EFFECT OF SMOKING ON RESPIRATORY PRESSURES AND LUNG VOLUMES IN YOUNG ADULTS

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ABSTRACT

Background: A limited number of studies have reported respiratory muscle strength as an early indicator of pulmonary dysfunction in younger age groups. Hence this study was carried out to analyze the same in young Saudi males. The objective of the study was to assess the effect of smoking habits on respiratory muscle strength in young Saudi males.

Methods: A total of 376 young subjects were inducted. The respiratory muscle strength was studued through PI_{max}, PE_{max} and MVV. Dynamic lung volumes included FVC, FEV_1, FEV_1 / FVC ratio and FEF_{25-75}. Smoking was quantified by estimating the total number of cigarettes smoked and the smoking behavior of subjects was categorized as: (1) never smoked; (2) smoking < 15 cigarettes a day; and (3) smoking > 15 cigarettes a day. The non-smokers formed the control group. Former smokers were not included. Respiratory muscle strength and dynamic lung volumes were measured by a dry electronic spirometer.

Results: Deteriorating effect of smoking was found on respiratory muscle strength, lung volumes and airflow parameters in our sample. Mild smokers showed a 5.39% decrease in FEF_{25-75} whereas a 01% increase in FEV_1 / FVC ratio compared to non-smokers. In heavy smokers both $FEF_{25-75\%}$ and FEV_1 / FCV% were decreased by 14.7% and 3.1% respectively. PI max was insignificant in mild smokers and heavy smokers whereas PE max was significant in heavy smokers $p > 0.03$.

Conclusion: Smoking was related to decline in respiratory muscle strength, lung volumes and airflow obstruction as well. This study indicated a positive dose response relationship of smoking and pulmonary dysfunction.

Key words: Smoking, respiratory pressure, respiratory muscle strength, pulmonary function tests, spirometry.

INTRODUCTION

In the present era, cigarette smoking is a major but preventable cause of death. Despite being aware of its harmful and hazardous effects, many young adults begin experimenting with cigarettes at a very early age and then adopt it as a regular habit. The striking increase in percentages of smoking among adolescents and young adults therefore, becomes a significant concern for smoking prevention and intervention efforts.[1-3] Burning tobacco forms an aerosol of vaporized chemicals and particulates (approximately 3×10^9 particles / mL of cigarette smoke) that includes nicotine, multiple carcinogens, oxidants and carbon nonoxide.[4] Cigarette smoke promotes deposition of particles in lower airways thus affecting respiratory defenses including mucociliary clearance. Smoking also promotes adherence of bacteria to airway epithelium, increases vascular and epithelial permeability and reversibly depresses function of natural killer (NK) cells.[5] Earlier reports have indicated that in young adults, relatively small amounts of cigarette smoke can cause deficit in lung functions. Smoking ≥ 15 cigarettes per day in males has been associated with 4% decline in forced mid – expiratory flow (FEF_{25-75}) as compared to those who never smoked.[6] The respiratory muscles are as vital as the heart and can be susceptible to fatigue under certain conditions. The evaluation of respiratory muscle performance, therefore, becomes very important if respiratory muscle function is impaired.[7] Like other skeletal muscles, respiratory muscle function should be described in terms of strength and endurance. If weakness of respiratory muscles is suspected, it is necessary to test the parameters of lung mechanics which include maximal static inspiratory and expiratory pressure (PI_{max} and PE_{max} respectively) and maximum voluntary ventilation (MVV).[8,9] However, only a few investigators have examined this aspect of respiratory muscle function. This study evaluates the effect of a common habitual factor like smoking on respiratory muscle strength in young adults.

METHODS

Most of the subjects were recruited from among the medical students of Faculty of Medicine and Medical Sciences, Umm Al Qura University, Makkah, Kingdom of Saudi Arabia. The remaining subjects were recruited from diverse socio-economic localities of Makkah and most of these were smokers. The subjects were required to fill in a questionnaire, giving personal smoking, eating and physical exercise habits. The history of a major respiratory or systemic illness in the subject and family was also obtained. By applying the exclusion criteria (major respiratory cardiovascular or systemic disease), a total number of 376 subjects were shortlisted into the study. By quantifying the total number of cigarettes smoked, subjects were divided into three categories: (1) never smoked; (2) smoking < 15 cigarettes a day; and (3) smoking > 15 cigarettes a day.[10] Those who never smoked comprised the control group. Former smokers were not included in the study.

Table 1: *Age – wise distribution of study parameters in sample (n = 376).*

Variables	*18 – 19 Years (n -= 175)*	*20 – 21 Years (n = 138*	*22 – 23 Years (n = 38)*	*24 – 25 Years (n = 25)*
Height (cm)	169.87	170.28	172.23	172.24
Weight (kg)	77.06	79.52	76.1	74.8
FVC (L)	4.05	4.06	3.79	3.74
FEV_1 (L)	3.53	3.48	3.26	3.23
FEV_1 / FVC (%)	86.74	86.01	85.83	86.5
FEF_{25-75} (L/sec)	4.13	3.96	3.56	3.56
PI_{max} (cm H_2O)	65.915	67.215	86.565	72.965
PE_{max} (cm H_2O)	93.085	92.195	99.31	98.325
MVV (L)	107.365	114.88	104.175	98.475

All data expressed as Mean ± SD

Table 2: *Distribution of study parameter according to different age – groups and smoking habits (n = 376).*

Variables	*18 – 19 Years (n = 175)*		*20 – 21 Years (n = 138)*		*22 – 23 Years (n = 38)*		*24 – 25 Years (n = 25)*	
	Smokers (n = 35)	*Non-Smokers (n = 140)*	*Smokers (n = 42)*	*Non-Smokers (n = 96)*	*Smokers (n = 37)*	*Non-Smokers (n = 01)*	*Smokers (n = 23)*	*Non-Smokers (n = 02)*
Age (years)	18.65	18.72	20.4	20.18	22.59	22	24.47	24.5
Height (cm)	170.14	169.8	170.85	170.03	172.05	179	172.26	172
Weight (kg)	74.79	77.57	75.57	81.25	75.1	113	76.26	58
FVC (L)	4.04	4.05	3.97	4.1	3.75	5.1	3.74	3.69
FEV_1 (L)	3.49	3.54	3.39	3.52	3.24	3.97	3.24	3.07
FEV_1 / FVC (%)	87.07	86.66	86.33	85.87	86.08	76.52	86.99	80.99
FEF_{25-75} (L/sec)	4.13	4.12	3.81	4.03	3.57	3.32	3.58	3.34
PI_{max} (CM H_2O)	65.57	66.26	65.97	68.46	60.13	113	63.43	82.5
PE_{max} (cm H_2O)	95.2	90.97	87.21	97.18	85.62	113	88.65	108
MVV (L)	95.2	119.53	108.5	121.26	93.38	114.97	91.75	105.2

All data expressed as Mean ± SD

Pulmonary function tests (PFTs) parameters of all subjects were determined by a portable, computerized, dry electronic spirometer (Datospir – 120, Gima, Italy). Initial calibration and standardization of the equipment was done by the authorized servicemen from the supplier of the spirometer. Measurements were done in accordance with the guidelines provided by American Thoracic Society (ATS).[11] Procedure of the spirometry was explained to each subject in detail. Test was repeated thrice and the highest reading was reported. Respiratory muscle function was assessed by measuring the respiratory muscle strength through maximal inspiratory pressure (PI_{max}), maximal expiratory pressure (PE_{max}) and maximum voluntary ventilation (MVV). We also recorded dynamic lung volumes namely forced vital capacity (FVC), forced expiratory volume in first second (FEV_1), ratio of FEV_1 to FVC (FEV_1 / FVC ratio) and forced expiratory flow between 25 to 75 percent of the FVC maneuver or forced mid – expiratory flow (FEF_{25-75}). For PI_{max}, subjects were instructed to exhale to residual volume (RV). At RV, the valve or shutter of the mouthpiece was closed and the subject was asked inhale as forcefully as possible, maintaining maximum pull for 1 – 2 seconds (sec). For PE_{max}, subjects were instructed to inhale to total lung capacity (TLC), when the valve was closed and the subject was asked to exhale as forcefully as possible maintaining maximum push for 1 – 2 sec. Both the pressures were recorded in cm of water (H_2O). A PI_{max} of -80 cm of H_2O and a PE_{max} of +80 cm of H_2O was taken as the cut – off point to exclude any significant weakness of respiratory muscles.[12] The measured values of FVC, FEV_1, FEV_1 / FVC ratio, FEF_{25-75}, PI_{max}, PE_{max} and MVV and percentage of predicted normal values for the same parameter based on the gender, age and height of the subject was calculated and analyzed. The threshold of abnormal PFTs was identified as < 80% of predicted value.

Data were analysed for normality. Mean values of PFTs in smoking categories were analysed by One Way Analysis of Variance (ANOVA). All statistical analyses were performed using the SPSS statistical software version 12.0 (SPSS, Inc., Chicago, IL).

Table 3: *Comparison of subjects by smoking hab-its (n = 376).*

Parameters	*Non-Smokers (n = 239*	*Mild Smokers (n = 109*	*Heavy Smokers (n = 239*
Age (years)	19.37 ± 0.97	21.09 ± 2.13	21.78 ± 1.95
Height (cm)	169.94 ± 6.21	170.82 ± 5.93	172.82 ± 7.80
Weight (kg)	79.03 ± 21.56	73.77 ± 17.41	81.78 ± 18.07
FVC (L)	4.07 ± 0.66	3.90 ± 0.52	3.82 ± 0.74
FEV_1 (L)	3.53 ± 0.57	3.38 ± 0.51	3.23 ± 0.67
FEV_1 / FVC (%)	86.25 ± 11.40	87.34 ± 8.59	83.54 ± 8.73
FEF_{25-75} (L/sec)	4.08 ± 1.20	3.86 ± 1.04	3.48 ± 1.68
PI_{max} (cm H_2O)	67.48 ± 21.51	64.44 ± 20.52	61.60 ± 22.73
PE_{max} (cm H_2O)	93.70 ± 25.38	90.69 ± 23.67	82.71 ± 33.91
MVV (L)	120.09 ± 27.23	103.78 ± 24.62	97.98 ± 23.02

All data expressed as Mean ± SD

RESULTS

Age – wise distribution of study parameters is summarized in Table 1. In a total of 376 subjects, 239 (63.56%) were non-smokers, 109 (28.98%) were mild smokers and 28 (7.44%) were heavy smokers. The overall prevalence of smoking was 36% with one third of smokers in 20 – 21 years age group, whereas 25% from 18 to 19 years. The mean height of the smokers was 171 ± 6.4 cm and it was greatest in the 24 to 25 year subjects. Distribution of study parameters according to smoking status and age – group is summarized in Table 2. Since boys attain their maximal height in their early twenties therefore peak maturation in growth of the body can be safely assumed to have reached during these years, the same age period during which maximum pulmonary function is achieved.

Smoking 15 cigarettes or more per day, as compared with nonsmokers was associated with reduction in the levels of FEV_1 / FVC and FEF_{25-75} of 3.1% and 14.7% respectively. Observing the 95% confidence interval, lower bound and upper bound for FEF_{25-75} (2.8% – 4.1%) and for FVC (3.5% – 4.1%), indicated a positive dose response between these relationships. The FEV_1 / FVC ratio, whereas it was found to increase in the mild smokers by 01% the $FEF_{25-75\%}$ decreased in mild smokers by 5.39%. The overall mean number of cigarettes smoked was 8.7 in the mild smokers with a median of 5.6 whereas the heavy smokers had a mean number of 19.8 with a median of 16.4. In this study FVC was larger in the nonsmokers than in the smokers except for the smokers in the 24 to 25 year subjects who showed a slightly larger FVC than the non-smokers (n = 23 vs. n = 02). The mean height of the smokers was 171cm ± 6.4 and it was comparatively greater in the 24 to 25 years old subjects. A comparison of study parameters in three categories of smoking status is shown in Table 3. PI_{max} showed no significance on comparison of the non-smokers with wild smoker or with heavy smokers. PE_{max} values on comparison were also insignificant in the mild smokers whereas these were significant in the heavy smokers.

DISCUSSION

Prevalence of smoking in this study sample of young adult male smokers was alarmingly high. More alarmingly, results indicated a smoking trend in early ages. In this study for young adult smokers, relatively small amounts of cigarette smoking caused decrease in the levels of FEV_1 / FVC and FEF_{25-75}. Similar changes have been described by previous studies to be the earliest indicators of airway obstruction which could then lead to adult airway diseases.[13-16] In addition to the above early indicators of airway obstruction FVC and FEV_1 also followed the same pattern of decrease when studied as the total number of smokers giving a dose response relation between smoking and all these parameters of lung function.

Comparing this study's observations with some of the others which have found that whereas older symptomatic adult smokers with histories of large numbers of pack – years may have lower FVC levels than non-smokers, young adult smokers have FVC levels equivalent to or higher than age equivalent non-smokers. It is possible that at the time they started smoking and then with the subsequent growth maturation years, particularly in the very early twenties, they had developed somewhat larger lungs and thus experienced no discomfort on smoking which led to their smoking on regular basis.[13-16] In this study also, greater FVC values and the development of greater height in the smokers fortifies the above observation made by these studies. This study also reports that the young adults with subsequent growth maturation developed greater inspiratory and expiratory muscle strength, however with the growth in age this study showed no significant difference when compared with the respiratory pressures. The greater strength of respiratory muscles may have been due to the difference in body size with the subsequent growth years. These observations were similar to some of the studies carried out in this respect.[7,8,17] Some studies have shown that airway resistance can be increased by acute smoking.[18,19] It may accordingly be derived that chronic cigarette smoking may also increase resistance of the air passages in smokers. In this study whereas the mean values of PI_{max} and PE_{max} decreased in the smokers as compared with nonsmokers when studied as whole groups of nonsmokers, mild smokers and heavy smokers they showed a similar response in the different age sub groups with the exception that PE_{max} was increased modestly in the 18 to 19 years age group. Relatively few complete studies are available on the respiratory muscle function. We attempted to determine only the respiratory muscle strength whereas some of these other studies have also taken up the respiratory muscle endurance. In this context many have developed sophisticated techniques, the reliability and accuracy of these is questionable. The test of maximum voluntary ventilation is usually done to determine the mechanical factors of breathing, increase in airway resistance, reduced compliances or respiratory muscle force and it also provides a measure of the respiratory muscle fatigue. The largest drawback of this test is that it needs complete cooperation and efforts on the part of the subject or the patient although the same is true for the other tests of pulmonary function. The old term maximum breathing capacity (MBC) was therefore replaced by maximum voluntary ventilation (MVV).[20] In this study mean MVV values were 113.71 ± 27. These values on comparison with the Caucasian European or Caucasian American were towards the lower side, however a subject bias or operator bias cannot be ruled out. On comparison for MVV values in the smokers and non-smokers, these were found to be significant and showed lesser mean values in the mild and heavy smokers and these showed an inverse relationship with age. The age subgroup analysis also showed lower values of MVV but a particular dose – response effect was not observed.

It is ***concluded*** that smoking was related to decline in respiratory muscle strength, lung volumes and airflow obstruction as well. This study indicated a positive dose response relationship of smoking and pulmonary dysfunction. Smoking cessation programs should form part of a major strategy to prevent chronic obstructive pulmonary disease in young people along with various leisure time sports activities at the local level of all academic institutions.

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