

diseases due to proliferating house dust mites & increasing concentration of indoor air pollutants, which lead to the elevation of serum Ig E levels or the enhancement of eosinophil activity (6–8). One of the component in modern lifestyle is intensive use of AC's, which has increased the risk of atopic sensitization (9, 10). While the absence of air conditioners and use of hot water heating systems is also reported to have a negative relationship with FEV1 (11). Increased prevalence of IgG induced sensitization and hypersensitivity pneumonitis is reported in persons exposed to aerosols of contaminated AC's (12). While fluorinated hydrocarbons collectively referred as freons have been shown to result in widespread toxicity after accidental or intentional inhalation. Freon inhalations may lead to the production of cardiac arrhythmias. Freons primarily serve as propellants and are widely used in cooling systems (13).

The above studies indicate a link between the use of AC's and various cardiorespiratory functions. To the best of our knowledge there is no study showing the effect of AC's on various pulmonary functions. Therefore the present study was planned to evaluate the lung function tests of young healthy nonsmokers using car AC's.

METHODS

Students of University College of Medical Sciences between 18–28 years of age were assessed for their pulmonary functions. The subjects were divided into two groups based upon usage of car AC's. Group I constituted ten subjects who were using car AC's for at least 1 hr daily for the past 6 months.

Recordings were done within one hour of using AC between 9–11 am. While ten subjects who did not use AC's either in car or anywhere else constituted group II. Exclusion criteria were:

- Presence of any acute or chronic respiratory disorder
- Systemic illness which directly or indirectly affects the respiratory system
- Smokers
- Use of car AC's on irregular basis or for less than 1 hr daily.

Anthropometrical measurements including age, height and weight were recorded. Further a preliminary clinical examination was carried out on the subjects to rule out any medical problems.

The pulmonary function test was carried out using Spiro 232 of PK Morgan with built in computer program, using the standard laboratory methods. The questionnaire was filled up & the relevant data (name, age, sex, height, weight, occupation, smoker/non smoker) was entered into the computer. The test module was now activated and the subject was given proper instructions about the procedure to be performed. All pulmonary function tests were done on the subjects comfortably seated in an upright position. The subject was connected to the mouthpiece and was asked to breathe in order to familiarize himself with the equipment. During the tests the subject was adequately encouraged to perform at their optimum level and also a nose clip was applied during the entire maneuver. Test

was repeated at least 3 times and the best matching results were considered for analysis. All recordings were done at BTPS. Residual volume, Functional residual capacity, Total lung capacity, airway resistance and compliance are derived values, rest all are measured by the machine. The algorithms used for calculation have been validated for Indian populations with the new software added up to the machine.

The outcome of pulmonary function tests was presented as a mean ± SD for each of the parameter. The two groups were compared by applying unpaired 't' test and P value of less than 0.05 was considered as significant.

RESULTS

The anthropometric parameters of the subjects and the controls are shown in Table I. No statistical difference was observed between the groups on these parameters.

All the expiratory flow rates were significantly decreased in AC users (Table II). The airway resistance and compliance of the lungs did not show a significant change (Table II).

TABLE I: Anthropometric parameters.

Parameters	Mean ± SD	
	Group I AC users	Group II None AC
Age (yrs)	21.75±3.33	20.00±2.16
Height (cms)	177.63±9.30	179.29±6.05
Weight (kg)	68.38±13.02	74.71±17.20

TABLE II: Flow rates (Liter/min) & Lung mechanics.

	Group I AC users n=10	Group II None AC n=10
PEFR	6.18±2.30	9.05±3.57*
FEF ₂₅	5.66±2.48	8.51±2.97*
FEF ₅₀	4.84±1.89	6.64±1.47*
FEF ₇₅	2.92±1.08	3.92±0.82*
FEF ₂₅₋₇₅	4.38±1.66	6.05±1.27*
Airway resistance	2.41±1.37	1.61±0.50
Compliance (L)	0.13±0.01	0.12±0.05

*P<0.05

The lung volumes and capacities (Table III) were not significantly different in the two groups except for forced expiratory volume in 0.5 sees (FEV0.5), which was significantly decreased in AC users.

TABLE III: Lung volumes & capacities (Liters).

	Group I AC users n=10	Group II None AC n=10
FEVC	3.79±0.86	4.22±1.26
FEV0.5	2.18±0.79	2.98±0.89*
FEV1	3.34±0.74	4.09±1.13
FEV1/FVC	90.41±15.87	97.46±0.93
ERV	0.82±0.71	1.04±0.52
RV	1.22±1.07	0.68±0.34
FRC	1.89±1.83	1.95±1.51
TLC	4.96±1.74	4.90±1.59
MVV	128.84±27.60	134.10±22.35

*P<0.05

Residual volume, Functional residual capacity, Total lung capacity, airway resistance and compliance are derived values, rest all are measured by the machine. The algorithms used for calculation have been validated for Indian populations with the new software added upto the machine.

DISCUSSION

The results of the present study show a predisposition of AC users towards respiratory dysfunction. There is a definite impairment in the expiratory flow rates especially the $FEF_{25-75\%}$, which is the flow rate over the middle half of the forced vital capacity (FVC). In the presence of normal FEV1, reduced $FEF_{25-75\%}$ is an evidence for mild airflow limitation (14). This index is recommended as a screening test for mild airflow limitation.

Peak expiratory flow rate is also significantly decreased in subjects using AC's. PEFr reflects mainly the caliber of the bronchi and larger bronchioles, which are subjected to reflex bronchoconstriction (14). Bronchoconstriction in asthmatic subjects has been reported on hyperventilation of cold dry air (1). It has also been reported in the above study that increasing the duration of ventilation from 2 to 3 minutes causes a significant fall in FEV1. The level of ventilation, more than the dryness of temperature of the inspired air was reported to be the principal determinant of the magnitude of bronchoconstriction induced by cold dry air (15).

Cold dry air is inhaled through AC's and hence the alterations in pulmonary functions may be simulated in AC users. The results of present study are also indicating towards early stages of airflow limitation. Since all the subjects of the present study were driving their cars themselves, the direction of the blow of air was directly on their face, which may be one of the reasons for these changes. In order to study the effect of AC

on pulmonary functions only car AC users were selected in the present study as the size of room, the direction of blow of air etc could not be kept uniform for all the subjects in room AC users. Also all our subjects were nonsmokers and none were suffering from upper respiratory tract infection hence our results cannot be related to these factors which influences the bronchial responsiveness the most.

Repeated cooling and dessication of peripheral airways can cause airway remodelling similar to that seen in asthma (16). Personal smoking and intensive use of AC's appeared to be positively related to atopic sensitization and enhanced eosinophil activity (10). Probably living conditions, such as indoor dampness and poor ventilation increases the exposure to indoor air pollutants (6). Crude water extracts of contaminated AC's are the antigen-source of the hypersensitivity pneumonitis in exposed workers (12). Moreover contamination of home, office and car air conditioners with fungi has been reported to cause hypersensitivity pneumonitis (17, 18).

The exclusion of particulate allergens by window AC's has also been reported (19). A study in the USA suggested that mite allergens detected in the dust samples are reduced by the use of air conditioners in summers because of their water drainage effects (20). Another investigator reported that air conditioning could reduce mite density, if it decreases relative humidity to below 50% (21). On the other hand a Japanese study found that specific mite populations, including *Der p*, were

significantly higher in homes with air conditioning (22). The intensive use of air conditioners is likely to reduce the indoor absolute humidity in comparison to the outdoor level. However the relative humidity in a room with AC rapidly increases locally near the wall and floor when the air conditioning stops and the outdoor air enters (22), because the relative humidity becomes higher as the temperature decreases due to reduced saturated vapor pressure, thus leading to a favorable local climate for mite proliferation. The intensive use of AC's cannot reduce relative humidity below the level of mite survival, but instead creates a mite friendly local environment in the hot and humid climate of the area studied (10). Our subjects used AC's in their cars during the hot humid environment, which is the climate prone for the growth of various allergens. Most of our car AC users, used AC's even at home hence the domestic factors must also be contributing to the results.

Children who lived in homes with hot water heating systems with no AC's had mean FEV1 lower than their counterparts who lived in homes with forced air heating and air conditioning (11). In their study many domestic factors were considered in addition to use of AC, like use of gas stoves, heating devices, crowded homes, smokers etc. The frequency of observations of pairs of exposure variables showed that those with AC also had more electric stoves and lived in less crowded homes. There results must be biased due to these combination of factors. While in our study only one factor was considered, and none of our subjects

belonged to low socioeconomic status.

Thus AC does more to our environment than just lowering temperature. AC's and central AC systems can have a profound impact on quality of air we breathe. The technical, hygienic and microbiological feature of air intakes must be better insured in order to avoid the air intake becoming a risk component as regards contamination and indoor air quality.

There can be invalid forced expiratory maneuvers in some of our subjects but the maximal flow volume curves of our subjects are showing normal inspiratory and expiratory phases. Moreover the normal range of FEV1/FVC ratio depending on age is between 51% to 97% in males and 63% to 96% in females (14). One of the reasons of the values coming on the higher side of normal range can be the younger age and middle or high socio economic status of our subjects.

We plan to extend the study in a larger population, as some insignificant values may show some consistency. The study can also be done in subjects using AC for varying duration and correlating it with the extent of impairment in pulmonary functions. Besides more parameters can be assessed like participate matter humidity level, ambient temperature, airflow velocity of air-conditioned room/car, space to which the subjects are exposed during air conditioning. This will further show as to how the quality of air we breathe during air conditioning affect our respiratory functions.

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