

Body Mass Index And Pulmonary Function Parameters Among Adults: A Correlational Study

Surbhi Ranga¹, Dr. Veenodini Warhade², Dr. Janardhan Vishvanath Bhatt³, Dr. Charushila Rukadikar⁴, Geetha Mohan⁵, Dr. Vinoth R⁶, Dr. Mantabha Singh⁷

¹ Research Scholar, Department of Physiology, Pacific Medical College & Hospital, Udaipur, Rajasthan-313001, India, surbharanga@gmail.com

², Professor and Head, Department of Physiology, Pacific Medical College & Hospital, Udaipur, Rajasthan-313001, India, warhadeveenodini@gmail.com

³ Professor and Head, Department of Physiology, Ananya Medical College, Kalol, Gandhinagar, Gujarat-382721, India, appiguj@gmail.com

⁴ Assistant Professor, Department of Physiology, AIIMS Gorakhpur, Uttar Pradesh-273008, India, charuruks11@gmail.com

⁵, Tutor, Department of Nursing, AIIMS Gorakhpur, Uttar Pradesh-273008, India, gthadeva@gmail.com

⁶ Assistant Professor, Department of Community and Family Medicine, AIIMS Gorakhpur, Uttar Pradesh-273008, India., rvinoth351@gmail.com

⁷ Scientist C, MRU, AIIMS Gorakhpur, Uttar Pradesh-273008, India. mantabha321singh@gmail.com

Abstract

Background: Anthropometric traits and occupational environmental exposures are recognized to affect pulmonary function. Long-term exposure to air-conditioned (AC) environments may modify respiratory mechanics, especially in individuals with differing body mass index (BMI). Nonetheless, evidence investigating the synergistic effects of BMI and air-conditioning exposure on pulmonary function is still scarce.

Objective: To examine the correlation between anthropometric variables and pulmonary function parameters, and to assess the impact of air-conditioning exposure on lung function in adults.

Methods: A comparative cross-sectional study was carried out over 2.5 years in Kalol, Gandhinagar, Gujarat, with 400 healthy adults aged 25 to 45 years. There were 200 people who used AC and 200 who didn't. Anthropometric measurements were taken, and BMI was categorized based on WHO standards. A portable spirometer was used to measure pulmonary function tests, such as forced vital capacity (FVC), forced expiratory volume in one second (FEV), the FEV/FVC ratio, the peak expiratory flow rate (PEFR), and the forced expiratory flow 25–75% (FEF₂₅₋₇₅). Pearson's 25 75 correlation and multivariable linear regression analyses were conducted to ascertain predictors of pulmonary function.

Results: BMI exhibited a significant negative correlation with PEFR ($p < 0.001$), whereas age displayed a robust inverse relationship with expiratory flow parameters. There was a positive relationship between height and PEFR ($p < 0.001$). In multivariable regression analysis, exposure to air conditioning was independently correlated with reduced FVC and FEV ($p < 0.001$). Being a man was a strong predictor of higher PEFR ($p < 0.001$).¹ The regression model that included age, sex, AC exposure, and BMI accounted for as much as 79.9% of the differences in PEFR.

Conclusion: Anthropometric variables, especially BMI and age, have a substantial impact on pulmonary function parameters. Long-term exposure to air conditioning is linked to smaller lung volumes, highlighting the importance of monitoring workplace health and making lifestyle changes to protect respiratory health.

Keywords: Air-conditioning exposure, Body mass index, Pulmonary function test, Peak expiratory flow rate, Anthropometric variables,

INTRODUCTION:

Pulmonary function is a key sign of respiratory health. It shows how well the lungs can support good ventilation and gas exchange by showing their mechanical and physiological ability to do so. Spirometry parameters, including forced vital capacity (FVC), forced expiratory volume in one second (FEV), and peak expiratory flow rate (PEFR), are extensively utilized in clinical and epidemiological studies to evaluate lung function across populations (1,2). Several things can affect how well the lungs work, such as age, sex, exposure to the environment, physical activity, and body measurements.

Body mass index (BMI) is a straightforward and widely acknowledged metric of overall adiposity and has gained recognition as a significant factor influencing pulmonary function. Both low and high BMI can affect how the lungs work in different ways. More fat in the body may make the chest wall less flexible, limit the movement of the diaphragm, and make the airways more resistant, which can change the volumes and flow of air in the lungs (3,4). On the other hand, a low BMI has been linked to weaker respiratory muscles and a lower pulmonary reserve (5).

The worldwide increase in overweight and obesity poses a significant public health challenge, affecting not only metabolic and cardiovascular disorders but also respiratory health. Numerous studies have investigated the correlation between BMI and pulmonary function, indicating substantial links between elevated BMI and diminished spirometry indices, including FVC and FEV₁ (6,7).

Nonetheless, results from various studies have shown inconsistency, with discrepancies ascribed to variations in age, sex, ethnicity, body fat distribution, and study design (8). These inconsistencies highlight the necessity for population-specific evidence to elucidate the nature and strength of the association between BMI and pulmonary function. Assessing pulmonary function across BMI categories offers further understanding of how fluctuations in body mass affect respiratory physiology(9). Such analyses are particularly pertinent for the early identification of individuals at risk of compromised lung function and for guiding preventive strategies that address modifiable factors, such as body weight. Although clinically significant, there is a paucity of correlational evidence from adult populations across various settings, especially utilizing systematic spirometry assessment.

Consequently, the current study sought to evaluate the relationship between body mass index and pulmonary function parameters, as well as to analyse the distribution of baseline characteristics and pulmonary function parameters across various BMI categories in an adult population utilizing a cross-sectional correlational design.

Objective of the Study to evaluate the correlation between body mass index and pulmonary function parameters, and to analyse the distribution of baseline characteristics and pulmonary function parameters across various body mass index categories in adults utilizing a cross-sectional correlational design.

MATERIALS AND METHODS

This comparative cross-sectional study was executed in Kalol, Gandhinagar district, Gujarat, India, spanning a total duration of 2.5 years, with data collection conducted over a period of 2 years. A total of 400 adults aged 25 to 45 years, both male and female, were recruited and allocated into two groups: a case group of 200 individuals with occupational exposure to air conditioning for over 6 hours daily for a minimum of one year, and a control group of 200 individuals without consistent exposure to air conditioning. The case group mainly consisted of bank workers, people who worked for multinational companies, and people who drove cars. Subjects were chosen according to established inclusion and exclusion criteria. Participants were healthy, non-smoking adults who consented to take part. Those with a history of acute or chronic respiratory disorders, inconsistent AC exposure, regular engagement in yoga or structured exercise, neuromuscular diseases, thoracic cage or vertebral column deformities, or who exhibited non-cooperation were excluded. Before they could join the study, all participants were told about the goals and methods of the study, and they had to give their written consent. We took baseline measurements like age, height, and weight, and then did a preliminary clinical exam to rule out any underlying medical problems. A portable spirometer (Helios 702 Spirometry System) that meets standard criteria for lung function testing was used to test pulmonary function. All tests were done with the participants sitting up straight, following standard spirometry rules. To stop air from leaking, a nose clip was put on, and participants were told to take a deep breath and then forcefully and steadily exhale for at least six seconds. Each manoeuvre was performed thrice with sufficient rest periods, and the most reliable reading was selected for analysis. The evaluated pulmonary function parameters comprised forced vital capacity (FVC), forced expiratory volume in one second (FEV), FEV/FVC ratio, forced expiratory flow between 25% and 75% of FVC (FEF - %), and peak expiratory flow rate (PEFR). The confidentiality of participant data was upheld throughout the study.

Statistical Analysis

Statistical Analysis: We used the Statistical Package for the Social Sciences (SPSS) to enter and analyze the data. The Shapiro-Wilk test was used to see if continuous variables were normal, and the results are

shown as mean \pm standard deviation (SD). Categorical variables are shown as frequencies and percentages. Based on the World Health Organization (WHO) BMI classification, participants were put into groups of underweight, normal weight, overweight, and obese. We used one-way analysis of variance (ANOVA) for continuous variables and the chi-square test for categorical variables to compare baseline characteristics and pulmonary function parameters across BMI categories.

We used Pearson's correlation coefficient (r) to look at the link between anthropometric variables (age, height, weight, and BMI) and pulmonary function parameters. We did a multivariable linear regression analysis to find independent predictors of pulmonary function parameters while controlling for age, sex, air-conditioning exposure, and BMI. Regression coefficients are shown as β estimates with 95% confidence intervals (CIs). We used the coefficient of determination (R^2), adjusted R^2 , and root mean square error (RMSE) to see how well the model worked. A two-tailed p -value of less than 0.05 was deemed statistically significant.

RESULTS:

Table 1. Distribution of baseline characteristics and pulmonary function parameters across BMI categories.

Variable	Normal (n = 113)	Obese (n = 167)	Overweight (n = 46)	Underweight (n = 74)
AC (users)	58 (51.3%)	81 (48.5%)	23 (50.0%)	38 (51.4%)
AC (no)	55 (48.7%)	86 (51.5%)	23 (50.0%)	36 (48.6%)
Sex - Female	58 (51.3%)	90 (53.9%)	15 (32.6%)	34 (45.9%)
Sex - Male	55 (48.7%)	77 (46.1%)	31 (67.4%)	40 (54.1%)
Age, years	30.72 (11.14)	41.56 (13.20)	43.63 (15.84)	29.30 (9.59)
Height, cm	172.44 (13.00)	163.75 (16.36)	167.54 (6.82)	170.36 (14.89)
Weight, kg	61.81 (10.61)	77.79 (15.61)	67.57 (6.16)	48.97 (8.56)
Smoker - No	113 (100.0%)	167 (100.0%)	46 (100.0%)	74 (100.0%)
FVC, L	3.79 (0.47)	3.88 (0.52)	3.88 (0.53)	3.74 (0.55)
FEV ₁ , L	3.17 (0.51)	3.14 (0.56)	3.09 (0.44)	3.18 (0.61)
FEV ₁ /FVC ratio	85.10 (18.48)	83.22 (25.17)	81.44 (18.14)	88.25 (30.63)
FEV ₁ /FVC (%)	0.85 (0.18)	0.83 (0.25)	0.81 (0.18)	0.88 (0.31)
BMI, kg/m ²	20.61 (0.98)	28.85 (2.86)	24.01 (0.41)	16.85 (1.60)
PEFR, L/min	658.17 (147.96)	572.40 (141.33)	614.18 (101.87)	671.45 (160.27)
PEFR, L/s	10.97 (2.47)	9.54 (2.36)	10.24 (1.70)	11.19 (2.67)
FEF ₂₅₋₇₅ , L/s	1.98 (0.65)	2.00 (0.61)	1.83 (0.48)	1.97 (0.62)

Table 1: presents the distribution of baseline characteristics and pulmonary function parameters across body mass index (BMI) categories. Of the total 400 participants, 113 were classified as normal weight, 167 as obese, 46 as overweight, and 74 as underweight. The proportion of air conditioner (AC) users and non-users was comparable across BMI categories. Female participants were slightly predominant in the normal-weight and obese categories, while males constituted a higher proportion in the overweight and underweight groups. Mean age was higher among overweight and obese participants compared to normal-weight and underweight individuals. Mean height was lowest in the obese group, whereas mean body weight and BMI were highest among obese participants. All participants were non-smokers. Pulmonary

function parameters including FVC, FEV₁, FEV₁/FVC ratio, PEFR, and FEF₂₅₋₇₅% showed variations across BMI categories, with comparatively lower PEFR values observed among obese participants.

Table 2. Correlation between anthropometric variables and Pulmonary Function parameters.

Anthropometric Variable	FVC	FEV ₁ (L)	FEV ₁ /FVC Ratio	FEV ₁ /FVC (%)	PEFR (L/min)	PEFR (L/sec)	FEF 25-75
AGE	0.050 (0.319)	-0.013 (0.798)	0.000 (0.997)	0.000 (0.994)	-0.497 (<0.001)	-0.497 (<0.001)	0.087 (0.083)
HEIGHT	-0.100 (0.047)	0.031 (0.531)	0.040 (0.424)	0.040 (0.427)	0.579 (<0.001)	0.579 (<0.001)	-0.002 (0.963)
WEIGHT	0.011 (0.832)	-0.012 (0.815)	-0.026 (0.606)	-0.027 (0.595)	0.170 (0.001)	0.170 (0.001)	0.011 (0.821)
BMI	0.092 (0.065)	-0.041 (0.419)	-0.061 (0.227)	-0.061 (0.224)	-0.286 (<0.001)	-0.286 (<0.001)	0.024 (0.628)

Table 2: presents the correlation analysis between anthropometric variables and pulmonary function parameters. Age showed a significant negative correlation with peak expiratory flow rate (PEFR) expressed in both Liters per minute and Liters per second ($r = -0.497$, $p < 0.001$). No statistically significant correlations were observed between age and FVC, FEV₁, FEV₁/FVC ratio, or FEF₂₅₋₇₅%. Height demonstrated a weak but statistically significant negative correlation with FVC ($r = -0.100$, $p = 0.047$) and a strong positive correlation with PEFR in both units ($r = 0.579$, $p < 0.001$). Weight was positively correlated with PEFR ($r = 0.170$, $p = 0.001$) but did not show significant correlations with FVC, FEV₁, FEV₁/FVC ratio, or FEF₂₅₋₇₅%. Body mass index exhibited a significant negative correlation with PEFR in Liters per minute and Liters per second ($r = -0.286$, $p < 0.001$), while its correlations with FVC, FEV₁, FEV₁/FVC ratio, and FEF₂₅₋₇₅% were not statistically significant.

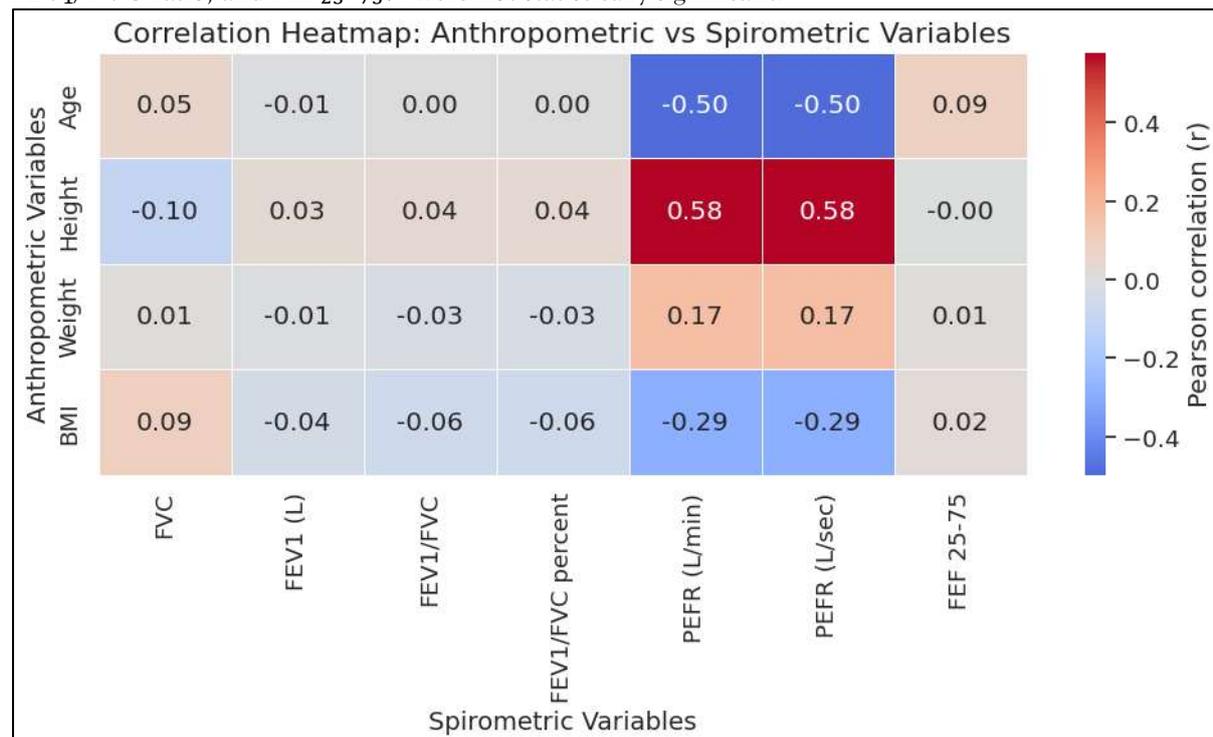


Figure 2. Correlation heatmap depicting the relationship between anthropometric variables and pulmonary function parameters

Table 3. Multivariable linear regression showing predictors of Pulmonary Function parameters

Predictor	FVC (L) β (95% CI), p	FEV ₁ (L) β (95% CI), p	FEV ₁ /FVC % β (95% CI), p	FEV ₁ /FVC (prop.) β (95% CI), p	PEFR L/min β (95% CI), p	PEFR L/s β (95% CI), p	FEF ₂₅₋₇₅ L/s β (95% CI), p
Age (years)	0.001 (-0.090 to 0.120), 0.766	0.000 (-0.104 to 0.106), 0.986	0.046 (-0.080 to 0.133), 0.623	0.001 (-0.079 to 0.134), 0.617	-4.970 (-5.060 to -4.100), <0.001	-0.083 (-0.506 to -0.410), <0.001	0.004 (-0.016 to 0.196), 0.097
USERS (Non-AC vs AC)	0.200 (0.200 to 0.580), <0.001	0.199 (0.174 to 0.561), <0.001	0.580 (-0.173 to 0.221), 0.809	0.006 (-0.172 to 0.222), 0.801	-6.990 (-13.600 to 4.180), 0.299	-0.116 (-0.136 to 0.042), 0.299	0.090 (-0.050 to 0.343), 0.143
Sex (Male vs Female)	-0.080 (-0.350 to 0.040), 0.116	0.051 (-0.099 to 0.289), 0.338	3.150 (-0.066 to 0.328), 0.190	0.031 (-0.066 to 0.328), 0.192	219.000 (138.200 to 155.900), <0.001	3.651 (1.382 to 1.559), <0.001	0.037 (-0.136 to 0.257), 0.548
BMI (kg/m ²)	0.008 (-0.030 to 0.180), 0.134	-0.005 (-0.149 to 0.061), 0.415	-0.320 (-0.176 to 0.038), 0.204	-0.003 (-0.176 to 0.037), 0.200	-2.560 (-3.140 to -0.410), <0.001	-0.043 (-0.137 to -0.041), <0.001	-0.001 (-0.117 to 0.096), 0.845
R ²	0.052	0.038	0.009	0.009	0.799	0.799	0.014
Adjusted R ²	0.042	0.029	-0.001	-0.001	0.797	0.797	0.004
RMSE	0.500	0.531	23.800	0.238	66.700	1.110	0.607

Table 3: presents the results of the multivariable linear regression analysis examining predictors of pulmonary function parameters. Age was a significant negative predictor of peak expiratory flow rate (PEFR), both in Liters per minute ($\beta = -4.97$; $p < 0.001$) and Liters per second ($\beta = -0.083$; $p < 0.001$), while its associations with FVC, FEV₁, FEV₁/FVC ratio, and FEF₂₅₋₇₅ were not statistically significant. Air conditioners use status (non-AC users versus AC users) was a significant predictor of FVC ($\beta = 0.20$; $p < 0.001$) and FEV₁ ($\beta = 0.20$; $p < 0.001$), but showed no significant association with FEV₁/FVC ratio, PEFR, or FEF₂₅₋₇₅. Sex was significantly associated with PEFR expressed in both Liters per minute ($\beta = 219.00$; $p < 0.001$) and Liters per second ($\beta = 3.65$; $p < 0.001$), whereas no significant associations were observed with FVC, FEV₁, FEV₁/FVC ratio, or FEF₂₅₋₇₅. Body mass index was independently associated with reduced PEFR in Liters per minute ($\beta = -2.56$; $p < 0.001$) and Liters per second ($\beta = -0.043$; $p < 0.001$), while its relationships with FVC, FEV₁, FEV₁/FVC ratio, and FEF₂₅₋₇₅ were not statistically significant. The regression models explained the highest proportion of variance for PEFR outcomes ($R^2 = 0.799$), whereas the explanatory power for other pulmonary function parameters was low.

Table 4: Comparison of R² values for Pulmonary Function parameters across regression models.

	FVC	FEV ₁ (L)	FEV ₁ /FVC Ratio	FEV ₁ /FVC (%)	PEFR (L/min)	PEFR (L/sec)	FEF 25-75
Age	0.002	1.65e ⁻⁴	2.73e ⁻⁸	1.44e ⁻⁷	0.247	0.247	0.007
Age, Sex	0.007	0.003	0.004	0.004	0.791	0.791	0.008
Age, Sex, AC users	0.046	0.036	0.004	0.004	0.792	0.792	0.014

Age, Sex, AC users, BMI	0.051	0.038	0.009	0.009	0.799	0.799	0.014
-------------------------	-------	-------	-------	-------	-------	-------	-------

Table 4: summarizes the proportion of variance explained (R^2) for pulmonary function parameters across sequential regression models. Models including age alone accounted for a negligible proportion of variance in FVC, FEV₁, FEV₁/FVC ratio, and FEF₂₅₋₇₅ but explained a moderate proportion of variance in PEFR ($R^2 = 0.247$). The addition of sex substantially improved model performance for PEFR ($R^2 = 0.791$), while only marginal increases were observed for other pulmonary function parameters. Incorporation of air-conditioning exposure further improved the explained variance for FVC ($R^2 = 0.046$) and FEV₁ ($R^2 = 0.036$), with minimal change in FEV₁/FVC outcomes. The fully adjusted model including age, sex, air-conditioning exposure, and body mass index demonstrated the highest explanatory power for PEFR ($R^2 = 0.799$), whereas the explained variance for FVC and FEV₁ remained modest and was minimal for FEV₁/FVC ratio and FEF₂₅₋₇₅. Overall, PEFR showed the greatest sensitivity to demographic and exposure-related predictors across all models.

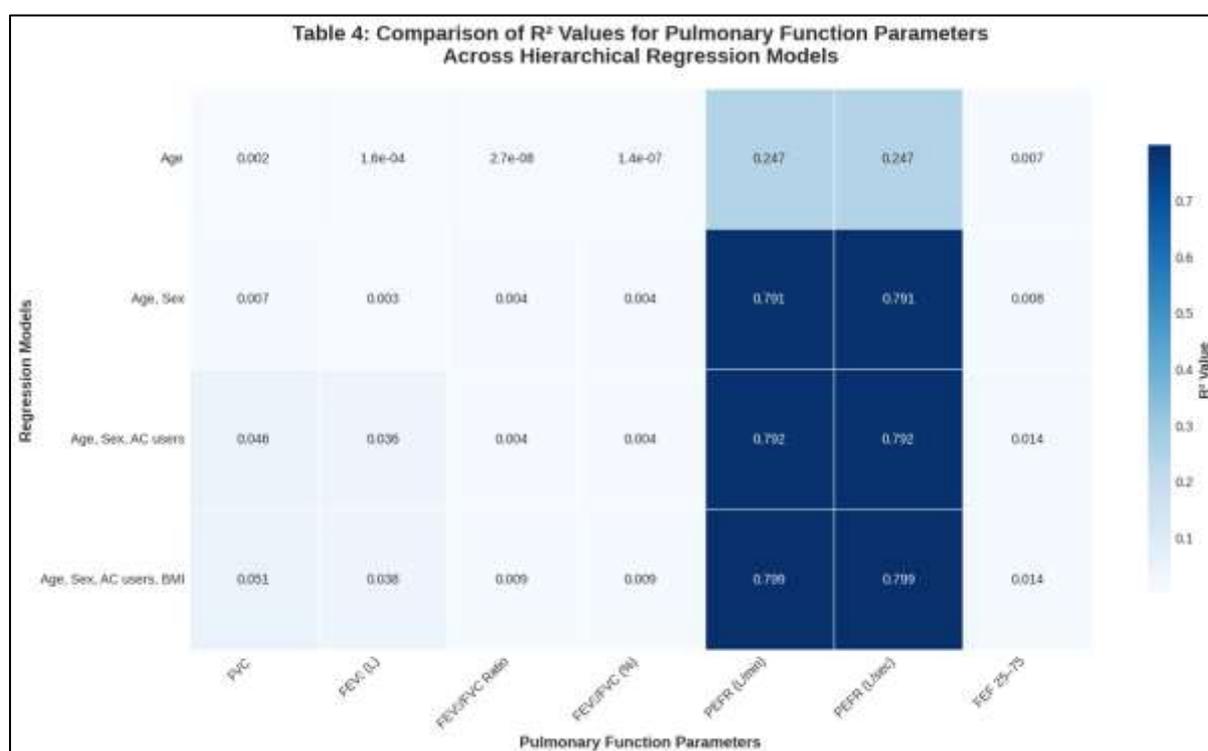


Figure 1. Hierarchical regression analysis showing the incremental explanatory power (R^2) of age, sex, air-conditioning exposure, and BMI on pulmonary function parameters

DISCUSSION

The present comparative cross-sectional study examined the association between anthropometric variables and pulmonary function parameters, with particular emphasis on body mass index (BMI) and air-conditioning (AC) exposure. The findings demonstrate that BMI, age, sex, and AC exposure independently influence specific spirometry indices, especially expiratory flow parameters.

In the current study, BMI showed a significant negative association with peak expiratory flow rate (PEFR), both in correlation and multivariable regression analyses. This finding is consistent with previous studies reporting reduced expiratory flow rates in individuals with higher BMI due to mechanical restriction of the chest wall, reduced lung compliance, and increased airway resistance associated with excess adiposity(1). Obesity-related fat deposition over the thoracic and abdominal regions may limit diaphragmatic excursion, thereby impairing maximal expiratory efforts and reducing PEFR(3,4).

Age was found to be a strong negative predictor of PEFR, explaining a substantial proportion of variance in expiratory flow parameters. This observation aligns with established evidence that advancing age is associated with reduced elastic recoil of the lungs, decreased respiratory muscle strength, and progressive

decline in airway caliber (1,2,9). However, age showed minimal influence on lung volumes such as FVC and FEV₁ in the adjusted models, possibly due to the relatively restricted age range (25–45 years) of the study population.

Height demonstrated a significant positive correlation with PEFr, supporting the physiological relationship between body size and lung dimensions. Taller individuals typically have larger lung volumes and greater airway diameter, resulting in higher expiratory flow rates (1,2). This finding reinforces the importance of accounting for anthropometric factors when interpreting pulmonary function tests.

Gender emerged as an independent predictor of PEFr, with males exhibiting significantly higher values than females. This is in agreement with earlier studies attributing sex differences in lung function to variations in thoracic dimensions, respiratory muscle strength, and airway size (5,6). Despite adjustment for height and BMI, sex-related differences persisted, suggesting inherent physiological differences between males and females.

A key finding of this study is the independent association between prolonged air-conditioning exposure and reduced FVC and FEV₁. Individuals exposed to AC environments demonstrated lower lung volumes compared to non-users, even after controlling for age, sex, and BMI. Chronic exposure to artificially cooled, low-humidity environments may predispose individuals to airway irritation, altered mucociliary clearance, and subclinical airway inflammation, ultimately affecting lung volumes(7). Similar associations between indoor environmental conditions and respiratory health have been reported in occupational and building-related studies(8).

The hierarchical regression analysis further demonstrated that the inclusion of sex, AC exposure, and BMI significantly improved the explanatory power of models predicting PEFr, with the final model explaining nearly 80% of the variance. This highlights the multifactorial nature of pulmonary function and underscores the need to consider environmental and anthropometric factors simultaneously rather than in isolation.

Strengths and Limitations

The strengths of the study include a relatively large sample size, inclusion of both sexes, standardized spirometry assessment, and the use of hierarchical regression modelling. However, the cross-sectional design limits causal inference. Additionally, environmental parameters such as indoor air quality, temperature, and humidity were not objectively measured, which may influence pulmonary outcomes. Future longitudinal studies incorporating detailed environmental assessments are warranted.

Implications

The findings emphasize the importance of monitoring respiratory health among individuals with prolonged AC exposure, particularly those with higher BMI. Workplace health policies should incorporate regular pulmonary function screening and lifestyle interventions aimed at maintaining optimal body weight to preserve lung function.

Conflict of Interest

The authors declare no conflict of interest.

CONCLUSION

This comparative cross-sectional study demonstrates that anthropometric variables, particularly BMI and age, are important determinants of pulmonary function parameters. Higher BMI was independently associated with a significant reduction in peak expiratory flow rate (PEFr), even after adjusting for age, sex, and air-conditioning exposure. Age showed a strong negative association with expiratory flow parameters, while sex emerged as a significant predictor of PEFr, with males exhibiting higher values than females. Air-conditioning exposure was independently associated with reduced FVC and FEV₁, suggesting a potential impact of prolonged exposure to artificially cooled environments on lung volumes. These findings highlight the importance of maintaining optimal body weight and considering occupational environmental exposures in the preservation of respiratory health. Periodic pulmonary function assessment may be beneficial for individuals with prolonged air-conditioning exposure, especially those with higher BMI.

Acknowledgements

The authors express their sincere gratitude to all the participants for their voluntary cooperation and active participation in the study. The authors also acknowledge the support of local administrative authorities and technical staff who assisted during data collection and pulmonary function testing.

Ethical Considerations

The study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki. Ethical approval was obtained from the Institutional Ethics Committee prior to the commencement of the study. Written informed consent was obtained from all participants after explaining the purpose and procedure of the study. Confidentiality and anonymity of the participants were strictly maintained throughout the research process.

Funding

This research was self-funded by the investigators and did not receive any external financial support from public, commercial, or non-profit funding agencies.

REFERENCES:

1. Pellegrino R, Viegi G, Brusasco V, Crapo RO, Burgos F, Casaburi R, et al. Interpretative strategies for lung function tests. *Eur Respir J.* 2005;26(5):948-968.
2. Quanjer PH, Stanojevic S, Cole TJ, Baur X, Hall GL, Culver BH, et al. Multi-ethnic reference values for spirometry for the 3-95-yr age range. *Eur Respir J.* 2012;40(6):1324-1343.
3. Chen Y, Rennie D, Cormier Y, Dosman J. Association between obesity and lung function in adults. *Thorax.* 1993;48(4):375-380.
4. Jones RL, Nzekwu MMU. The effects of body mass index on lung volumes. *Chest.* 2006;130(3):827-833.
5. Canoy D, Luben R, Welch A, Bingham S, Wareham N, Day N, et al. Abdominal obesity and respiratory function in men and women. *Am J Epidemiol.* 2004;159(12):1140-1149.
6. Dockery DW, Ware JH, Ferris BG Jr, Glicksberg DS, Fay ME, Spiro A. Distribution of forced vital capacity and forced expiratory volume in one second in healthy nonsmokers. *Am Rev Respir Dis.* 1985;131(4):511-520.
7. Sin DD, Jones RL, Man SFP. Obesity is a risk factor for dyspnea but not for airflow obstruction. *Arch Intern Med.* 2002;162(13):1477-1481.
8. Seppänen O, Fisk WJ, Mendell MJ. Association of ventilation rates and indoor environmental quality with health and other responses in commercial and institutional buildings. *Indoor Air.* 1999;9(4):226-252.
9. Mendell MJ, Mirer AG, Cheung K, Tong M, Douwes J. Respiratory and allergic health effects of dampness and indoor environmental exposures. *Environ Health Perspect.* 2011;119(6):748-756.