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EFFECTS OF VARIATION IN AIR CONDITIONER TEMPERATURE ON SMALL AIRWAY FUNCTIONS OF AIR CONDITIONER USERS

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ABSTRACT

Background: Increasing use of air conditioner (AC) has now become a new public health concern as the lung functions can be adversely affected by the cold, dry air provided by it or to be more specific by the sudden temperature change experienced by AC users. AC temperature may play an important part in this regard as more the difference between indoor and outdoor air temperature more could be the chance of this harmful consequences. **Aim:** This study observed the effect of AC temperature variation on mid maximal expiratory flow rate (MMEF). **Materials and Method:** Individuals having exposure to daily air conditioned environment for at least 6 hours for 2 to 4 years were recruited following their provision of informed consent in written format. Forty eight such participants (24 female and 24 male) were distributed into 4 groups, A_1 and B_1 (12 male and 12 female subjects) and A_2 and B_2 (12 male and 12 female subjects) depending on the temperature of the AC they were having exposure of. The A_1 and B_1 group had exposure to temperature of 18° C to 22°C while A_2 and B_2 experienced temperature of 23°C to 25°C for a certain period of time. In both of these groups MMEF was estimated using digital auto spirometer. Unpaired Student's 't' test was applied performing statistical analysis and *p* value 0.05 was taken as the level of significance. **Result:** This study displayed significantly lower MMEF value for group A_1 subjects in comparison to group A_2. **Conclusion:** So, this study concludes that reduction of MMEF value in AC users may be related to the AC temperature to which they are exposed.

Keywords: Air conditioner, AC temperature, MMEF, Autospirometer

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INTRODUCTION

Rapid modernization and industrialization are leading to more and more infrastructural and commercial development specially in urban areas. That is one of the leading causes for population overgrowth in these areas. This results in environmental pollution and increase in environmental temperature is an unavoidable outcome of all these factors[1]. This made air conditioner very popular in the city areas particularly in summer seasons of the year as the device can release cold air by reducing air humidity and thus create a thermally comfortable environment[2]. Exposer to this AC dry and cold air can change functions of lung in various ways. These alternations may develop from activation of osmoreceptors in nose and parasympathetic nerve which results in bronchoconstriction. Various mediators of inflammation produced by mast cell may also aggravate this condition of lung[3-4].

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AC users have to face a sudden change in environmental temperature when going outside from air conditioned environment and vice versa. Respiratory system may be affected negatively when there is a sudden drop in air temperature (even in case of a drop of 2^0C to 3^0C and in particular a drop more than 5^0C) without being gradually adapted to it. Energy spent for cooling a space by 72% is 60 % more than that needed to cool it by 78%[2,5-6].

Spirometry being a sensitive and cost-effective lung function test is very commonly used to assess the condition of the respiratory system. The mean value of forced expiratory flow when lung volume decreases from 75% to 25% of vital capacity is known as mid portion of maximal expiratory flow (MMEF) volume curve which is presented by FEF^{25-75} (forced expiratory flow at 25% and 75% of the pulmonary volume). It is easily detectable with spirometry. It provides important information regarding inflammation of small non cartilaginous bronchioles which have internal diameter of less than 2 mm and thus help to detect the small airway diseases at an early stage. Which is important to prevent more complicated lung diseases in future[7-10].

Significant alteration in MMEF was found in air conditioner users when compared to non users in studies done by some researchers[4,5]. However, AC usage has become necessary as the temperature of our environment rises due to global warming. Therefore, the low temperature up to which our body, particularly our respiratory system, can withstand without suffering harm should be known. With the best of our knowledge, no study till date was found where this issue was addressed. So, this study tried to evaluate the effect of AC temperature on MMEF in AC users which serves as an important tool to detect small airway obstruction from the very beginning even when other lung function parameters may still remain normal which may hinder any early intervention to be taken. So, there remains a chance of development of more complicated lung diseases. We hope a new light on this issue can be shed by the study which will create a public awareness about this in future.

MATERIALS AND METHOD

Study design

Research performed using cross sectional design.

Study place and period

This research was completed at Dhaka Medical College, Bangladesh in department of Physiology starting from July 2018 and ending in June 2019.

Study Population

The population under study consisted of individuals having exposure to daily air conditioned environment for at least 6 hours for 2 to 4 years, recruited following their provision of informed consent in written format. Forty eight such participants (24 female and 24 male) were distributed into 4 groups, 12 male (A_1) and 12 female subjects (B_1) and 12 male (A_2) and 12 male subjects (B_2) depending on the temperature of the AC they were having exposure of. The A_1 and B_1 (group had exposure to temperature of 18° C to 22°C while A_2 and B_2 experienced temperature of 23°C to 25°C for a certain period of time.

Selection Criteria

The criteria for inclusion and exclusion for this research work has been displayed in Table 1.

Table 1: Criteria for selection of participants into the research:

Criteria of inclusion into the research for both A_1 and A_2 group	Criteria of exclusion from the research for both A_1 and A_2 group
Age of participants selected between 18 years and 44 years	The research excluded individuals with chronic obstructive pulmonary disease, pneumonia, asthma, pleural effusion, tuberculosis, diabetes mellitus, hypertension or having any cardiac or respiratory disease symptoms.
BMI of participants selected ranged between 18.4 and 24.9 Kg/m^2	Subjects with history of consuming tobacco, drugs such as diuretics, cardiac glycosides and beta blocker
AC exposure for 2 to 4 years	Individuals who perform physical exercise regularly and women who were lactating or pregnant

AC: Air Conditioner**; BMI:** Body Mass Index.

Sampling Technique

The technique chosen was purposive sampling.

Sample Collection

Since the procedure to be performed was to be carried out by the participants using the spirometer, it was necessary for the researcher to explain the steps of the procedure with clarity and details to those individuals. Therefore, the participants were allowed to perform the procedure only after their proper understanding of the steps they were to do was confirmed.

The selected subjects were informed about nature, purpose and benefits of the study and informed written consent was taken from them. To make them understand the procedure of spirometry it was explained to them in detail and some demonstrations were also performed. Spirometry was done between 9 am to 12 pm using digital autospirometer version AS-507 following a standardized procedure adherent to American Thoracic Society (ATS) guideline[11] under direct supervision of the principal researcher. A minimum of 3 and maximum of 8 tests were performed by the subjects to obtain the best value of MMEF. ATS acceptability and repeatability criteria were followed to accept the best results.

Data Collection

Data was collected using a structural questionnaire that was used to collect information regarding the AC temperature the participants were exposed to; the number of years they have been exposed to AC. Their medical and lifestyle history was also taken. Their general characteristics including age, BMI, Blood pressure were recorded. The MMEF of the subjects were recorded.

Ethical Approval

Ethical approval was collected from the Research review committee and Ethical review committee of Dhaka Medical College, Dhaka-1000, Bangladesh.

Statistical Analysis Plan

The completed questionnaire data were compiled, appropriately sorted, and analyzed using Statistical Package for Social Sciences [(SPSS) IBM Corporation. IBM SPSS Statistics for Windows, Version 25.0. All the lung function parameters are 20-25% more in male than female because of increased size of thoracic cage and strength of respitatory muscle. So, gender could act as a confounding factor in this research findings.

So, we nutralised the effect of gender to prevent bias while doing this research and designed the whole pattern of statistical analysis accordingly to compare this lung function gender wise among different groups.

RESULTS

The demographic characteristics displayed non-significant difference (Table 1, 2). Group A_1 had a significantly lower MMEF when compared to group A_2 (Table 3, 4).

Table 1: Demographic characteristics of male subjects in both groups

Parameters	Group A_1 (n=12)	Group A_2 (n=12)	*p* value
Age (years)	34.58±5.85	36.08±5.09	0.510^{ns}
BMI (Kg/m^2)	23.24±1.00	22.72±2.00	0.424^{ns}
Systolic BP (mm/Hg)	110.42±5.82	109.17±10.19	0.716^{ns}
Diastolic BP (mm/Hg)	78.33±3.89	75.42±6.56	0.199^{ns}

Mean ± SD was used to express data. Group A_1= male users of air conditioner having exposure to 18^0C to 22^0C AC temperature, Group A_2= male users of air conditioner having exposure to 23^0C to 25^0C AC temperature, BP= blood pressure, BMI= Body mass index.

Table 2: General characteristics of female subjects in both groups

Parameters	Group B_1 (n=12)	Group B_2 (n=12)	*p* value
Age (years)	29.50±7.00	31.67±7.54	0.473^{ns}
BMI (Kg/m^2)	23.19±1.89	22.33±1.79	0.265^{ns}
Systolic BP (mm/Hg)	106.25±8.56	107.50±6.22	0.686^{ns}
Diastolic BP (mm/Hg)	74.58±4.98	72.92±6.20	0.476^{ns}

Mean ± SD was used to express data. Group B_1= female users of air conditioner having exposure to 18^0C to 22^0C AC temperature, Group B_2= female users of air conditioner having exposure to 23^0C to 25^0C AC temperature, BP= blood pressure, BMI= Body mass index.

Table 3: Study parameter of male participants in both group (n=24)

Parameter	Group A nA_1=12	Group A nA_2=12	*p* value
MMEF	1.39±0.83	2.41±0.50	$<0.001^{***}$

n= Total number of male participants, nA_1= group A male participants exposed to 18^0C to 22^0C AC Temperature, nA_2= group A male participants exposed to 23^0C to 25^0C AC Temperature, MMEF=Mid Maximal Expiratory Flow rate **/***=Significant

Table 4: Study parameters of female subjects in both group(n_1=24)

Parameter	Group B nB_1=12	Group B nB_2=12	*p* value
MMEF	1.18±0.77	2.30±0.63	<0.001*

n= Total number of female participants, nB_1= group B female participants exposed to 18^0C to 22^0C AC Temperature, nB_2= group B female participants exposed to 23^0C to 25^0C AC Temperature, MMEF=Mid Maximal Expiratory Flow rate **/***=Significant

DISCUSSION

People working in air conditioned environment are not only in the risk of being exposed constantly to AC's dry and cold air but they also experience sudden change in surrounding temperature when going out of this air conditioned environment and vice versa. This sudden rise or drop in air temperature without being gradually adapted to it may affect their function of lung negatively and ultimately cause various lung diseases[5,6]. The fact that more the difference between indoor and outdoor air temperature the more could be the chance of harmful consequence on respiratory tract is clearly evident from this. So, AC temperature should be considered as an important factor in evaluating the AC's influence on function of lung.

This study revealed that exposure to lower temperature (18°C to 22°C) of AC significantly lowered the MMEF when compared to AC temperature (23°C to 25°C) in both gender. Similar studies could not be found with intensive search however comparison of lung function like forced expiratory volume in 1st second (FEV1), forced vital capacity (FVC), peak expiratory flow rate (PEFR), forced expiratory flow :FEV1, FVC, FEV1/FVC, PEFR, and FEF25-75 was carried out between AC and non-AC users by Agarwal and Devi[12].They concluded that low temperature of AC aggravated restrictive pattern in lung function. This is in agreement with our study as cold, dry air of AC exposure displayed lower lung function.

Dry, cold air inhalation may lead to loss of water from mucosa of airway by evaporation. Activation of TRPM8 receptor (Transient receptor potential melastatin 8) and irritant receptor of mucosal lining may occur due to mucosal cooling and hyperosmolarity in users of AC. These receptors are able to cause parasympathetic vagal nerve stimulation. Vagal stimulation along with the mediators from mast cells like histamine, prostaglandin etc. can also aggravate bronchoconstriction and ultimately airway obstruction. Thickening of airway, leakage from microvasculature, and mucosal hyper secretion may also take place. Reduction of MMEF in AC users may result from a combined effect of these changes[8,13,18].

Use of AC has negative impact on lung function as an outcome of various pathophysiology as noted by previous studies[12-19]. Lower temperature exposure leads to more damage to the respiratory system. This is particularly the case when individuals are exposed to temperatures lower than that which they are adapted to (seasonal temperature range that exists in their geographical location). The seasonal temperature variations that people of Bangladesh (the place where this research was conducted) are used to (during post monsoon, pre-monsoon and monsoon) are 26°C, 27.5 °C, and 28.6°C respectively. Although there does not exist any universal cut-off value for the lowest temperature that an individual may be exposed to without suffering respiratory damage but having exposure to temperature lower than to which they are adapted to would aggravate such damage[1,6].

CONCLUSION

Individuals need to avoid decreasing AC to very low temperatures. Routine health assessments need to include pulmonary function test to ensure early diagnosis of any change in respiratory functions in regular AC users so that irreversible damage may be prevented with intervention in time. Policies may be developed to impart knowledge to general population of the harmful effects of regular very low temperatures in AC users.

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CONFLICT OF INTEREST

There is no conflict of interest.

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