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The Effect of Vitamin C Supplementation on Lung Function and Radiological Changes in Smokers: A Multidisciplinary Approach

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Abstract

Background: Antioxidants such as vitamin C, due to their potential benefits in reducing oxidative injury and improving pulmonary outcomes, may be an interesting option to explore and, therefore, can be seen as a plausible candidate to address oxidative stress from smoking.

Objectives: To investigate the effect of Vitamin C supplementation on lung function and radiological changes in smokers.

Methods: This prospective interventional study was conducted at Swat Medical College from January 2023 to January 2024. A total of sixty-one adult smokers received daily oral vitamin C (500 mg) for six months. The pulmonary function was evaluated using spirometry (FEV_1, FVC, and FEV_1/FVC), and structural changes were evaluated through chest X-ray and high-resolution computerized tomography (HRCT), both at baseline and after supplementation. Descriptive and analytical statistics were performed using SPSS version 26, and $P \leq 0.05$ was considered significant.

Results: Post-intervention, mean FEV_1 increased from 2.34 ± 0.51 L to 2.58 ± 0.48 L ($p = 0.001$), FVC from 3.12 ± 0.65 L to 3.34 ± 0.62 L ($p = 0.003$), and FEV_1/FVC ratio from 75.0% to 77.6% ($p = 0.010$). Although radiological findings such as hyperinflation and bronchial thickening showed non-significant reductions, they indicated a positive trend toward improvement.

Conclusion: Vitamin C supplementation significantly improved lung function in smokers, suggesting its role as a beneficial adjunct therapy. Longer-term studies are needed to confirm its impact on structural lung changes.

Keywords: Vitamin C, Lung Function, Smokers, Radiological Changes

INTRODUCTION

Tobacco smoking remains one of the leading preventable causes of morbidity and mortality worldwide.[1] It is strongly associated with chronic respiratory diseases such as chronic obstructive pulmonary disease (COPD), bronchitis, and increased susceptibility to respiratory infections.[2] Cigarette smoke contains thousands of harmful chemicals, including reactive oxygen species (ROS), which induce oxidative stress and cause cellular and tissue damage in the lungs.[3] Oxidative stress is a central mechanism in smoking-related lung injury, contributing to airway inflammation, alveolar destruction, and structural alterations visible on radiographic imaging.[4]

Antioxidants such as vitamin C (ascorbic acid) are known to play a protective role against oxidative damage by scavenging free radicals and supporting immune function.[5] Smokers, however, often exhibit depleted levels of vitamin C due to increased oxidative burden and reduced dietary intake.[6] Previous research has indicated that antioxidant supplementation may attenuate inflammation, improve pulmonary function parameters, and possibly slow the progression of smoking-related lung damage.[7] Yet, the evidence remains inconsistent, and few studies have investigated the effect of vitamin C on both functional and structural lung changes using a multidisciplinary lens that incorporates clinical, biochemical, and radiological evaluations.[8]

As smoking and smoking-related pulmonary diseases continue to represent a significant burden of disease, and because vitamin C has the potential to deliver a low-cost intervention for lung health, there is an urgent need to explore and formalize the impact that vitamin C may have on lung health, given the associations between smoking and oxidative stress.[9] We designed this study to address this gap in the literature by assessing the association of vitamin C supplementation with pulmonary function tests (PFTs) and radiologic findings in a group of smokers. Using clinical respiratory assessment and PFTs, and chest imaging, this multidisciplinary study was developed to provide expertise and evidence on the therapeutic role of vitamin C in lung health.

This investigation was shaped by the key antecedents of oxidative stress from smoking and the incremental effects of vitamin C (a potent antioxidant). Smokers have much lower levels of vitamin C, and oxidative stress may lead to lung deterioration. There have been studies that show the benefits of antioxidants in smokers, yet only a few have assessed the lung function and the radiological changes longitudinally in smokers. A multidisciplinary assessment will be invaluable in determining if vitamin C therapy provides any real protection or improvement in lung health and function. This study aimed to assess the effect of vitamin C supplementation (compared to placebo) on lung function and both radiological and clinical changes in smokers, using a multidisciplinary approach.

METHODOLOGY

This was a prospective interventional study at Swat Medical College, Swat, Pakistan, which aimed to investigate the effects of vitamin C supplementation on pulmonary function and radiological findings in smokers. The study was conducted for 12 months (January 2023 to January 2024). The study was approved by the Institutional Review Board (IRB) of Swat Medical College. Written informed consent was obtained from all participants.

The study recruited a total of 61 adult smokers by non-probability purposive sampling. The inclusion criteria for this study included adults aged 18 years and older with a smoking history of five pack-years and no prior diagnosis of chronic respiratory disease. Participants who had a known course of antioxidant supplementation, active respiratory infections, or chronic illness (i.e., diabetes, cardiovascular disease) were excluded from the study.

The participants in the study took an oral dose of 500 mg of vitamin C daily every day for six months. The participants were provided with a tablet form of supplementation and requested to take it daily at the same time - ideally after consuming food, as some participants had reported adverse gastrointestinal side effects. At the time of consent - adherence to the program was reviewed, while we advised participants that side effects with vitamin C supplementation are rare and of low signal, including nausea or heartburn.

The data was collected using a structured proforma to collate demographic, clinical, functional, and radiological data in detail. At baseline, the demographic details of the participants were recorded to include age, gender, height, weight, education status, occupation, and socio-economic status. The smoking history was detailed, including number of cigarettes smoked daily, how long they had been smoking (yrs), and units calculated as 'pack years' to show cumulative tobacco exposure. Relevant

medical history was obtained to exclude individuals with chronic respiratory diseases or other conditions that may confound the result of lung function.

The Research evaluated pulmonary function using standardized spirometry, performed by trained respiratory technicians, following American Thoracic Society (ATS)/European Respiratory Society (ERS) guidelines. We evaluated Forced Expiratory Volume in the first second (FEV_1), Forced Vital Capacity (FVC), and the ratio of FEV_1/FVC. We performed spirometry at two time points. The first assessment of participants was at baseline, before starting supplementation, and the 2nd assessment was after six months of continuous vitamin C intake. All evaluations were completed using the same spirometer and under similar environmental conditions to control for inter-test variability.

Radiological assessment involved a baseline chest X-ray and HRCT of the lungs and follow-up assessments after six months. Chest X-rays were taken in the posteroanterior (PA) view, and HRCTs were performed using a multi-slice CT scanner and thin-section imaging to allow an assessment of fine parenchymal detail. The imaging studies were intended to assess specific lung-related structural injury or change, such as emphysematous changes, bronchial wall thickening, or the observation of interstitial changes.

Two experienced radiologists, who were blinded to the clinical information regarding participants and group allocation of participants, reviewed all imaging studies independently. Disagreements between the radiologists during the interpretation of the imaging were resolved by consensus or by referring to a third radiologist for their input into the decision-making. This combination of clinical assessment, spirometry, and radiological imaging represented a robust and multidisciplinary approach to evaluating the potential protective or restorative effects of vitamin C supplementation in smokers.

IBM SPSS Statistics version 26 was used to enter and analyze data. Continuous variables (e.g., Age, BMI, smoking duration, and pack years, FEV_1, FVC, and FEV_1/FVC ratio) were expressed as means ± standard deviations (SD) and categorical variables (e.g., gender, education, occupational exposure, socioeconomic status and radiological findings) were expressed as frequency and percentages. Vitamin C supplementation was assessed by comparing pre- and post-intervention spirometry values (FEV_1, FVC, and FEV_1/FVC ratio) using a paired sample t-test. Differences in radiological findings (e.g., hyper-inflation, bronchial wall thickening, ground glass opacities, and centrilobular emphysema) pre and post supplementation were assessed using a Chi-square test. A p-value of<0.05 was considered to be statistically significant for all analyses.

RESULTS

The present study involved 61 adult smokers aged 42.5 ± 8.6 years. Most smokers were male. Participants had an average smoking duration of over 17 years, with a daily consumption of approximately 14 cigarettes, resulting in a mean cumulative exposure of 13.7 pack-years. The average body mass index (BMI) fell within the normal range, suggesting that most individuals were neither underweight nor obese. Educational levels varied across the sample, with representation from all educational categories, though secondary education was most common. A small portion of participants reported occupational exposure to dust or fumes, indicating potential additional respiratory risk factors. Socioeconomically, most individuals belonged to low or middle-income groups, highlighting the relevance of cost-effective interventions like vitamin C in such populations.

Table 1: Baseline Characteristics of Participants (n = 61)

Variable	Mean ± SD / n (%)
Age (years)	42.5 ± 8.6
Gender	
Male	56 (91.8%)
Female	5 (8.2%)
Body Mass Index (kg/m²)	23.8 ± 3.2
Smoking Duration (years)	17.4 ± 6.9
Cigarettes per Day	14.2 ± 5.1
Pack-years	13.7 ± 4.8
Educational Status	
No formal education	12 (19.7%)
Primary	15 (24.6%)

Secondary	21 (34.4%)
Higher	13 (21.3%)
Occupational Exposure (Dust/Fumes)	9 (14.8%)
Socioeconomic Status	
Low	23 (37.7%)
Middle	29 (47.5%)
High	9 (14.8%)

Following six months of vitamin C supplementation, significant improvements were observed in pulmonary function parameters. The mean FEV_1 increased from 2.34 L to 2.58 L, reflecting a mean gain of 0.24 L, which was statistically significant ($p = 0.001$). Similarly, the mean FVC rose from 3.12 L at baseline to 3.34 L post-intervention, with a mean increase of 0.22 L ($p = 0.003$). The FEV_1/FVC ratio also showed a statistically significant improvement, increasing from 75.0% to 77.6% ($p = 0.010$). These findings suggest a beneficial effect of vitamin C on lung function in smokers, indicating improved airway performance and reduced airflow limitation over the supplementation period.

Table 2: Comparison of Pulmonary Function Tests before and After Vitamin C Supplementation (n = 61)

Parameter	Baseline (Mean ± SD)	Post-Intervention (Mean ± SD)	Mean Change ± SD	p-value
FEV_1 (L)	2.34 ± 0.51	2.58 ± 0.48	+0.24 ± 0.16	0.001**
FVC (L)	3.12 ± 0.65	3.34 ± 0.62	+0.22 ± 0.18	0.003**
FEV_1/FVC Ratio (%)	75.0 ± 5.4	77.6 ± 4.8	+2.6 ± 2.2	0.010*
**Paired t-test used.* **p < 0.05, **p < 0.01 – statistically significant.*				

Radiological assessment using chest X-ray and HRCT revealed a trend toward improvement in lung structural changes following vitamin C supplementation, though none of the observed differences reached statistical significance. The prevalence of hyperinflation on chest X-ray decreased from 36.1% at baseline to 29.5% post-supplementation ($p = 0.563$). Similarly, bronchial wall thickening observed on HRCT declined from 44.3% to 32.8% ($p = 0.264$). Ground glass opacities reduced slightly from 16.4% to 11.5% ($p = 0.601$), and centrilobular emphysema showed a minimal decrease from 24.6% to 21.3% ($p = 0.830$). Although these changes were not statistically significant, the downward trend in abnormal findings suggests a potential structural benefit of vitamin C in mitigating smoking-related lung damage over time.

Table 3: Radiological Findings Before and After Supplementation (Chest X-ray and HRCT)

Radiological Finding	Pre-Supplementation n (%)	Post-Supplementation n (%)	p-value
Hyperinflation (CXR)	22 (36.1%)	18 (29.5%)	0.563
Bronchial Wall Thickening (HRCT)	27 (44.3%)	20 (32.8%)	0.264
Ground Glass Opacities (HRCT)	10 (16.4%)	7 (11.5%)	0.601
Centrilobular Emphysema (HRCT)	15 (24.6%)	13 (21.3%)	0.830
Chi-square test used. *p < 0.05 is considered statistically significant.*			

DISCUSSION

The present study demonstrated that six months of vitamin C supplementation in adult smokers led to statistically significant improvements in pulmonary function parameters, including FEV_1, FVC, and the FEV_1/FVC ratio. While radiological improvements were observed in a proportion of participants, the changes did not reach statistical significance. These findings support the hypothesis that antioxidant

supplementation, particularly with vitamin C, may contribute to respiratory health preservation in smokers.

Our findings are consistent with those of Lei et al., 2022, who in a meta-analysis reported that vitamin C supplementation improved FEV_1 in patients with compromised pulmonary function, particularly among smokers.[10] Similarly, Braun et al.2020 observed that higher dietary intake of vitamin C was associated with better lung function and lower airway inflammation in school-aged children exposed to environmental tobacco smoke.[11] In a randomized controlled trial, Bashir et al.2024 found that vitamin C improved exercise-induced bronchoconstriction and FEV_1 among smokers and ex-smokers, suggesting its potential in reducing oxidative injury to the airways.[12]

Moreover, Addissouky et al.2024 emphasized the role of oxidative stress in smoking-related lung injury and the potential of antioxidants like vitamin C in mitigating inflammatory responses and tissue remodeling.[13] This aligns with the improvements seen in spirometry in the present study, where FEV_1 and FVC both showed significant positive changes post-supplementation. In a population-based cohort study by Chen et al. 2024 higher plasma vitamin C levels were positively correlated with FEV_1 and FVC in both smokers and non-smokers, reinforcing the protective association of vitamin C with lung function.[14]

However, radiological outcomes in our study showed only a non-significant trend toward improvement. This partially aligns with findings by Victoni et al. 2021, who noted that while antioxidants improved inflammatory markers and lung function, radiographic structural changes, especially emphysematous destruction, tend to require longer durations or higher doses to reverse.[15] A cross-sectional analysis by Gea et al.2023 showed that dietary antioxidants, including vitamin C, were associated with less emphysema severity on HRCT among smokers, although causality could not be established due to the study design.[16]

In contrast, Chen, et al. 2024 found no significant changes in spirometry or imaging results following short-term antioxidant supplementation in smokers, suggesting that factors such as dose, duration, and baseline oxidative burden may influence outcomes.[17] The present study, using a moderate dose over six months, may have been sufficient to improve functional but not structural parameters.

The findings of this study highlight the potential role of vitamin C supplementation as a supportive intervention to improve lung function in smokers, offering a low-cost, accessible, and safe antioxidant therapy that may help mitigate smoking-induced pulmonary decline. Although structural lung improvements were not statistically significant, the observed trends suggest that longer duration or higher dosing may yield more pronounced radiological benefits. Clinically, incorporating vitamin C into preventive strategies for high-risk populations, such as chronic smokers, could enhance respiratory health and delay progression to obstructive lung disease.

CONCLUSION

This study demonstrated that vitamin C supplementation significantly improved pulmonary function parameters (FEV_1, FVC, and FEV_1/FVC ratio) in smokers over six months, indicating its beneficial role in counteracting oxidative damage caused by tobacco exposure. Although radiological findings did not show statistically significant changes, the downward trend in abnormalities suggests potential structural benefits with longer intervention durations. These results support the use of vitamin C as a cost-effective, non-pharmacological adjunct in respiratory care for smokers.

Future Recommendations

Future recommendations include conducting larger, randomized controlled trials with extended follow-up to evaluate long-term radiological outcomes and the effect of higher or combined antioxidant dosages. Additionally, incorporating serum oxidative stress markers and assessing smoking cessation status may provide more comprehensive insights into the protective mechanisms of vitamin C on lung health.

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