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ORIGINAL ARTICLE

NEGATIVE IMPACT OF SMOKING ON LUNG FUNCTION: COMPARING FEV1/FVC VALUES IN SMOKERS AND NON-SMOKERS

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ABSTRACT

Background. Cigarette smoking has been reported as the significant adverse effects on lung function, which can be evaluated by measuring forced expiratory volume in one second (FEV1), forced vital capacity (FVC), and the ratio of FEV1 to FVC (FEV1/FVC) values.

Objective. This study investigated the prevalence of tobacco use and nicotine dependence among college students and their stress levels to inform targeted interventions for smoking prevention and cessation.

Material and methods. A total of 429 participants were interviewed face-to-face, of which 71.6% were female and 28.4% were male. Pulmonary function tests were exclusively administered to the 9.8% of participants who reported using tobacco.

Results. Our findings revealed a low prevalence of nicotine dependence among college students, with only 6.8% exhibiting moderate or high levels of dependence. Students who reported tobacco use were found to have moderate stress levels, suggesting a potential association between smoking and stress. Chi-square tests revealed that gender, school affiliation, and nicotine dependence were significantly associated with smoking behavior. Long-term smoking (>5 years) was found to be associated with negative health outcomes, such as higher BMI, and increased smoking per day. The analysis of lung function parameters showed that smoking frequency and duration were negatively associated with lung function, while nicotine dependence increased with smoking frequency and duration.

Conclusion. Our study suggests that targeted prevention and cessation programs should address these factors to reduce smoking rates among college students.

Key words: *smoking status, lung function test, nicotine dependence, cigarette smoking, college students,*

INTRODUCTION

Smoking is a well-known risk factor for various health problems, such as chronic obstructive pulmonary disease (COPD), emphysema, and lung cancer, among the global population, including Thailand [1]. The use of cigarette products has been reported to increase the incidence of respiratory diseases and premature death, affecting 1.7 million people [2, 3]. Nicotine addiction is the primary reason for the continuous use of cigarettes [4]. After smoking, nicotine is absorbed by the lungs and distributed to the brain through the bloodstream [5]. It stimulates the release of dopamine in the brain's reward system, inducing cravings for cigarettes [6]. Smoking exposes the lungs not only to nicotine but also to other toxic substances that cause DNA damage, especially double-stranded DNA breaks, leading to lung cell death through apoptosis and necrosis, and impaired gas exchange [7]. Moreover, *Grundy* et al. [8] found a link between smoking history and the severity of SARS-CoV-2 infection.

The previous study was conducted to examine the impact of smoking on COVID-19 incidence, comorbidities, and mortality rates. A relationship was identified between smoking and the severity of COVID-19, which was classified into non-severe and severe cases. A correlation was observed between the percentage of smokers in each group and the severity of the disease.

Among all fatalities (2.8%), the deceased were found to be smokers [11]. *Zhou* et al. [9] analyzed 5,889 COVID-19 patients and found that smokers had an increased risk of developing complications from COVID-19, such as acute respiratory distress

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syndrome (odds ratio [OR] 1.69; 95% confidence interval [CI] 1.09-2.55), acute kidney injury (OR 1.55; 95% CI 1.10-2.14), and acute liver damage (OR 1.33; 95% CI 1.01-1.74), compared to non-smokers. *Zhao* et al. [10] evaluated seven studies investigating the relationship between COVID-19 mortality and smoking, discovering that the risk of severe COVID-19 outcomes was doubled in smokers.

Another study examined the impact of smoking on the incidence of COVID-19, co-morbidities, and mortality. It found that the relationship between smoking and the severity of COVID-19 was categorized according to mild and severe cases, with the percentage of smokers in each group correlated with disease severity [11, 12]. Previous studies have found that smoking for several years can have a negative effect on lung function, possibly due to airflow obstruction, and smokers have significantly lower FVC values than non-smokers [13].

The increasing prevalence of smoking among college students presents a significant public health and educational problem, particularly in developing countries where smoking prevention measures are not strictly enforced [14]. In Thailand, 20.9% of men aged 15 and over smoke, and smoking tends to increase from the first year to the last year in college [15].

Moreover, smoking is often associated with other substance use, such as alcohol and marijuana, among college students, and school-related stress has been found to be associated with smoking [16]. However, there are no widespread studies on the effects of smoking on lung capacity among youth students, after the students who obtained the COVID-19 vaccine.

Therefore, in this study, the researchers aim to investigate the smoking habits of university students and determine the relationship between frequency, quantity, and duration of smoking on FEV1/FVC% during the COVID-19 pandemic to provide valuable information on the impact of smoking on lung function in young adults, who are often considered a high-risk group for smoking initiation. Additionally, the study can help inform public health policies and interventions aimed at reducing the negative health consequences of smoking.

MATERIAL AND METHODS

Participants and study design

The cross-sectional study was conducted among participants from Walailak University, located at Latitude: 8° 38’ 42.2’’ N and Longitude: 99° 53’ 47.6’’ E, during the 2021 academic year. This study complied with the ethical guidelines approved by the Walailak University’s Office of the Human Research Ethics Committee, under the reference number WUEC-21-266-01. The minimum sample size of 429 participants was calculated using the Taro Yamane equation. The inclusion criteria for this study were 1) students enrolled in the second and third semesters of the 2021 academic year, 2) those aged between 18 and 22 years. The exclusion criteria included participants who were unwilling to answer the questionnaire or who chose to withdraw from the study. To collect data on the intensity of cigarette use, the *Fagerstrom* Test for Nicotine Dependence (FTND) questionnaire was used. The research questionnaire was divided into two parts: Part 1 encompassed gender, age, body mass index (BMI), and smoking experience, while Part 2 consisted of a test to determine the level of nicotine dependence. Before data collection, all participants were briefed on the study’s objective, procedures, advantages, and potential hazards. Following this, they gave their written informed consent and assent to take part in the study.

Lung capacity test

Smoking participants (n=30) and matched case non-smoking (n=30) were recruited to determine lung function tests. All participants refuse to be infected with COVID-19. The lung capacity of participants was measured using spirometry, which is a pulmonary function test that measures the amount of air a patient can inhale and exhale, as well as how quickly they can exhale. Spirometry is a reliable and valid measure of lung function and is considered the gold standard for pulmonary function testing. To ensure accurate results, patients were instructed to avoid exercise, tight-fitting clothing, and large meals before the test, and to refrain from taking certain medications. The weight and height of participants were accurately measured, and the testing procedures were explained and demonstrated beforehand. During the test, the patient sat upright, inhaled deeply, placed their mouth on the mouthpiece, and exhaled as hard and fast as possible. The test was repeated three times or more. The results were checked against criteria for acceptability, including the correct start of the test, extrapolated volume, exhalation time, and absence of coughing or stopping breathing during the test. The results of forced expiratory volume in one second (FEV1), forced vital capacity (FVC), and the ratio of FEV1 to FVC were determined.

Statistical analysis

Descriptive statistics, including measures of central tendency (mean, median) and dispersion (standard deviation, interquartile range), were used to describe the sociodemographic characteristics of the study population, such as age, BMI, and smoking experience, using SPSS. Chi-square tests were performed to examine the relationships between categorical variables and smoking status. The statistical

significance level was set at 0.05. Additionally, t-tests or ANOVA were conducted to determine the mean differences between pulmonary function tests, including forced expiratory volume in one second (FEV1), forced vital capacity (FVC), and the FEV1/FVC ratio, and smoking behaviors, such as smoking per day and smoking experience. A significance level of 0.05 was used to assess the statistical significance of the observed differences.

RESULTS

Our study investigated the prevalence of tobacco use and nicotine dependence among college students, along with their stress levels, in order to inform targeted interventions for smoking prevention and cessation. Among the 429 participants, 71.6% were female, and the majority of students were in their first year (43%), followed by their second year (21.8%). Surprisingly, our findings revealed a low prevalence of tobacco use among college students, with only 9.8% (n=42) reporting tobacco use. Of these, 8 participants were ex-smokers, and only a small minority (6.6%) exhibited moderate or high levels of nicotine dependence. Additionally, our study assessed stress levels among students using the ST5 questionnaire and found that 45.9% had low-stress levels, while 36.4% had moderate levels. However, among students who reported tobacco use, 46.15% had moderate stress levels (Table 1).

According to the Chi-square test, the results showed that gender, school affiliation, and nicotine dependence were significantly associated with smoking status ($p<0.05$). In terms of gender, male students were found to be more likely to smoke than female students ($p<0.001$). This suggests that gender is an important factor in determining smoking behavior among college students. Regard to school affiliation, students from certain schools were found to be more likely to smoke than students from other schools ($p<0.001$). This indicates that school affiliation may also play a role in determining smoking behavior among college students. Finally, nicotine dependence was strongly associated with smoking behavior, with nicotine-dependent students being much more likely to smoke than non-dependent students ($p<0.001$). Taken together, these findings suggest that gender, school affiliation, and nicotine dependence are important factors in determining smoking behavior among college students. Addressing these factors through targeted prevention and cessation programs may be effective in reducing smoking rates among this population (Table 1).

In Table 1, among 42 smokers in this study, 85.71% were male, and the highest proportion of smokers was found among second-year students (31%), followed by first-year students (28%). Interestingly, stress levels were found to be inversely related to smoking rates, with only 7.1% of students reporting the highest stress levels being smokers, compared to 52.4% of students with low-stress levels who smoked. Among the smokers, the level of nicotine addiction was relatively low at 61.6%, with only 9.6% of smokers exhibiting high levels of addiction. The median number of cigarettes smoked per day was 5 (1^{st} quartile = 3, 3^{rd} quartile = 10), and the median smoking duration was 3 years (1^{st} quartile = 1 year, 3^{rd} quartile = 5 years). Packaged cigarettes from convenience and department stores were the most commonly used type of cigarette among students, accounting for 90% of smokers, followed by Dry tobacco leaves (6.6%), and electronic cigarettes (3.3%). These findings suggest that stress during online classes may not be the primary driving force behind smoking behavior among students and that nicotine addiction may not be as prevalent as previously believed. Additionally, the use of dry tobacco leaves with hand-made cigarettes in the southern region may be a unique characteristic of smoking behavior among this population.

To explore the association between smoking experience and various health-related factors, we conducted an ANOVA non-parametric test to determine the mean difference between BMI/number of cigarettes smoked per day/nicotine dependence/stress score, and smoking experience. In Table 2, participants who have smoked for more than five years demonstrated a significantly higher median BMI (26.12 kg/m^2), nicotine dependence score (1), and number of cigarettes smoked per day (15 cigarettes/day) compared to those with less than one year of the smoking experience. These findings suggest that long-term smoking may be associated with negative health outcomes.

To assess the relationship between smoking habits and lung function among college students by analyzing Forced Expiratory Volume in 1 second (FEV_1), Forced Vital Capacity (FVC), and the FEV1/FVC ratio. Participants were divided into smoking and non-smoking groups. Smoking students were further classified into three subgroups based on their smoking habits: those who smoked less than three cigarettes per day, those who smoked between three and nine cigarettes per day, and those who smoked ten or more cigarettes per day. Lung function parameters (FEV1, FVC, and FEV1/FVC ratio) were measured and compared between the groups using *Student's* t-test. The results show that average FEV_1/FVC ratios for the three smoking subgroups were 95.17±2.9% (<3 cigarettes/day), 94.77±3.61% (3-9 cigarettes/day), and 97.00±2.69% (>10 cigarettes/day), respectively, all within the normal range but significantly lower than the non-smoking students' average value of 105.8±1.6%

Table 1. Characteristics of the participants

Variables	Smoking Status						*p*-value
	Currently smoking		Ex-smoking		Non-smoking		
	n	%	n	%	n	%	
Gender							
Male	36	30.0	7	5.8	77	64.2	<0.001
Female	6	2.0	1	0.3	300	97.7	
Other	0	0	0	0.0	2	100.0	
School of							
Public Health	6	2.7	3	1.3	217	96.0	<0.001
Engineering	5	9.4	0	0.0	48	90.6	
Allied Health Sciences	1	2.0	1	2.0	48	96.0	
Liberal Arts	2	7.7	1	3.8	23	88.5	
Political Science and Laws	10	38.5	2	7.7	10	53.5	
Pharmacy	0	0.0	0	0.0	12	100.0	
Nursing	1	14.3	1	14.3	5	71.4	
Informatics	1	16.7	0	0.0	5	83.3	
management	0	0.0	0	0.0	5	100.0	
Science	0	0.0	0	0.0	3	100.0	
International College	0	0.0	0	0.0	1	100.0	
Medicine	0	0.0	0	0.0	1	100.0	
Dentistry	0	0.0	0	0.0	1	100.0	
Education level							
1st-year student	12	6.6	2	1.1	167	92.3	0.273
2nd-year student	13	13.3	4	4.1	81	82.7	
3rd-year student	10	11.1	2	2.2	78	86.5	
4th-year student	7	13.5	0	0.0	45	86.5	
> 4th-year student	0	0.0	0	0.0	8	100.0	
Academic Stress level							
Low	22	11.2	7	3.6	168	85.3	0.322
Medium	13	8.3	1	0.6	142	91.0	
High	4	8.2	0	0.0	45	91.8	
Very high	3	11.1	0	0.0	24	88.9	
Nicotine Dependence							
Very low	19	73.01	7	26.92	0	0.0	<0.001
Low	6	85.33	1	14.29	0	0.0	
Medium	5	100.0	0	0.0	0	0.0	
High	1	100.0	0	0.0	0	0.0	
Very high	1	100.0	0	0.0	0	0.0	

Chi-square test, *p-value < 0.05

Table 2. The association of smoking experience and factors influence smoking among students

Characteristic	Smoking experience			*p*-value
	>5 year (n=7)	2-4 years (n=14)	<1 year (n=8)	
Age (Median)	20.00	19.75	19.50	0.680
BMI (Median)	26.12	21.97	20.02	0.038*
Stress score (Median)	0	0.45	1	0.090
Nicotine dependence Score	1.63	0.46	0	0.001*
Smoking/ day (Median)	15	5	2	0.011*

Anova non-parametric test, *p-value < 0.05

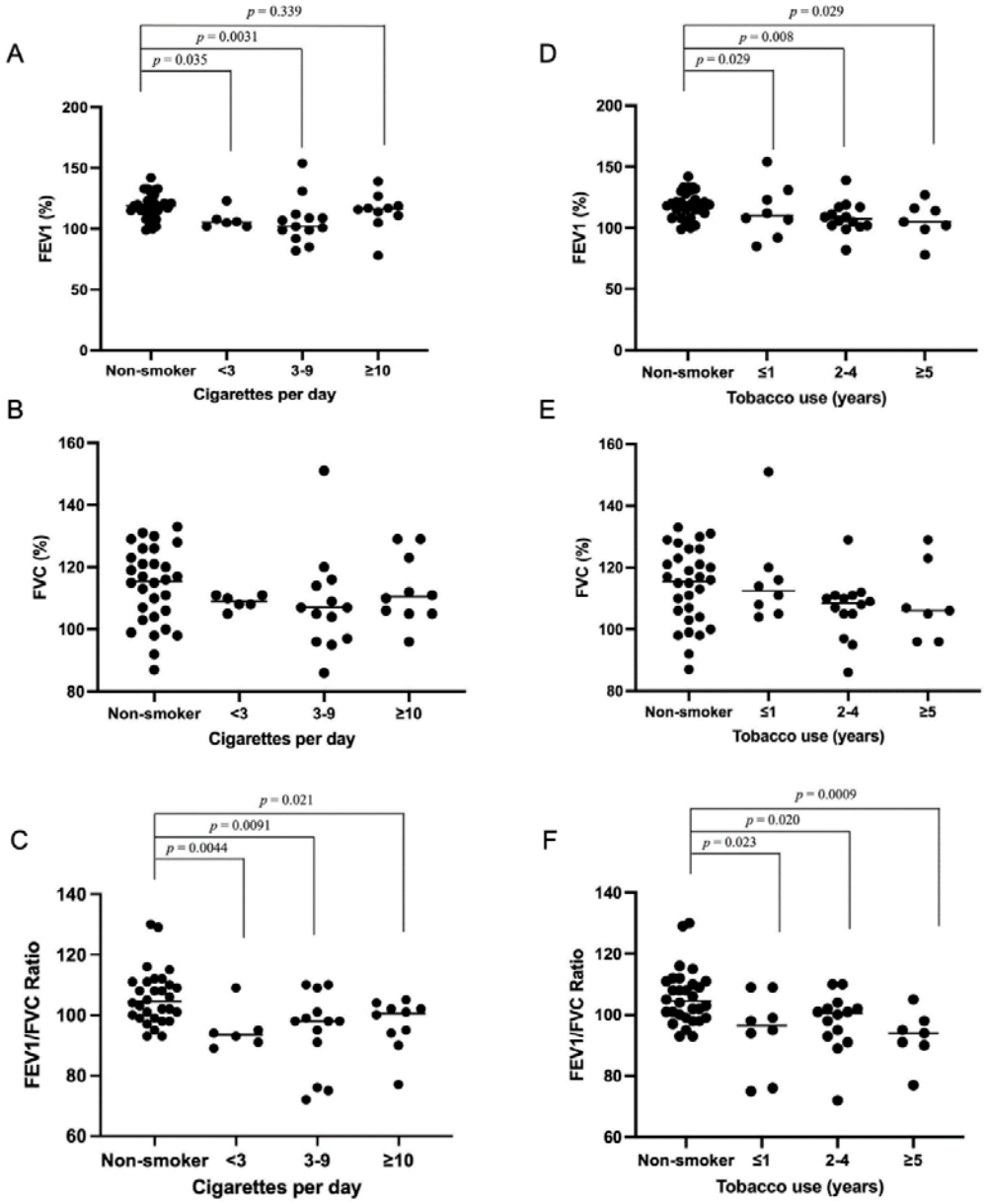

Figure 1. The effect of the number of cigarettes smoked per day on FEV1 (A), FVC (B), and FEV1/FVC ratio (C), and the effect of tobacco use on the number of cigarettes smoked per day on FEV1 (D), FVC (E), and FEV1/FVC ratio (F) were determined using non-parametric t-test (*Mann-Whitney* U test).

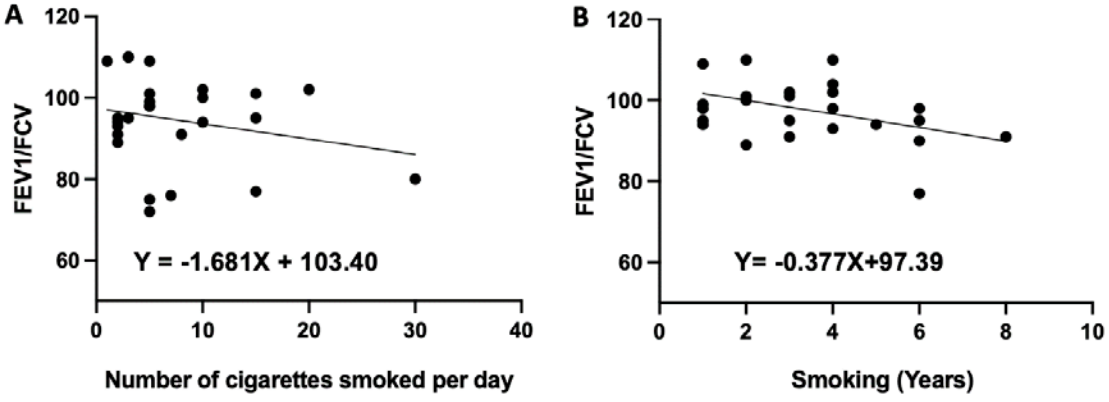

Figure 2. The association of the number of cigarettes smoked per day and FEV1:FVC (A) and smoking experience (year) and FEV1:FVC (B) was determined using linear regression analysis

(*p*-values: 0.0041, 0.0091, and 0.021, respectively). A decrease in lung function was observed among students who smoked more frequently. The average FEV_1 values for the smoking subgroups were 118.6±2.0% (<3 cigarettes/day), 107.67±3.21% (3-9 cigarettes/day), and 114.3±4.97% (>10 cigarettes/day), respectively. Statistically significant differences were observed between the non-smoking students (average FEV_1 value: 118.6±2.0%) and the students who smoked less than three cigarettes per day (*p*-value=0.035) and those who smoked between three and nine cigarettes per day (*p*-value=0.0031). No statistically significant differences were found in FVC values between the smoking and non-smoking groups (Figure 1).

To investigate the association between the duration and frequency of smoking habits and lung function parameters (FEV_1, FVC) and nicotine dependence among college students. Participants were divided into smoking and non-smoking groups, with smoking students further classified based on the duration (≤1 year, 2-4 years, ≥5 years) and frequency (<3 cigarettes/day, 3-9 cigarettes/day, ≥10 cigarettes/day) of smoking. Lung function parameters (FEV1, FVC) and nicotine dependence scores were measured and compared between the groups using Student's t-test. The results demonstrated that smoking students demonstrated significantly lower FEV1 values than non-smoking students across all duration-based subgroups (*p*-values: 0.029, 0.008, and 0.029, respectively). No significant differences in FVC values were found between smoking and non-smoking groups. Nicotine dependence scores increased with the frequency and duration of smoking. Students who smoked ≥10 cigarettes/day had higher scores than those who smoked <3 cigarettes/day (*p*=0.0005) and those who smoked 3-9 cigarettes/day (*p*=0.0003). Similarly, students who smoked for ≥5 years had higher nicotine dependence scores than those who smoked for ≤1 year (*p*=0.0002) and those who smoked for 2-4 years (*p*=0.0046). As shown in Figure 2, the FEV1/FVC ratio of the 30 participants gradually decreased by 1.681 and 0.37 for every 1-unit increase in cigarette/day and smoking experience, respectively.

DISCUSSION

Cigarette smoking is a well-known causative factor for a range of respiratory diseases, including chronic obstructive pulmonary disease (COPD) [17], and lung cancer [18]. However, it is interesting to note that many young smokers do not exhibit respiratory symptoms. In a recent study, 8.39% of male participants reported smoking, while only 1.39% of female participants reported smoking. This is consistent with previous research showing that the prevalence of smoking is higher among males than females, with 67% of males and 41.9% of females being smokers [19]. Another study by *Mandil* et al. (2010) found that smoking habits among female students in a sample of 7,550 undergraduate students at King Saud University were significantly influenced by the smoking behavior of fathers and friends [16]. In contrast, female students' smoking behavior was also affected by the smoking habits of female siblings and peers. The overall prevalence of smoking at King Saud University was 14.5%, with 32.7% and 5.9% among male and female students, respectively. Male smoking behavior was influenced by age and the smoking habits of fathers and friends, while female smoking behavior was affected by the habits of older sisters and peers. These findings highlight the important role of family members and peers, often of the same gender, in shaping smoking behavior [20]. Additionally, the lower prevalence of smoking among females can be attributed, in part, to social unacceptability. University students typically obtain cigarettes from department stores, shops, convenience stores, and friends. A comparative study between Thailand and Malaysia found that approximately 20-30% of smokers acquired cigarettes from friends [21].

In this study, we observed that participants who had smoked for more than five years demonstrated a significantly higher median BMI of 26.12 kg/m^2 (Table 2), which is concerning given the negative health outcomes associated with both smoking and obesity. While smoking has been linked to weight loss in adolescents [22] and decreased appetite due to nicotine being a recognized metabolic stimulant and appetite suppressant [23], our finding suggests the opposite - that smoking experience may be associated with higher BMI. It is possible that the decreased physical activity resulting from the COVID-19 pandemic has contributed to this trend. As public health professionals, it is essential to educate individuals on the risks associated with smoking and promote healthy behaviors that reduce the risk of chronic diseases. Addressing smoking and obesity requires a multifaceted approach that considers the complex factors that contribute to these issues. Further investigation is needed to develop effective strategies that promote healthy behaviors and reduce the risk of chronic diseases associated with smoking and obesity.

We further investigated the effects of the number of cigarettes smoked per day and smoking experience on lung function, as measured by FEV1, FVC, and FEV1/FVC values. We found that smokers had a significantly lower FEV1/FVC ratio than non-smokers, indicating reduced lung function. This result is consistent with previous research by *Dugral* and *Balkanci* [24], who also reported lower FEV1/FVC values in smoking university students compared to non-smoking. We found that the FEV1/FVC ratio of the 30 participants

gradually decreased by 1.681 and 0.37 for every 1-unit increase in cigarette/day and smoking experience, respectively (Figure 2). This finding is similar to *Boksabady* et al. [25] who found a significant correlation between number of cigarettes smoked per day and reduced pulmonary function tests (PFTs), as well as a slight decrease in FEV1 among smokers compared to non-smokers. This slight decrease in FEV1 may be due to the respiratory system's capacity for cell recovery. The study results suggest that increased smoking duration leads to a decline in the FEV1/FVC ratio. The reduced FEV1/FVC ratio observed in smokers may be due to respiratory system cell death or the loss of elasticity in lung tissue smooth muscle.

Studies have shown that chronic exposure to cigarette smoke can increase the production of pro-inflammatory cytokines and decrease the production of anti-inflammatory cytokines, leading to cell death, including apoptosis of lung epithelial cells, which is associated with the development of emphysema [26]. In addition, several epidemiological studies have identified population characteristics that are associated with the severity of clinical cases of COVID-19, including age and gender [27]. Specifically, elderly and male patients are at higher risk for severe disease [28], and smokers who are infected with COVID-19 tend to experience more severe diseases and require special medical treatment [29]. A study of 1,099 patients confirmed with COVID-19 found that current smokers were more likely to require mechanical ventilation, ICU admission, or die compared to non-smokers [30]. The reasons for these differences in outcomes are not yet clear, but studies have shown that smokers have consistently higher levels of the SARS-CoV-2 receptor ACE2 in their respiratory tract [31]. This may partly explain why smokers are more likely to experience severe cases of SARS-CoV-2 infection and require aggressive medical intervention. However, based on a literature review, there are reports indicating that nicotine and/or cigarette smoke have the potential to induce the expression of ACE2 in certain tissues or cell types. Smoking cessation leads to the restoration of respiratory epithelium structure, reduction in hyperplasia, and decreased ACE2 levels, which may ultimately reduce the risk of SARS-CoV-2 infection [32, 33].

However, we found only one case of a smoker who had previously been infected with COVID-19 and had lower FEV1/FVC compared to non-smokers and smokers without infection. This case had a BMI of 25 kg/m2 and used dry leaf hand-made cigarettes. It is possible that being overweight and having an infection may have led to a decrease in FEV1/FVC. However, further studies need to recruit participants who smoke both with and without infection, as well as different types of cigarettes. In addition, further studies should investigate the effects of different types of smoking, such as traditional cigarettes, e-cigarettes, smokeless tobacco, and herbal cigarettes, on ACE2 expression.

CONCLUSION

This study highlights the negative effects of smoking on lung function and BMI. Our findings indicate that smoking experience is associated with a higher median BMI, which is concerning given the established links between obesity and chronic diseases. We also observed that smokers had a lower FEV1/FVC ratio, suggesting reduced lung function. Furthermore, smoking is a known risk factor for severe COVID-19, and smokers infected with the virus are more likely to experience severe symptoms. Studies have shown that smoking cessation can restore respiratory epithelium structure and decrease ACE2 levels, potentially reducing the risk of SARS-CoV-2 infection. Further research is needed to investigate the effects of different types of smoking on ACE2 expression and the potential benefits of smoking cessation in reducing the risk of severe COVID-19. This study highlights the importance of addressing smoking and obesity as significant public health challenges that require a multifaceted approach.

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Conflict of interest
Authors declare no conflict of interest.

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