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Original Research Article

Protective effect of physical activity on small airway function across different age groups

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ABSTRACT

Background: Small airways play a critical role in maintaining efficient pulmonary function and are often the earliest site of age-related and inactivity-related functional decline. Regular physical activity is known to improve respiratory mechanics, but its protective effect on small airway function across age groups remains unclear. The aim of the study was to evaluate the impact of physical activity and aging on small airway function in adults using expiratory flow rate parameters.
Methods: A cross-sectional study was conducted among 1000 participants in Anand and Kheda Districts. Participants were categorized into four groups (n=250 each): young exercisers (YE), young non-exercisers (YNE), elderly exercisers, and elderly non-exercisers. Spirometric assessment was performed to measure small airway parameters, including MEF25, MEF50, MEF75 and MEF25-75, and peak expiratory flow (PEF). Comparisons were made to assess the effects of age and exercise on small airway function.
Results: Exercisers in both the young and elderly groups demonstrated higher mean expiratory flow rates across all MEF parameters than non-exercisers. YE demonstrated the highest pulmonary efficiency, with a PEF of 10.2±0.8 suggesting an improved overall airflow capacity. Small airway function, measured via MEF 25-75, was highest in the YE group (4.5±0.4) and lowest in the elderly non-exercisers (ENE) group (3.5±0.3) ($p<0.05$). Elderly non-exercisers showed the lowest values, indicating a pronounced decline in small airway function with aging and inactivity.
Conclusions: The study highlights the protective role of regular physical activity in preserving small airway function across different age groups. Although aging is associated with a decline in expiratory flow rates, regular exercise significantly attenuates this decline. Promoting physical activity may therefore be an effective strategy for maintaining respiratory health and preventing early small airway dysfunction.

Keywords: Small airway function, Physical activity, Aging, Expiratory flow rates

INTRODUCTION

Small airways, often referred to as the "silent zone" of the lungs, contribute significantly to overall pulmonary function but typically remain asymptomatic until substantial functional impairment occurs.[1] These airways, generally less than 2 mm in diameter, are particularly susceptible to early pathological changes due to aging, physical inactivity, and environmental exposures.[2]

Unlike larger airways, dysfunction in small airways may not be detected by conventional spirometric indices such as forced expiratory volume in one second (FEV_1) or forced vital capacity, making their assessment crucial for early identification of respiratory decline.[3]

Aging is associated with progressive structural and functional alterations in the respiratory system, including reduced lung elastic recoil, increased airway resistance, decreased chest wall compliance, and weakening of respiratory muscles.[4,5] These changes collectively contribute to diminished expiratory flow rates, particularly affecting the small and medium-sized airways.[6,7] Parameters such as mean expiratory flow at 25%, 50%, and 75% of forced vital capacity (MEF25, MEF50 and MEF75), as well as MEF25-75, are considered sensitive indicators of small airway function and early airflow limitation.[8] PEF further reflects the combined influence of airway caliber and respiratory muscle strength.

Regular physical activity has been shown to exert beneficial effects on pulmonary mechanics by enhancing respiratory muscle strength, improving airway patency, and promoting efficient ventilation.[9,10] Exercise-induced increases in ventilatory demand stimulate adaptive changes in the respiratory system, potentially preserving airflow dynamics and delaying age-related decline in lung function.[7,11] Several studies suggest that physically active individuals demonstrate superior spirometric parameters compared to sedentary individuals, even in older age groups.[12] However, the specific protective effect of physical activity on small airway function across different age groups remains underexplored.

Understanding how exercise influences small airway function in both young and elderly adults is clinically significant, as early small airway dysfunction may precede overt obstructive pulmonary diseases such as chronic obstructive pulmonary disease.[13] Identifying modifiable lifestyle factors, such as physical activity, that preserve small airway health could play a crucial role in preventive respiratory care.

The present study aims to compare small airway function (MEF25, MEF50, MEF75 and MEF25-75) between young and elderly adults, evaluate the effect of regular physical activity on small airway expiratory flow rates, analyze PEF as an indicator of overall expiratory capacity, and assess whether regular exercise mitigates age-related decline in small airway function.

METHODS

A cross-sectional observational study was conducted in Anand and Kheda districts to evaluate the protective effect of physical activity on small airway function across different age groups. Data collection was carried out from August 2024 to August 2025. The study design enabled comparison of pulmonary function parameters between individuals of varying age and physical activity status at a single point in time. The study population consisted of individuals aged 18-24 years and 60-75 years. Participants were categorized into two study-defined age groups: the young and elderly groups. This classification was adopted to compare pulmonary function between earlier and later stages of adulthood. Based on age and physical activity status, participants were further divided into four groups: YE, YNE, elder exercisers, and ENE. Each group comprised 250 participants, yielding a total sample of 1000 individuals.

Participants were included if they were apparently healthy and willing to participate in the study. Individuals classified as exercisers were those who engaged in regular physical activity for at least 30 minutes per day, on at least five days per week, for at least six months. Participants who did not meet these criteria were categorized as non-exercisers. Individuals with a history of chronic respiratory diseases such as asthma, chronic obstructive pulmonary disease, or tuberculosis, those with current or past smoking history, recent acute respiratory infections, cardiovascular or neuromuscular disorders, or occupational exposure to respiratory pollutants were excluded from the study. Anthropometric measurements, including height and weight, were recorded using standardized methods. Body mass index was calculated as weight (in kilograms) divided by height (in meters squared). BMI was recorded to assess its potential influence on pulmonary function parameters.

Pulmonary function testing was performed using a calibrated computerized RMS spirometer in accordance with the guidelines of the American Thoracic Society and the European Respiratory Society. All measurements were conducted with participants seated, and a nose clip was used to prevent nasal air leakage. Participants were instructed and familiarized with the procedure before testing. A minimum of three acceptable and reproducible spirometric maneuvers were obtained for each participant, and the best recorded value was used for analysis.

Small airway function was assessed using expiratory flow rate parameters, including mean expiratory flow at 25%, 50%, and 75% of forced vital capacity (MEF25, MEF50, and MEF75), mean expiratory flow between 25% and 75% of forced vital capacity (MEF25-75), and PEF. These parameters were selected as they are sensitive indicators of peripheral airway function and early airflow limitation. All data were recorded systematically in a structured data collection sheet. Spirometry was performed under similar environmental conditions for all participants to minimize measurement variability, and adequate rest was provided between successive attempts to avoid fatigue-related errors. Statistical analysis was performed using appropriate statistical software.

Continuous variables were expressed as mean ± standard deviation. Comparisons among the four groups were carried out using one-way analysis of variance, followed by post-hoc tests where applicable. A p value of less than 0.05 was considered statistically significant. The study was conducted in accordance with ethical principles for research involving human participants. Informed consent was obtained from all participants prior to data collection, and confidentiality of participant information was strictly maintained throughout the study.

RESULTS

The study cohort consisted of 1000 participants evenly distributed across 250 individuals per group. As shown in Table 1, the sex distribution was balanced across all cohorts, with the total population comprising 498 males (49.8%) and 502 females (50.2%). The analysis of small airway function revealed that exercise had a positive effect across all age groups. YE demonstrated the highest mean expiratory flow rates at MEF25, MEF50, MEF75, and MEF25-75, indicating optimal small airway patency. Elderly exercisers also showed better flow rates than their non-exercising counterparts, suggesting that regular physical activity helps preserve small airway function even with advancing age. PEF followed a similar trend, with exercisers achieving higher values than non-exercisers in both young and elderly groups. Aging was associated with a decline in small airway flows and PEF, but this decline was attenuated in individuals who regularly exercised, highlighting the protective role of physical activity on small airway function.

MEF25 consistently exhibits the highest flow rates, followed by MEF50 and MEF25-75, while MEF75 shows the lowest values across all groups. YE have the highest mean values for all MEF parameters (e.g., EF25=6.2 L/s), while ENE show the lowest (e.g., MEF25=4.9 L/s), highlighting the decline associated with aging and inactivity. Standard deviations range from 0.2 to 0.5 L/s, indicating moderate variation within groups. The trends emphasize that regular exercise positively influences small airway function across all measured parameters, attenuating the age-related decline (Table 2). PEF revealed significant variation across the four study groups ($p<0.01$). PEF was highest in YE (10.2±0.8), followed by elderly exercisers (9.8±0.7). The non-exercising individuals showed lower flow rates in both age groups. These suggest that while aging is associated with a decline in PEF, regular exercise exerts a positive and protective effect (Table 3).

The X-axis categorizes participants into four groups based on age and exercise status: YE, YNE, elder exercisers, and ENE. Adjacent to each group label, the corresponding standard deviation values are also presented, reflecting the variability in expiratory flow measurements within each group. The chart displays four small airway function parameters: MEF25, MEF50, MEF75, and MEF25-75. The primary Y-axis shows the mean expiratory flow rates (L/s) for MEF25, MEF50, and MEF75, ranging approximately from 0 to 7 L/s, with MEF25-75 values overlaid on the secondary Y-axis, which ranges from 0 to 5 L/s (Figure 1).

The X-axis represents 4 participant groups categorized by age and exercise status: YE, YNE, elder exercisers, and ENE. Adjacent to each group label, the corresponding standard deviation is displayed, indicating ariability in the PEF measurements within each group. Y-axis quantifies the PEF values in liters per second (L/s), reflecting the maximal expiratory flow achieved by participants. The chart visually highlights that YE have the highest mean PEF (10.2 L/s), followed by elder exercisers (9.8 L/s), YNE (9.3 L/s), and ENE (8.6 L/s), with standard deviations ranging from 0.6 to 0.8 L/s. This distribution underscores the positive impact of regular physical activity on respiratory function, especially in preserving maximal expiratory flow across age groups (Figure 2).

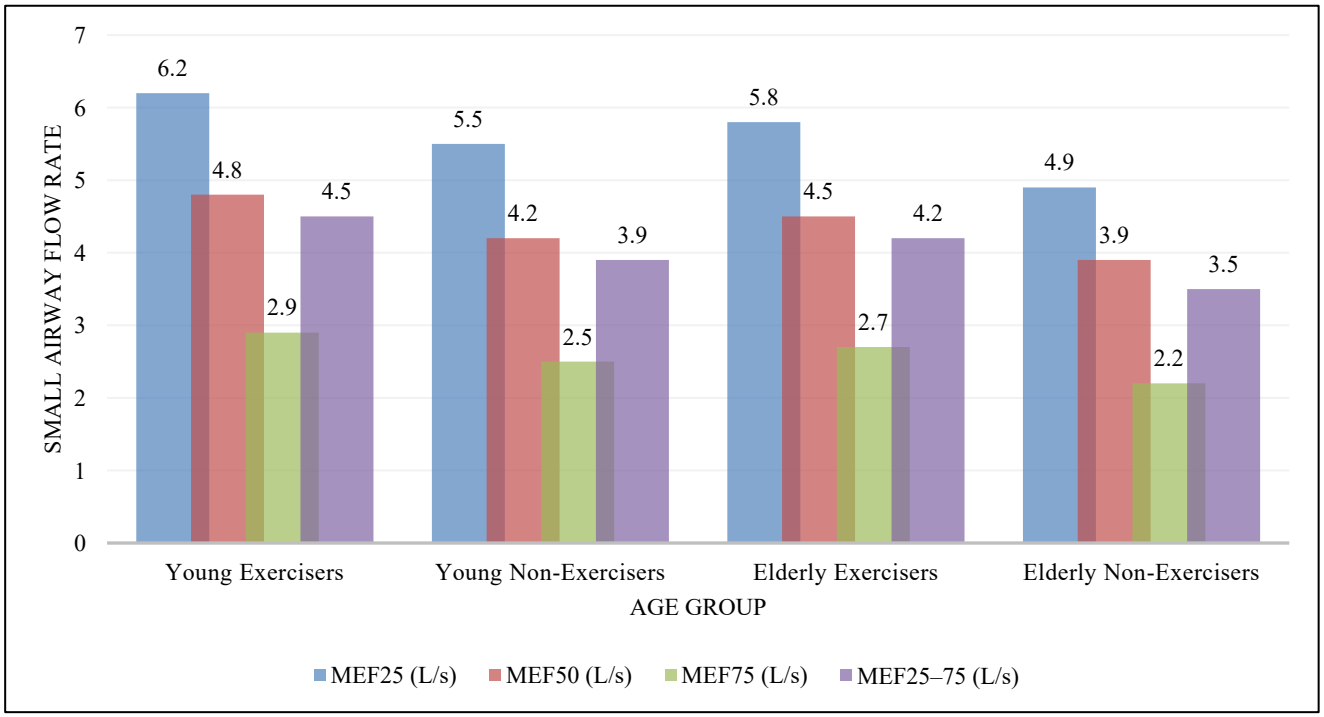

Figure 1: Effect of exercise and age on small airway flow rates.

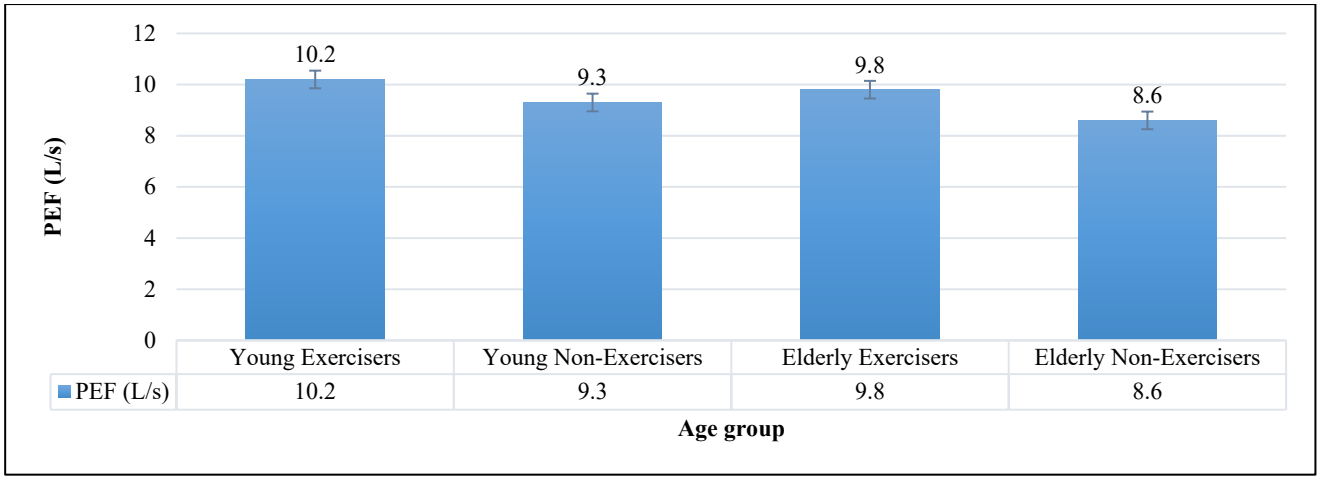

Figure 2: Peak expiratory flow across age and exercise groups.

Table 1: Age and sex distribution among study groups.

Groups	Age range (in years)	Male		Female		Total
		N	%	N	%	
YE	18-24	130	52	120	48	250
YNE	18-24	120	48	130	52	250
Elder exercisers (EE)	60-75	125	50	125	50	250
ENE	60-75	123	49	127	51	250

Table 2: Small airway flow rates across groups.

Parameters	YE	YNE	Elder exercisers	ENE	P value
MEF25%	6.2±0.5	5.5±0.4	5.8±0.5	4.9±0.4	<0.001
MEF50%	4.8±0.1	4.2±0.3	4.5±0.4	3.9±0.3	<0.001
MEF75%	2.9±0.3	2.5±0.2	2.7±0.3	2.2±0.2	<0.001
MEF25-75%	4.5±0.4	3.9±0.3	4.2±0.4	3.5±0.3	<0.001

Table 3: PEF across groups.

Parameter	YE	YNE	Elder exercisers	ENE	P value (ANOVA)
PEF(L/s)	10.2±0.8	9.3±0.6	9.8±0.7	8.06±0.6	<0.001

DISCUSSION

The present study demonstrates a clear protective effect of regular physical activity on small airway function across different age groups. Small airways are particularly vulnerable to early functional decline due to aging and inactivity, and impairment at this level may occur well before changes are evident in conventional spirometric indices.[14] The findings of this study show that exercisers-both young and elderly exhibited consistently higher values of MEF25, MEF50, MEF75, and MEF25-75 compared to their non-exercising counterparts, indicating superior airflow through the peripheral airways. YE demonstrated the highest expiratory flow rates across all small airway parameters, reflecting optimal airway patency and respiratory muscle efficiency. This can be attributed to enhanced ventilatory demand during physical activity, which promotes better lung compliance, airway stability, and respiratory muscle conditioning. In contrast, YNE showed comparatively reduced flow rates, suggesting that physical inactivity may negatively influence small airway function even at a younger age.[15] Among elderly participants, an age-related decline in small airway function was evident, consistent with previous literature describing reduced lung elasticity, airway narrowing, and diminished respiratory muscle strength with advancing age.[16] However, elderly exercisers maintained significantly better expiratory flow rates than elderly non-exercisers, indicating that regular physical activity attenuates physiological decline associated with aging. This preservation of small airway function among elderly exercisers highlights the role of exercise in slowing respiratory aging and maintaining ventilatory efficiency.

The elderly non exercisers group exhibited the lowest mean MEF 25-75 (3.5), indicating small airway

dysfunction that often precedes a major decline in FEV1. This is consistent with the longitudinal findings of Fukuda et al which highlight that small airway impairment is an early marker of chronic respiratory conditions.[13]

It is also established that small airway dysfunction significantly impacts large airway parameters in elderly adults, a trend reflected in our study where lower MEF values was found in sedentary groups.[2] By using the standards set by the American thoracic society (2002), our study confirms that these peripheral airways, often called the "silent zone," are the most protected by active lifestyles.[9]

PEF followed a similar trend, with higher values observed in exercisers across both age groups. Since PEF reflects maximal expiratory effort and respiratory muscle strength, these findings further support the beneficial impact of physical activity on overall pulmonary performance. Elderly non-exercisers exhibited the lowest PEF values, reflecting the combined adverse effects of aging, reduced muscle strength, and physical inactivity on expiratory airflow. Clinically, preservation of small airway function is essential to prevent early airflow limitation and reduce the risk of obstructive pulmonary disease. The present findings align with previous studies suggesting that physical activity enhances airway caliber, improves respiratory muscle endurance, and supports efficient ventilation.[16] Regular exercise may therefore serve as a non-pharmacological intervention to preserve pulmonary function and delay the onset of age-related respiratory disorders.

Clinical significance

The findings from this study underscore the vital importance of maintaining regular physical activity to preserve small airway function, especially in older populations who are more susceptible to early respiratory decline. Small airway dysfunction is often an early marker of chronic obstructive pulmonary disease and other obstructive respiratory conditions, which significantly impair quality of life and increase healthcare burdens. By demonstrating that exercise mitigates the age-related decline in expiratory flow rates MEF25, MEF50, MEF75, MEF25-75 and PEF, this study suggests that physical activity can serve as a simple, non-pharmacological intervention to maintain airway patency and lung health. Clinicians and healthcare providers should incorporate routine assessment of small airway function and advocate for tailored exercise programs that enhance respiratory muscle strength, improve ventilation, and reduce airway resistance. Promoting physical activity may also delay or prevent the onset of obstructive lung diseases, reduce respiratory-related hospitalizations, and improve functional independence among the elderly. Additionally, awareness campaigns targeting sedentary adults could help reduce the long-term respiratory morbidity associated with inactivity and aging.

Limitations

The study employs a cross-sectional, rather than a longitudinal, design. Although efforts are made to control for factors such as age, sex, and body composition, other potential factors, such as socioeconomic status, environmental exposures, diet, and genetics, are not fully controlled for or discussed.

CONCLUSION

In conclusion, this study clearly demonstrates that regular physical activity plays a protective role in maintaining small airway function across both young and elderly populations. While aging is inevitably associated with a decline in expiratory flow rates and overall pulmonary function, engaging in consistent exercise significantly attenuates this decline, preserving better airway mechanics and airflow capacity. The enhanced MEF parameters and PEF seen in exercisers reflect improved peripheral airway patency and respiratory muscle efficiency. Encouraging an active lifestyle is therefore an accessible, cost-effective strategy to safeguard respiratory health, improve exercise tolerance, and enhance quality of life, especially in aging populations at risk of early airway dysfunction. Future longitudinal studies and controlled interventions are warranted to further elucidate the long-term benefits and optimal exercise prescriptions for maintaining lung health throughout the lifespan.

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