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Pulmonary Function Tests and Their Reversibility in Smokers

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ABSTRACT

Background: *Smoking is known as the major cause of chronic obstructive pulmonary disease (COPD). In COPD, most of pulmonary function tests (PFTs) specially those indicating the diameter of airways are reduced. There are reports that bronchodilator drugs have no or a very little effect on PFT of COPD patients. Therefore, in this study PFTs of smokers were compared with those of nonsmokers, and the effect of bronchodilator inhaler (salbutamol) on PFTs of smokers were also examined.*

Materials and Methods: *Pulmonary function tests were measured in 97 male smokers (height 171.71±6.68 cm, age 36.49±13.06 years old) and compared with 95 male nonsmokers (height 171.79±8.81 cm, age 35.56±12.83 years old). The subjects underwent measurement of spirometric flow and volume. The following variables were measured: forced vital capacity (FVC), forced expiratory volume in one second (FEV_1), maximal mid-expiratory flow (MMEF), peak expiratory flow (PEF), maximal expiratory flow at 75%, 50%, and 25% of the FVC (MEF_{75}, MEF_{50}, and MEF_{25} respectively). In addition, pulmonary function tests of 33 male smokers (height 172.79±11.94 cm, age 38.30±6.65 years old) before and 10 minutes after administration of 200 µg salbutamol inhaler were measured.*

Results: *The results showed that most values of PFTs in smokers were significantly lower than those of non-smokers ($p<0.001$ for FVC, FEV_1, PEF, MEF_{75}, $p<0.01$ for MMEF, and $p<0.02$ for MEF_{50}). However, there were not significant differences in MEF_{25} of smokers and non-smokers. There were significant correlations between the smoking duration and FEV1, PEF, MEF_{75}, and MEF_{50} ($p<0.05$ to $p<0.01$), but correlations between smoking quantity and values of PFTs were not significant. The results also showed that all values of PFTs were significantly increased after salbutamol administration ($p<0.05$ to $p<0.01$). The enhancement in PEF, MEF_{75}, and MEF_{50} was around 12% and that of MEF_{25} was 17%.*

Conclusion: *The profound effect of smoking on PFT showed that smoking leads to constriction of large and medium sized airways which is mostly due to duration not to quantity of smoking. The airway constriction in smokers was reversible which, was mostly seen for medium sized airways.* ***(Tanaffos 2003; 2(8): 23-30)***

Key words: *Pulmonary function tests, Smoking, Reversibility, Smoking duration, Smoking quantity*

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INTRODUCTION

Chronic obstructive pulmonary disease (COPD) is a major cause of chronic morbidity throughout the world. Many people suffer from this disease for years and die prematurely from it or its complications. COPD is currently the fourth leading cause of death in the world (1), and further increases in its prevalence and mortality can be predicted in the coming decades (2).

Cigarette smoking is by far the most important risk factor for COPD and the most important way that tobacco contributes to the risk of COPD (3). Cigarette smokers have a higher prevalence of respiratory symptoms, pulmonary function abnormalities, greater annual rate of decline in FEV1, and a greater COPD mortality rate than those of non-smokers (4). These differences between cigarette smokers and non-smokers increase in direct proportion to the quantity of smoking. Smoking leads to rapid decline in pulmonary function tests (PFTs) specially those indicating diameter of airways such as forced expiratory flow in one second (FEV1) (5). Even in teenagers who have smoked only a few years, maximum expiratory flow-volume curves demonstrate decreases in flow rates at small lung volumes (6) yet another expression of small airway obstruction. If smoking causes changes in small airway calibre at such an early age , one might expect that smoking also causes acute changes in these small airways. Until now, the only well-documented acute effect of smoking on the airways was the decrease of airway conductance demonstrated by Nadel and Comroe (7).

The obstruction to airflow that develops in 15 to 20% of heavy smokers is thought to be due to abnormalities in airways with less than 2 mm internal diameter (8). Previous studies from several laboratories have shown that this airway obstruction is associated with chronic inflammatory process in the membranous and respiratory bronchioles (9-10).

It is believed that the airway constriction in COPD and decline in PFT are not reversible. Therefore, in the present study the pulmonary function tests of smokers was compared with those of non-smokers. The effect of quantity and duration of smoking on PFT and the reversibility of PFT were also evaluated in the present study.

MATERIAL AND METHODS

Subjects

Ninety seven smokers (age 36.49±13.06, range 19-71 years old and height 171.71±6.68 range 158-190) and ninety five non-smoker men (age 35.56±12.83, range 18-65 years old and height 171.79±8.81 range 154-194) were randomly selected from the visitors of Ghaem Medical Centre (Table 1). All subjects had no history or symptoms of cardiovascular or respiratory diseases that required treatment (excluding the common cold). The protocol was approved by the "Ethics Committee" of our institution, and each subject gave informed consent.

Measurement

Expiratory flow-volume curves were recorded by a spirometer with a pneumotachograph sensor (Model ST90, Fukuda Sangyo Co. Ltd. Japan). The spirometer was calibrated daily for few days at the beginning, end and, a few intervals during the middle of the study with a three- litre calibrating syringe. However, because there were almost no differences in daily calibrations, calibration of the spirometer was carried out weekly in the rest of the study. All tests were conducted by a final-year medical student who was fully trained regarding the procedure of spirometry by a supervisor. Prior to testing, the required manoeuvre was demonstrated by the operator, and subjects were encouraged and supervised throughout the test performance. Studies were performed using the acceptability standards outlined by the "American Thoracic Society" (ATS) with subjects in a standing position and wearing nose

clips (11). All tests were carried out between 1000 and 1700 hours.

In 33 smokers, PFTs were repeated 10 min after 200 µg inhaled salbutamol**.** Pulmonary function tests were performed three times in each subject with an acceptable technique. The highest levels for forced vital capacity (FVC), forced expiratory volume in one second (FEV_1), maximal mid-expiratory flow (MMEF), peak expiratory flow (PEF), and maximal expiratory flow at 75%, 50%, and 25% of the FVC (MEF_{75}, MEF_{50}, and MEF_{25} respectively) were taken independently from the three curves.

Data analysis

The data of height, age, and pulmonary function parameters were expressed as mean±SD. PFTs of smokers were compared with those of nonsmokers using unpaired t-test. PFTs obtained after inhaled salbutamol were compared with the baseline values using paired t-test. The duration and quantity of smoking were related to decrease in their PFT values, using the least square regression. The criterion of significance was $p<0.05$.

RESULTS

Duration and quantity of smoking

Mean duration of smoking was 17.41±4.68 years (range 2-50 years) and mean quantity of smoking was 12.09±9.68 Cigarettes per day (range 0.25-50), (Table1).

Table 1: Characteristics of studied population.

	Nonsmokers		Smokers	
Variables	**Range**	**Mean±SD**	**Range**	**Mean ±SD**
Height (cm)	154-194	171.79±8.81	158-190	171.71±6.68
Age (year)	18-65	35.56±12.83	19-71	36.49±13.06
Amount			0.25-50	12.09±9.68
Duration			2-50	17.41±9.68
Number	95		97	
FVC	71.36-134.50	95.71±12.22	24-126	83.78±16.83
FEV_1	80.90-184.40	102.04±17.29	15-130	89.80±16.80
MMEF	69.70-239.60	104.15±20.33	8-158	92.51±27.19
PEF	61.50-150.90	100.13±16.84	5-151	85.88±24.72
MEF_{75}	51.50-170.50	105.62±21.65	6-170	90.01±29.07
MEF_{50}	52.10-213.30	104.28±28.89	12-196	94.70±30.36
MEF_{25}	68.50-223.80	110.48±27.58	36-257	110.84±42.42

FEV_1: forced expiratory volume in one second; FVC: forced vital capacity; MMEF: maximal mid-expiratory flow; PEF: peak expiratory flow; MEF_{75}, MEF_{50}, and MEF_{25}: maximal expiratory flow at 75%, 50%, and 25% of the FVC, respectively. All values of PFTs were quoted as percentage predicted.

Pulmonary function tests

All values of pulmonary function tests in smokers were significantly lower than those of nonsmoker subjects ($p<0.02$ to $P<0.001$) except MEF25 (Table-2).

Table 2: Pulmonary function tests (PFTs) among smoker and non-smoker subjects and statistical differences between two groups.

	Nonsmokers	Smokers	Statistical
PFTs	Mean±SD	Mean±SD	Differences
FVC	95.71±12.22	83.78±16.83	P<0.001
FEV_1	102.04±17.29	89.80±16.80	P<0.001
MMEF	104.15±20.33	92.51±27.19	P<0.01
PEF	100.13±16.84	85.88±24.72	P<0.001
MEF_{75}	105.62±21.65	90.01±29.07	P<0.001
MEF_{50}	104.28±94.70	94.70±30.36	P<0.02
MEF_{25}	110.48±27.58	110.84±42.42	NS

Correlation between duration and quantity of smoking with PFTs in smokers

There were significant negative correlation between duration of smoking and decrease in FEV1, PEF, MEF_{75}, and MEF_{50} ($p<0.05$ to $p<0.01$). However, the correlations between the quantity of smoking and values of PFT were not significant.

Low PFTs among smoker and nonsmoker subjects

The percentage of low values of most PFTs (lower than 80% predictive values) among smoker was significantly more than those of normal subjects (Table 3). Only 0-10.6% of non-smokers had low PFT values while in 21.6-42.3% of smokers PFT values were lower than normal range.

Effect of sulbutamol on PFTs of smokers

Pulmonary function tests of 33 male smokers (height 172.79±11.94 cm, age 38.30±6.65 years) before and 10 min. after administration of 200 µg salbutamol inhaler were measured. All values of PFT in smokers significantly increased 10 min. after 200 µg inhaled sulbotamol ($p= 0.005$ to $p<0.001$). The enhancement in PEF, MEF_{75}, and MEF_{50}, was around 12% and that of MEF_{25} was 17% (Table 4).

Table 3: The percentage and range of low PFTs (lower than 80% predicted values among smoker and nonsmoker subjects.

	Nonsmokers				Smokers				
PFTs	Mean±SD	Range	Age	No	Mean±SD	Range	Age	No	Statistical Differences
FVC	74.00±2.4	71-79	19-44	10	69.39±10.2	24-79	20-71	41	p<0.05
FEV_1	--	--	--	--	68.27±14.4	15-79	21-71	22	--
MMEF	73.75±3.3	69-76	29-45	4	68.06±15.0	8-78	21-68	33	NS
PEF	72.20±5.9	61-78	22-64	11	61.14±17.2	5-79	19-68	36	P<0.01
MEF_{75}	65.38±11.2	51-78	22-64	8	60.69±18.7	6-79	19-71	32	NS
MEF_{50}	68.11±10.0	52-79	22-49	9	64.48±14.5	12-79	21-68	31	NS
MEF_{25}	72.56±3.2	68-78	23-63	8	64.71±10.7	36-79	21-53	24	P<0.05

Table 4: Pulmonary function tests (PFTs) of smoker subjects before and 10 min. after inhalation of 200 µg salbutamol.

PFTs	Before	After	Statistical Differences
FVC(l)	76.76±13.23	81.68±16.32	P<0.001
FEV_1(l)	82.79±12.79	90.62±14.74	P<0.001
MMEF(l/s)	80.74±19.07	90.03±24.09	P=0.002
PEF(l/s)	76.63±19.00	86.91±18.13	P<0.001
MEF_{75}(l/s)	79.79±20.43	93.47±18.40	P<0.001
MEF_{50}(l/s)	81.15±19.60	93.32±21.40	P<0.001
MEF_{25}(l/s)	97.25±36.03	114.09±45.65	P=0.005

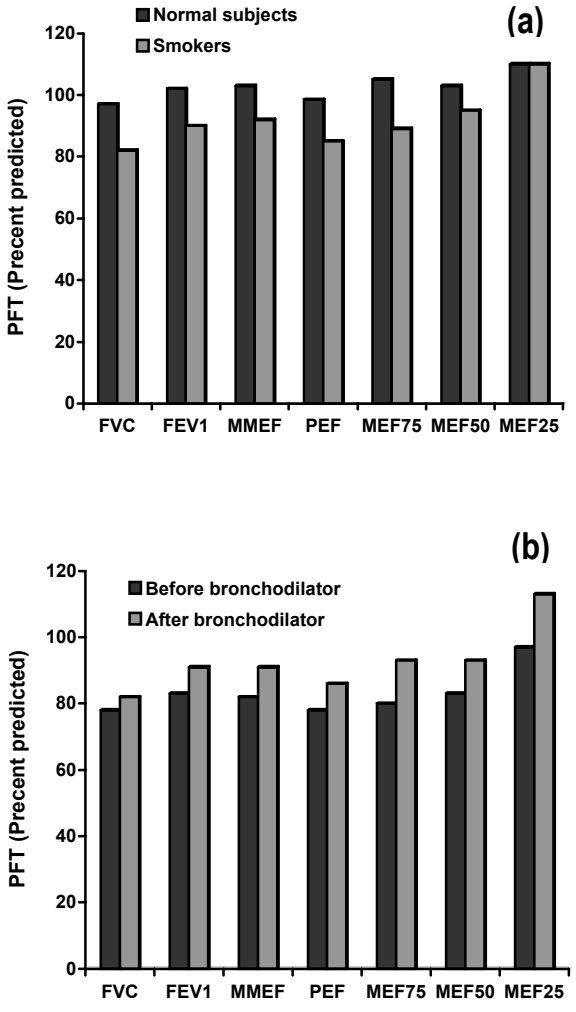

Figure 1: (a): Comparison of pulmonary function tests between smokers and nonsmokers, and (b): comparison of PFTs before and after 200 µg inhaled salbutamol in smokers

DISCUSSION

This study has shown reduction of all values of pulmonary function tests in smokers compared to those of nonsmoker subjects. Although the mean values of PFTs in smokers was in normal range (83.78±16.83 to 110.84±42.42), they were significantly lower than PFT values in normal subjects. However, in 21.6-42.3 % of smokers, the values of PFT were lower than normal range, while only 0-10.6% of normal subjects had low values of PFT. In addition, relatively younger smoker subjects had low values of PFT comparing to normal subjects. Pervious studies (12-20) also showed reduction of different values of PFT among smokers comparing to normal subjects. The result of the present study showed the reduction in PEF and MEF_{75} among smoker subjects was significantly more than other values of PFT.

These results may indicate that in smoker subjects medium and large airways are affected more than other airways. The results of our study were supported by previous studies indicating reduction of PFTs in smokers (17-18). However, there is some evidence that small airways are affected more by smoking (14).

The results of the present study also showed negative correlation between decrease in most values of PFT and duration of smoking. However, the relationships between decrease in PFTs and quantities of smoking were not significant. These results showed that duration of smoking has more profound effect on airways than quantity of smoking. The studies of Sherrill et al.(21) and Verschakelen et al. (22) also showed correlation between smoking and reduction in most values of PFT which support the results of the present study. In addition, Burrows et al. also showed quantitative relationship between cigarette smoking and reduction in values of PFT (5).

Furthermore, the results of the present study, showed that the values of PFT of smokers were

significantly increased due to 200 µg inhaled salbutamol indicating some degree of reversibility of the airway constriction in smokers. Although the mean value of MEF_{25} among smokers was normal, increase in this value of PFT due to salbutamol administration was more than other values of PFT. This may indicate that in smokers small airways are more liable to reversible constriction. It is believed that airway constriction of COPD patients is not reversible, or there is very small reversibility of airways in these patients. However, the results of our study demonstrated a relatively large component of reversibility of airways in smokers, which is a novel finding of the present study.

In conclusion, the results of the present study demonstrated the profound effect of smoking on PFT and, therefore, indicated that smoking leads to constriction of large and medium airways, which is mostly due to duration, not to quantity of smoking. The airway constriction in smokers was reversible which was mostly seen for medium and small sized airways.

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