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Original Research Article

A Comparative Study of Pulmonary Function Tests in Air-Conditioner Users and Non Users

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Abstract: In recent times a great increase in the use of Air conditioners (AC) by common man has been observed. AC causes air to become cold and dry. This can adversely affect the health of the AC users, particularly respiratory system. The present study was selected to study the adverse effects of use of AC on respiratory health as measured by pulmonary function tests. The study was aimed to assess the effect of using AC on pulmonary function tests. To compare the parameters of pulmonary function tests of AC users with those not using AC and follow up of the same after 1 year.100 healthy, nonsmoker adults of age 25 – 50 yrs exposed to AC for minimum 6 hours a day since minimum 1 year were selected as study group. Controls were age and sex matched healthy, non-smoker 100 adults, not exposed to AC. Exclusion criteria were smoking, those with respiratory disorders, sportsmen & those doing pranayam or breathing exercises. Spirometry parameters recorded were, FVC, FEV_1, FEV_1/FVC, $FEF_{25-75\%}$, $FEF_{25-75\%}$/FVC and PEFR. Statistical analysis was done by applying students unpaired t test, Mann Whitney test and Wilcoxon's signed rank sum test. The PFT parameters, FEV_1, $FEF_{25-75\%}$ and $FEF_{25-75\%}$/FVC in AC users were significantly less than non AC users and follow up after 1 year showed $FEF_{25-75\%}$, $FEF_{25-75\%}$/FVC and PEFR significantly less in AC users than non AC users. The cool and dehumidified air of AC can cause increased airway resistance and may bring changes in pulmonary function tests of AC users. AC users should be advised for regular spirometry to prevent any further complications.
Keywords: AC, FEV_1, $FEF_{25-75\%,}$ PEFR, airway resistance.

INTRODUCTION

Today's modern lifestyle has led to increased use of Air conditioners (ACs) for providing cool pleasant atmosphere along with ventilation and disinfection of air. In addition to cooling they also make the air dry [1]. Inhalation of this cold dry air causes protective naso pulmonary reflex, bronchoconstriction and increases airway resistance [2, 3]. This ultimately decreases pulmonary function tests (FEV1, PEFR, $FEF_{25-75\%}$) and causes obstructive disease like pattern [4].

Prolonged use of ACs can also present with nasal irritation, rhinorrhea, sneezing, dyspnoea, wheezing etc [5 6]. There may also be hypersensitivity pneumonitis, increased eosinophils and IgG Ab [7]. ACs can also harbour and transmit Legionella, causative agent of Legionnaire's disease [8, 9]. Other hazards include toxicity of refrigerant materials which can present with headache, nausea, vomiting or with life threatening conditions like cardiac arrhythmias [10]. Hence the present study was undertaken in order to evaluate the effects of ACs on health by comparing the pulmonary function tests between AC users and non AC users.

AIMS AND OBJECTIVES

1. To study the effect of using AC on various pulmonary function tests as measured by spirometry in healthy, adult subjects and to compare spirometric parameters of AC users with non AC users.
2. To study and compare spirometric parameters of AC users and non AC users after 1 year.

MATERIAL AND METHODS

Study Design:

The study was approved from the ethical committee of BJ Govt Medical College, Pune. This is a comparative study. Subjects (100) were healthy, on obese males and females exposed to air conditioner for at least 6 hrs a day for minimum 1 year. Controls (100) were age, sex, BMI matched and not exposed to AC. Persons of age<25 and >50 years, smokers, sportsperson, obese (BMI >29.9, waist circumference males>90 cm and females >85cm [11]), those with respiratory disorders, doing pranayam and with H/o major surgery were excluded. Informed consent was taken and a questionnaire was filled. The same subjects were followed up and the procedure was repeated after 1 year.

Readings	AC users (Study group)			Non AC users (Control group)		
	Males	Females	Total	Males	Females	Total
1st (Basal)	60	40	100	59	41	100
2nd (Follow up)	54	37	91	40	32	72

The following pulmonary function parameters were measured using a computerized portable NDD Easy ware spirometer, which is automated and has a flow sensor:

a) Forced vital capacity (FVC) in litres.
b) Force expiratory volume in one second (FEV_1) in litres.
c) FEV_1/FVC in %.
d) Forced expiratory fraction $_{25\text{-}75\%}$ in litre per second
e) Peak expiratory flow rate (PEFR) in litre per second and

In addition to the parameters recorded, $FEF_{25\text{-}75\%}$/FVC ratio was also calculated. The tests were conducted according to the American Thoracic Society/ European Respiratory Society (ATS/ERS) task force guidelines [12].

Statistical analysis was done using BMDS 2 (Boi medical data system) software. Age, height, weight, BMI and waist circumference of both groups were compared using Student's unpaired t test and p value was calculated. For the comparison of pulmonary function test parameters between AC users and Non users, independent sample 't' test was done .Non-parametric test namely Mann-Whitney 'U' test was also done. For the statistics of follow up reading, Wilcoxon's signed rank sum test was applied.

OBSERVATRIONS AND RESULT

The table-1 shows that both the groups are age, sex, ht, wt and BMI matched.

The table-2 shows that **FEV_1 (L), $FEF_{25\text{-}75\%}$(L/sec) and $FEF_{25\text{-}75\%}$/FVC (L/sec)** of AC users is significantly less than that of non AC users.

The table-3 shows that the above table shows that there was significant decrease in **FVC, FEV1, FEF25-75%** and **PEFR** of AC users after 1 year.

The table-4 shows that there is no significant change between 1st and 2nd readings of pulmonary function test parameters of Non AC users.

Table 1: Comparison of demographic parameters between AC users and Non-users

Parameter	AC Male n=60 Mean±SD	Non AC Male n=59 Mean±SD	p value	AC Female n=40 Mean±S.D	Non AC Female n=41 Mean±SD	p value	AC M+F n=100 Mean±SD	Non AC M+F n=100 Mean±SD	p value
Age(years)	33.5±5.33	33.61±7.95	>0.05	33.74±5.46	33.88±7.71	>0.05	33.59±5.35	33.56±7.78	>0.05
Sex	60	59	>0.05	40	41	>0.05	-	-	-
Height(cm)	168.7±7.16	168.7±7.29	>0.05	162.82±9.49	160.92±5.64	>0.05	165.38±8.61	165.53±7.68	>0.05
Weight(kg)	68.83±10.47	67.69±8.47	>0.05	64.94±10.15	63.41±7.39	>0.05	67.30±10.47	65.94±8.28	>0.05
BMI(kg/m^2)	24.02±3.06	24.15±2.59	>0.05	24.43±2.76	24.49±2.43	>0.05	24.18±2.94	24.92±2.52	>0.05
Waist(cm)	81.63±5.91	81.66±3.76	>0.05	79.55±4.43	80.07±3.27	>0.05	80.81±5.45	81.05±3.63	>0.05

p >0.05 is non-significant

Table 2: Comparison of 1st (basal) readings of pulmonary function test parameters between AC users and non-users.

Parameter	**AC user(M+F) n=100**	**Non user(M+F) n=100**	**p value**
	Mean±S.D.	Mean±S.D.	
FVC(L)	3.30±0.82	3.32±0.81	>0.05
FEV_1(L)	**2.79±0.70**	**2.85±0.76**	**<0.05***
FEV_1/FVC%	84.69±8.23	85.98±7.1	>0.05
$FEF_{25-75\%}$ (L/sec)	**2.81±0.9**	**3.23±0.93**	**<0.05***
$FEF_{25-75\%}$/FVC (L/sec)	**0.89±0.36**	**1.02±0.32**	**<0.001****
PEFR(L/sec)	6.51±2.27	6.92±1.73	>0.05

p<0.05* is significant and p<0.001** is highly significant

Table 3: Comparison between 1st (basal) and 2nd (follow up) readings of pulmonary function test parameters of AC users

Parameter	**AC users n=100 1st Readings Mean±S.D.**	**AC users n=91 2nd Readings Mean±S.D.**	**p value**
FVC(L)	**3.30±0.82**	**3±0.87**	**<0.001****
FEV_1(L)	**2.79±0.70**	**2.57±0.69**	**<0.001****
FEV_1/FVC%	84.69 ±8.23	86.32± 7.98	>0.05
$FEF_{25-75\%}$ (L/sec)	**2.81±0.9**	**2.60±0.86**	**<0.05***
$FEF_{25-75\%}$/FVC (L/sec)	0.89±0.36	0.94±.47	>0.05
PEFR(L/sec)	**6.51±2.27**	**5.61±2.04**	**<0.001****

p<0.05* is significant and p<0.001* is highly significant.

Table 4: Comparison between 1st (basal) and 2nd (follow up) readings of pulmonary function test parameters of non AC users

Parameter	**non AC users n=100 1st Readings Mean±S.D.**	**non AC users n=72 2nd Readings Mean±S.D.**	**p value**
FVC(L)	3.32±0.81	3.08±0.68	>0.05
FEV1(L)	2.85±0.76	2.70±0.66	>0.05
FEV1/FVC%	85.98±7.1	87.3±5.22	>0.05
FEF25-75% (L/sec)	3.23±0.93	3.21±0.72	>0.05
FEF25-75%/FVC (L/sec)	1.02±0.32	1.07±0.28	>0.05
PEFR (L/sec)	6.92±1.73	6.48±1.47	>0.05

p>0.05 is not significant

DISCUSSION

The present study was undertaken to evaluate the adverse effects of using AC on respiratory system by doing comparison of pulmonary function tests between AC users and non AC users. Table 1 shows the comparison of demographic parameters between AC users and Non users .For this, student's unpaired 't' test was applied except for the variable of sex which was compared by using Pearson's Chi square test. The p value for all these parameters was >0.05 which is non-significant which shows that both the groups were comparable with respect to anthropometric parameters.

Table 2 shows the comparison 1st (basal) readings of pulmonary function test parameters between AC users and non-users. For this comparison, Mann Whitney test was applied .It was observed that p value >0.05 for FVC which shows that the difference of FVC in both the groups is non-significant. For FEV_1 $p<0.05$* which shows that FEV_1 of AC users is significantly low as compared to that of Non AC users. The ratio of FEV_1/FVC% showed $p>0.05$. So the difference of this ratio between two groups is non-significant. The next parameters that were compared were $FEF_{25-75\%}$ and $FEF_{25-75\%}$/FVC with $p<0.001$** which is highly significant lower values in AC users. For PEFR (L/sec),p >0.05 and therefore non-significant.

In Table 3, comparison is done between 1st (Basal) and 2nd (Follow up) readings of pulmonary function test parameters of AC users. Here, Wilcoxon's signed rank test was applied since the readings of same persons are compared after 1 year. According to this table, the decrease in FEF25-75% over 1 year period was significant ($p<0.05$) and decrease in FVC, FEV1, and PEFR was highly significant ($p<0.001$) in AC users. Whereas, the changes in FEV1/FVC and FEF25-75%/FVC were non-significant ($p>0.05$).

Table 4 shows the comparison between 1st (Basal) and 2nd(follow up) readings of pulmonary function test parameters of Non AC users. All the changes were non-significant with $p>0.05$ There are evidences that inhalation of cold and dry air has detrimental effects on health, especially respiratory system. Our respiratory system has inherent reserve capacity due to which symptoms of a disease appear only after considerable pathological changes have occurred. Hence there are chances that subjects exposed to cold and dry air may have certain alterations in pulmonary function test parameters at subclinical stage.

Due to cold air inhalation, airway becomes hyper responsive [13, 14]. Bronchoconstriction occurs and it increases resistance of airways. This makes person susceptible to COPD [3]. The mechanism causing bronchoconstriction is vagal mediated nervous reflex [15]. The other factor behind it is increase in the number of mast cells. They release histamine which is a known bronchoconstriction [4, 16, 17]. Cold air also causes epithelial desquamation and loss of epithelial derived relaxation factor which leads to bronchoconstriction [18]. Repeated cooling and desiccation also causes airway remodeling same as that of asthma [19, 20]. Other effects of cold and dry air are: Increased mucosal blood flow [19] and congestion of nasal mucosa, sneezing and rhinorrhoea [4]. It also removes the protective mucosal barrier which exposes underlying submucosa [18]. This leads to inflammatory changes and increase in the number of eosinophils [21].

In the present study we compared PFT parameters like: FVC (L), FEV_1 (L),FEV_1/FVC (%), $FEF_{25-75\%}$(L/sec), $FEF_{25-75\%}$/FVC (L/sec) and PEFR (L/sec) in the subjects with controls. FEV_1 is the volume of air which can be forcibly exhaled from the lungs at the end of first second of a forced expiratory maneuver. It measures about 80 % of FVC in normal healthy subjects. In our study, it was observed that the 1st (basal) reading of FEV_1 in AC users was significantly less than Non AC users. FEV_1 values though significantly less in AC users were within normal limits. These results point towards development of obstructive pattern [22] in AC users. When the comparison was done between 1st (Basal) and 2nd (Follow up after 1 year) readings of AC users we observed that their FEV1 was significantly decreased after 1 year. This again points towards development of obstructive pattern in AC users.

$FEF_{25-75\%}$ is the mean forced expiratory flow between 25% and 75% or middle half of the FVC. It is also known as the maximum mid-expiratory flow. This index is taken from the blow with the largest sum of FEV_1 and FVC. Normally it is ≥60%. Decrease in $FEF_{25-75\%}$ indicates early smaller airway obstruction. It is regarded more sensitive but variable measure of narrowing of smaller airways than provided by FEV_1 [23-25].

In our study, it was observed that in AC users the 1st (basal) reading of $FEF_{25-75\%}$ was significantly less than Non AC users. When the comparison was done between 1st (Basal) and 2nd (Follow up) readings after 1year of AC users we observed that heir FEF25-75% was significantly decreased after year. These results suggest that exposure to cold and dry air leads to small airway obstruction though to a subclinical extent. $FEF_{25-75\%}$/FVC is the ratio between airway calibre and lung size (airway size relative to lung size). In our study the 1st (basal) readings of $FEF_{25-5\%}$/FVC was significantly less in AC users than Non AC users. Decrease in $FEF_{25-75\%}$/FVC also points towards development of obstructive pattern in AC users [26]. PEFR is maximum flow rate achieved by the patient during the forced vital capacity maneuver. It measures about 5-6 L/sec. It denotes the size of larger bronchi and bronchioles.

In our study it was observed that in AC users the 1st (basal) reading of PEFR was less than Non AC users but it was non-significant. When the comparison was done between 1st (Basal) and 2nd (Follow up) readings after 1 year of AC users we observed that their PEFR was significantly decreased after 1 year. Decrease in $FEF_{25-75\%}$ without decrease in PEFR in AC users in basal readings and decrease in $FEF_{25\text{-}75\%}$ along with decrease in PEFR after 1 year indicates that initially there is involvement of small airways and later on medium and large size airways are also involved over a period of time.

FVC is the volume of air which can be forcibly and maximally exhaled out of the lungs after the patient has taken in the deepest possible breath. In our subjects, 1^{st} (basal) reading of FVC was less than that of controls, though it was not significant. Also all our subjects were asymptomatic. This may be the beginning of development of restrictive pattern in AC users due the hypersensitivity pneumonitis which causes interstitial disease like changes [27, 28]. The comparison between 1^{st} (Basal) and 2^{nd} (Follow up) readings after 1 year of AC users showed significant decrease in FVC, without statistically significant alteration in FEV1/FVC ratio. Decreased FVC values without statistically significantly altered FEV1/FVC ratio indicates restrictive pattern. In summary, our results are suggestive of mixed type of respiratory pattern but at a subclinical level.

Applications of the study:

- Here, we would like to mention that though AC provides cool and pleasant environment, one should try to cut down its use as far as possible.
- AC users should practise breathing exercises like pranayam to improve their pulmonary function tests.
- They should also undergo pulmonary function tests regularly to detect any changes at an earlier stage.

SUMMARY AND CONCLUSION

The present study was undertaken with the aim of comparision of pulmonary function tests between AC users and non AC users. And it was observed that: FEV_1, $FEF_{25\text{-}75\%}$, and $FEF_{25\text{-}75\%}$/FVC were significantly low in AC users as compared to Non AC users. Follow up after 1 year showed that the parameters, FVC, FEV1, FEF25-75% and PEFR were significantly decreased in AC users .This decrease in AC users is attributed to vagally mediated bronchoconstriction due to cold and dry air of AC. Hence, we can conclude that cool dry air of AC affects respiratory system and causes obstructive disorder which in turn decreases pulmonary function tests.

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