

Original Research Article

Pulmonary functions in car air conditioner users and non-air conditioner users in tertiary care centre, South Tamilnadu, India

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ABSTRACT

Background: Air conditioners are used extensively these days of the modern lifestyle. Inhalation of cold dry air while using Air conditioners causes bronchoconstriction due to which alteration may occur in pulmonary function. This study was aimed to compare the Pulmonary Function tests of Car AC users and non AC users.

Methods: The Study included 52 employees not exposed to car air conditioner as a control (group I) and 52 employees exposed to car air conditioner with minimum exposure of 1 hour per day for 6 months as a subject (group II). Pulmonary function tests were performed using computerised spirometer. Statistical analysis was done by unpaired t test.

Results: Age, Height and weight are not statistically significant between study group and control group. Forced vital capacity, forced expiratory volume in 1 second, Ratio of Forced vital capacity and Forced expiratory volume in 1 second, Inspiratory reserve volume, Expiratory reserve volume, Maximum voluntary ventilation are decreased in car air conditioner users compared to non-users, but was not significant. Forced expiratory flow (FEF), Peak expiratory flow rate (PEFR) values shows statistically significant decreased in car air conditioner users.

Conclusions: The present study shows hyper-responsive airways on exposure to cold air which leads to bronchoconstriction. The significant decrease in PEFR, FEF suggest that upper airways as well as smaller airways are affected on exposure to car AC. So, Exposure to car Air Conditioner leads to risk of developing respiratory dysfunction.

Keywords: Air conditioner, Forced expiratory flow, Peak expiratory flow rate, Pulmonary Function test

INTRODUCTION

Air conditioners usage is being increased now a day. Air-conditioner gives cool air by decreasing the humidity of the air through vapour condensation.¹

Air Conditioner (AC) made of refrigerant materials like ammonia, non-halogenated hydrocarbons like methane and works on principle of Refrigeration cycle. They

decrease the humidity of air and make it dry. There is a cold condenser coil which condenses water vapour and this formed water can be removed by drain. Hence, AC makes the air cool and dry.² There is marked increase in the number of Respiratory illness, more commonly in persons who use AC's. AC users have complaints of irritation in nasal mucosa, difficulty in breathing, skin irritation, headache and fatigue.¹

The Modern lifestyle of using air conditioner leads to the airway problems, which cause decrease in the pulmonary function test parameters. Long duration of inhalation of cold dry air leads to airway hyper responsiveness. The cold air inhalation causes inflammation and Airway epithelial damage which is a critical feature of airway hyper-responsiveness. Exposure to cold dry air may stimulate mast cells. The above factors lead to the airways hyper-responsive and bronchoconstriction.^{3,4}

Cold air challenge test, in which hyperventilation of cold dry air is given as stimuli that produce bronchial responsiveness. The bronchial responsiveness produced is mainly bronchoconstriction.^{5,6} Thus it is also observed that the same bronchial response is seen in asthmatics when they are exposed to cold dry air.⁷⁻⁹ So AC usage leads to exposure of cold dry air that in turn leads to alteration in pulmonary functions.

Hyperpnoea produced by cold air exposure cause the airway surface fluid to evaporate more rapidly and leads to drying and hyper tonicity of the airway surface fluid, this influences release of inflammatory mediators from the airway mucosa.¹⁰

Inhalation of cold dry air increases the response of epithelial cells that cause increase in nasal secretion and still longer duration of cold air exposure leads to increase in Broncho-alveolar lavage fluid and granulocytes in healthy humans.¹⁰

Car AC users have decrease in pulmonary functions as the cold air flow in the direction towards the subject's face and the subjects used car AC during the hot humid environment, this climate is prone for the growth of allergens.¹¹

Pulmonary ventilation is studied by recording the volume of movement of air into and out of the lung with the help of spirometer. Pulmonary function tests are valuable non-invasive investigation in diagnosis, management of respiratory diseases, and prognosis of diseased patients who were treated previously, monitoring response of treatment to disease, helps in planning for further treatment and intervention. They provide important information related to the large and small airways, the pulmonary parenchyma, the size and the integrity of the pulmonary capillary bed.¹²⁻¹⁴

There is no clear study so far showing the effect of Air Conditioner's on pulmonary functions. The present study is to compare the pulmonary functions of car Air Conditioner users and who do not use AC and so as to substantiate the fact that Air Conditioner users have an effect on their Pulmonary Functions.

Aims and Objectives

- To determine Pulmonary Function Tests in Car AC users.

- To determine Pulmonary Function Tests in non AC users.
- To compare the Pulmonary Function tests of Car AC users and non AC users.

METHODS

It was a Cross Sectional Study conducted at Department of Physiology, Sree Mookambika Institute of Medical Sciences, Kulasekharam (kanyakumari District), Tamilnadu. This study was done in Hundred and four subjects who were staffs of Sree Mookambika Institute of Medical Science are included in the study after written informed consent obtained from them before enrolling them into study. There were two groups of subjects based on car AC's usage and non-users, among employees of Sree Mookambika Institute of Medical Science. Group I constituted 52 employees of Sree Mookambika Institute of Medical Science of age group 25-50 who did not use Car AC's and group II consist of 52 employees of Sree Mookambika Institute of Medical Science of same age group, who use car air conditioner for at least 1 hour each day during last 1 year.

Inclusion criteria

- Age: 25-50 years
- Males and Females
- Exposure to Car AC for at-least one hour per day for one year.

Exclusion criteria

- History of bronchial Asthma and cough
- History of acute or chronic respiratory disorders
- Systemic illness may affect the Respiratory system
- Smokers
- On chronic medications like
- Bronchoconstriction drugs like pilocarpine, oxymetazoline , Phenylephrine, beta blockers like propranolol
- Bronchodilators drugs like Beta- agonist (salbutamol), Xanthine (deriphylline), Steroids (hydrocortisone).

After considering inclusion and exclusion criteria, the details of each study subject including age, sex and height of the individual and weight of the subject was recorded. These data were entered in the computer before the pulmonary function test was performed. Further Pre-clinical examination was done to rule out respiratory problems.

The parameters taken for the study using computerized spirometry is Forced Vital Capacity(FVC), Forced Expiratory Volume in1 second (FEV1), Ratio of FEV1 to FVC (FEV1/FVC), Peak Expiratory Flow Rate (PEFR), Forced Expiratory Flow at 25% to 75% (FEF25%),

Forced Expiratory Flow at 25% (FEF25%), Forced Expiratory Flow at 50% (FEF50%), Forced Expiratory Flow at 75% (FEF75%), Inspiratory reserve volume, expiratory reserve volume, and Maximum voluntary ventilation.

The procedure was carried out in Spiro excel with Medicaid systems, using the standard laboratory methods. It was carried out between 10:00 AM to 11:00 PM. The test module is now activated & the subject was given proper instructions about the procedure to be performed. The subjects were made to relax for 5 minutes and then following various maneuvers were performed. Throughout the procedure the subject were seated comfortably in erect Position. The mouthpiece was connected to the subject to breath in it. The procedure and equipment was made familiar to the subject before doing.

Pulmonary test maneuver 1

This maneuver was carried out for the following parameters: Forced Vital Capacity (FVC), Forced Expiratory Volume in 1 second (FEV1), Ratio of FEV1 to FVC (FEV1/FVC), Peak Expiratory Flow Rate (PEFR), Forced Expiratory Flow at 25% to 75% (FEF25%), Forced Expiratory Flow at 25% (FEF25%), Forced Expiratory Flow at 50% (FEF50%), and Forced Expiratory Flow at 75% (FEF75%).

The steps for this maneuver as follows

- Subject was asked to take a full deep breath
- Then hold the mouthpiece in the lips tightly and nose clip was kept in the nose.
- Breathe out as forcefully as possible into the mouthpiece.

The maneuver was repeated 3 times with 5 minutes interval and average of the 3 readings was noted in the case record sheet, which was used for the data analysis.

Pulmonary function testing Maneuver 2

The pulmonary function testing maneuver 2 was carried out for following parameters: Expiratory reserve volume (ERV) and Inspiratory reserve volume (IRV).

These parameters were recorded with the following steps

- Hold the mouthpiece between the lips tightly with nose clip in the nose
- Breathe normally for 2 to 3 times into the mouthpiece
- Then followed by maximum expiration slowly as long as possible
- Then inspire to the maximum slowly as long as possible
- Finally continue normal breathing for 2 to 3 times.

The above maneuver was repeated 3 times with 5 min interval and the average was noted which was recorded in case record form for final data analysis.

Pulmonary function testing maneuver 3

This maneuver was carried out for the following parameter: Maximum voluntary ventilation (MVV). It was recorded in the study subject with the following steps.

- Hold the mouthpiece very tightly with the lips and the nose clip placed in the nose.
- Breathe deeply at the rate of 30 breaths per minute for minimum of 15 seconds.

The above maneuver was repeated 3 times with 5 min interval and the average of the 3 readings was noted in the case record form for the data analysis.

Values of all the pulmonary function test parameters obtained from each subject were saved in the computer.

All the parameters were maintained in a separate file and were noted in the case record form which was taken for data analysis. Unpaired 't' test was used to find out the statistical significance between the two groups. $P < 0.05$ was considered as statistically significant. The results in tables are presented as Mean \pm SD.

RESULTS

In this study, total 104 numbers of subjects were included after considering inclusion and exclusion criteria and were made into 2 groups of 52 numbers each.

Group I consist of subjects not exposed to AC and Group II consist of subjects exposed to Car AC. Data are represented as Mean \pm SD and P value < 0.05 is significant. The baseline characteristics of the study subjects are mentioned in Table 1.

Table 1: Baseline characteristics of study subjects.

	Group I	Group II
Age (in years)	33.53 \pm 6.864	35.980 \pm 7.157 ^o
Height(in centimetres)	165.019 \pm 7.434	163.153 \pm 7.044#
Weight(in kilograms)	65.25 \pm 9.74	63.30 \pm 9.106\$

The baseline characteristics like age, height, weight of the study subjects were analysed by unpaired 't' test and are not found to be significant between Group II and Group I.

The changes among the study group and control group have been displayed in table 2. The study showed decline in FVC, FEV1, FEV1/FVC in Group II, but statistically was not significant ($P > 0.05$). But the study showed

decline in FEF 25-75%, FEF 25% FEF75%, PEFR in Group II was statistically significant(P< 0.05).

Table 2: Assessment of change in FVC, FEV1, FEV1/FVC, PEFR, FEF 25-75%, FEF 25% FEF75% between study groups I and II.

Parameters	Group I (Mean± SD)	Group II (Mean± SD)	T	p-value
FVC(L)	3.228±0.690	3.146±0.614@	0.64	0.52
FEV1 (L/sec)	2.874±0.638	2.691±0.648#	1.44	0.15
FEV1/FVC%	87.51±7.736	86.14±7.357\$	0.92	0.35
PEFR(L/sec)	7.069±2.138	6.129±1.583*	2.54	0.012*
FEF25-75% (L/sec)	5.005±1.327	4.386±1.104	2.58	0.01*
FEF25%(L/sec)	6.180±1.706	5.501±1.354	2.250	0.026\$
FEF 50%(L/sec)	5.279±0.187	4.664±0.201	2.240	0.027#
FEF 75%(L/sec)	3.188±0.119	2.763±1.054	2.251	0.026@

Figure 1 shows the comparison between Group I and Group II The study showed decline in FEF 25-75%, FEF

25% FEF75%, PEFR in Group II compared to Group I, it was found statistically significant (P< 0.05).

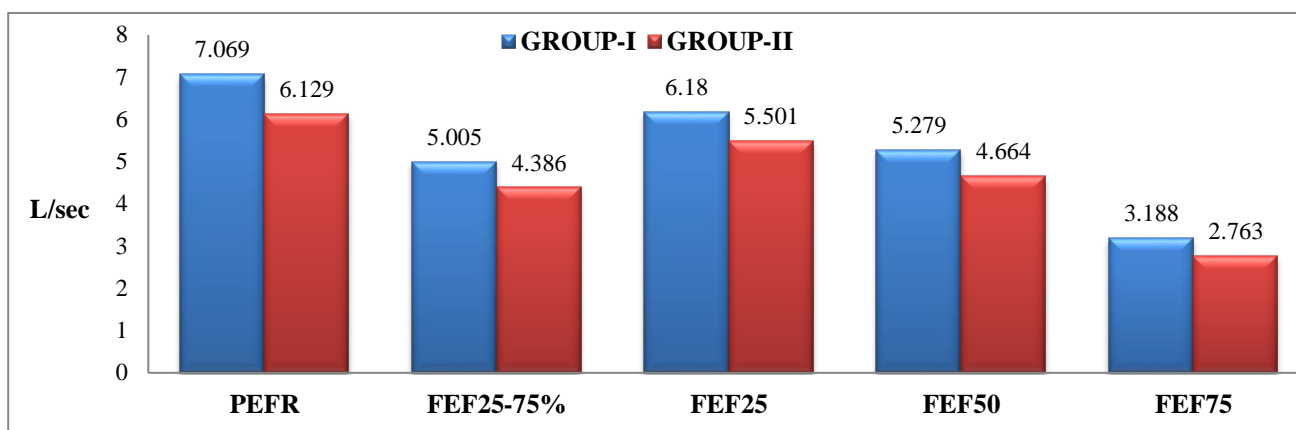


Figure 1: Comparison of PFT parameters between Group I and Group II.

Table 3: comparison of PFT parameter (IRV, ERV, MVV) between Groups I and II.

Parameter	Group I (Mean±SD)	Group II (Mean±SD)	T	p- Value
IRV(L)	0.68±0.50	0.61±0.54	0.825	0.4
ERV(L)	1.048±0.54	0.94±0.51	0.94	0.34
MVV(L/sec)	75.85± 10.75	71.63± 12.46	1.844	0.06

The changes in ERV, IRV, and MVV among study groups have been shown in table 3. The study results showed decrease in ERV in Group II, but not statistically significant change.

DISCUSSION

The present-day lifestyle leads to extensive AC usage leads to respiratory problems. The companies and offices for the comfort of staffs and to make them do more work for long duration centralised AC’s are preferred. During

travel by using cars or any other vehicles now AC is required for the purpose of comfort.

Present study has shown that using air conditioner in cars during travel causes impairment in respiratory functions which in future may lead to complications.¹⁵

This Study was carried out among hundred and four subjects. It consist of 2 groups on the basis of AC car usage, Group I act as control and group II consist of

subjects of same age group, who uses AC car for minimum of 1 hour each day during last 1 year.

This study showed significant decline of PEFr, FEF_{25-75%}, FEF_{25%}, FEF_{50%}, FEF_{75%} on subjects exposed to car AC. It also show decrease in FVC, FEV₁, FEV₁/FVC, MVV, IRV, ERV, but the decrease was not significant.

PEFR is the maximum velocity at which air is blown out from the lungs following deep inspiration. It is expressed in litres per sec. It depends on expiratory efforts and status of upper airways; it also reflects the calibre of bronchi.¹⁵ This decreases in conditions that cause airway obstruction.³

In the present study it was found there was a significant decrease in peak expiratory flow rate in Car Air Conditioner users when compared to non-users. This may be due to involvement of the upper airways due to exposure to AC environment. A study on pulmonary function test to assess the effect of Air Conditioner in 96 healthy subjects, showed significant decrease in PEFr on AC users compared to non-users.¹⁶

Maximum Mid Expiratory Flow Rate (FEF 25-75%) is the flow rate at middle half of FVC. It is not dependent on effort. This indicates patency of smaller airways. FEF 25-75% is useful in identifying small airway diseases. The Obstruction in the small airways is the main cause for asthma and this may gradually lead to problem in larger airways later.³

FEF 25% is the flow rate of air of 25% to that of FVC, indicative of status of medium bronchi. FEF 50% indicates air flow at the rate of 50% to that of FVC, indicates the patency of medium and smaller airways. And FEF 75% indicates air flow at the rate of 75 % to that of FVC and is the indicative of patency of smaller airways.^{3,17}

In the present study it shows that the values of FEF 25-75%, FEF 25%, FEF 50%, and FEF 75% were decreased significantly in AC users which suggest that cold dry air exposure due to AC usage affects the smaller airways.

This may be due to the inhalation of cold dry air which cause dehydration injury and desquamation of the epithelial cells of the airway that results in the destruction of mucosal barrier in nose, loss of relaxant factor from epithelium of mucosa, these all factors contribute to bronchoconstriction following AC exposure.³

For adequately dressed person skin of face and nose are the parts of body that are exposed to AC. Inhalation of cold dry air on AC exposure results in stimulation of cold receptors present in mucosa leads to bronchoconstriction.¹⁶ The inhalation of cold dry air causes bronchoconstriction by non-nervous reactions. Nasal inhalation of cold dry air will lead to mast cell

activation and stimulation of sensory nerve. 18Sensory nerve exposure which leads to “Naso-bronchial reflex”, the afferent nerve is maxillary and the efferent nerve is vagal. Vagal Parasympathetic nerve gets activated and may lead to bronchoconstriction.¹⁰

When the sub mucosa got exposed to cold dry air leads to the release of inflammatory Mediators, mast cells and the inflammatory cells which leads to bronchoconstriction.¹⁸ The stimulation of irritant receptors and release of histamine produces reflex tachypnoea and bronchoconstriction.³ Bronchoconstriction increases airway resistance which in turn increases respiratory rate.⁶

Long durational and repeated exposure results in remodelling of airways which is seen similarly in asthmatics. It may also cause atopic sensitization and increase in eosinophil activity. Hence long term AC use affects lung function, which may predispose to Asthma in sensitive Subjects.¹⁶

Subjects who are being exposed to AC for a long duration results in Respiratory tract hyper-responsiveness and decrease in patency of the airways, which results in decreased FEV₁, FEF_{25-75%} and PEFr values. 15So the reason behind the findings in the present study is mainly hyper-responsiveness in airways and the other contributing factors results in bronchoconstriction and reduced dynamic compliance of lungs following exposure to AC.

Timed vital capacity (FEV₁) was found to be the detector of generalized airway obstruction.³ Maximum Voluntary Ventilation is the greater amount of air that can be blown out of lungs per minute by voluntary effort.² In the present study there was a statistically significant decrease in PEFr, FEF and a decline in MVV which was not significant.

In the present study the values of PEFr, FEF 25-75%, FEF 25%, FEF 50%, FEF_{75%} were significantly decreased with normal FEV₁ and decline in FVC, FEV₁/FVC, IRV, ERV, but not significant. This significant decrease in PEFr, FEF_{25-75%}, FEF_{25%}, FEF_{50%}, FEF 75% with normal FEV₁ suggests early small airway obstruction.^{4,19,20}

Similar study done on pulmonary function tests to assess the effect of (AC) in 10 healthy young non-smoking males who use car AC's for minimum of 1 hour each day for past 6 months and ten control subjects showed the parameters PEFr, FEF_{25-75%}, FEF_{25%}, FEF_{50%}, FEF_{75%} were significantly reduced with no decrease in FEV₁ and decrease in FVC, FEV₁/FVC, ERV, MVV but not significant decreased in subjects using car AC's.²¹

Present study on the effect of AC exposure on respiratory tract evidence more due to decrease in surface area in cars, air blowing will be directly to face. The room AC

users air flow is not uniform and more surface area so the effect of PFT on car AC users are more affected than room AC users.²⁰

Subjects using car AC's in this hot humid environment, that climate is prone for the growth of various allergens.¹⁹ Air conditioners in cars also give rise to respiratory problems, due to microorganisms that are formed in the Air conditioner units.¹ Present study indicates that the car AC had significantly lower lung volumes and capacities when compared with controls. The decreased values of lung functions may indicate underlying lung dysfunction due to exposure to AC environment.²

CONCLUSION

Car Air Conditioner Usage cause statistically significant decrease in PEFR, FEF 25-75%, FEF 25%, FEF 50%, FEF 75% .Thus from the present study it was found both upper larger as well as smaller airways gets affected due to cold dry air exposure from AC cars. The inhalation of cold dry air causes inflammation and stimulation of mast cells which cause release of histamine. It also leads to stimulation of cold receptors in nasal mucosa that in turn stimulate parasympathetic nerves. Above all factors lead to hyper-responsiveness and bronchoconstriction. Thus decreases the lung functions. AC exposure also increases the risk of allergic disorders. So regular Spirometry screening was suggested for car AC users.

Recommendations

Car AC users should undergo pulmonary function tests regularly which will ensure early detection of underlying respiratory dysfunctions, also early intervention and thereby prevention of complications that may arise later in life. Usage of humidifiers, heat and moisture retaining masks can prevent the effect of cold Air from car AC.

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Ethical approval: The study was approved by the Institutional Ethics Committee

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