Original Article

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

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Abstract

Background: One of the components of the modern life style is the intensive use of air conditioner for thermal comfort. With modernization, use of electric machines along with AC is rising day by day. Increased inhalation of cold dry air of air conditioner ultimately may cause alteration of pulmonary functions. The objective of this study was to assess the effect of air conditioner on pulmonary function tests.

Materials and methods: This quasi experimental study was conducted in the Department of Physiology, Chittagong Medical College, Chattogram, during January 2019 to December 2019 in collaboration with Continental Group Private Limited (Abu Baqar Ciddique) Chattogram and EPV (Energypac Power Venture) Chittagong Limited, Patiya, Chattogram. 35 apparently healthy adult males between the ages 20-45 years, working in air conditioned environment were taken as case. 35 healthy age and sex matched subjects, working in non air conditioned environment were taken as control. This study was done to measure pulmonary function test parameters among healthy Air Conditioner (AC) users and they were compared with non users of AC to see the effects of Air Conditioner (AC) on lung functions. Lung function test parameters like PEFR, MMF, $FEF_{25\%}$, $FEF_{50\%}$ and $FEF_{75\%}$, were measured by digital spirometer. Unpaired Student's t test and Chi-square test were done by using SPSS-25 for statistical analysis.

Results: The mean value of PEFR, MMF, $FEF_{25\%}$ and $FEF_{50\%}$ were significantly ($p<0.05$) lowered in AC users comparing with control. The mean value of $FEF_{75\%}$ were ($p>0.05$) lowered in AC users comparing with control.

Conclusion: The result of this study suggest that pulmonary function is significantly decreased after usage of air conditioner. Therfore public awareness for proper maintenance of AC, periodic analysis of pulmonary functions, limited use of AC and regular respiratory exercise can be recommended for preserving respiratory efficiency.

Key words : Air conditioner; Pollution; Pulmonary function test.

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Introduction

Our environment has been changed due to global warming, rapid industrialization, excessive environmental pollution and changing life style.[1,2] Climate change is one of the biggest global threats through out the world.[3,4] It negatively affects on health and environment.[5] Increasing temperature of the environment is one of the effect of climate change.[6]

An urban area is warmer than its surrounding rural areas.[7] High urbanization and population growth leads to thermal stress.[8] Thermal stress have serious adverse effects on body function, work performances and health.[9] This is called urban heat island effect.[8] It decreases the work performances of people by 11% in comparison to those exposed to normal thermal environment.[10]

Thermal stress is closely related to thermal comfort.[11]Thermal comfort is the satisfaction of mind with specific thermal environment.[11,12]

Thermal comfort can be achieved by using Air Conditioner (AC). It cools and dehumidify indoor air.[1,13]

Air conditioning helps by reducing heat stress.[14] It provides indoor thermal comfort.[24] Heat-related health problem can thus be avoided.[14,15]

AC is becoming part and parcel in homes, hospitals, colleges, offices etc.[16] Central AC is preferred in companies and offices for the comfort of staffs.[17,18] Their work performances and productivity thusbecome better.[17]

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Air conditioner has bad effects also. Long term use of air conditioning system is destructive to the environment and harmful to the health.[19] Air conditioner pumps out heat from inside to outside. Thus leading to environmental heating

Till recently, air conditioned environment was thought to be pleasant and harmless. According to previous researchers, persons working and living in air conditioned environment for prolong periods shows different problem. It may causesuffering from headache, fatigue and respiratory symptoms.[16] Italso causes drying effect on skin and mucous membrane.[20]

Thakur et al andBorse et al observed inhalation of cold dry air for prolonged period may lead to an alteration in the pulmonary functions also.[1] The symptoms depend onindividual susceptibility and duration of exposure to cold dry air.[11]

Inhalation of cold dry air causes repetitive dehydration injury withdesquamation of the epithelial cells of the airway.[1]

Intensive use of AC may cause atopic sensitization with eosinophilia.[11]

Repeated cold dry air inhalation can lead to structural and functional changes in respiratory system. Airway remodeling and desiccation were also observed in some study.[21]

Respiratory tract of air conditioner user is hyper-responsive and the patency of the airway is reduced.[22]

Pulmonary function test is important for assessment of pulmonary diseases.[3]

A very common effective diagnostic test to determine the lung functions is spirometry. It is a useful diagnostic tool for assessing lung condition in both diseased and healthy person.

Different spirometric lung function tests were done in different studies on air conditioner users. A significant reduction of lung functions in exposed groups were seen by different studies.[1]

Prolong exposure along with poor maintenance of AC can result in deleterious effects on the respiratory system with reduced lung functions and hypoxia.[1] So whole body function may be affected.

There is scarce of study showing the effects of AC on various pulmonary functions conducted on Bangladeshi population. Therefore this study was planned to evaluate the impact of air conditioner on lung functions .

Pulmonary function test is important for assessment of lung diseases.[16] Different factors can contribute to poor lung function including cold dry environment, smoking, asthma, allergy, Chronic Obstructive Pulmonary Diseases (COPD) hypertension, obesity and stress.

Materials and methods

The quasi experimental study was conducted in the Department of Physiology, Chittagong Medical College, Chattogram, Bangladesh with collaboration of ABC private limited, Chattogram and EPV Chittagong, Patiya, Chattogram from January 2019 to December 2019. The protocol of this study was approved by the members of Ethical Review Board of Chittagong Medical College, Chattogram.

35AC users were taken as experimental group and 35 non AC users were taken as control.Adult male employees working in different selective air conditioned and non air conditioned organization of Chattogram were selected on the basis of inclusion and exclusion criteria were enrolled in this study.

Non random quota sampling method was adopted to select all the subjects. According to the selection criteria, total 70 subjects with specific age range suitable for the aim and objectives of the study were enrolled.

All employees of the selected organization were provided with a predesigned case record form.Information about age of employees, duration of job, site and position of workplace, information of general health, history of present or past disease, food habits and habits of smoking and alcohol consumption or tobacco chewing were collected and recorded in predesigned case record form.

For the purpose of exclusion history of respiratory distress, skin rash, chronic cough, fever and surgery in the recent past was taken. Recent history of taking paracetamol, antibiotics or any drugs such as bronchodilator, anti tubercular, sedative, antidepressant, beta blocker, ACE inhibitor, anticonvulsant, steroid, chemotherapeutic drug, aspirin and other NSAID were taken.

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Height and body weight were measured and recorded.

General and systemic examination were done to see general physical condition of the subjects for inclusion and exclusion. For the purpose of exclusion anemia, jaundice, cyanosis, oedema were observed; blood pressure and temperature were measured; pulse and respiratory rate were counted. Auscultation of heart and lung was done to exclude any other cardio-respiratory abnormality.

Blood sample were collected for estimation of Hb% and RBS of subjects to exclude anemia and diabetes mellitus respectively.

Subjects were selected on the basis of inclusion and exclusion criteria by anlysing of case record form .Experimental group were selected on the basis of AC uses and exposed temperature between 18 and 22 degree centigrade for minimum of 6 hours per day and at least 5 days per weeks for more than 6 months.

Control group were selected from non air-conditioned offices.

Pulmonary function test parameters -PEFR, MMF, $FEF_{25\%}$, $FEF_{50\%}$ and $FEF_{75\%}$were measured by using digital spirometer of experimental and control group at the beginning of the study.

After collecting data, all the data were compiled in a Microsoft Office Excel worksheet to generate a master sheet. Later on data were fed into SPSS (Statistical Package for Social Science). Windows Version 25 software for processing and analysis. Between groups comparison of these variables were done by unpaired Students 't' test. Categorical data were expressed as frequency and percentages and between groups comparison was done by Chi-square test.

Results

Table I Age, height, weight, BMI, Hb concentration, RBS, pulse and blood pressure in control group and experimental group (n=70)

Attributes	Control Group [n=35] Mean ± SD (Range)	Experimental Group [n=35] Mean ± SD (Range)	p value (t value)
Age (Years)	33.80 ± 3.604 (20 - 40)	32.77 ± 3.82 (20 - 40)	0.251 ns (1.159)
Height (cm)	165.74 ± 4.841 (157 - 177)	167.31 ± 6.21 (152 - 178)	0.242 ns (-1.181)
Weight (Kg)	61.43 ± 3.680 (55 - 68)	62.49 ± 4.804 (52 - 72)	0.305 ns (-1.033)
BMI (Kg/m^2)	22.32 ± 0.636 (18.50 – 22.90)	22.21 ± 0.613 (18.50 – 22.90)	0.415 ns (0.821)
Hb level (gm/dl)	14.01 ± 0.445 (13.2- 15.4)	14.18 ± 0.647 (13.2- 15.6)	0.201 ns (1.292)
RBS (mmol/L)	5.63 ± 0.452 (4.9-6.8)	5.83 ± 0.662 (4.6-7.2)	0.139 ns (1.497)
Pulse (Beats/min)	72.342 ± 5.480 (60 - 85)	70.886 ± 7.335 (60 - 80)	0.662 ns (0.439)
SBP (mm of Hg)	110.571 ± 11.868 (100 - 130)	106.571 ± 9.684 (100 - 130)	0.242 ns (1.181)
DBP (mm of Hg)	70.428 ± 6.810 (60- 80)	70.00 ± 6.860 (60 - 80)	0.795 ns (0.941)

Data expressed as Mean ± SD, n = number of the subjects, Figures in parenthesis indicate Range, BMI = Body Mass Index, Hb = Haemoglobin, RBS = Random Blood Sugar, SBP = Systolic Blood Pressure, DBP = Diastolic Blood Pressure, Statistical analysis was done by Unpaired Student's ' t'-test, ns = statistically not significant ($p>0.05$) Control group = without AC use, Experimental group= with AC use

Table I shows no significant difference in age, height, weight, BMI, Hb concentration, RBS, SBP = Systolic blood pressure, DBP = Diastolic blood pressure and pulse rate between control and experimental group.

Table II Comparison of socio-demographic characteristics between control and experimental group at the beginning of the study (n=70)

Socio-demographic characteristics		Control group (n=35)	Experimental group (n=35)	p value (Chi-square)
Education level (%)	Graduate	65.7%	71.4%	0.607 ns
	Undergraduate	34.3%	28.6%	(0.265)
Marital status (%)	Married	54.3%	60%	0.629 ns
	Unmarried	45.7%	40%	(0.233)
Salary structure (%)	Grade I	46.9%	52.6%	0.631 ns
	Grade II	53.1%	47.4%	(0.230)

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Data expressed as frequency percentage, n = number of the subjects, Control group = without AC use, Experimental group= with AC use, Grade I = Income (20-30) thousands taka per month, Grade II = Income (30-40) thousands taka per month, Statistical analysis was done by Chi-square test, ns = statistically not significant (p>0.05)

Table II shows no significant difference in socio-demographic charateristics between control and experimental group.

Table III Respiratory parameters in both control and experimental group at the beginning of the study (n=70)

Respiratory Attributes	Control Mean ± SD (Range)	Experimental group Mean ± SD (Range)	p value (t value)
PEFR (Liter/sec)	7.83 ± 1.187 (4.25 – 8.86)	5.68 ± 2.170 (2.28 – 8.59)	<0.05** (5.145)
MMF (Liter/sec)	4.19 ± 0.623 (2.40 – 6.36)	3.65 ± 1.399 (1.74 – 7.50)	<0.05* (2.093)
$FEF_{25\%}$ (Liter/sec)	7.52 ± 1.281 (3.64 – 8.61)	5.32 ± 2.246 (2 – 9.03)	<0.05** (5.302)
$FEF_{50\%}$ (Liter/sec)	4.52 ± .711 (1.72– 6.41)	3.86 ± 1.182 (2.78 – 7.05)	<0.05** (2.834)
$FEF_{75\%}$ (Liter/sec)	2.33 ± .531 (1.27 – 4.24)	2.17 ± .768 (1.57 – 4.08)	0.299 ns (1.047)

Data expressed as Mean ± SD, n = number of the subjects,Control group = without AC use, Experimental group= with AC use, PEFR = Peak Expiratory Flow Rate, MMF =Maximum Mid Expiratory Flow Rate, $FEF_{25\%}$ = Forced Expiratory Volume in 25% FVC, $FEF_{50\%}$ = Forced Expiratory Volume in 50% FVC, $FEF_{75\%}$ = Forced Expiratory Volume in 75% FVC, Figures in parenthesis indicate Range, Statistical analysis was done by Unpaired Student's 't' test,ns = not significant (p>0.05), *indicates statistically significant (p<0.05), ** indicates statistically highly significant (p<0.001)

Table III shows significant reduction in PEFR, MMF, $FEF_{25\%}$, and $FEV_{50\%}$ between control and experimental group at the beginning of the study.

Discussion

Age, height, weight , BMI, Hb level, RBS, blood pressure, pulse rate and socio-demographic characteristics of study subjects of both groups were measured and compared (Table-I, II).

On the basis of general examination and inclusion and exclusion criteria 35 subjects were selected as experimental group from AC offices and 35 apparently healthy control were selected from non AC offices.

At the beginning of the study a baseline respiratory parameters-PEFR, MMF, $FEF_{25\%}$, $FEF_{50\%}$ and $FEF_{75\%}$, were taken both from experimental and control group (Table- III).

Nodifference was observed between experimental and control group in respect of age, height, weight, BMI, Hb level, RBS, blood pressure, pulse rate and socio-demographic characteristics (p>0.05) (Table-I, II).

PEFR, MMF, $FEF_{25\%}$ and $FEV_{50\%}$ shows significantly decreased in experimental group at the beginning of the study (p<0.05) (Table-III). This finding is consistent with some previous studies.[16] They supposed that pulmonary functions might be decreased due to hyper responsive airway epithelium, thick lamina propria and airway remodeling by using AC for prolong period.

The result of present study showed AC and central AC system had a profound negative impact on pulmonary functions.

Consumption of fresh fruit, fish, vegetables, vitamin A, C, E supplementation and increase dietary fibre intake can also improve lung function.

So, periodic analysis of pulmonary functions of employees working in air conditioned environment is very much helpful for early diagnosis of respiratory dysfunction as well as prevention of further different respiratory complications.

Limitations

This study was conducted for academic purpose in short period of time. Although optimal care had been tried by the researcher in every step of the study but there were some limitations. The limitations were-

- Small sample size that might not represent the whole community.
- Study was done with limited age group.
- Short period of study.
- Facilities were limited.
- Blood pressure was measured only in left hand.
- Chest X-ray was not done due to not giving permission by office authority.

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- Pre-employment data regarding lung functions were not available.
- Follow up of the subjects were not done.

Conclusion

The present study shows working in air conditioned environment brought significant reduction in respiratory functionsin AC exposed group in comparison to non AC exposed group. It is difficult to explain about the exact mechanism involved here but probably hyperresponsive respiratory tract, reduced airway patency of AC exposed subjects and lack of proper regular maintenance of AC may be responsible for these changes. Therefore, this study concludes that AC has profound negative impact on respiratory health.

Recommendations

From this study, the following recommendations can be made for further study:

- Similar study with different age groups and longer duration can be conducted.
- Further study can be done by using other parameters like humidity level, air flow velocity, culture swap from AC to know the growth of the bacteria and fungi, space to which subjects are exposed during air conditioning.
- Chest X-ray should be done to ensure any pathological changes in lungs.
- Further study can be done by giving intervention with breathing exercise and proper facemask.
- Campaigning can be done for public awareness regarding proper maintenance of AC and limit the use of AC to certain extent to improve different pulmonary functions.
- Advice can be given to the authority of AC offices to do periodical medical check up of the.
- Authority can also advise to do mandatory pre-employment medical check up of the new employees.
- Advice can be given to the employees of AC offices about consumption of fresh fruit, fish, vegetables; vitamin A, C, E supplementation and increase dietary fibre intake for improvement of lung functions.

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Contribution of authors

SAB-Acquisition of data, data analysis, interpretation of data, drafting & final approval.

MSAK-Data analysis, drafting, critical revision & final approval.

MB-Conception, design, critical revision & final approval.

SA-Conception, desigtn, data analysis, interpretation of data, critical revision & final approval.

MMR-Data analysis, interpretation of data, critical revision & final approval.

Disclosure

All the authors declared no conflict of interest.

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