

Co-Relation Between Pulmonary Function and Physical Fitness in Middle Age Adults - An Observational Study

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Abstract:

➤ Background

Pulmonary function and physical fitness decline progressively with age, yet limited evidence exists on their inter-relationship in middle-aged adults. Understanding this correlation is important for designing preventive strategies to maintain respiratory health and functional capacity.

➤ Methods

A cross-sectional study was conducted on 100 adults aged 40–59 years, divided into four age groups (n=25 each). Physical activity levels were assessed using the IPAQ, and pulmonary function was evaluated with spirometry, measuring FVC, FEV₁, FEV₁/FVC ratio, and MVV. Pearson correlation and ANOVA were applied for statistical analysis.

➤ Results

People who were more active generally had better lung function, and this trend was especially clear in the youngest subgroup (40–44 years) between IPAQ and FVC ($r=0.41$, $p<0.05$) and MVV ($r=0.42$, $p<0.05$). In older subgroups (45–59 years), correlations weakened and did not reach statistical significance. MVV demonstrated the strongest responsiveness to physical activity, while FEV₁/FVC ratios remained relatively stable across all groups.

➤ Conclusion

Physical activity is positively associated with pulmonary function in early middle age, particularly influencing ventilatory capacity and respiratory muscle strength. These associations diminish with advancing age, highlighting the importance of maintaining regular physical activity from early middle age to mitigate age-related decline in pulmonary health.

Keywords: Pulmonary Function, Physical Activity, Middle-Aged Adults, International Physical Activity Questionnaire (IPAQ), Age-Related Decline, Respiratory Health.

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I. INTRODUCTION

Physical fitness is a crucial factor in maintaining health throughout life, and it becomes especially significant in middle-aged and older adults by slowing age-related physiological decline, reducing the risk of chronic illnesses, and supporting functional independence. (1).

Respiratory function progressively declines with age due to weakening of respiratory muscles, reduction in type II fibres, and loss of lung elasticity, which collectively reduce ventilatory efficiency and increase susceptibility to fatigue and illness (2). Additional structural factors such as decreased chest wall compliance and weakening of the diaphragm and intercostal muscles further compromise ventilation in later life (3). Age-related changes also include diminished lung elastic recoil, stiffening of the thoracic cage, and reduced reserve capacity, which together contribute to the decline in pulmonary efficiency while increasing vulnerability to respiratory complications (4).

Demographic and anthropometric variables are essential considerations in the assessment of lung function. According to the European Community Respiratory Health Survey, lung function peaks in early adulthood, varies with sex, height, and ethnicity, and progressively declines with age (5). Spirometric indicators such as FEV1 and FVC attain their highest values in the mid-20s, followed by a gradual decline; this process is often accelerated by factors like smoking or chronic illness, leading to increased morbidity and mortality (6). Spirometry remains the gold standard for evaluating lung volumes and airflow, offering vital insights for the diagnosis and follow-up of respiratory conditions. (7).

Physical fitness and respiratory function are strongly interdependent. Exercise improves respiratory muscle strength, lung mechanics, and oxygen utilization, while robust pulmonary function supports endurance and performance (8). Conversely, Low levels of physical activity represent a significant public health challenge with widespread implications, contributing significantly to cardiovascular disease, diabetes, obesity, certain cancers, and premature mortality. The IPAQ offers a reliable and standardized method for evaluating physical activity and managing related health risks at the population level. (9).

II. METHODOLOGY

The research was carried out at RJS College of Physiotherapy employing a simple random sampling. Data were collected from the RJS Institute, Kopargaoon, over a six-month period. The study population comprised middle-aged adults between 40 and 59 years, with a total sample size of 100 participants. All data were collected by the principal investigator.

➤ Selection Criteria

The participants for this study were selected based on predetermined inclusion and exclusion criteria. Individuals eligible for inclusion were men and women aged 40 and 59 years who were capable to understand and follow instructions and individuals who are willing to take part in the study. Individuals were excluded if they reported a history of smoking, recent surgical procedures, diagnosed neurological disorders, or existing cardiovascular or respiratory diseases. In addition, individuals with cognitive or mental impairments that could interfere with their ability to follow multistep commands, as well as those unwilling to participate, were not considered for inclusion.

III. PROCEDURE

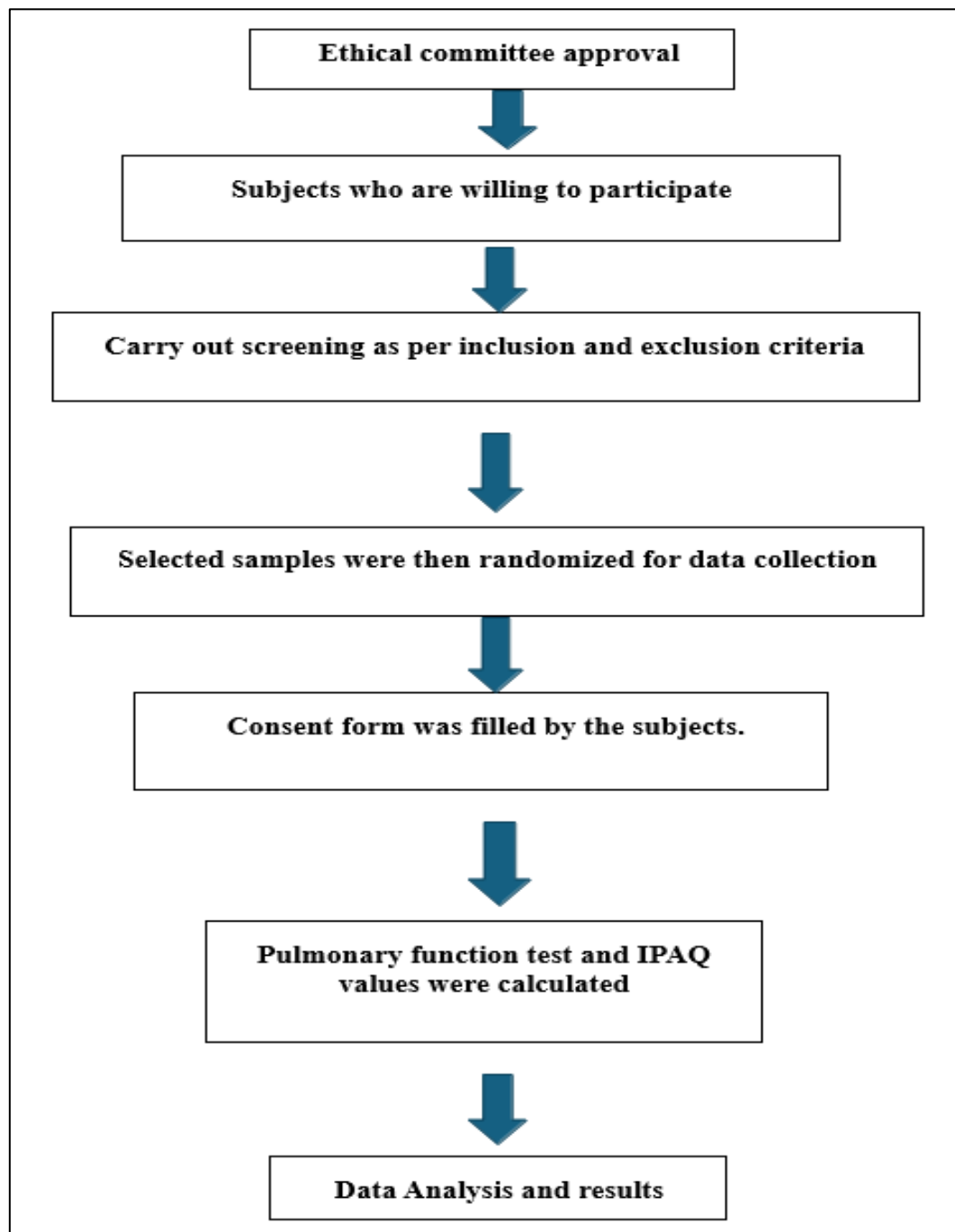


Fig 1 Procedure

Ethical clearance for the study was granted by the Institutional Ethical Committee before commencement. Recruitment was based on predefined inclusion and exclusion criteria, with participation limited to individuals who voluntarily consented. The following study was explained in detail, and informed consent was obtained from all those participated in the study. A total of 100 middle-aged adults aged 40–59 years were enrolled and stratified into four groups of 25 each: Group A (40–44 years), Group B (45–49 years), Group C (50–54 years), and Group D (55–59 years). Prior to data collection, all participants underwent screening as per eligibility criteria. The PFT was performed using a

computerized Clarity Spirotech+ device. Demographic details including age, height, sex, and weight were entered into the system before testing. Each subject was seated in an upright position on a chair or stool and instructed to wear non-restrictive clothing. A nasal clip was applied to prevent air leakage, and the mouthpiece was securely positioned with lips sealed around it. Detailed instructions with demonstrations were provided, and the participants were allowed to perform a few tidal breaths to adapt to the apparatus. To assess FVC, FEV1, and the FEV1/FVC ratio, participants performed a maximal inhalation followed by a forceful and complete exhalation lasting at least one second.

Each manoeuvre was repeated three times following the standard guidelines as per American Thoracic Society (ATS), with the best value recorded. For MVV, participants were asked to inhale and exhale as quickly and deeply as possible for 15 seconds. This procedure was also repeated three times, and the highest value was documented in line with ATS recommendations.

Alongside pulmonary function testing, physical activity was evaluated using the IPAQ. Participants provided information on activities across three categories: walking, moderate-intensity exercise, and vigorous-intensity exercise. For each activity type, both frequency (days per week) and duration (minutes per day) were recorded separately.

Following completion of data collection, pulmonary function values and IPAQ scores were analysed. Data from the randomized sample were analysed using suitable statistical techniques to examine the association between physical activity levels and pulmonary function measures.

➤ Outcome Measures

Level of Physical activity was measured using the International Physical Activity Questionnaire (IPAQ), which categorizes individuals as inactive, minimally active, or HEPA active according to standardized criteria based on activity frequency, duration, and intensity. The IPAQ has demonstrated strong reliability (test-retest stability with $\alpha > 0.80$) and robust validity across predictive, concurrent, convergent, criterion, and discriminant measures. Pulmonary function was assessed through spirometry, evaluating Forced Vital Capacity (FVC), Forced Expiratory Volume in one second (FEV1), the FEV1/FVC ratio, and Maximum Voluntary Ventilation (MVV). These parameters provided both subjective and objective insights into participants'

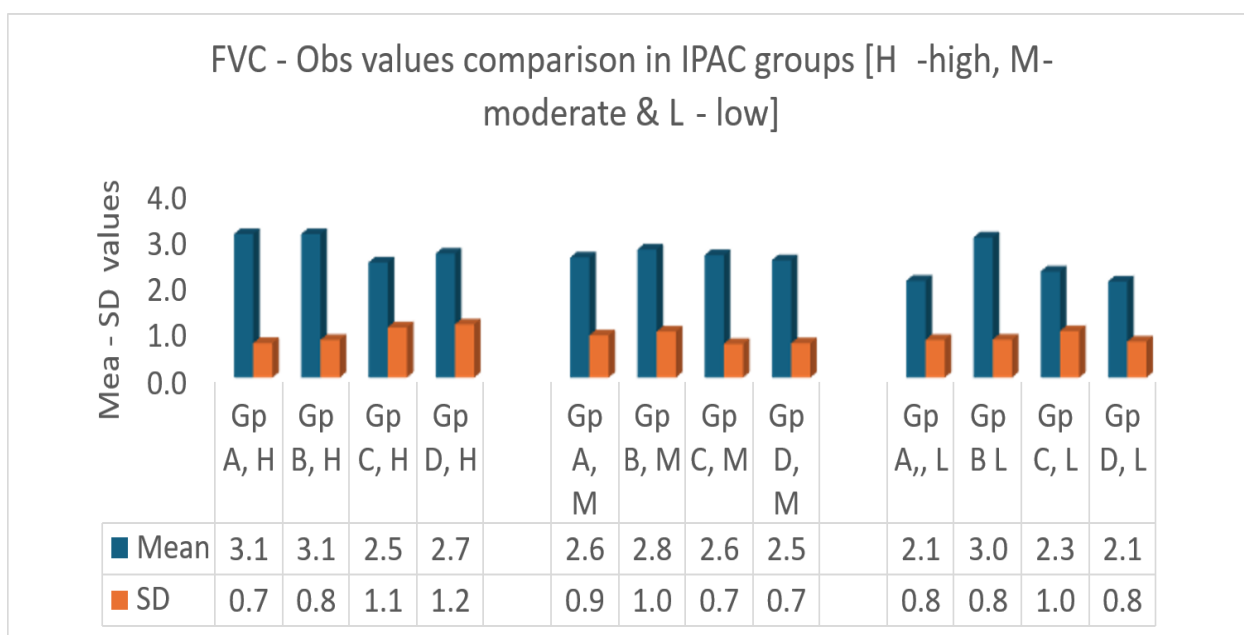
activity levels and respiratory function, with spirometry showing excellent reproducibility (ICC ≈ 0.90 – 0.95 ; bias < 50 – 150 mL; ICC ≈ 0.76 – 0.95)

IV. DATA ANALYSIS

The study included 100 middle-aged adults (65% male, 35% female) between 40 and 59 years of age, evenly distributed into four age groups of 25 participants each. Lung function parameters (FVC, FEV1/FVC, FEV1, and MVV) and physical activity classifications (IPAQ categories: low, moderate, high) were recorded. Descriptive statistics indicated that in younger age groups (40–44 and 45–49), participants classified as highly active generally exhibited better lung function values, including higher mean FVC, FEV1, and MVV, compared to moderately and low active groups. However, in older groups (50–54 and 55–59), moderate activity was sometimes associated with better or comparable pulmonary function than high activity, suggesting potential age-related changes in the physical activity-pulmonary function relationship.

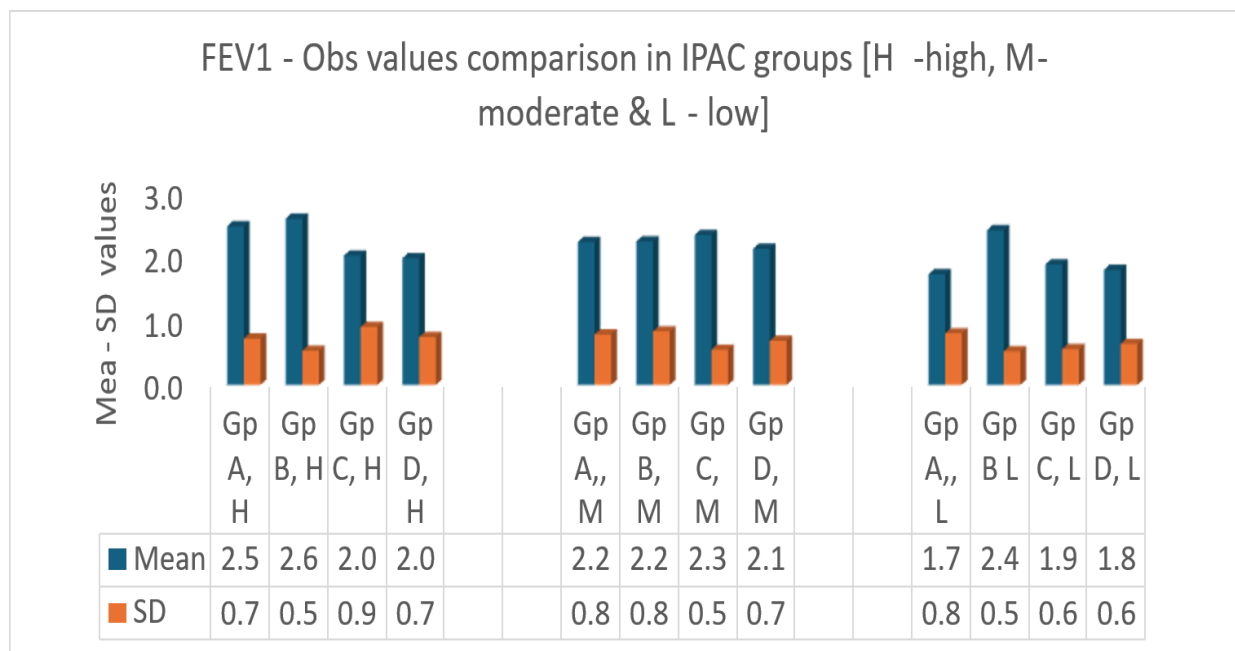
V. RESULTS

ANOVA revealed no statistically significant differences in pulmonary function outcomes across age groups, IPAQ activity categories, or their interactions (all p-values > 0.05). Pearson correlation analyses showed significant positive correlations between IPAQ scores and FVC ($r = 0.41$, $p = 0.044$) and MVV ($r = 0.42$, $p = 0.038$) in the youngest age group (40–44 years), while no significant correlations were found in older age groups. Overall, higher physical activity levels appear to be associated with better pulmonary function primarily in early middle age, with this relationship attenuating with advancing age.



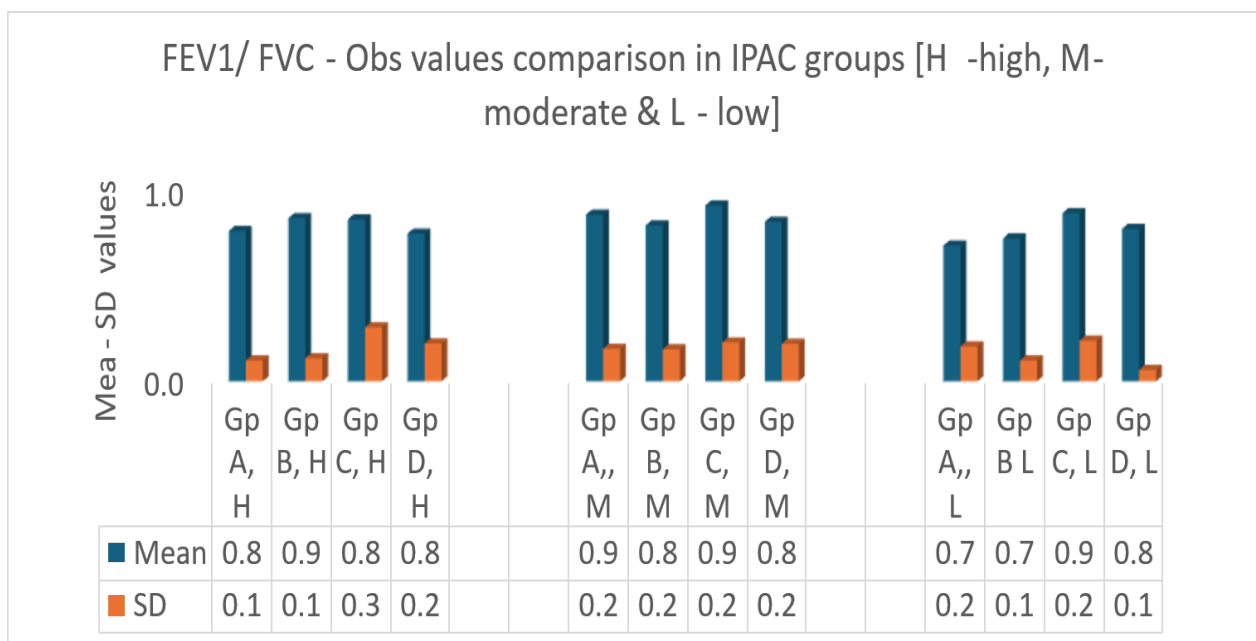
Graph 1- Graphical Representation of Descriptive Statistics of FVC - Mean and SD Values as Per Age Groups and IPAQ Groups

Across groups A–D, Forced Vital Capacity (FVC) is generally higher in highly and moderately active participants compared to low-active ones, though some inconsistencies appear. Group A and D show a clear decline from high to low activity, while Group B’s low group is unexpectedly close to the high group, and Group C records the highest mean in the moderate group. Overall, higher activity tends to be linked with better FVC, but variability and small sample sizes affect consistency.



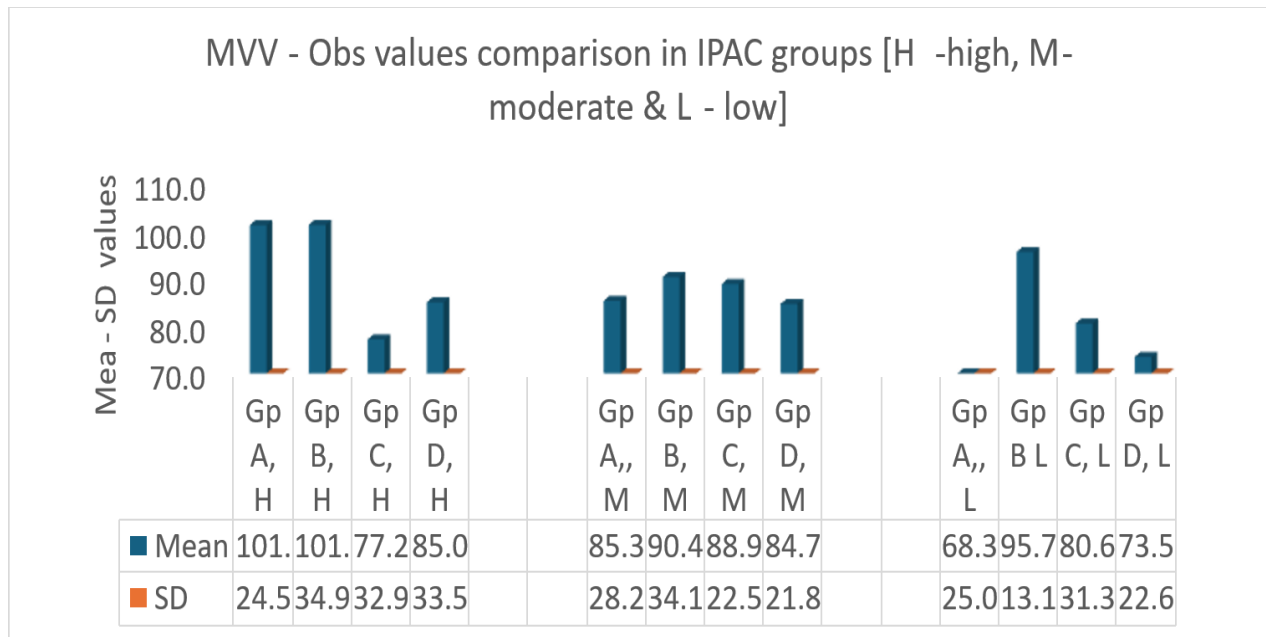
Graph 2- Graphical Representation of Descriptive Statistics of FEV1 - Mean and SD values as Per Age Groups and IPAQ Groups

FEV1 values show that in younger groups (A and B), highly active participants had the best lung function, while in older groups (C and D), moderate activity produced the highest values. Low-active individuals consistently showed the weakest FEV1, and variability was greater in smaller groups. Overall, high activity benefits younger adults, whereas moderate activity is more favorable in older age, alongside the natural age-related decline in lung capacity.



Graph 3- Graphical Representation of Descriptive Statistics of FEV1/FVC - Mean and SD Values as Per Age Groups and IPAQ Groups

Across Groups A–D, the FEV1/FVC ratio is generally highest in moderately active participants, while low-active individuals show the poorest values. Younger groups maintain healthy ratios with best outcomes in moderate or high activity, whereas in older groups, moderate activity remains most favorable, reflecting that balanced exercise supports airway function, while overall ratios decline with age.



Graph 4- Graphical Representation of Descriptive Statistics of MVV - Mean and SD Values as Per Age Groups and IPAQ Groups

MVV generally improves with physical activity, with younger groups (A and B) showing a clear gradient favoring highly active participants, while in older groups (C and D) moderate activity sometimes equals or exceeds high. Overall, higher activity supports better ventilatory capacity, though variability and age reduce the consistency of this trend.

Table 1. Comparison Between Pulmonary Function Parameters and it's Correlation with IPAQ.

OUTCOME MEASURE	TWO-WAY ANOVA (AGE × IPAQ)	PEARSON CORRELATION (IPAQ VS PULMONARY FUNCTION)
FVC	No significant effects of age ($F=1.76$, $p=0.16$), IPAQ ($F=1.80$, $p=0.17$), or interaction ($F=0.57$, $p=0.74$)	Group A: $r=0.41$, $p=0.044$ (significant) Group B: $r=0.07$, $p=0.735$ (ns) Group C: $r=0.06$, $p=0.775$ (ns) Group D: $r=0.25$, $p=0.232$ (ns)
FEV1	No significant effects of age ($F=1.75$, $p=0.16$), IPAQ ($F=1.43$, $p=0.24$), or interaction ($F=0.74$, $p=0.61$)	Group A: $r=0.32$, $p=0.122$ (ns) Group B: $r=0.15$, $p=0.476$ (ns) Group C: $r=0.04$, $p=0.861$ (ns) Group D: $r=0.08$, $p=0.697$ (ns)
FEV1/FVC	No significant effects of age ($F=1.20$, $p=0.31$), IPAQ ($F=1.45$, $p=0.23$), or interaction ($F=0.44$, $p=0.84$)	Group A: $r=0.06$, $p=0.780$ (ns) Group B: $r=0.31$, $p=0.135$ (ns) Group C: $r=-0.07$, $p=0.749$ (ns) Group D: $r=-0.07$, $p=0.723$ (ns)
MVV	No significant effects of age ($F=1.36$, $p=0.25$), IPAQ ($F=1.12$, $p=0.32$), or interaction ($F=0.72$, $p=0.63$)	Group A: $r=0.42$, $p=0.038$ (significant) Group B: $r=0.10$, $p=0.637$ (ns) Group C: $r=-0.07$, $p=0.748$ (ns) Group D: $r=0.16$, $p=0.448$ (ns)

VI. DISCUSSION

The present study evaluated pulmonary function parameters including FEV1, FEV1/FVC ratio, and MVV, and correlated them with physical fitness levels (IPAQ scores) in middle-aged adults. The findings showed that individuals with greater physical activity levels consistently exhibited improved pulmonary function outcomes, particularly in the younger subgroup (40–44 years), where positive correlations were observed between IPAQ scores and both FVC and MVV which is statistically significant. These findings suggest that physical activity exerts a protective effect on pulmonary function, with greater impact during the earlier decades of middle age. As age advanced, particularly in the 50–59 year

range, the association between physical activity and pulmonary outcomes declined, reflecting the natural physiological deterioration of pulmonary function and respiratory muscle strength with aging.

When examining individual parameters, it was noted that FVC and FEV1 were higher in physically active individuals compared to those with low activity, particularly in the 40–49 year groups. This highlights the contribution of physical activity to preserving lung volumes and expiratory flow rates. However, in the older groups, the advantage of high activity was less distinct, with moderate activity sometimes yielding better outcomes. This pattern may reflect the fact that moderate activity is more sustainable and less

fatiguing for older adults, whereas very high-intensity exercise might not always translate into superior ventilatory benefits at this age. The FEV1/FVC ratios remained relatively stable across groups and within normal limits, indicating that while inactivity and obesity reduce lung volumes, they do not appear to induce significant airway obstruction in this population. Among all the parameters, MVV appeared to be the most sensitive to physical activity levels, as active participants achieved markedly higher values than sedentary peers, emphasizing the importance of respiratory muscle endurance and ventilatory reserve. IPAQ correlations supported these findings, with the strongest positive associations observed in the younger subgroup, suggesting that physical activity has a more pronounced effect earlier in middle age.

Comparison with existing literature further strengthens these observations. Verónica Sanz-Santiago et al. (2020) demonstrated that a structured exercise program improved both lung function and overall fitness in adolescents with asthma, which parallels the present findings where physically active individuals displayed better FVC, FEV1, and MVV outcomes. Similarly, Márcio de Almeida Mendes et al. (2018) established metabolic equivalent (MET) thresholds for moderate and vigorous physical activity, showing that greater exercise intensity is linked with better physiological outcomes. In the present study, IPAQ-based classification of activity levels revealed a similar pattern, where moderate to high physical activity levels were linked to enhanced pulmonary function outcomes. Taken together, these results reinforce the concept that maintaining regular physical activity has measurable benefits on lung function and ventilatory capacity, although the magnitude of this benefit is influenced by age.

VII. CONCLUSION

This study concludes that physical activity levels significantly influence pulmonary function and ventilatory capacity, particularly in early middle age. Among adults aged 40–59 years: Higher FVC, FEV1, and MVV were observed in physically active individuals. MVV showed the strongest positive association with physical activity, reflecting enhanced respiratory muscle performance. FEV1/FVC ratios remained relatively unaffected, suggesting preserved airway patency. The association among physical activity and lung function was strongest in the younger age group (40–44 years) and gradually weakened with increasing age. When compared with earlier studies, the current results align with prior evidence demonstrating the beneficial effects of physical activity on lung function (Study 1) and emphasize the significance of activity thresholds in determining health benefits (Study 2). Overall, sustaining physical activity during middle age is crucial for maintaining pulmonary health and slowing age-related functional decline. Public health strategies should therefore emphasize promotion of regular physical activity—both moderate and vigorous—tailored to age and individual capacity, to safeguard respiratory health and overall fitness across the lifespan.

STRENGTHS AND LIMITATIONS

➤ *Strengths of the Study*

Clear age stratification (40–44, 45–49, 50–54, 55–59 yrs) with equal sample size (n=25 each). This is good design-wise.

Significant correlations in younger group (40–44 yrs):

* FVC ($r \approx 0.41$, $p < 0.05$)

* MVV ($r \approx 0.42$, $p < 0.05$)

Suggests physical fitness (IPAQ) is more strongly related to pulmonary capacity and muscle strength in early middle-age adults.

Non-significant correlations in older groups: This negative finding remains important, as it indicates a diminishing impact of physical fitness on lung function with advancing age.

➤ *Limitations of the Study*

- Sample size* is modest (n=25 per group). While adequate for correlations, higher n would strengthen statistical power.
- IPAQ is categorical (Low/Moderate/High) rather than continuous MET-min scores. Some journals may prefer continuous variables for correlation/regression.
- Cross-sectional design → Can't establish causality (only association).
- Only Pearson correlations (you're adding Spearman, which is good) but regression models adjusting for confounders (age, sex, smoking, BMI) would make it stronger.
- No external validation or longitudinal follow-up.

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