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Can nasal septum deviation affect thoracoabdominal diaphragm? An ultrasonographic study

Nazal septum deviasyonu torakoabdominal diyaframı etkileyebilir mi? Ultrosonografik çalışma

Hilal Irmak Sapmaz[1], Elif Kaya Çelik[2], Sakine Sarman[3], Gülçin Uysal[2], Zafer Özmen[4], Ceyhun Aksakal[5], Fatma Kökcü[4]

[1]*Department of Anatomy, Tokat Gaziosmanpaşa University, Faculty of Medicine, Tokat, Türkiye*
[2]*Department of Otolaryngology, Tokat Gaziosmanpaşa University, Faculty of Medicine, Tokat, Türkiye*
[3]*Department of Radiology, İskilip Atıf Hoca State Hospital, Çorum, Türkiye*
[4]*Department of Radiology, Tokat Gaziosmanpaşa University, Faculty of Medicine, Tokat, Türkiye*
[5]*Department of Otolaryngology, Tokat Private Medical Park Hospital, Tokat, Türkiye*

ABSTRACT

Objectives: This study aimed to evaluate the effect of nasal septum deviation (NSD) on the thoracoabdominal diaphragm (TAD).

Patients and Methods: This prospective study was conducted between December 2022 and January 2024. The TAD thickness of 51 patients with NSD (45 males, 6 females; mean age 25.7±9.5 years; range, 19 to 51 years) and 51 healthy controls (44 males, 7 females; mean age: 28.5±5.2 years; range, 19 to 47 years) were evaluated ultrasonographically. Thoracoabdominal diaphragm thickness was measured from the anterior axillary line on the right and left sides of the chest wall.

Results: Compared to the control group, the mean height was higher and the mean weight and body mass index were lower in the NSD group ($p<0.05$). Eighty-eight percent of deviated individuals were male. Thoracoabdominal diaphragm thickness measured at the end of both inspiration and expiration was higher in the NSD group ($p<0.001$). However, the amount and percentage of interphase change of the TAD was lower in the NSD group than in the control group ($p<0.001$).

Conclusion: The incidence of NSD is high in tall, thin, young men. We believe that the TAD was thicker in the NSD group compared to the control group due to hypertrophy of the diaphragm muscles, which contract more strongly to overcome respiratory distress.

Keywords: Deviated septum, thoracoabdominal diaphragm, ultrasonography.

ÖZ

Amaç: Bu çalışmada solunum güçlüğüne neden olan nazal septum deviasyonu (NSD)'nun torakoabdominal diyafram (TAD) üzerine etkisi değerlendirildi.

Hastalar ve Yöntemler: Bu prospektif çalışma Aralık 2022 - Ocak 2024 tarihleri arasında yürütüldü. Nazal septum deviasyonlu 51 hastanın (45 erkek, 6 kadın; ort. yaş 25.7±9.5 yıl; dağılım, 19-51 yıl) ve 51 sağlıklı kontrolün (44 erkek, 7 kadın; ort. yaş: 28.5±5.2 yıl; dağılım, 19-47 yıl) TAD kalınlığı ultrasonografik olarak değerlendirildi. Torakoabdominal diyafram kalınlığı göğüs duvarında sağ ve sol tarafta ön aksiller çizgiden ölçüldü.

Bulgular: Kontrol grubu ile karşılaştırıldığında, NSD grubundaki bireylerin boy ortalaması daha yüksek, kilo ortalaması ve vücut kitle indeksi ise daha düşüktü ($p<0.05$). Deviasyonlu bireylerin %88'i erkekti. Hem inspirasyon hem de ekspirasyon sonunda ölçülen TAD kalınlığı NSD grubunda daha yüksekti ($p<0.001$). Ancak, TAD'nin interfaz değişiminin miktarı ve yüzdesi NSD grubunda kontrol grubundan daha düşüktü ($p<0.001$).

Sonuç: Nazal septum deviasyonu insidansı uzun, zayıf, genç erkeklerde yüksektir. Solunum sıkıntısının üstesinden gelmek için daha güçlü kasılan diyafram kaslarının hipertrofisi nedeniyle TAD'nin NSD grubunda kontrol grubuna kıyasla daha kalın olduğu görüşündeyiz.

Anahtar sözcükler: Septum deviasyonu, torakoabdominal diyafram, ultrasonografi.

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Correspondence: Hilal Irmak Sapmaz, MD.
E-mail: hisapmaz@yahoo.com

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The nose constitutes an important part of the airway resistance. The nasal septum, which divides the cavity into two, is formed by bone in the back and cartilage in the front. The nasal cycle is an alternating fluctuation of nasal blockage and airflow through the nasal passages. This airflow change continues in periods of 1 to 5 h.[1]

Diagnoses such as concha bullosa, nasal polyp, and concha hypertrophy are among the causes that prevent air passage from the upper respiratory tract in adults, but the most common is nasal septum deviation (NSD).[2] Rao et al.[3] classified NSD into seven different types according to the shape of the deviation, similar to the classification of Mladina. In deviation, airflow is blocked due to obstruction and hypoxia occurs.[4] Although medical treatment is applied for symptoms in NSD, the definitive treatment is septoplasty.[5,6] Thoracoabdominal diaphragm (TAD) is a fibromuscular structure and responsible for two-thirds of the inspiration of healthy individuals.[1] It was shown that the thickness of TAD varies in conditions that affect respiration, such as obstructive sleep apnea syndrome, sepsis, and neck surgery.[7,8] Ultrasonography (USG), which is very useful in the diagnosis of muscle diseases, is a valuable imaging method in the evaluation of the thickness and movements of TAD due to its absence of radiation risk, easy applicability, noninvasiveness, high resolution, and imaging quality.[7,8] This study aimed to evaluate the effect of NSD on TAD thickness by USG, which is a topic not covered by the previous studies.

PATIENTS AND METHODS

The prospective study was conducted at the Tokat Gaziosmanpaşa University, Faculty of Medicine between December 2022 and January 2024. Fifty-one patients (45 males, 6 females; mean age 25.7±9.5 years; range, 19 to 51 years) who applied to the otorhinolaryngology outpatient clinic, underwent an otorhinolaryngology examination and nasal endoscopic examination, complained of difficulty breathing through the nose, and was diagnosed with type 3, 4, 6, or 7 deviation according to Mladina's classification were determined as the NSD group. Patients in this group were planned to undergo septoplasty. Based on examination results, 51 individuals (44 males, 7 females; mean age: 28.5±5.2 years; range, 19 to 47 years) with similar demographic characteristics, who were found not to have nasal pathology, were included in the control group. Patients with pathologies causing nasal obstruction other than septum deviation (concha bullosa, nasal polyp, acute or chronic rhinosinusitis) and revision surgeries were excluded. The presence of apnea was determined by questioning the patient's relative. Those who described witnessed apnea, those with chronic lung pathology, patients with psychiatric isues, those under the age of 18, and those with another disease that would cause respiratory distress were not included in the study. Written informed consent form was obtained from the participants. Permission was obtained from the Tokat Gaziosmanpaşa University Clinical Research Ethics Committee for this study (Date: 24.11.2022, No: 83116987-768). The study was carried out in accordance with the principles of the Declaration of Helsinki.

The age, sex, and body mass index (BMI) of all subjects included in the study were recorded. Thoracoabdominal diaphragm thickness was measured ultrasonographically.

All USG measurements were performed by the same experienced radiologist using the same device. The ABCDE technique was used for measurements. This technique was reported to be easy, fast, reproducible, and reliable for the visualization of TAD.[9] Measurements were made on the chest wall from the anterior axillary line on the right and left sides. A 7-12 MHz linear probe (Philips EPIQ 5G; Philips Ultrasound Inc., Bothell, WA., USA) was used to image TAD, which appears as a hypoechoic structure between two hyperechoic lines (pleura above and peritoneum below). The distance between these two white lines was measured as the thickness of the TAD with the help of electronic calipers at the end of inspiration and expiration (Figure 1). The change in thickness was calculated by the following formula: level of change = thickness at the end of inspiration - thickness at the end of expiration. The following formula was used for the thickening ratio (TR): level of change/thickness at the end of

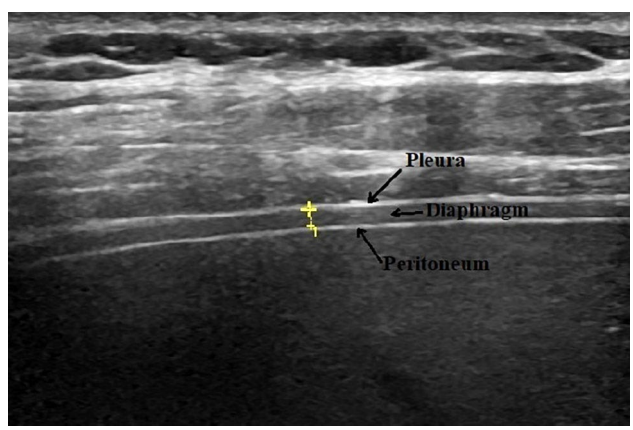

Figure 1. Diaphragm thickness.

Figure 2. Radiographs of a type 6 nasal septum deviation.

expiration × 100. The TR indicates the percentage of change with respect to the thickness at the end of expiration.[9-11] Both of these parameters were used to evaluate diaphragm function.

Statistical analyses

A power analysis was conducted using G*Power version 3.1.9.7 software (Heinrich-Heine-Universität Düsseldorf, Düsseldorf, Germany). Based on the results, 102 participants were required, with an effect size of 0.500 and error (alpha) rate of 80%.[7]

Data were analyzed using IBM SPSS version 26.0 software (IBM Corp., Armonk, NY, USA). Student's t-test was used to compare the groups on the fulfillment of parametric assumptions. A p-value <0.05 was considered statistically significant.

RESULTS

Figure 2 shows the paranasal sinus computed tomography image of a patient with type 6 NSD. There was no significant difference between the NSD and control groups in terms of sex and age (p>0.05). The mean height of the NSD group was higher (p=0.001), while the mean weight (p=0.008) and BMI (p<0.001) were lower (Table 1).

The thickness of TAD measured in both phases of respiration was higher in the NSD group (p=0.001 and p<0.001 for the right and left sides in end-inspiration, respectively; p<0.001 for both sides in end-expiration). However, the amount of interphase respiration change (p=0.014 on the right and p=0.009 on the left) and the percentage (p<0.001)

Table 1
Demographic characteristics of individuals in the NSD and control groups

	Control group (n=51)		NSD group (n=51)		
Variables	n	Mean±SD	n	Mean±SD	*p*
Age (year)		28.5±5.2		25.7±9.5	>0.05
Sex					>0.05
Female	7		6		
Male	44		45		
Height (cm)		171.73±7.91		176.67±7.26	0.001
Weight (kg)		74.71±9.90		69.08±11.05	0.008
Body mass index (kg/m^2)		25.32±2.65		22.18±2.94	<0.001

NSD: Nasal septal deviation; SD: Standard deviation; Student t test; p<0.05 statistical significant.

Table 2
Comparison of TAD measurement values in the NSD and control groups

Variables	Control group Mean±SD	NSD group Mean±SD	*p*
InspT (mm)			
Right	2.60±0.51	2.99±0.58	**0.001**
Left	2.61±0.51	3.00±0.58	**<0.001**
ExpT (mm)			
Right	1.94±0.40	2.48±0.51	**<0.001**
Left	1.97±0.40	2.52±0.54	**<0.001**
Change (mm)			
Right	0.66±0.40	0.51±0.17	**0.014**
Left	0.64±0.38	0.48±0.18	**0.009**
Ratio (%)			
Right	35.72±22.18	20.85±6.63	**<0.001**
Left	34.01±20.69	19.99±8.16	**<0.001**

TAD: Thoracoabdominal diaphragm; NSD: Nasal septal deviation; SD: Standard deviation; InspT: TAD thickness at end-inspiration; ExpT: TAD thickness at end-expiration; Change: Change in TAD thickness; Ratio: TAD thickening ratio, Student T test, Mean±SD p<0.05 statistical significant.

of TAD were lower in the NSD group than in the control group (p<0.05; Table 2; Figures 3,4).

DISCUSSION

It was shown in various studies that hypoxia and hypercapnia occur in NSD, resulting in changes in many organs and structures in the body, and the quality of life is negatively affected.[4,5] A literature review yielded studies indicating the negative effects of NSD on the heart, lungs, and eyes.[4,12,13] However, we did not come across any study examining the effect of NSD on TAD.

Since the nasal airflow is provided alternately from the right and left sides, difficulty in air passage from the convex side of the deviation arises in the presence of NSD. This condition can cause apnea or hypopnea during sleep.[14] It was reported that the cardiopulmonary system is affected as a result of

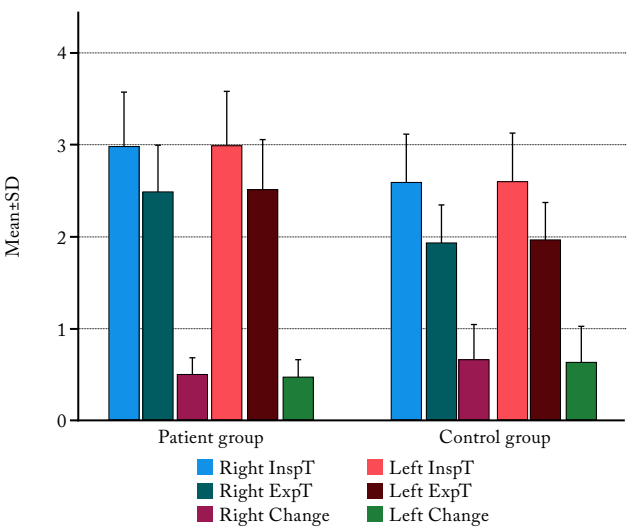

Figure 3. Comparison of parameters in the control and patient groups.

SD: Standard deviation; InspT: TAD thickness at end-inspiration; ExpT: TAD thickness at end-expiration; Change: Change in TAD thickness; TAD: Thoracoabdominal diaphragm.

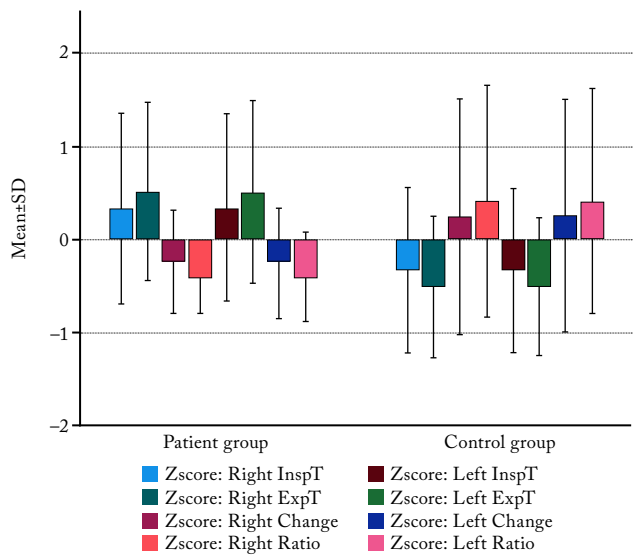

Figure 4. Zscores of parameters in both groups.

SD: Standard deviation; InspT: TAD thickness at end-inspiration; ExpT: TAD thickness at end-expiration; Change: Change in TAD thickness; Ratio: TAD thickening ratio.

chronic hypoxia, hypercarbia, sympathetic activation, and vascular circulation disorder, even causing bronchial hyperactivity.[4,13-15] In the literature, it was also reported that there is thinning of the vascular layer of the eye in NSD.[12]

Thoracoabdominal diaphragm is the main muscle of respiration and is dome-shaped.[1] Its thickness increases in the inspiratory phase and decreases in the expiratory phase.[16] Thoracoabdominal diaphragm measurement with USG can be performed from midclavicular, midaxillary, and posterior axillary lines.[17] In our study, we measured from the anterior axillary line according to the ABCDE method described by Khurana et al.,[9] which provides simple, reliable, and fast image acquisition. Van Dorn et al.[17] reported that the TR was low and TAD thickness at end-expiration was high in individuals with low BMI. Our findings for TR and TAD thickness at end-expiration were consistent with the literature in NSD subjects with low BMI. Haaksma et al.[18] investigated the anatomical variations of TAD in young adults with relatively low BMI using USG. Measurements were made on three separate vertical lines: midclavicular, midaxillary, and posterior axillary. It was determined that the lowest level of change in the thickness of TAD was in the values measured from the midaxillary line. Thoracoabdominal diaphragm was found to have the highest thickness in the midclavicular line and the lowest thickness in the posterior axillary line. O'Gorman et al.[19] found that there was a change in the thickness and thickening rate of TAD with abnormal conduction in the phrenic nerve in individuals with myopathy. In neuromuscular diseases, respiratory failure caused by muscle weakness can be life-threatening. Noda et al.[20] found that diaphragm thickness was lower in neuromuscular diseases compared to the control group. They determined that TAD thickness was correlated with compound muscle action potential amplitude and lung capacity obtained by phrenic nerve stimulation. Topcuoğlu et al.[21] found that the thickness and mobility of TAD in the presence of chronic obstructive pulmonary disease (COPD) was lower than in the healthy control group, and reported that thickness and mobility decreased more with the increase in the severity of COPD. Similarly, Hafez and Abo-Elkheir[22] observed that the decrease in thickness in TAD was associated with COPD severity, smoking index, and advanced age. It was stated that it would be useful to evaluate TAD together with lung function tests in determining the course of COPD.[21,22]

Santana et al.[8] observed that immediately after neck dissection, the thickness of TAD was the same as the preoperative values, but there was a decrease in inspirational power. They also reported that there may be difficulty in inspiration due to the fact that the respiratory muscles in the neck region are affected by surgery. Additionally, they indicated that one month after surgery, the intensity of the incidence increased to preoperative values, but there was atrophy in the TAD. In a very small number of patients, they detected TAD immobility without clinical findings. They reported that there may be muscular atrophy due to the lack of protein-calorie intake and little physical activity in the postoperative period. In the literature, it was reported that there may be transient TAD immobility due to nerve damage, but phrenic nerve is rarely affected even in bilateral radical neck dissection.[23]

Goligher et al.[10] evaluated the changes in TAD due to mechanical ventilation and observed an increase in TAD thickness in some of the patients and a decrease in some of them. About half of them were found to have no change. They found that low contraction activity was associated with a decrease in TAD thickness, whereas high contractile activity was associated with an increase in TAD thickness.

Another study in the literature found that TAD was thicker in individuals with obstructive sleep apnea syndrome than in normal individuals, and the thickness increased in proportion to the severity of obstructive sleep apnea syndrome. It was reported that the thickness of TAD is correlated with the apnea-hypopnea index, and hypertrophy develops over time due to excessive contraction in TAD, which contracts more strongly to overcome obstruction.[7] The reason for the increase in TAD thickness observed in obstructive diseases has not been fully explained, and it was thought to be related to various adaptations such as collagen accumulation in severe obstruction. Ogan et al.,[24] on the other hand, stated that individuals with COPD developed adaptation to overwork against increasing mechanical load, and therefore, TAD thicknesses were normal in deep inspiration and normal breathing.

In the present study, we found that hospital admission because of respiratory distress due to NSD was higher in young people and males. We attributed this situation to the fact that young male patients are more likely to be exposed to trauma in daily life. In addition, we believe that taller and thinner patients with NSD increase exposure to nasal trauma, including the intrauterine period, which could contribute to a higher incidence of deviation. However, we believe that individuals who already have respiratory distress due to deviation may have tried not

to gain weight to avoid the respiratory strain that may be caused by excess weight.

We found that TAD thickness increased in NSD compared to healthy individuals. We are of the opinion that due to hypertrophy in the diaphragm muscles, which contract more strongly to overcome respiratory distress, the TAD thickens. Consequently, the amount and percentage of thickness change between phases of respiration decreases in NSD.

This study was limited by the small number of individuals included. Nonetheless, its strengths include being the first study on this subject and the detailed presentation of the results with the current literature.

In conclusions, this study is important as it is a rare evaluation of TAD in individuals with NSD. We believe that NSD is a disease that should not be neglected, as it affects TAD, which is the main muscle of respiration.

Data Sharing Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

Author Contributions: Idea, design, interpretation: H.I.S., E.K.Ç.; Analysis, literature review, article writing, references: H.I.S.; Data collection: E.K.Ç., S.S., G.U., Z.Ö., C.A., F.K.; Data processing: H.I.S., E.K.Ç., S.S., G.Ü., Z.Ö.; Control: Z.Ö., F.K.; Interpretation: H.I.S., E.K.Ç., F.K.; Critical review: E.K.Ç.

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REFERENCES

1. Standring S, Ellis H, Healy J, Johnson D, Williams A. Gray's anatomy. London: Churchill Livingstone; 2008.
2. Zhou M, Tan KS, Guan WJ, Jiang LJ, Deng J, Gao WX, et al. Proteomics profiling of epithelium-derived exosomes from nasal polyps revealed signaling functions affecting cellular proliferation. Respir Med 2020;162:105871. doi: 10.1016/j.rmed.2020.105871.
3. Rao JJ, Kumar EC, Babu KR, Chowdary VS, Singh J, Rangamani SV. Classification of nasal septal deviations-relation to sinonasal pathology. Indian J Otolaryngol Head Neck Surg 2005;57:199-201. doi: 10.1007/BF03008013.
4. Simsek Z, Simsek E. Does nasal surgery affect right ventricular myocardial functions at the tissue level in patients with nasal septum deviation? J Clin Med 2018;7:186. doi: 10.3390/jcm7080186.
5. Stewart MG, Smith TL, Weaver EM, Witsell DL, Yueh B, Hannley MT, et al. Outcomes after nasal septoplasty: Results from the Nasal Obstruction Septoplasty Effectiveness (NOSE) study. Otolaryngol Head Neck Surg 2004;130:283-90. doi: 10.1016/j.otohns.2003.12.004.
6. Bilgin E, Kaya Celik E, Baklaci D, Say MA, Dalgic M. Evaluation of the use of different spreader techniques in primary open septorinoplasty in terms of nasal and olfactory functions. J Craniofac Surg 2021;32:2016-8. doi: 10.1097/SCS.0000000000007485.
7. Pazarlı AC, Özmen Z, İnönü Köseoğlu H, Ekiz T. Ultrasonographic measurement of the diaphragm thickness in patients with obstructive sleep apnea syndrome. Sleep Breath 2020;24:89-94. doi: 10.1007/s11325-019-01931-2.
8. Santana AFSG, Caruso P, Santana PV, Porto GCLM, Kowalski LP, Vartanian JG. Inspiratory muscle weakness, diaphragm immobility and diaphragm atrophy after neck dissection. Eur Arch Otorhinolaryngol 2018;275:1227-34. doi: 10.1007/s00405-018-4923-6.
9. Khurana J, Gartner SC, Naik L, Tsui BCH. Ultrasound identification of diaphragm by novices using ABCDE technique. Reg Anesth Pain Med 2018;43:161-5. doi: 10.1097/AAP.0000000000000718.
10. Goligher EC, Laghi F, Detsky ME, Farias P, Murray A, Brace D, et al. Measuring diaphragm thickness with ultrasound in mechanically ventilated patients: Feasibility, reproducibility and validity. Intensive Care Med 2015;41:642-9. doi: 10.1007/s00134-015-3687-3.
11. Malas FÜ, Köseoğlu F, Kara M, Ece H, Aytekin M, Öztürk GT, et al. Diaphragm ultrasonography and pulmonary function tests in patients with spinal cord injury. Spinal Cord 2019;57:679-83. doi: 10.1038/s41393-019-0275-3.
12. Şahin E, Songur MS, Kantekin Y, Bayhan HA, Can IH. Effect of deviated nasal septum on choriodal thickness. J Craniofac Surg 2020;31:e439-42. doi: 10.1097/SCS.0000000000006374.
13. Öğreden Ş, Tansuker HD, Cengiz AB, Tabaru A, Özyilmaz C, Oğur Ö, et al. Effect of septoplasty on cardiopulmonary functions in the patients with nasal obstruction. J Craniofac Surg 2018;29:e706-8. doi: 10.1097/SCS.0000000000004955.
14. Olsen KD, Kern EB, Westbrook PR. Sleep and breathing disturbance secondary to nasal obstruction. Otolaryngol Head Neck Surg 1981;89:804-10. doi: 10.1177/019459988108900522.
15. Bulcun E, Kazkayasi M, Ekici MA, Tahran FD, Ekici M. Effects of septoplasty on pulmonary function tests in patients with nasal septal deviation. J Otolaryngol Head Neck Surg 2010;39:196-202. doi: 10.2310/7070.2009.090027.
16. Erail S, Bostancı Ö, Polat A. Ultrasound assessment of diaphragm thickness in athletes. Int J Morphol 2022;40:376-383. doi: 10.4067/S0717-95022022000200376.
17. van Doorn JLM, Wijntjes J, Saris CGJ, Ottenheijm CAC, van Alfen N, Doorduin J. Association of diaphragm thickness and echogenicity with age, sex, and body mass index in healthy subjects. Muscle Nerve 2022;66:197-202. doi: 10.1002/mus.27639.
18. Haaksma ME, van Tienhoven AJ, Smit JM, Heldeweg MLA, Lissenberg-Witte BI, Wennen M, et al. Anatomical variation in diaphragm thickness assessed with ultrasound in healthy volunteers. Ultrasound Med Biol 2022;48:1833-9. doi: 10.1016/j.ultrasmedbio.2022.05.008.

19. O'Gorman CM, O'brien TG, Boon AJ. Utility Of diaphragm ultrasound in myopathy. Muscle Nerve 2017;55:427-9. doi: 10.1002/mus.25429.
20. Noda Y, Sekiguchi K, Kohara N, Kanda F, Toda T. Ultrasonographic diaphragm thickness correlates with compound muscle action potential amplitude and forced vital capacity. Muscle Nerve 2016;53:522-7. doi: 10.1002/mus.24902.
21. Topcuoğlu C, Yümin ET, Hizal M, Konuk S. Examination of diaphragm thickness, mobility and thickening fraction in individuals with COPD of different severity. Turk J Med Sci 2022;52:1288-98. doi: 10.55730/1300-0144.5435.
22. Hafez MR, Abo-Elkheir OI. Sonographic assessment of diaphragm thickness and its effect on inspiratory muscles' strength in patients with chronic obstructive pulmonary disease. Eurasian J Pulmonol 2017;19:76-83. doi: 10.5152/ejp.2017.42104.
23. Dedivitis RA, Guimarães AV, Pfuetzenreiter EG Jr, Castro MA. Neck dissection complications. Braz J Otorhinolaryngol 2011;77:65-9. doi: 10.1590/s1808-86942011000100011.
24. Ogan N, Aydemir Y, Evrin T, Ataç GK, Baha A, Katipoğlu B, et al. Diaphragmatic thickness in chronic obstructive lung disease and relationship with clinical severity parameters. Turk J Med Sci 2019;49:1073-8. doi: 10.3906/sag-1901-164.