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Original Article

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Rhinomanometric Assessment of The Impact of High Altitude on Nasal Airway Resistance

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ABSTRACT

Aim of this study is to carry out a rhinomanometric assessment for the impact of altitude variation (1050-2215m) on nasal airflow. First of all, rhinomanometry standard values were specified in 100 healthy people (0.53 on the left; 0.55 Pa/cm^3/sec on the right). 42 people were enrolled into the study. Nasal resistance was calculated for Group 1 when ascending from 1050m to 2215m and for Group 2 when descending from 2215m to 1050m. Nasal resistances and total nasal resistances were compared. Mean nasal resistances were determined as 0.54 Pa/cm^3/sec on the right and 0.54 Pa/cm^3/sec on the left for Group 1 and as 0.52 Pa/cm^3/sec on the right and 0.59 Pa/cm^3/sec on the left for Group 2. Altitude variation in Group 1 and 2 was detected to have no statistically significant effects on right and left nasal resistances. No variation in total resistance was determined either. Although ,Altitude variation from 1050 m to 2215 m or from 2215 m to 1050 m does not affect the nasal resistance in this study, due to the many factors that affect the physiology of the nose at high altitude a decisive conclusion can not be said. multi-factorial studies are needed.

Key words: *Altitude variation, anterior rhinomanometry, high altitude, nasal resistance, rhinomanometry.*

Nazal Havayolu Direncinde Yüksek Rakımın Etkisinin Değerlendirilmesinde Rinomanometrik Ölçümler

ÖZET

Bu çalışmanın amacı yüksek irtifa değişikliğinin burun havayolu direnci üzerine etkisinin rinomanometrik olarak değerlendirilmesidir. Öncelikle 100 sağlıklı kişide rinomanometri standart değerleri belirlendi(sagda 0, 53 solda 0, 55 Pa / cm^3 /sn).Çalışmaya 42 kişi alındı.2 gruba ayrıldı.Grup 1 de 1050 den 2215 m ye çıkışta grup 2 de ise 2215 den 1050 ye inişte nazal direnç hesaplandı.Nazal dirençler ve total nazal dirençler karşılaştırıldı. Grup 1 de sagda 0,54 solda 0,54 grup 2 de ise sagda 0,52 solda 0,59 Pa / cm^3 / sn ortalama nazal direnç tesbit edildi. Grup 1 ve 2 de irtifa değişikliğinin sag ve sol nazal dirençlerde istatiksel olarak anlamlı bir etkisinin olmadığı gözlendi (Mann Whitney u testi). Total dirençte de degisiklik tesbit edilmedi (Student t testi). Bu çalışmada alçaktan yükseğe veya yüksekten alçağa irtifa değisikliği nazal direnci etkilememektedir şeklinde sonuç çıkmasına rağmen yüksek irtifada burun fizyolojisini etkileyen çok sayıda faktör olduğundan kesin sonuç söylenemez.Çok faktörlü çalışmalara ihtiyaç vardır.

Anahtar kelimeler: *Rakım değişikliği, anterior rinometre, yüksek rakım, nazal direnç, rinomanometre*

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INTRODUCTION

Obstruction grade identified by rhinoscopic examination is a subjective measurement. However, nasal airway resistance, and nasal airflow and pressure can be measured quantitatively by rhinomanometry. Respiratory volume per minute at high altitude increases due to hypobaric hypoxia. Thus, more voluminous air is required (1). There are limited studies in the literature indicating the changes in nasal mucosa of mountaineers and climbers, which are caused by high altitude (2), its causing changes in the feeling of subjective nasal congestion and prolonging (3). The aim of this study is to carry out a rhinomanometric assessment of the impact of high altitude on nasal resistance and to determine how this affected the nasal airflow.

MATERIALS AND METHODS

Having informed the subjects on the procedure and obtained their consents, they were included into the study according to the following criteria: Subjects with a history of nasal surgery (endoscopic sinus surgery, septoplasty, rhinoplasty, concha cauterization, etc.), allergic rhinitis, chronic rhinitis or rhinosinusitis, and systemic diseases (hypertension, diabetes mellitus, asthma, etc.) were excluded. Physical examination was performed by anterior rhinoscopy and/or nasal endoscopy. Those of diagnosed with septal perforation, nasal polyp, allergic rhinitis, and rhinosinusitis were excluded. Laboratory examination: In suspicious cases, diagnosis of allergic rhinitis was confirmed by nasal smear, IgE and prick test, whereas diagnosis of rhinosinusitis was confirmed by paranasal sinus CT. 100 people meeting these criteria were included in the standard assay study. 33 of cases were female and 67 of those were male. Ages ranged between 18-52. Mean age was 32. Smoking and drinking coffee, receiving medications that could change the test result (antihistamines, decongestants, etc.), and heavy exercise were not recommended prior to the test. Repeating anterior rhinoscopy prior to anterior rhinomanometry (ARMM), secretions and dried substances, if any, were cleaned. Subjects were kept in the measurement room for 20 min to accommodate to the room temperature and humidity. Anterior rhinomanometry was performed by Homoth Rhino 4000. ARMM test was carried out for both nasal cavities separately by using mask in sitting position without applying distortion on alar region. ARMM test was repeated at 1 hour intervals. Each subject underwent ARMM test five times. These values were accepted as standard nasal resistance values. 42 healthy adults were included in the study. Out of those, 21 subjects were male with ages varied between 16-60 (mean age 37), whereas 21 subjects were female with ages ranged between 13-49 (mean age 30). ARMM test was repeated for each nasal cavity after 10 min by performing decongestion with 2 puff oxymetazoline spray. Subjects were divided into two groups. Group 1 included 23 healthy subjects, who fitted to the above-mentioned criteria and lived in the city center at an altitude of 1050 m for at least one month. This group consisted of 8 males, 15 females and the mean age was 27. Then, Group 1 was driven up to Erciyes Mountain at an altitude of 2215m and ARMM test was repeated. Tests were carried out at least 3 hours later after climbing to the mountain. Group 2 included trainee referees, who had been camping for 5 days at an altitude of 2215m. those in group 1 was rhinomanometry after their stay at high altitude for 3 hours. those in group 2 was rhinomanometry after their stay at low altitude for 3 hours. This group, which was formed out of people suited to the indicated criteria, consisted of a total of 19 people, and included 13 male and 6 females with their ages varying between 16-55 (mean age 33). ARMM tests were performed. Thereafter, ARMM values at 1050m altitude were calculated. The rate of nasal airway resistance to airflows detected at a constant pressure of 150 pascal was calculated. Both nasal cavity resistances for inspirium and expirium were calculated prior to and after decongestion separately. Comparing the obtained values from Group 1 after ascending from low-level to higher and from Group 2 after descending from high-level to lower, the impact of altitude variation on nasal resistance was determined (Mann-Whitney U test). Moreover, all values were compared to the results acquired during Standard assay. Total nasal airway resistance for both nasal cavities was calculated prior to and after decongestion separately. Impact of altitude variation on the total nasal resistance was detected (Student t test). $P<0.05$ was considered as statistically significant in all the statistical tests. This study was approved by the Ethical Committee decree of Erciyes University Faculty of Medicine with date 06/06/2006 and no. 01/198.

RESULTS

Standard nasal resistance values were 0.53 Pa/cm^3/sec

***Table 1**. Comparison of the 1050 and 2215 m nasal resistance values of Group 1*

	Avg. Nasal resistance Before decongestıon	*P	Avg. Nasal resistance After decongestion	*P
Right nose (inspiratıon)	0,54 Pa/cm3/sn	0,86	0,50 Pa/cm3/sn	0,89
Right nose (ekspiratıon)	0,49 Pa/cm3/sn	0,5	0,46 Pa/cm3/sn	0,46
Left nose (inspiratıon)	0,54 Pa/cm3/sn	0,44	0,50 Pa/cm3/sn	0,79
Left nose (ekspiratıon)	0,50 Pa/cm3/sn	0,14	0,47 Pa/cm3/sn	0,23

* Mann Whitney u test

for the right nasal cavity and 0.55 Pa/cm^3/sec for the left nasal cavity. Mean nasal resistance for Group 1 was detected to be 0.54 Pa/cm^3/sec on the right and 0. 54 Pa/cm^3/sec on the left. On the other hand, measurements for Group 2 were performed first at 2215 altitude and then at 1050m altitude. Mean nasal resistance for Group 2 was determined to be 0.52 Pa/cm^3/sec on the right and 0.59 Pa/cm^3/sec on the left. Altitude variations from 1050m to 2215m and from 2215m to 1050m had no statistically significant effects on right and left nasal resistances (Mann-Whitney U test). Nasal resistance values and standard nasal resistance values were compared by Kruskal-Wallis test. No significant differences in both Group 1 and Group 2 were determined between nasal resistance values and standard values at altitude (right nasal cavity P:0.790, left nasal cavity p=0.822).

DISCUSSION

Nasal congestion is a quite frequently recorded symptom in society. Clinical quantitative evaluation of nasal congestion is very difficult unless the subjective feeling of the congestion is complete or nearly complete. In a study by Gertner et al. conducted in 1984, it was demonstrated by rhinomanometric measurements that people with congested nasal airway could be easily differentiated from those of having normal airway (4). ARMM test is preferred for this study. ARMM is the most applied method. No active pathology can be specified by rhinomanometry; however, the amount of airflow passing through several regions of the nasal passage can be determined. Rhinomanometry provides objective information (5). Direct measurement of the total nasal airway resistance can not be performed by the anterior, but the total resistance is obtained by the unilateral measurements of both sides.

Nasal secretions increase the nasal resistance. Thus, if there are any secretions prior to the test, they should be eliminated (6). Cold air increases the nasal resistance (6, 7). Humidity has no significant effect on the total resistance (7). Cole et al. showed that moderate exercise barely affected the nasal resistance (8). Forsyth et al. determined that the nasal resistance decreased depending on the intensity of exercise, but they detected that it happened following the exercise (6). No changes were

***Table 2**. Comparison of the 2215 and 1050 m nasal resistance values of Group2*

	Avg. Nasal resistance Before decongestıon	*p value	Avg. Nasal resistance After decongestion	*p value
Right nose (inspiratıon)	0,52 Pa/cm3/sn	0,36	0,49 Pa/cm3/sn	0,28
Right nose (ekspiratıon)	0,46 Pa/cm3/sn	0,33	0,44 Pa/cm3/sn	0,41
Left nose (inspiratıon)	0,59 Pa/cm3/sn	0,70	0,53 Pa/cm3/sn	0,92
Left nose (ekspiratıon)	0,59 Pa/cm3/sn	0,68	0,55 Pa/cm3/sn	0,54

* Mann Whitney U test

observed in total nasal resistance after being exposed to ozone, sulfur dioxide, and smoking (8). In the studies conducted, it was demonstrated that aspirin resulted in a mild increase in the resistance, and antihistamines could increase the nasal resistance (9). Smoking, performing heavy exercise, and receiving medications such as antihistamines and corticosteroids were not recommended for subjects prior to the test. The subjects were kept in the test room for 20 min to accommodate to the room temperature and humidity.Body position affects the nasal resistance. Resistance is at highest level in lying position and at lowest level in sitting position. Resistance on the side where pressure is applied to is at its highest level when the patient is in lateral position (10). In this study, ARMM test was performed once in sitting position both due to the limited amount of time and in order to carry out a standard evaluation for subjects. There are a limited number of publications in the literature, which review the impact of high altitude on the nasal resistance. Yet, there are no publications studying how high altitude affects the nasal resistance. Current publications study the impact of high altitude on the physiology of the lower respiratory system and on other systems. In this study, a rhinomanometric evaluation for the impact of altitude variation (1050 – 2215m) on the nasal resistance and the changes it caused in the nasal airflow was performed.

Heights of 1000m and above are accepted as altitude. Barometric pressure decreases as the altitude increases, and this causes PO2 pressure to decrease as well. Because the rate of O2 in the air is constant. Atmospheric pressure and oxygen pressure decrease to 50% at 5500m, and to 30% at 8900m (11). Therefore, hypoxia develops at high altitude (12). Effects of hypoxia on the organism may alter depending on the altitude level, rate of ascend, length of stay, ambient temperature and exercises performed as well as on individual factors (13). Respiration increases depending on hypoxia. Nasal resistance increases with the elevation of respiration rate (14). More O2 is inhaled and more CO2 is exhaled by hyperventilation. Lack of inhaled carbon dioxide causes the nasal resistance to reduce (15). Acute hypoxia results in nasal vasoconstriction and decreases the resistance (16). Nasal mucosa surrounds the intact bone and cartilage. Thus, it limits the area to reduce the nasal resistance (17). However, acute hypoxia is also effective on the secretion of nasal mucus. In this study, all these factors may have balanced each other and caused the nasal resistance not to alter at high altitude.

To adapt to altitudes up to 2300m, 2 weeks are required, and for each 610m (up to 4572m) above 2300m, an additional week is needed (12). ARMM tests at high altitude were performed at 1st day for Group 1, whereas at 5th day for Group 2. Cases physiologically adapted to 1050m altitude; however, they could not adapt to 2215m altitude. There are no publications indicating when nasal physiology, thus nasal resistance, starts to alter in case of altitude variation. The presence of numerous factors affecting the nasal resistance, and the physiological, metabolic and hematologic effects of high altitude, which may affect the nasal resistance, make it hard to establish standard conditions. More detailed studies on this matter are required. In a study of 3,937 meters altitude, high altitude, studied the effect of the upper and lower respiratory tract, and the following results. The effect of high altitude on nasal function was found to parallel that of the effect on lower airway function, together accounting for an adverse effect on airway flow rates. The nasal mucosa responded to high altitude with an increase in airway resistance and a consequent impaired sense of smell (18). Another article in the same group, Nasal conchal and mucosal congestion affects airflow through the nasal cavity at HA, transforming it from a laminar pattern to turbulent flow (19).

It was observed that altitude variation (1050 – 2215m) did not affect both the right and left nasal resistances and the total nasal resistance. No significant differences were detected between nasal resistance values at high altitude and standard nasal resistance values of both groups. Mean nasal resistances in both groups were found to be very close to the standard values.Systemic and environmental factors that affect the resistance of the nose are numerous.Therefore difficult to control all the factors.Further studies are needed that long period of adaptation to altitude.

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