Respiratory Function Parameters of Turkish Jet Pilots

Türk Jet Pilotlarının Solunum Fonksiyon Testi Parametreleri

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ABSTRACT Objective: Aim; Jet aircraft pilots, in acute manner, sustain many physiological and dynamic changes during the course of flight. The respiratory system takes the lead among those systems that have been inflicted with such changes. The changes in the lung and pleural pressures, occurrence of ventilation and perfusion imbalance, sometimes the development of linear atelectasises associated with this imbalance and the raising of respiration frequency after the tidal volume got declined, are considered to be the primary pulmonary changes. As a rule of flight physiology, the fliers sustain a "G" force. This force is rather a positive G but also partly turns into a negative "G" load. Nevertheless, the pilots when they have been inflicted with a hypoxia during the course of flight, occasionally receive oxygen at a level 100%. In regard with the respiratory function test parameters of jet aircraft pilots, we have planned this retrospective study with a view to find out their exact levels of getting affected at the end of cumulative flights. **Material and Methods:** Together with the inclusion of 162 jet aircraft pilots, a control group consisting of 65 healthy subjects who were not suffering from any known obstructive or restrictive diseases, were included in this study. By taking into consideration that also the smoking has an adverse effect on the respiratory function, three groups were set up in respect with a sound statistics. These three groups which are sorted as the one that comprised the smoker and non-smoker pilots and the other one that comprised the non-smoker pilots and non-smoker healthy subjects, with respect to the spirometric parameters, were compared with each other. This spirometric evaluation was performed by taking into accounts the factors such as age, gender, height and weight. **Results:** When the comparison made among the smoker pilots and healthy subjects, all spirometric parameters with the exception of FEV1 differed significantly. No statistically significant difference has been observed in non-smoker pilots and non-smoker control group. All spirometric parameters of smoker pilots had displayed a significant decline but this decline was not sufficient to establish a diagnosis of airway obstruction. **Conclusion:** We concluded that the cumulative effect of flight, in respect with the spirometric evaluation, did not cause any negative or positive change on the respiratory functions but the smoker pilots, when compared with the non-smoker pilots, were faced with a small airway obstruction at a meaningful rate.

Key Words: Hypoxia, respiratory function test

ÖZET Amaç: Jet pilotları uçuş esnasında birçok fizyolojik değişime akut olarak maruz kalmaktadır. Solunum sistemi bu değişikliklere maruz kalan sistemlerin başında gelmektedir. Akciğer ve plevral basınçların değişmesi, ventilasyon-perfüzyon dengesizliğinin ortaya çıkması, bazen buna bağlı lineer atelektazilerin gelişmesi, tidal volümün düşerek solunum sıklığının artması başlıca pulmoner değişikliklerdir. Uçuş fizyolojisi gereği, uçucular "G" kuvvetine maruz kalmaktadırlar. Bu kuvvet daha çok pozitif G olmakta ancak kısmen de negatif "G" olmaktadır. Yine uçuş esnasında pilotlar, hipoksiye maruz kaldıkları anda zaman zaman %100 seviyesinde oksijen almaktadırlar. Jet pilotlarında solunum fonksiyonlarının, spirometrik olarak etkilenme düzeyini tespit etmek amacıyla bu retrospektif çalışmayı yaptık. **Gereç ve Yöntemler:** Yüz altmış iki jet pilotu ile 65 sağlıklı kontrol grubu çalışmaya alındı. Sigaranın da etkisi düşünülerek, 3 grup oluşturuldu. Sigara içen ve içmeyen pilotlar, sigara içmeyen pilot ve sağlıklı kontrol grup, sigara içen pilot ve sağlıklı kontrol grup olmak üzere spirometrik parametreler açısından karşılaştırıldılar. **Bulgular:** Sigara içen pilotlarla sağlıklı kontrol grubu spirometrik parametreler açısından değerlendirildiğinde FEV1 dışında tüm parametrelerde anlamlı farklar saptandı. Sigara içmeyen pilotlarla sigara içmeyen kontrol grubu arasında ise istatistiksel olarak bir fark saptanmadı. Sigara içen pilotların tüm spirometrik değerlerinde anlamlı düşüşler saptandı ancak bu düşüş hava yolu obstrüksiyonu tanısı koymak için yeterli değildi. **Sonuç:** Uçuşun, solunum fonksiyonlarına, spirometrik inceleme açısından negatif ya da pozitif anlamda bir etkisi olmadığı ancak sigara içen pilotlarda içmeyenlere göre anlamlı oranda küçük hava yolu obstrüksiyonu neden olduğu görüldü.

Anahtar Kelimeler: Hipoksi, solunum fonksiyon testi

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Any changes in the body will primarily be reflected to the respiratory system of system. Serious changes may be expected in respiratory and circulatory systems during flight. Jet pilots often fly at a height of between 15.000 and 30.000 feet and this means they are exposed to 200 to 300 mmHg pressure. This "G" force is caused dynamic respiratory changes.[1] The "G" force is a force from head to feet which is created by the circular motion of the aircraft. As a result of this force some respiratory changes occur. These changes are; decrease in vital capacity and tidal volume, increase in functional residual capacity as a result of the downward movement of diaphragm and abdomial contents, ventilation-perfusion imbalance,and micro atelectasies.[2]

It is important to determine if these cahanges are permanent. To determine this, it is aimed to evaluate the respiratory functions of jet pilots with simple spirometry.

MATERIAL AND METHODS

We evaluated the respiratory function tests of retired 162 jet pilots retrospectively. As a control group 65 healthy subjects with similar age and gender was taken. The control group was free of any airway diseases and their hemogram, routine biochemical analyses and chest radiographs were all in normal ranges. After ethics committee approval, we compared the spirometric parameters of 162 jet aircraft pilots and control group. Because this was a retrospective study, spirometric measurements could not be done immediately after the end of of flight but in elective conditions. Thirty five subjects in control group and 124 in study group were smokers. Three groups were formed before statistical evaluation. In the first group smokers of study and control group were took place. Second group consisted of nonsmokers of the groups and finally in the third group smoker and non-smoker pilots were compared. Student's t test was used for statistical analysis and the value of $p< 0.05$ was considered significant.

RESULTS

There was no statistically significant difference in mean age of study and control groups (48 ± 3.2 and 47 ± 2.4 respectively). Study and control group subjects' ages were between 44 to 53 years. Smoker group had a mean 22 pack/year smoking history (minimum 8 and maximum 44 pack/year). The average flight time of pilots within 15-20 years was 3325 ± 1096 hours. Jet pilots and healthy control group had normal chest radiographs and were not suffering from any obstructive or restrictive pulmonary disease which might affect adversely their respiratory functions. These jet aircraft pilots get a very detailed health check before starting their professional job. So they all were healthy and had normal pulmonary functions initially. Comparison of simple spirometric values of smoker groups is shown on Table 1. As seen on this table a significant decrease in all parameters except FEV_1 was shown in smoker pilots when compared with smoker healthy subjects. There was no statistically significant difference in pulmonary functions of non-smoker control and study groups (Table 2). Smoker pilots had significantly decreased spirometric parameters when compared with non-smoker ones but this decrease was not enough to say that those subjects had an obstructive lung disease (Table 3).

DISCUSSION AND CONCLUSION

Sudden pressure changes during flight and many sharply decreases or increasees in oxygen may cause respiratory dynamics changes. Long-term pulmonary function test parameters of pilots did not show statistically significant changes when compared to the control group.

It has been known that cardiovascular, respiratory, and muscle-skeletal systems and some organs such as kidney, eye, and brain may be affected during the flight. Jet pilots fly at an altitude of 10 thousand to 30 thousand feet for every flight which lasts approximately in 1 hour. During this one-hour flight, all thoracic and abdominal organs show physiological and dynamic changes. Depending on the nature of the task, pilots may be exposed to 3-5 G during flight. Sometimes this may increase to 8 to 9 G for 1 to 2 minutes.[1] G force occurs due to the circular motion of the aircraft from head toward the feet. A 70 kilograms man may be exposed to 350 kilograms force from

TABLE 1: Comparison of smoking pilots with smoking control group.

	Pilot (smoker) n= 124 mean ± standart deviation	Control (smoker) n= 35 mean ± standart deviation	p
FEV_1	88% ± 8.61	86% ± 5.08	0.25
FVC	91%± 6.08	88% ± 4.21	0.006
FEV1/FVC	87%± 5.27	85% ± 4.95	0.009
FEF_{25}	86%± 4.31	84% ± 3.64	0.02
FEF_{25-75}	83%± 5.57	78% ± 4.76	0.001
PEF	91%± 4.01	84% ± 3.67	0.001

$p < 0.05$ statistically significant.

head to feet for 5G's. Depending on this G some respiratory changes occur. Up to 5G, minimal changes occur in the respiratory system.[2] Respiratory rate increases proportionally with the increase in G. This increase is balanced with reduced tidal volume.[3] Up to 3G, total lung capacity and vital capacity are not affected.[4] Abdominal contents and diaphragm go downward with G exposure.[1,2] Thus, the functional residual capacity (FRC) gets increased nearly 500 cc at 3G level.[5] Jet pilots wear a special anti-G suit. A *G*-suit is a special garment and generally takes the form of tightly-fitting trousers, which fit either under or over (depending on the design) the flying suit worn by the pilots. The trousers are fitted with inflatable bladders which, when pressurized through a *G*-sensitive valve in the aircraft, press firmly on the abdomen and legs, thus restricting the draining of blood away from the brain during periods of high acceleration.[2]

TABLE 2: Respiratory functions of non-smoker pilots compared with the non-smoker control group.

	Pilot (nonsmoker) n= 38 mean ± standart deviation	Control (nonsmoker) n= 30 mean ± standart deviation	p
FEV_1	94% ± 5.39	91% ± 4.06	0.01
FVC	97% ± 5.94	93% ± 4.55	0.001
FEV1/FVC	95% ± 3.74	92% ± 4.75	0.002
FEF_{25}	94% ± 3.62	90% ± 4.80	0.001
FEF_{25-75}	93% ± 3.21	91% ± 4.91	0.05
PEF	98% ± 4.21	94% ± 5.81	0.003

$p < 0.05$ statistically significant.

TABLE 3: Respiratory functions of smoker pilots compared with non-smoker pilots.

	Pilot (smoker) n= 124 mean ± standart deviation	Pilot (nonsmoker) n= 38 mean ± standart deviation	p
FEV_1	88% ± 8.61	94% ± 5.39	0.0001
FVC	91% ± 6.08	97% ± 5.94	0.0001
FEV1/FVC	87% ± 5.27	95% ± 3.74	0.0001
FEF_{25}	86% ± 4.31	94% ± 3.62	0.0001
FEF_{25-75}	83% ± 5.57	93% ± 3.21	0.0001
PEF	91% ± 4.01	98% ± 4.21	0.0001

$p < 0.05$ statistically significant.

Local ventilation changes can also be expected in lungs. Due to the positive G effect, lung ventilation distribution varies in different parts of the lung. Basal pleural pressure is approximately 30 cmH_2O more than the pressure on apex at a 5 G.[6,7] Closing time of alveoli in the meantime also varies.[1,3] Pulmonary blood flow is also affected from the G but since pulmonary blood flow is much slower than the systemic blood flow this interaction will be minimum.[1]

As a result of changes on ventilation and perfusion, local atelectasies can be seen at the end of positive acceleration phase. When chest radiographs had taken without deep inspiration shortly after the flight, bilateral costa-diaphragmatic sinus closure revealed.[1,4,8] This condition was terminated in 24 hours. Microatelectasies occurred during the flight may cause the low spirometric values in the first 24 hour after the flight.[4]

In our study we measured the pulmonary functions of pilots with normal chest radiographs in elective conditions to see the permanent respiratory dysfunction after 3325 ± 1096 hours of flight in 15-20 years.

There are few studies that shows decrease in spirometric parameters immediately after the flight.[1] This decrease might be because of flight fatigue. In parallel to this retrospective study we have done a prospective spirometric measurement in four jet pilots immediately after the flight and we did not detect any change.

Jet pilots frequently exposed to positive G but a negative G may also partly effect the pulmonary system in a similar manner.[1,5,9,10] As a result we can say that dynamic changes occur continuously during the flight.

Despite all these G forces we found that jet pilots had better respiratory functions than healthy control group (Table 1, Table 2). This may be explained by better health conditions of the pilots. All air force pilots are subject to careful and detailed medical screening before their appointment. These medical screenings are done in definite time intervals after appointment. Many medical condition including bronchial asthma and chronic obstructive pulmonary disease which do not constitute a problem for other military personnel, can be debarring cause for pilotage. The difference between smoking and non-smoking pilots can be attributed to negative effect of smoking on respiratory function.

As a result, decreased spirometric parameters of smoker pilots were attributed to the negative effect of smoking. Working as a jet pilot did not effect the simple spirometric parameters.

However, more detailed further studies by doing ventilation-perfusion scintigraphy, carbon monoxide diffusion test, and high resolution computed tomography of thorax needed to evaluate the paranchimal changes.

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