Original Article

Deterioration of lung functions is similar in bidi and cigarette smokers in younger population despite mild, low duration smoking - an observational study

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Abstract

Background and Aim: Smoking in the form of bidi or cigarette is a preventable cause of lung damage. There are limitations of routine spirometry which fails to reveal functional residual capacity (FRC), residual volume (RV), and total lung capacity (TLC). These are functionally significant parameters affected earlier by cigarette smoking. However, less is known about the effect of bidi smoking which is 10 times more prevalent in India than cigarette. We studied the effect of type of smoking bidi versus cigarette on complete profile of lung volumes and capacities in young male smokers.

Methods: We conducted a cross-sectional observational study using random sampling from community. Fifty-four apparently healthy, young, asymptomatic current male smokers were recruited from community. We used Ultima PFX real time diffusion system, BreezeSuite software, flow volume calibration, and guidelines laid by American Thoracic Society. We measured spirometric parameters followed by FRC measurement by nitrogen washout technique and derived RV and TLC. We compared the distribution of means by unpaired *t*-test and evaluated linear correlation between parameters by Pearson's correlation test, setting *P* value significance at 0.05.

Results: Male smokers had mean age 30 years, mean duration 7 years, predominance of light smoking. Age, body mass index, duration, and intensity of smoking correlated negatively with most parameters with significance mainly for spirometric parameters. Values did not differ between bidi or cigarette smoker significantly. Majority showed either normal or mixed spirometric pattern with none showing obstructive one.

Conclusion: Young, asymptomatic, sedentary male smokers had reduced lung functions - spirometric or nonspirometric, unaffected by type of smoking – bidi or cigarette, despite low duration and predominant light smoking with restrictive or mixed pulmonary dysfunction whose progression can be suggested to be prevented by cessation of smoking.

Key words: Bidi, cigarette, lung volumes, male smokers, nitrogen washout

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INTRODUCTION

Tobacco use has been a global epidemic that results in 5 million deaths per annum.[1] Picture becomes even dangerous in India where bidi, offering unfiltered smoke exposure, is ten times more common than cigarette[2] and 24% males above age 15 smoke tobacco.[3] Smoking has an extensive effect on the respiratory function[4] and pulmonary function testing,[5] and it has been clearly implicated in the etiology of respiratory diseases including bronchial carcinoma.[2] Majority of the studies

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are done in aged and symptomatic individuals, with computerized spirometry[6] which falls short of residual lung functions such as functional residual capacity (FRC), residual volume (RV), and total lung capacity (TLC).[7] These parameters can be measured by nitrogen wash out technique.[8] By this study, we tried to inquest about lung functions other than diffusion lung capacity (DLC) in same young asymptomatic male smokers focusing on the effect of type, duration, and quantity of smoking.

MATERIALS AND METHODS

Study population

This observational transverse study was carried out from September 15, 2014, to January 5, 2015, in pulmonary function laboratory of Department of Physiology. By random sampling, we recruited from community, 54 apparently healthy, young, asymptomatic male smokers - smoking bidi or cigarette for minimum 1 year. After taking approval for the study, sample size was calculated by software Raosoft (Raosoft, Inc., free online software, Seattle, WA, USA). A size of 54 for population of the city (6 lakhs) with 19.8% prevalence of smoking in males in our state[3] was sufficient to have 90% confidence level and 10% margin of error.

Inclusion and exclusion criteria

We included asymptomatic apparently healthy male smokers aged between 20 and 50 years, who were regular smokers for more than 1 year, not chewing tobacco, not having any other addiction and ready to give written informed consent. Female participants are excluded due to low prevalence of smoking among them,[3] and the fact that only 1% females smoke regularly.[9] We excluded ex-smokers, occasional smokers, alcoholics, tobacco chewers, hypertensives, diabetics, participants with current respiratory diseases, doing yoga or breathing exercises, and those who are unwilling to give informed consent.

Quantification of smoking

We included only current smokers as defined by the World Health Organization guidelines.[10] Smoking was quantified by the smoking index (SI). As previously published, SI was defined as a number of bidis/cigarettes smoked in a day multiplied by number of years smoked.[11] The concept of using SI concept instead of packs per year was used for quantification of exposure to smoke because bidi - the hand rolled form of tobacco wrapped in the dried tendu leaf - is the most common smoking product in India.[12] Moreover, the number of bidis in a given pack is variable in contrast to cigarettes since the former is a cottage industry with much less standardization in its manufacturing process. Previous studies have shown that bidis and cigarettes impose similar risks in relation to lung cancer and that for calculating time-intensity tobacco smoke exposure, one bidi should be considered to be equivalent to one cigarette.[13] Depending on SI, participants were categorized into the following groups: Group I, light smokers (SI = 1–100) and Group II, moderate smokers (SI = 101–300). We did not include heavy smokers or ex-smokers or occasional smokers.

Instrument used

In the present study, we used Ultima PFX (Medgraphics Diagnostic Company, Saint Paul, MN, USA) instrument using real-time diffusion, with facility of exact flow sensor calibration by 3 L syringe calibration and gas analyzer calibration before each testing. We also followed quality control procedure after installation. The Ultima Series system uses the BreathPath patient circuit and PreVent flow sensor. BreezeSuite is a true multitasking software package that allows digital data acquisition and precise breath by breath analysis.

Spirometric measurements

All the participants were physically healthy on the basis of clinical examination, without any symptoms of any acute respiratory illness. The approval of Institutional Review Board of our Government Medical College was obtained, and participants were properly explained about the aim, objectives, methodology, expected outcome, and implications before the commencement of the study. Written informed consent was obtained from all the participants. Participants were given practice and minimum 3 attempts. All recordings were accomplished between 8 am and 12 pm in the morning. For maximum voluntary ventilation, we used frequency 60–80/min and testing was done for 15 s. We used reference values laid by Indian Kamat *et al*.[14] for getting predicted values to compare with the test results.

Nonspirometric measurements

Nitrogen washout method has been validated for use as per previously published work. All procedures were accomplished as per guidelines laid by American Thoracic Society.[8] We used reference values laid by Stocks and Quanjer[15] for getting predicted values for each test participant to compare test value with expected value for various parameters.

Nitrogen washout involves flushing nitrogen from all areas of the lungs. This technique uses prolonged breathing of 100% oxygen. As the participant inspires pure oxygen, nitrogen begins to exit the lungs. The total amount of N_2 is measured per each breath. When an exhaled breath contains <1.5% nitrogen, BreezeSuite adds in the total volume of nitrogen exhaled, to the equation. The comparison between the total nitrogen volume and room air yields the FRC. The computer automatically uses the slow vital capacity data saved in spirometry to calculate RV and TLC.

Statistical analysis

The data were transferred to Excel spreadsheet, and descriptive analysis was expressed as a mean ± standard deviation. All calculations were accomplished using GraphPad in Stat 3 software (demo version free software of GraphPad Software, Inc., California, USA). We calculated the statistical significance difference in the mean distribution of various parameters among various subgroups by Student's *t*-test. Difference was considered as statistically significant with $P < 0.05$.

RESULTS

Study participants had mean age 29 years, mean body mass index (BMI) 23 kg/m^2, average duration of smoking 7 years, and predominance of cigarette smoking ($n = 30$) than bidi smoking ($n = 24$) with majority being mild smokers (46 out of 54) [Table 1].

Cigarette smokers had a slightly better profile of pulmonary function tests as compared to bidi smokers, but all differences were statistically insignificant [Table 2].

Most of the dynamic lung function parameters correlated positively and significantly with age, BMI, smoking duration, quantity, and intensity. However, with these variables, static lung functions correlated negatively having mixed result when tested for significance. For nonspirometric measurements, these negative correlations were predominantly statistically insignificant. In general, association for parameters such as forced expiratory volume at the end of 1 s/forced vital capacity, expiratory reserve volume, RV, TLC, and RV/TLC ratio were predominantly insignificant (≤one out of five), duration or quantity of smoking yielded lesser significant correlations alone than together as SI [Table 3].

Typifying pattern of lung disease by GOLD criteria,[16] we found the majority of participants having normal pattern or mixed changes of obstructive and restrictive disease. Ten participants out of 54 had changes of restrictive lung disease, but none revealed pure obstructive lung disease [Table 4].

DISCUSSION

Smoking is perhaps the most potential preventable cause of various lung disorders, and tobacco is injurious to health or ban on smoking at the public place are effective but not sufficient enough means to minimize this popular indulgence. India has over 100 million current tobacco smokers that account for approximately one-fifth of global tobacco-related deaths.[17] Eighty-five percent of bidis produced around the globe are manufactured in India whose cheap availability[18] and certain stimulant effects make cessation of smoking difficult. Damage to lung parenchyma by smoke can lead to obstructive or restrictive or mixed pattern of lung diseases.[19-21] Smoking cessation is the only proven way of slowing down this disease progression.[20] Spirometry is routinely done as pulmonary function test, but it falls short of inferences which are of residual and functional importances such as

Table 1: General characteristics of study group (*n*=54)

Parameter	Mean±SD
Age (years)	28.78±7.08
Height (cm)	161.22±6.61
Weight (kg)	59.93±10.54
BMI (kg/m^2)	23.04±3.74
Smoking-duration	7.43±4.53
Type	
Bidi (*n*)	24
Cigarette (*n*)	30
Numbers per day	6.09±3.57
Smoking index	49.46±56.27

BMI: Body mass index, SD: Standard deviation

Table 2: Comparison of test values of lung volumes and capacities between bidi smokers and cigarette smokers (*n*=54)

Parameter	Test value		*P*
	Bidi smokers (*n*=24)	Cigarette smokers (*n*=30)	
Age (years)	29.94±7.78	27.09±6.21	0.25
BMI (kg/m^2)	23.52±4.22	22.34±2.87	0.48
Duration (years)	7.47±4.54	7.37±4.62	0.99
Number	6.06±4	6.14±2.93	0.67
Smoking index	47.53±54.82	52.27±59.49	0.65
VC (L)	3.16±0.90	3.26±0.82	0.70
FEV1 (L)	2.81±0.75	3.01±0.77	0.36
FEV1/FVC (%)	76.28±4.42	77.37±6.21	0.97
FEF - 25% (L/s)	4.54±1.86	5.75±2.02	0.0266*
FEF - 75% (L/s)	2.39±0.80	2.37±0.84	0.45
FEF - 25-75% (L/s)	3.67±1.11	3.96±1.31	0.54
FEF-max (L/s)	5.62±2.20	6.10±2.12	0.42
FIVC (L)	2.98±0.76	2.80±0.82	0.40
FIF max (L/s)	3.73±1.06	3.63±1.01	0.73
MVV (L/min)	109.63±29.93	113.59±37.76	0.98
SVC (L)	3.44±0.84	3.17±0.87	0.27
IC (L)	2.40±0.78	2±0.76	0.16
ERV (L)	0.99±0.55	1.01±0.64	0.90
FRC (L)	2.18±0.63	2.22±0.67	0.82
RV (L)	1.44±0.99	1.38±0.68	0.83
TLC (L)	4.18±1.18	4.39±1.01	0.50
RV/TLC (%)	20.81±2.38	21.36±2.67	0.35

*Statistical significance. BMI: Body mass index, VC: Vital capacity, FEV1: Forced expiratory volume at the end of 1 s, FVC: Forced vital capacity, FEF: Forced expiratory flow rate, FIVC: Forced inspiratory vital capacity, FIF max: Maximum inspiratory flow rate, MVV: Maximum voluntary ventilation, SVC: Slow vital capacity, IC: Inspiratory capacity, ERV: Expiratory reserve volume, FRC: Functional residual capacity, RV: Residual volume, TLC: Total lung capacity

Table 3: Correlation of age, body mass index, and smoking parameters with lung volumes and capacities among study group (*n*=54)

Parameter	Statistic	Age	BMI	Duration	Smoked/day	SI
FVC (L)	*r*	−0.47	−0.12	−0.28	−0.18	−0.33
	P	0.0003*	0.38	0.0411*	0.20	0.0135*
FEV1 (L)	*r*	−0.55	−0.22	−0.42	−0.27	−0.46
	P	0.0001*	0.11	0.0017*	0.0493*	0.0004*
FEV1/FVC (%)	*r*	−0.16	−0.28	−0.03	−0.18	−0.17
	P	0.24	0.0421*	0.81	0.21	0.21
FEF - 25% (L/s)	*r*	−0.37	−0.31	−0.36	−0.26	−0.41
	P	0.0069*	0.0239*	0.0080*	0.0547	0.0019*
FEF - 75% (L/s)	*r*	−0.60	−0.06	−0.48	−0.29	−0.45
	P	0.0001*	0.68	0.0002*	0.0324*	0.0007*
FEF - 25-75% (L/s)	*r*	−0.42	−0.27	−0.41	−0.31	−0.50
	P	0.0014*	0.0499*	0.0023*	0.0239*	0.0001*
FEF - max (L/s)	*r*	−0.32	−0.24	−0.33	−0.02	−0.33
	P	0.0179*	0.08	0.0166*	0.86	0.0143*
FIVC (L)	*r*	−0.41	−0.01	−0.21	−0.16	−0.27
	P	0.0021*	0.94	0.13	0.24	0.0451*
FIF max (L/s)	*r*	−0.33	−0.17	−0.23	−0.28	−0.30
	P	0.0165*	0.23	0.10	0.0384*	0.0254*
MVV (L/min)	*r*	−0.36	−0.32	−0.29	−0.25	−0.37
	P	0.0085*	0.0201*	0.0362*	0.0688	0.0054*
SVC (L)	*r*	−0.36	−0.03	−0.29	−0.21	−0.30
	P	0.0076*	0.86	0.0374*	0.12	0.0302*
IC (L)	*r*	−0.28	0.07	−0.16	−0.32	−0.25
	P	0.0402*	0.60	0.26	0.0198*	0.0634
ERV (L)	*r*	−0.14	0.01	−0.19	−0.26	−0.22
	P	0.32	0.95	0.19	0.0580	0.10
FRC (L)	*r*	−0.27	−0.27	−0.29	0.07	−0.18
	P	0.0478*	0.0501	0.0350*	0.61	0.0312*
RV (L)	*r*	−0.21	−0.31	−0.21	−0.09	−0.17
	P	0.14	0.0235*	0.14	0.53	0.21
TLC (L)	*r*	−0.40	−0.10	−0.23	−0.21	−0.26
	P	0.0020*	0.46	0.0921	0.121	0.0592
RV/TLC (%)	*r*	0.16	−0.07	−0.02	0.19	0.07
	P	0.25	0.63	0.86	0.17	0.60

*Statistical significance. BMI: Body mass index, VC: Vital capacity, FEV1: Forced expiratory volume at the end of 1 s, FVC: Forced vital capacity, FEF: Forced expiratory flow rate, FIVC: Forced inspiratory vital capacity, FIF max: Maximum inspiratory flow rate, MVV: Maximum voluntary ventilation, SVC: Slow vital capacity, IC: Inspiratory capacity, ERV: Expiratory reserve volume, FRC: Functional residual capacity, RV: Residual volume, TLC: Total lung capacity, SI: Smoking index

Table 4: Typifying respiratory patterns among study participants based on forced expiratory volume at the end of 1 s, forced vital capacity, and forced expiratory volume at the end of 1 s/forced vital capacity using gold criteria

Category	Normal	Obstructive	Restrictive	Mixed
n	23	0	10	21

FRC, RV, and TLC, and we measured the same. More so, there is no exact calibration of flow-volume plus, presence of dead space of spirometer itself, and other limitations[22] make results less reliable. Most studies are done in aged, symptomatic smokers in whom cessation is supposed to be less effective. In a sample of young, asymptomatic, nonobese, predominantly mild male smokers, we found declined lung transfer factor (DLC) which was comparatively small as compared to predicted.[9] We tried to have lung functions other than DLC in young, asymptomatic, predominantly mild smokers that too with prior and exact flow and volume calibration before each testing.

Despite lesser exposure to smoke and mild intensity of smoking and young age, spirometric parameters as well as FRC, RV, and TLC were found to be significantly reduced. This indicated restrictive pattern of disease as against obstructive or mixed which is seen in many studies.[20,22-24] It is in line with our previous work showing declined PFT parameters in habitual smokers who otherwise were taken as control for the study.[5] The contrast, though, can be attributed to method which is computerized spirometry in most cases,[4,6,12,22] participants which are young aged (mean age 30 years) as against older participants of other studies,[25] mean duration of smoking 7 years, low average SI, and predominance of mild smoking (80%) with no severe smokers. This may explain the absence of changes of obstructive pattern such as raised RV. A spirometer can measure volume changes, but measurement of pressure changes is more difficult as the changes in the transpulmonary pressure gradient must be taken into account. Hence, the FRC can be considered to determine the compliance. Decreased FRC indicates decreased compliance of lung-thorax together,[6] more requirement of work of breathing and diminished residual capacity of lungs for gas exchange. Hence, despite being asymptomatic, these participants can have reduced exercise tolerance as we saw none of the test participants being involved in sports activity requiring enduring strength.[26]

There are four levels to assess the pulmonary functioning – two out of which we have been scrutinized in the form of air breathed at relatively normal barometric pressure and measurement of lung volumes and capacities.[27] DLC and regional ventilation, perfusion are remaining two parameters[27] left to be explored. Moreover, we found DLC to be relatively unaffected in same participants, using same calibrated instrument but alveolar ventilation was significantly compromised due to smoking.[9] However, we found compromise even at the second level of simple indirect measures such as lung volumes and capacities. This indicates adequacy of this simple pulmonary function testing as a screening tool.

Bidi smoking is ten times more prevalent than tobacco,[2] but we found sixty percent prevalence of cigarette smoking, and that is due to sampling of participants from urban area, majority being working with young age[28] and comparatively good socioeconomic status. Despite the smaller amount of tobacco in bidis, they can produce more nicotine, carbon monoxide, and tar than the average manufactured cigarette due to the way users puff on them.[29] Bidi smokers had small and insignificantly reduced FRC, TLC, and RV in line with the fact that both form damages equally and filtered cigarettes are not much in use in India.[2,30] Insignificant effect of type of smoking was also seen in our previous work with respect to DLC.[9] However, regardless of the type of smoking, there was a negative association between smoking duration, intensity, SI, and declined lung functions which is in line with previous studies[18,20,31,32] and in same participants for results of DLC.[9] With years to come and with increase in intensity, these parameters can further decrease that accelerate age-induced diminished lung functions. Age was negatively and significantly related with lung functions indicating effect of aging on compromised lung status. Similarly, BMI negatively correlated with results, which is supported by a similar study.[33] Although average BMI was 23.4, it affects the lung volumes significantly suggesting once again the fact that lower BMI cutoff instead 25 is needed for Indian population.[34] Significance was more with combined SI than with individual contributor. This is due to low average years of smoking and young age with smoking per day being less. It highlights the fact that it is the SI that depends on duration and number of bidi/cigarette smoked per day is more important than mere duration of smoking, in line with observation of Prasad *et al*.,.[2] RV and TLC are associated weakly with SI showing that these functional parameters are not much affected in mild young smokers. Thus, stoppage of smoking, before any clinically evident respiratory impairment takes place, bears potential scope for preventive programs.

Limitations of the study

Although we highlighted significantly declined values of spirometric and nonspirometric lung functions in young, predominantly mild smokers, there were certain limitations of this study. We had smaller sample size, exclusion of females, no severe smokers with the absence of vertical follow-up, and use of Western prediction formula for calculation. Still it can be suggested that both functional and nonspirometric parameters can decline earlier, and screening can be used to reinforce antitobacco campaign. It warrants further study in this regard to reinforce the observation of our study.

CONCLUSION

We observed reduced dynamic, static, residual, and functional parameters of pulmonary functioning in predominantly mild, young, nonobese, sedentary apparently healthy smokers indicating restrictive pattern of lung disease that was unaffected by duration or type but by the intensity of smoking. These lung parameters regardless of its type are affected earlier, and cessation of smoking is suggested to be primordially preventive.

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Conflicts of interest

There are no conflicts of interest.

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