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Pulmonary Function Among College-Going Students: Effect of Physical Activity Level and Geographical Location – A Cross-Sectional Study

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ABSTRACT

Background: Pulmonary function is influenced by multiple factors, including age, gender, environmental exposure, and physical activity levels. While the roles of age and gender in determining lung health are well documented, the interplay between physical activity, geographical location, and pulmonary function in healthy individuals remains unexplored. Aim: This study examines the effects of geographical origin and physical activity levels on pulmonary function in healthy individuals. The primary objective is to understand how environmental variations in lifestyle factors contribute to lung performance and respiratory health.

Methods: A total of 90 healthy participants from Delhi were recruited based on geographical origin and physical activity levels. Participants were divided into subgroups. Pulmonary functions were evaluated using spirometry, measuring forced vital capacity (FVC), forced expiratory volume in one second (FEV1), and (FEV1/FVC).

Results: A significant positive correlation was observed between physical activity and pulmonary parameters, including FEV1 ($r=0.425$, $p<0.001$), FVC ($r=0.470$, $p<0.001$), and FEV1/FVC ($r=0.325$, $p=0.002$). Geographic origin demonstrated minimal impact, with only FEV1 showing a statistically significant difference ($r=0.880$, $p<0.001$).

Conclusion: This study highlights the critical role of physical activity in improving pulmonary function, with geographical origin showing a relatively minor influence. These findings reinforce the importance of promoting physical connectivity and maintaining optimal respiratory health.

Keywords: Spirometry, Lung Health, Physical Activity, Pulmonary Function, Geographical Location.

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INTRODUCTION

Optimal lung function supports daily living activities, including rest and physical exertion [1]. Physical activity (PA), essential for enhancing population health, significantly influences quality of life and healthcare costs globally [2,3]. This growing awareness has led both governmental and private institutions to encourage regular PA [2,3]. However, the paradox lies in the fact that exercising in areas with poor air quality may pose significant health risks [4]. Achieving and maintaining lung health involves engaging in physical activities, breathing clean air, preserving homeostasis, and ensuring proper repair and adaptation mechanisms within the lungs [4].

Pulmonary function tests (PFTs), especially spirometry, are indispensable tools for assessing respiratory health [5]. Widely recognized for its reliability, spirometry measures key lung function parameters such as air volume and flow rate during inhalation and exhalation [5]. These metrics are critical for diagnosing and monitoring respiratory conditions, including asthma, chronic obstructive pulmonary disease (COPD), and pulmonary disorders [6-8]. Spirometry typically involves a deep inhalation followed by a forceful exhalation, providing the key details like forced vital capacity (FVC), forced expiratory volume in one second (FEV1), and the FEV1/FVC ratio [9]. The FVC reflects the maximum air volume exhaled after a deep breath, while the FEV1 indicates the volume of air expelled during the first second [9]. The FEV1/FVC ratio serves as a vital index for detecting airflow limitations indicative of obstructive lung diseases [9].

Numerous factors influence pulmonary function, making it imperative to explore their impact to devise effective interventions for promoting lung health [10]. This study examines the interplay between geographical location, physical activity, and lung function, providing insights into how these variables influence respiratory health in diverse populations.

India, known for its severe air pollution, has initiated extensive efforts to enhance air quality monitoring in response to increasing evidence of its adverse effects on public health, agriculture, and the economy [11-19]. Studies reveal that rapid industrialization and urbanization have exacerbated air quality, leading to predictions of further declines in ambient conditions. By 2050, an estimated 24% rise in particulate matter (PM2.5) associated premature deaths is expected compared to 2015 [20-23]. Chronic exposure to polluted air, particularly fine PM 2.5, is linked to heightened risks of respiratory, cardiovascular, and neurological disorders, as well as a significant reduction in life expectancy [24-37].

Given India's alarming pollution levels, examining their impact on lung health is critical [38,39]. The current study focuses on the effects of ambient air pollution on respiratory function in young individuals, utilising spirometry to measure FVC and FEV1 [38,39]. By comparing data from regions with distinct pollution levels, this research seeks to highlight disparities in lung health and inform strategies for mitigating future disease burdens.

Therefore, the study's objective is to evaluate the influence of geographical location and physical activity on pulmonary function among healthy individuals. Specifically, it investigates how variations in altitude, environmental factors, and physical activity levels affect respiratory performance. Emphasis is placed on the interaction between environmental pollutants, oxygen availability at different altitudes, and physical activity to provide a comprehensive understanding of their combined effects on lung health.

METHODOLOGY

The study recruited a total of 90 healthy individuals (sample size calculated by G* power 3.1 at an effect size of 0.33 and an alpha value of 0.05) aged between 18 and 30 years. Participants were selected from a pool of college students attending diverse academic institutions in the Delhi NCR region. The IEC ethically approved this study. A two-step stratification process was employed, aligning with research objectives: 1) evaluating the impact of geographic location on pulmonary health and 2) investigating the influence of physical activity levels on lung function.

Step 1: Geographic location-based stratification:

To investigate the potential influence of geographic location on pulmonary health, participants were divided into two groups based on their place of origin:

Group 1 (Delhi-born): 45 participants who were born and raised in Delhi for the first 15 years of life.

Group 2 (Non-Delhi-born): 45 participants from various regions of India, representing diverse environmental exposures and living conditions (for the initial 15 years of life) and now living in Delhi.

This classification facilitated a comparative analysis of lung function among individuals from distinct environmental settings.

Step 2: Physical activity level-based stratification:

To assess the impact of physical activity on pulmonary health, instead of considering their geographic location. Based on responses to the International Physical Activity Questionnaire (IPAQ) [40], participants were further classified into two groups according to their reported levels of physical activity:

Group 1 (High Physical Activity): 45 participants who achieved higher levels of PA on the IPAQ scale.

Group 2 (Low Physical Activity): 45 participants who achieved lower levels of PA on the IPAQ scale.

This classification enabled the study to examine the impact of varying PA levels on lung function.

Inclusion and Exclusion Criteria:

Participants included in the study met the following criteria: aged 18-30 years, with no history of respiratory, cardiac, neurological, or musculoskeletal disorders, non-smokers originating from Delhi or other regions of India, categorized into high or low physical activity levels based on IPAQ scores, and willing to provide consent forms.

The study excluded individuals with a recent history of cardiac, neurological, and respiratory trauma, chronic respiratory complications, and musculoskeletal conditions, allergic to environmental factors like pollen or dust, chronic occupational exposure to environmental pollutants, and failure to meet/provide the required details.

PROCEDURE

Before testing, participants were briefed about the process and given written informed consent. Assessments were carried out in a well-ventilated room, and participants were instructed to abstain from strenuous activities or meals for 45-60 minutes before the test.

Demographic data and relevant medical history were documented. Physical activity levels were assessed using IPAQ Short Form, with the results categorized into- Low PA: <600 MET-min/week; Moderate PA: 600-1500 MET-min/week; and High PA: >1500 MET-min/week.

After that, PFTs were conducted using a SpiroTech Portable USB-powered spirometer, which ensured precision with its intelligent flow meter, as shown in Figure 1.

Figure 1: PFT Examination

Participants were seated upright during the tests to optimize lung expansion. A nose clip was applied, and the spirometer mouthpiece was secured to prevent air leakage.

The testing procedure included: a) Inhalation: participants were instructed to take a deep breath, fully inflating their lungs; b) Exhalation: participants exhaled forcefully and rapidly into the spirometer, continuing until no further air could be expelled.

Each participant performed the test at least three times, with a one-minute rest between attempts, and the best result was recorded.

The primary outcomes were spirometry-derived lung function parameters [41]:

1. FEV 1: reflects airway patency, with normal values >80% of predicted.
2. FVC: indicates lung volume capacity, with normal values >80% of predicted.
3. FEV1/FVC Ratio is a key indicator of obstructive lung conditions, with normal values >70%.

Data Analysis:

Statistical analysis was performed using SPSS (version 21.0). Descriptive statistics were calculated for each lung function parameter. Correlation analysis evaluated the relationship between pulmonary function, geographical location, and physical activity levels. Statistical significance was set at p=0.01.

RESULTS

A total of 90 participants, aged between 18 and 30, were involved in the study. Of these, 51 were males, and thirty-nine were females as shown in Table 1. No significant differences were observed in the demographic details of the study, as per the inclusion and exclusion criteria.

The results revealed that geographic location exerted a limited influence on pulmonary health. The association between FVC and geographic region was weak, as reflected by a correlation coefficient (r) of 0.181. The p-value of 0.088 suggests no statistically significant relationship between FVC and geographic location. A positive correlation was observed between FEV1 and geographic regions with a correlation coefficient r = 0.880 and a p-value of <0.001. This finding indicates a statistically significant difference in FEV1 between participants from different geographic locations. The association between the FEV1/FVC ratio and geography was non-significant, with a correlation coefficient r = 0.027 and a p-value of 0.08, suggesting a negligible impact of geographic location on the FEV1/FVC ratio, as shown in Table 2.

Furthermore, the IPAQ score findings indicated that physical activity had a more significant impact on pulmonary health compared to geographic location.

A moderate positive correlation was identified between FEV1 and IPAQ scores, with a correlation coefficient r = 0.425 and p-value <0.001, as shown in Figure 1. This demonstrates a statistically significant association between increased PA levels and improved FEV1 values. Similarly, FVC exhibited a moderate positive correlation with IPAQ scores, with a correlation coefficient r = 0.470, p<0.001. The finding suggests that higher physical activity levels are associated with improved FVC. A moderate positive correlation was observed between the FEV1/FVC ratio and IPAQ scores, with a correlation coefficient r = 0.325 and a p-value of 0.002. This suggests that increased PA is positively associated with improved FEV1/FVC ratio, as shown in Table 1.

Table 1: Demographic Details

Variable	(Mean ± Standard Deviation)
Age in (Years)	18-30 years (21.86±2.10)
M:F	51:39 (1.41±0.49)
Geographic Difference	45 (Delhi) 45 (Outside Delhi) (3.5±0.50)

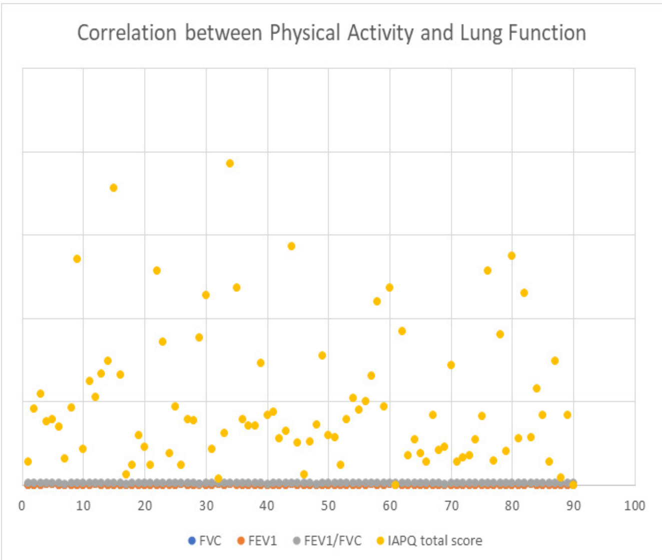
Table 2: Correlation between Physical Activity, Geographical Origin, and Spirometry

Parameters (N=90)	FVC	REGION	FEV1)	IPAQ TOTAL	FEV/ FVC	
FVC	1	.181	.880	.470	.010	Pearson Correlation (r)
		.088	<.001	<.001	.929	Significant value (2-tailed) (p)
REGION	.181	1	.153	.1120	.027	Pearson Correlation (r)
	.088		.150	.258	.800	Significant value (2-tailed) (p)
FEV1	.880	.153	1	.425	.325	Pearson Correlation (r)
	<.001	.150		<.001	.002	Significant value (2-tailed) (p)
IPAQ TOTAL SCORE	.470	.120	.425	1	.128	Pearson Correlation (r)
	<.001	.258	<.001		.229	Significant value (2-tailed) (p)
FEV/FVC	.010	.027	.325	.128	1	Pearson Correlation (r)
	.929	.800	.002	.229		Significant value (2-tailed) (p)

* Correlation is significant at the 0.01 level (2-tailed)

Overall, the results revealed that there was a notable relationship between FEV1 and geographic location ($p<0.001$); the influence of geographic origin on overall pulmonary health was minimal, particularly in terms of FVC and FEV1/FVC ratio. Also, the findings suggested a moderate positive relationship between PA levels and pulmonary function. Higher levels of PA were associated with significant improvements in FEV1, FVC, and the FEV1/FVC ratio, underscoring the beneficial role of physical activity in maintaining optimal pulmonary health.

Figure 1: Correlation between Physical Activity and Lung Function



DISCUSSION

This study examined the relationship between lung function metrics – FVC, FEV1, and the FEV1/FVC ratio – and two factors: levels of physical activity, as assessed by IPAQ, and geographic origin. Our findings demonstrate that while PA levels significantly influence pulmonary function, geographic location exerts only a minimal impact on lung health among young adults.

Impact of Physical Activity on Lung Function:

The analysis identified a significant association between physical activity and pulmonary function. Participants with higher IPAQ scores showed improved lung function across all three parameters studied. Specifically, FVC demonstrated a moderate positive correlation with IPAQ scores ($r=0.470$, $p<0.001$), suggesting that greater PA enhances lung capacity. Similarly, FEV1 showed a moderate correlation with PA levels ($r = 0.425$, $p < 0.001$), reinforcing the importance of regular exercise in maintaining effective expiratory airflow. A weaker but still statistically significant relationship was observed between PA and the FEV1/FVC ratio ($r=0.325$, $p=0.002$). These findings suggest that while PA strongly influences lung volume and expiratory flow, its effect on airway dynamics, as reflected by the FEV1/FVC ratio, is less pronounced.

These results align with previous studies, which have demonstrated that PA, especially aerobic exercise, improves respiratory muscle strength, ventilation efficiency, and lung volume [42-45]. Such physiological benefits are particularly significant for young adults, who can use regular physical activity as a preventive strategy to optimize pulmonary health. The findings highlight a pressing need for longitudinal studies to investigate whether consistent increases in PA can result in sustained improvements in lung function over time.

Impact of Geographic Origin on Lung Function:

Contrary to the strong associations observed with PA, geographic location appeared to play a limited role in determining pulmonary health [46]. FVC showed no significant relationship with geographic region, as indicated by $r=0.81$ and a p-value=0.088. Similarly, the FEV1/FVC ratio showed a nonsignificant association with geographic origin ($r=0.027$, $p=0.800$). Interestingly, FEV1 exhibited a strong and statistically significant correlation with geographic location ($r=0.880$, $p<0.001$). This isolated finding could suggest some regional variability in specific aspects of lung function, but overall, the data indicate that geographic differences do not substantially affect pulmonary health [47].

Compared to less polluted regions of India, environmental factors such as urban pollution in Delhi were expected to influence lung function. However, the lack of consistent regional variation in our study may reflect the relatively short-term exposure experienced by young adults, as opposed to the prolonged exposure seen in other studies that identified geographic disparities in lung health. Individual behaviors such as smoking, diet, and physical activity may overshadow environmental influences in this age group. These findings emphasize the need for more comprehensive studies involving diverse populations and broader environmental conditions better to understand the role of geography in respiratory health.

Cross-sectional or longitudinal studies would provide more robust evidence regarding the impact of exercise on respiratory health. Additionally, future studies should consider confounding variables that may also affect pulmonary functions.

CONCLUSION

This study highlights the significant and beneficial impact of physical activity on lung function in young adults, while geographic origin appeared to have minimal influence. These findings reinforce the value of regular physical activity as a vital component of respiratory health and emphasize the need for continued research to unravel the complex interactions between environmental, behavioral, and physiological factors in determining pulmonary outcomes.

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