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Original Article

The Effect of Surgical Mask Use on Respiratory Functions of Healthcare Professionals at Different Physical Activity Levels

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Abstract

Objectives: We aimed to show the effect of surgical mask use on pulmonary functions in healthy healthcare workers at different physical activity levels.

Methods: This analytical cross-sectional study included healthy and active sports physicians and sports physiotherapists. Participants were subjected to respiratory function tests and arterial oxygen saturation (SpO_2) measurements at rest and after the non-inclined treadmill activities at constant speeds of 3 km/h and 6.5 km/h with a surgical mask.

Results: SpO_2 measurements taken immediately after the participants' physical activities at a speed of 6.5 km/h were significantly lower than the basal SpO_2 measurements (p=0.045) as well as 1st second of forced expiration (FEV_1)/forced vital capacity (FVC), and FEV_1/FVC% in pulmonary function test measurements were significantly higher than baseline measurements (p=0.005; p=0.012, respectively). The flow velocity value in the last quarter of the forced expiration (FEF75) and its percentile were (FEF%75) found to be significantly higher than the measurements taken at rest after walking at 6.5 km/h (p=0.005 vs. p=0.004, respectively). The differences between the ERV values obtained after the participants' physical activities at two speeds (3 km/h vs. 6.5 km/h) were significant (p=0.045).

Conclusion: Using surgical masks by health workers while performing their low-moderate occupational activities may cause changes in respiratory parameters due to the microenvironment formed in the mask and increased respiratory resistance.

Keywords: Oxygen saturation; physical activity; pulmonary function test; surgical mask.

Cerrahi Maske Kullanımının Farklı Fiziksel Aktivite Seviyelerindeki Sağlık Çalışanlarının Solunum Fonksiyonları Üzerine Etkisi

Özet

Amaç: Çalışmamızda farklı fiziksel aktivite seviyelerinde cerrahi maske kullanımının sağlık çalışanlarının solunum fonksiyonları üzerine olan etkisini göstermeyi amaçladık.

Gereç ve Yöntem: Analitik kesitsel tipteki bu çalışmamıza sağlıklı ve aktif spor hekimleri ve spor fizyoterapistleri dahil edildi. Katılımcılar cerrahi maske olmadan istirahat düzeyinde (bazal) ve cerrahi maske ile sabit hızlardaki (3 km/saat ile 6.5 km/saat) eğimsiz koşu bandı aktiviteleri sonrasında solunum fonksiyon testi (SFT) ve kan oksijen satürasyonu (SpO_2) ölçümlerine tabi tutuldu.

Bulgular: Katılımcıların 6.5 km/saat hızdaki fiziksel aktivite sonrası SpO_2 ölçüm değerleri bazal seviyede ölçülen SpO_2 değerlerinden anlamlı olarak düşüktü (p=0,045). 6.5 km/sa hızdaki fiziksel aktivite sonrasında gerçekleştirilen SFT sırasındaki FEV_1/FVC ve FEV_1/FVC% parametrelerine ait değerler, aynı parametrelerden bazal düzeyde elde edilenlere göre anlamlı olarak daha yüksek bulundu (sırasıyla, p=0,005; p=0,012). Zorlu ekspirasyonun son çeyreğindeki akım hızı değeri (FEF75) ve yüzdesi (FEF%75) 6.5 km/saat hızla yürüdükten sonra bazalde alınan ölçümlere göre anlamlı olarak yüksek tespit edildi (sırasıyla, p=0,005 ve p=0,004). Ek olarak katılımcıların iki farklı hızdaki (3 km/saat ile 6.5 km/saat) fiziksel aktiviteleri sonrasında saptanan ERV değerleri arasındaki fark anlamlıydı (p=0,045).

Sonuç: Sağlık çalışanlarının düşük-orta şiddette gerçekleşen mesleki aktiviteleri sırasında cerrahi maske kullanmalarının, maske içinde oluşan mikro ortam ve artmış solunum yolu direnci nedeniyle solunum fonksiyonlarında anlamlı değişikliklere neden olabileceğini düşünüyoruz.

Anahtar sözcükler: SpO_2; fiziksel aktivite; solunum fonksiyon testi; cerrahi maske.

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Introduction

To prevent person-to-person transmission of respiratory viruses, which cause infections, physical distancing, hand hygiene, and the use of masks are widely recommended by national and international guidelines, especially in public and health-care areas.[1] It is emphasized that using masks reduces the spread of viruses from asymptomatic individuals through droplet transmission.[2]

Although FFP2/N95 masks that fit more tightly on the face and can filter even smaller particles have been recommended for healthcare workers to reduce exposure to viral infections,[3] previous scientific studies have not found significant differences between using FFP2/N95 type masks and surgical disposable masks to protect against influenza infections and other respiratory diseases.[4]

As it is known, physicians and other healthcare workers are often mildly or moderately physically active during working hours. They must wear masks for long periods of time during their working hours due to pandemic conditions.[5] The use of medical face masks may increase individuals' perception of respiratory distress due to the microenvironment (increased humidity and temperature) and restriction of airflow[6] and may have restrictive effects on cardiorespiratory functions, which are essential for strenuous physical and occupational activities.[7]

It has also been reported that due to slightly increased airway resistance and decreased respiratory functions due to mask use, a decrease in ventilation values and, consequently, a decrease in physical work performance may be observed.[8–10]

In a recent study, it was shown that the use of medical face masks by healthcare workers during long working hours may increase airway resistance and cause decreases in forced vital capacity (FVC), air volume expelled in the 1st second of forced expiration (FEV_1), peak expiratory flow rate (PEF), and maximal voluntary ventilation (MVV) parameters in pulmonary function testing, but this was minimal.[9]

However, with the emergence of variants such as Omicron, which have high transmission rates among fully vaccinated young and middle-aged adults, especially in indoor environments, the importance of the habit of using medical masks, which may have been neglected over time since the summer of 2021, is understood again.[11]

Compared to other medical care units, sports medicine clinics, and sports rehabilitation departments are units where more and longer physical activities are performed during a working day, and close individual contact is frequently experienced in a closed environment. In this context, masks are an essential obligation for health-care professionals who have close physical contact with patients due to the nature of their work.

Therefore, our study aimed to examine the effects of medical face masks on the respiratory functions of a group of health professionals consisting of sports physicians and sports physiotherapists during their professional activities. The outputs obtained will shed light on the performance and health of health professionals during their professional practices.

Materials and Methods

This clinical study was approved by the Ethics Committee of İstanbul University Faculty of Medicine (no: E-29624016-050.99-206319, date: 18.05.2021), and was conducted following the latest version of the World Medical Association Declaration of Helsinki. In our study, a prospective descriptive design was established to evaluate the acute effect of the wearing process of a specific mask preferred for the facial area on pulmonary function test (PFT) parameters and blood oxygen saturation (SpO_2).

Twenty-three healthy and active individuals (12 females and 11 males) working as sports physicians and sports physiotherapists at Istanbul University, Istanbul Medical Faculty, Department of Sports Medicine were included in our study. Those with known cardiac, pulmonary, neurologic, and rheumatologic diseases; those with musculoskeletal disorders that prevented physically active movement, and those with acute upper/lower respiratory tract infection findings were excluded from the study. The participants in the study were non-smokers and were asked not to make any changes in their daily work routines before the planned tests. Participants were allowed to talk during the tests to mimic their work routines.

Data Collection

Participants were subjected to solunum fonksiyon testi (SFT) and SpO_2 measurements at rest without a surgical mask and immediately after (at minute 0) incline-free treadmill activities at constant speeds of 3 km/h and 6.5 km/h.

The manufacturer specified the medical mask used in our study (UNL MASK® Turkey) as a three-layer surgical face mask with an integrated nose clip made of non-woven fabric, free of allergic substances. These masks were used during exercise on the treadmill at speeds of 3 km/h and 6.5 km/h by wearing them on the face to cover the mouth and nose completely.

The SFT was performed without a mask using the Spirobank Mir (SN A23-048)/Winspro v.3.1.1 open circuit spirometer. The test results were evaluated according to the Turkish Thoracic Society Spirometry Consensus Report.[12]

During SFT, FVC, the volume of air expelled in the FEV_1, the ratio and percentage of FVC to the volume of air expelled in the FEV_1 (FEV_1/FVC, FEV_1/FVC%), PEF, forced expiratory flow rate (PEF), forced expiration seconds of forced expiration (FEV_1/FVC, FEV_1/FVC%), PEF, and flow rates at levels where 25%, 50% and 75% of the volume are removed during forced expiration (respectively, FEF25%, FEF50%, and FEF75%), maximal mid-expiratory flow rate (FEF25%-75%), MVV, and expiratory reserve volume (ERV) were recorded. SpO_2 values were monitored with ChoiceMMed® MD300C20 OLED Finger Pulse Oximeter Saturation Monitor (Beijing, China) model pulse oximetry device.

Statistical Analysis

Data were analyzed using the SPSS 21.0 program (IBM, New York, USA). Differences between variables were analyzed by Friedman's ordered two-way analysis of variance. Categorical variables were evaluated by the pairwise comparison method. Statistical hypothesis checks were performed at p=0.05 significance level, and p<0.05 was accepted as significant.

Table 1. Demographic data of the participants

n=(23)	Minimum	Maximum	Mean	SD
Height (cm)	154	190	172.87	10.01
Weight (kg)	54	93	70.78	10.86
BMI (kg/m^2)	18.71	27.8	23.63	2.61

SD: Standard deviation; BMI: Body mass index.

Results

Demographic information of the study group is shown in Table 1. There was no significant difference between the arterial SpO_2 measurements of the participants at 0 min after basal (1st measurement) and 3.0 km/h (2nd measurement) physical activity ($p>0.05$). SpO_2 measurements taken after the participants' physical activity at a speed of 6.5 km/h (3rd measurement) were significantly lower than the baseline SpO_2 measurements (p=0.045) (Table 2 and Fig. 1).

The results of FEV_1/FVC and FEV_1/FVC% in SFT measurements performed after physical activity at 6.5 km/h were significantly higher than the baseline measurements (p=0.005, p=0.012, respectively) (Table 2 and Fig. 1). However, no significant difference was found between SFT measurements of the same parameters after physical activity at 3.0 km/h and baseline measurements ($p>0.05$).

The difference between the ERV values obtained in SFT measurements of the participants after physical activity at 3 km/h and 6.5 km/h was significant (p=0.045). However, there was no significant difference between baseline ERV and ERV values after physical activity at 6.5 km/h ($p>0.05$) (Table 2 and Fig. 2). Finally, FEF75 and FEF%75 values after walking at 6.5 km/h were significantly higher than baseline FEF75 and FEF%75 values (p=0.005 and p=0.004, respectively) (Table 2 and Fig. 2).

On the other hand, there was no statistically significant difference between the results of baseline measurements of FVC, FEV_1, PEF, MVV, FEF%25, FEF%50, and FEF%25–75 parameters of SFT and the results obtained after physical activity performed at two different speeds ($p>0.05$).

Discussion

According to our results, using surgical masks during physical activity in healthy individuals may cause changes in some respiratory functions examined by SFT. In our study, transcutaneous SpO_2 values measured by pulse oximetry during physical activity at two different speeds simulating the working environment in sports medicine and sports rehabilitation practice did not show a significant difference compared to baseline at low activity level (3 km/h). However, they were significantly lower at moderate physical activity (6.5 km/h) (Table 2 and Fig. 1).

A study conducted by Beder et al.[13] in 2008, showed that transcutaneous SpO_2 of healthcare workers using surgical masks during major surgical operations of 60 min or more were slightly decreased, and these decreases were attributed to mask use and occupational stress.

In 2020, no significant difference was found in the transcutaneous SpO_2 of healthcare workers measured after a 4-h shift with basal and surgical masks.[9] Our results are consistent with these studies' results, showing slight decreases in transcutaneous SpO_2 in low- to moderate-intensity occupational activities with surgical mask use.

The microenvironment (increased humidity and temperature) created by the use of surgical masks and, therefore, decreased airflow may cause a decrease in blood oxygenation as the intensity of physical activity increases, leading to significant decreases in transcutaneous SpO_2.

On the other hand, the data obtained from previous studies evaluating the effect of mask use on pulmonary function are quite heterogeneous. In the case reports presented by Ciocan et al.,[9] it was reported that there were no significant changes in some SFT parameters (VC, FVC, FEV_1, and FEV_1/FVC) with mask use during light-moderate work activities. In contrast, only statistically significant decreases in MVV value were reported. The reason for this has been shown that the mechanical barrier effect of the mask becomes apparent at high-intensity ventilation volumes.

Fikenzer et al.[7] and Lässing et al.[5] reported in their prospective studies that the use of surgical masks during exercise with a bicycle ergometer in healthy volunteer groups of 12 and 40 people caused an increase in airway resistance and decreases in FVC, FEV_1, and PEF parameters compared to baseline measurements.

Table 2. Mean and standard deviation of significant parameters in measurements taken at baseline, 3.0 km/h and 6.5 km/h

	SpO_2 ±SD	p	FEV1/FVC ±SD	p	FEV1/FVC% ±SD	p
1. Measurement	98.6±0.8	1.0–2.0 Measurement: 0.81	87.1±7.8	1.0–2.0 Measurement: 0.10	104.4±8.4	1.0–2.0 Measurement: 0.08
2. Measurement	98.4±0.7	2.0–3.0 Measurement 0.55	87.8±8.0	2.0–3.0 Measurement: 0.91	105.4±9.1	2.0–3.0 Measurement: 1.0
3. Measurement	98.1±1.0	1.0–3.0 Measurement 0.045*	88.4±8.6	1.0–3.0 Measurement: 0.005*	105.9±9.8	1.0–3.0 Measurement: 0.012*
	FEF75 ±SD	**p**	**FEF%75 ±SD**	**p**	**ERV ±SD**	**p**
1. Measurement	2.3±0.7	1.0–2.0 Measurement: 0.17	95.3±31.3	1.0–2.0 Measurement: 0.20	1.5±0.5	1.0–2.0 Measurement: 0.81
2. Measurement	2.45±0.9	2.0–3.0 Measurement: 0.63	101.4±37.9	2.0–3.0 Measurement: 0.48	1.59±0.6	2.0–3.0 Measurement: 0.045*
3. Measurement	2.48±0.8	1.0–3.0 Measurement: 0.005*	102.9±32.2	1.0–3.0 Measurement: 0.004*	1.45±0.7	1.0–3.0 Measurement: 0.55

*: Indicates $p<0.05$. SpO_2: Arterial O_2 saturation; SD: Standard deviation; FEV_1/FVC: Ratio of the volume of air expired in the 1st second of forced expiration to the forced vital capacity; FEV1/FVC%: Percentage of the volume of air expired in the 1st second of forced expiration to the forced vital capacity; FEF75: Flow rate value in the last quarter of forced expiration; FEF%75: Percentage of flow rate value at the last quarter of forced expiration; ERV: The amount of air expelled with a forced expiration after the expiration is completed during normal breathing.

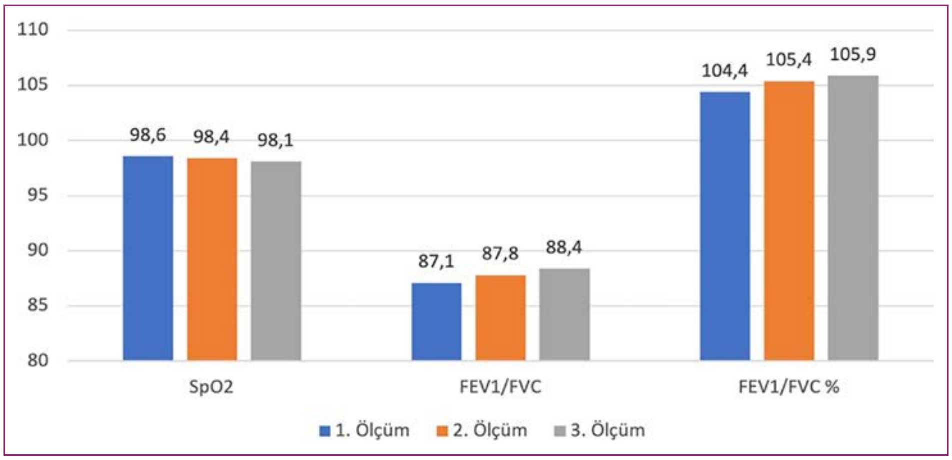

Figure 1. Results of SpO_2, FEV_1/FVC, and FEV_1/FVC% parameters of the participants. Measurement 1 (blue); refers to the values determined at rest, measurement 2 (orange); after walking at 3 km/h, and measurement 3 (gray); after walking at 6.5 km/h.

SpO_2: Arterial O_2 saturation; FEV_1/FVC: Ratio of the volume of air expired in the 1st second of forced expiration to the forced vital capacity; FEV1/FVC%: Percentage of the volume of air expired in the 1st second of forced expiration to the forced vital capacity.

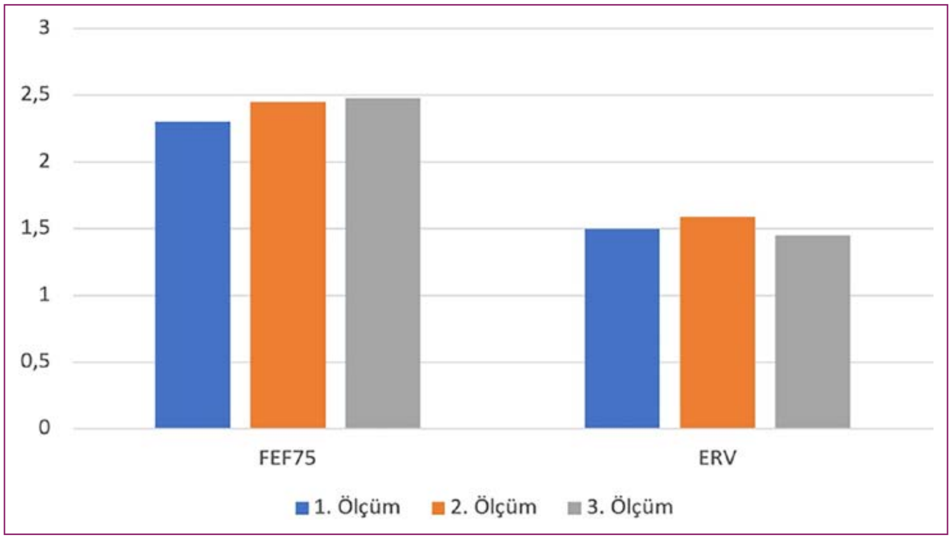

Figure 2. Participants' results for FEF75 and ERV parameters. Measurement 1 (blue); refers to the values determined at rest, measurement 2 (orange); after walking at 3 km/h, and measurement 3 (gray); after walking at 6.5 km/h.

FEF%75: Percentage of flow rate value at the last quarter of forced expiration; ERV: The amount of air expelled with a forced expiration after the expiration is completed during normal breathing.

The outputs of FVC, FEV_1, PEF, and FEF25 parameters examined during SFT are mostly effort-dependent. They also require cooperation during measurements and reflect the flow from large airways. However, FEF50 and FEF25-75 are the least affected by effort. During these stages of forced expiration, flow rates are determined by the elastic retraction force of the lung and the resistance of the small airways. However, their reproducibility is low, and their values depend on FVC. FEV_1/FVC is generally used to evaluate airway obstruction.[12]

Despite the physical barrier effect of the mask used in our study, no significant difference was found between the baseline values and the values obtained after physical activities at two different speeds in forced respiratory parameters such as FVC, FEV_1, PEF, MVV, FEF25%, FEF50%, and FEF25%–75%.

However, FEV_1/FVC, FEV_1/FVC%, FEF75, and FEF%75 parameters determined after physical activity at a speed of 6.5 km/h were significantly lower than baseline measurements (Table 2, Figs. 1, 2).

However, the differences between ERV values in SFT measurements performed after physical activities at two different levels were significant (Table 2 and Fig. 2).

ERV is the amount of air expelled with a forced expiration after the expiration is completed during normal breathing.[14] Decreases in ERV on SFT can often be seen in patients with severe central obesity in association with a decrease in FRC due to decreased chest wall compliance. Thus, calm breathing occurs with a reduced lung volume. These decreases in FRC and ERV may cause the formation of segments that restrict airflow, especially in the lower regions of the lung, and trigger hypoxemia.[15,16]

When we evaluate the results of our study with the existing literature, moderate physical activity with a mask may likely have affected the small airways by causing a decrease in chest compliance with a similar mechanism. Whether this effect will leave a permanent effect can be clarified in future studies. We should also emphasize that these results should be carefully examined regarding patient performance, test motivation, and reproducibility of the values, and further studies should be planned.

In addition, as a limitation of our study, we did not have a control group, and the preferred fatigue scales (Borg scale and Effort perception rate scale) were not used to determine the intensity of physical activity.

Conclusion

Surgical masks worn by healthcare workers during their professional activities at low-to-moderate exertion intensity may cause significant changes in respiratory function due to the microenvironment and increased airway resistance in the mask.

Disclosures

Ethics Committee Approval: The study was approved by the İstanbul University İstanbul Faculty of Medicine Ethics Committee (no: E-29624016-050.99-206319, date: 18/05/2021).

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References

1. Islam MS, Rahman KM, Sun Y, Qureshi MO, Abdi I, Chughtai AA, et al. Current knowledge of COVID-19 and infection prevention and control strategies in healthcare settings: A global analysis. Infect Control Hosp Epidemiol 2020;41(10):1196–206. doi: 10.1017/ice.2020.237.
2. Bourouiba L. Turbulent gas clouds and respiratory pathogen emissions: Potential implications for reducing transmission of COVID-19. JAMA 2020;323(18):1837–8. doi: 10.1001/jama.2020.4756.
3. Daeschler SC, Manson N, Joachim K, Chin AWH, Chan K, Chen PZ, et al. Effect of moist heat reprocessing of N95 respirators on SARS-CoV-2 inactivation and respirator function. CMAJ 2020;192(41):E1189–97. doi: 10.1503/cmaj.201203.
4. Radonovich LJ Jr, Simberkoff MS, Bessesen MT, Brown AC, Cummings DAT, Gaydos CA, et al; ResPECT investigators. N95 respirators vs medical masks for preventing influenza among health care personnel: A randomized clinical trial. JAMA 2019;322(9):824–33. doi: 10.1001/jama.2019.11645.
5. Lässing J, Falz R, Pökel C, Fikenzer S, Laufs U, Schulze A, et al. Effects of surgical face masks on cardiopulmonary parameters during steady state exercise. Sci Rep 2020;10(1):22363. doi: 10.1038/s41598-020-78643-1.
6. Li Y, Tokura H, Guo YP, Wong AS, Wong T, Chung J, et al. Effects of wearing N95 and surgical facemasks on heart rate, thermal stress and subjective sensations. Int Arch Occup Environ Health 2005;78(6):501–9. doi: 10.1007/s00420-004-0584-4.
7. Fikenzer S, Uhe T, Lavall D, Rudolph U, Falz R, Busse M, et al. Effects of surgical and FFP2/N95 face masks on cardiopulmonary exercise capacity. Clin Res Cardiol 2020;109(12):1522–30. doi: 10.1007/s00392-020-01704-y.
8. Morgan WP. Psychological problems associated with the wearing of industrial respirators: A review. Am Ind Hyg Assoc J 1983;44(9):671–6. doi: 10.1080/15298668391405544.
9. Ciocan C, Clari M, Fabbro D, De Piano ML, Garzaro G, Godono A, et al. Impact of wearing a surgical mask on respiratory function in view of a widespread use during COVID-19 outbreak. A case-series study. Med Lav 2020;111(5):354–64. doi: 10.23749/mdl.v111i5.9766.
10. Hodous TK. Screening prospective workers for the ability to use respirators. J Occup Med 1986;28(10):1074–80. doi: 10.1097/00043764-198610000-00031.
11. Brandal LT, MacDonald E, Veneti L, Ravlo T, Lange H, Naseer U, et al. Outbreak caused by the SARS-CoV-2 Omicron variant in Norway, November to December 2021. Euro Surveill 2021;26(50):2101147. doi: 10.2807/1560-7917.ES.2021.26.50.2101147.
12. Ulubay G, Dilektaşlı AG, Börekçi Ş, Yıldız Ö, Kıyan E, Gemicioğlu B, et al. Turkish Thoracic Society Consensus Report: Interpretation of spirometry. Turk Thorac J 2019;20(1):69–89. doi: 10.5152/TurkThoracJ.2018.180175.
13. Beder A, Büyükkoçak U, Sabuncuoğlu H, Keskil ZA, Keskil S. Preliminary report on surgical mask induced deoxygenation during major surgery. Neurocirugia (Astur) 2008;19(2):121–6. doi: 10.1016/s1130-1473(08)70235-5.
14. Ranu H, Wilde M, Madden B. Pulmonary function tests. Ulster Med J 2011;80(2):84–90.
15. Lutfi MF. The physiological basis and clinical significance of lung volume measurements. Multidiscip Respir Med 2017;12:3. doi: 10.1186/s40248-017-0084-5.
16. Pellegrino R, Gobbi A, Antonelli A, Torchio R, Gulotta C, Pellegrino GM, et al. Ventilation heterogeneity in obesity. J Appl Physiol (1985) 2014;116(9):1175–81. doi: 10.1152/japplphysiol.01339.2013.