, we did not find a statistically significant difference between FM-100 Hue test scores at 4200m compared to 1640m in an acclimatized group of middle aged climbers although a detoriation was observed. We conclude that in future studies effects of various day light conditions and longer acclimatization period must be taken into consideration preferably in larger group of climbers from various age groups. This would help establish more precise interpretation of colour vision changes as an early sign of emerging acute mountain sickness.

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Table I: Comparison of error scores of 16 climbers between 1640m and 4200m

Sectors	Error scores at 1640m		Error scores at 4200m		Z	p*
	Median	Minimum-Maximum	Median	Minimum-Maximum		
All 4 sectors	80.0	16.0-277.0	104.0	36.0-216.0	0.057	0.905
Sector 1 (caps 76-12)	19.5	0.0-71.0	17.0	0.0-59.0	0.796	0.426
Sector 2 (caps 13-33)	24.0	4.0-96.0	18.5	8.0-54.0	0.337	0.736
Sector 3 (caps 34-54)	22.0	0.0-108.0	32.5	5.0-91.0	0.828	0.428
Sector 4 (caps 55-75)	17.5	4.0-72.0	25.0	8.0-66.0	0.966	0.334

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