

Comparison of pulmonary function and respiratory symptomatology in university student smokers according to physical activity level and gender

Comparación de la función pulmonar y la sintomatología respiratoria en estudiantes universitarios fumadores según el nivel de actividad física y el sexo

Mario Lerma^{id}, Cristina Mazas^{id}, Marta V. Santiago-García^{*id}, Miguel Heres^{id} and Susana Pulgar^{id}

Faculty of Health Sciences, European University of the Atlantic, Santander, Spain

Abstract

Background: Smoking in young adults may negatively affect respiratory health, whereas physical activity could help preserve lung function. However, evidence regarding this relationship among university students who smoke remains limited. **Objective:** The aim of this study was to compare lung function and perceived respiratory symptoms among university students who smoke, based on their level of physical activity (PA) and sex. **Materials and methods:** The sample consisted of 22 university students (11 women and 11 men), divided into 9 active and 13 sedentary individuals. The measurement of respiratory symptom perception and lung function was conducted using the Saint George Respiratory Questionnaire (SGRQ) and spirometric values through forced spirometry with a portable chronic obstructive pulmonary disease 6 spirometer. Sedentary students reported greater perceived respiratory symptom impact, with significantly higher scores in the impact dimension of the SGRQ, whereas differences in the total score did not reach statistical significance. No statistically significant differences were observed between active and sedentary participants in spirometric parameters or 6-min walk distance. **Results:** Women showed higher scores in the activity dimension of the SGRQ and significantly lower spirometric values compared with men. Overall, only weak or moderate associations were observed between perceived respiratory symptoms and objective measures of pulmonary function. **Conclusions:** In conclusion, in this sample of young smokers with low cumulative tobacco exposure, perceived respiratory symptoms and pulmonary function showed limited correspondence, and PA level did not emerge as an independent predictor of objective respiratory outcomes. Spirometric assessment appears to provide a more objective evaluation of respiratory health than self-reported symptom questionnaires in this population.

Keywords: Chronic obstructive pulmonary disease. Lung function. Physical activity. Physical exercise. Tobacco. Young adults.

Resumen

Antecedentes: El tabaquismo en adultos jóvenes puede afectar negativamente a la salud respiratoria, mientras que la actividad física podría contribuir a preservar la función pulmonar; sin embargo, existe escasa evidencia sobre esta relación en estudiantes universitarios fumadores. **Objetivo:** El objetivo de este estudio fue comparar la función pulmonar y la percepción de los síntomas respiratorios en estudiantes universitarios fumadores, en función de su nivel de actividad física y del sexo. **Materiales y métodos:** La muestra estuvo compuesta por 22 estudiantes universitarios (11 mujeres y 11 hombres), divididos

*Corresponding author:

Marta V. Santiago-García

E-mail: marta.santiago@uneatlantico.es

Received: 25-03-2025

Accepted: 24-06-2026

DOI: 10.24875/RPR.25000018

Disponible en internet: 19-10-2026

Rev Pat Resp. (Ahead of print)

www.revistadepatologiarrespiratoria.org

1576-9895 / © 2026 Sociedad Madrileña de Neumología y Cirugía Torácica. NEUMOMADRID. Publicado por Permanyer. Este es un artículo open access bajo la licencia CC BY-NC-ND (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

en 9 individuos activos y 13 sedentarios. La medición de la percepción de los síntomas respiratorios y de la función pulmonar se llevó a cabo utilizando el Cuestionario Respiratorio de Saint George (SGRQ) y valores espirométricos mediante espirometría forzada con un espirómetro portátil COPD 6. Los estudiantes sedentarios informaron un mayor impacto percibido de los síntomas respiratorios, con puntuaciones significativamente más altas en la dimensión de impacto del SGRQ, mientras que las diferencias en la puntuación total no alcanzaron significación estadística. No se observaron diferencias estadísticamente significativas entre los participantes activos y sedentarios en los parámetros espirométricos ni en la distancia recorrida en la prueba de marcha de seis minutos. **Resultados:** Las mujeres mostraron puntuaciones más altas en la dimensión de actividad del SGRQ y valores espirométricos significativamente más bajos en comparación con los hombres. En general, solo se observaron asociaciones débiles o moderadas entre los síntomas respiratorios percibidos y las medidas objetivas de la función pulmonar. **Conclusiones:** En conclusión, en esta muestra de fumadores jóvenes con baja exposición acumulada al tabaco, los síntomas respiratorios percibidos y la función pulmonar mostraron una correspondencia limitada, y el nivel de actividad física no emergió como un predictor independiente de los resultados respiratorios objetivos. La evaluación espirométrica parece proporcionar una valoración más objetiva de la salud respiratoria que los cuestionarios de síntomas autoinformados en esta población.

Palabras clave: EPOC. Función pulmonar. Actividad física. Ejercicio físico. Tabaco. Adultos jóvenes.

Introduction

Smoking is considered one of the preventable pandemics of the 20th and 21st centuries, having claimed over 60 million lives in the past 70 years.¹ Although the number of male and female smokers has significantly decreased in Spain since 1987, the figures remain alarming (almost 20% of the total population), with variations in smoking prevalence among different communities, especially among women.² In addition, it is known that the average age for starting smoking is 14.1 years,³ with tobacco industry marketing being the major factor for this early initiation. The industry views the initiation of smoking as a process introduced during adolescence to promote consumption among young adults.⁴ Given that smoking starts at a very young age, cigarette consumption among young adults has received considerable attention in recent years, particularly among university students.⁵ In this regard, although students who exercise tend to smoke less, smoking among university students remains high and is closely linked to the onset of numerous lung diseases, such as chronic obstructive pulmonary disease (COPD).⁶ The main reasons given by this population for starting smoking during university are the relief provided by smoking in a period marked by stress, or for social and entertainment reasons.⁵

As highlighted, one of the major issues related to smoking is the onset of COPD, a disease characterized by an accelerated decline in lung function,⁷ and one of the most significant chronic diseases in Spain due to the high prevalence of smoking.⁸ This disease, in addition to being associated with reduced exercise capacity, correlated with functional impairment and airway

obstruction, presenting symptoms such as wheezing, dyspnea, cough, and chest tightness.⁹ This is mainly due to prolonged exposure to tobacco smoke, which triggers the release of inflammation-related cells and other inflammatory mediators from smooth muscle epithelial cells, initiating the inflammatory process.¹⁰⁻¹² Although it is well-known that the most direct approach to reducing the risk of contracting this disease is eliminating smoking, numerous studies have shown the association between physical activity (PA) and improved lung function,¹³ and consequently, COPD.¹⁴⁻¹⁶ A study by Holmen et al.¹⁷ aimed at observing the relationship between PA and improved lung capacity in a sample of non-smoking adults demonstrated that as PA gradually increased, so did various representative values of airflow obstruction, such as forced expiratory volume in one second (FEV1).

Furthermore, scientific evidence demonstrates the non-pharmacological effect of regular physical exercise in reducing lung-related diseases,¹⁸ decreasing inflammatory factors through the activation of anti-inflammatory signaling pathways.¹² This anti-inflammatory property of physical exercise improves pulmonary rehabilitation, reducing both the symptoms related to respiratory diseases and their severity, thus increasing endurance, strength, and the quality of life of affected individuals.¹⁹ In a study by Krüger et al.,²⁰ which aimed to observe the benefits of therapeutic exercise on inflammation caused by tobacco smoke exposure, it was shown that the applied intervention program was beneficial in providing a protective function for subjects exposed to tobacco smoke over a long period, due to the immunoregulatory effects of physical exercise and its role in mitigating the harmful effects of smoking.

Table 1. Statistical descriptive. Quantitative variables

Variable	Mean	Median	Std. Dev.*	Min	Max	n
Age	21	21	1.56	19	24	22
Height	170.4	170	8.9	150	189	22
Weight	67.5	67.5	13.97	42	92	22
BMI	22.6	22.1	3.26	17.7	29.4	22
Years of smoking	4.08	3.5	1.99	1.1	8	22

*Std. Dev.: standard deviation of the variable; BMI: body mass index; n: number of subjects.

Regarding COPD and the loss of lung function characteristic of the disease, it is known that it occurs more rapidly in the early stages of the disease. Therefore, early detection is crucial, allowing for the early initiation of treatments and strategies to reduce complications caused by the disease.²¹ It is common for the diagnosis of this disease, based on detecting a poorly reversible airway obstruction, to use both clinical data (considering the perception of symptoms associated with the disease) and forced spirometry data.²² However, due to the difficulty in performing the test and possible inconveniences for patients, conventional spirometry is not commonly used today. Instead, portable devices that quickly obtain FEV1, forced expiratory volume in six seconds (FEV6), and their ratio (FEV1/FEV6) are often used, making them especially useful for diagnosing lung function impairments in non-specialized settings.²³

Another common method for diagnosing COPD is evaluating exercise capacity through submaximal aerobic endurance tests, such as the six-minute walk test (6MWT), validated by Cheng et al.²⁴ By performing this test, it can be observed that when comparing healthy individuals with COPD patients, the former group shows better results than the latter.²⁵ The importance of this test lies in the difference in distance covered during the test, as exercise capacity in COPD patients can be limited by the characteristic respiratory symptoms of the disease before reaching cardiovascular limits.^{26,27}

Therefore, considering the scientific evidence supporting the benefits of regular PA, the detrimental effects of smoking among university students, and the lack of evidence on the relationship between smoking and PA in this population, this study aims to compare lung function and perceived respiratory symptoms in university students who smoke based on their level of PA.

Methodology

This study complies with the Declaration of Helsinki for research involving human subjects and was

approved by the Ethics Committee of the European University of the Atlantic (Spain) (ID: CEI16/2024). The cross-sectional study, conducted from March to April 2024, used a snowball sampling method to recruit participants through the university's platforms. All participants read the study information and gave their consent to participate by clicking on the first page of the survey (first part of the study). For the second part of the study, the principal recruiter contacted the participants who had previously given their consent and provided their personal data for this purpose.

Participants

The sample consisted of a total of 22 university students, 11 women and 11 men, from the autonomous community of Cantabria, divided into 9 in the active group (AG) and 13 in the sedentary group (SG). The inclusion criteria for participation in the study were: Being a university student, being between 18 and 29 years old, regularly consuming tobacco, and not having any associated chronic or respiratory pathologies.

Variables and instruments

Participants were previously informed about the study's objectives, the ethical nature of the research, and the anonymous treatment of the data following the guidelines of the Declaration of Helsinki.

First, the participants were given a questionnaire that included, in the first part, questions related to self-developed categorical variables concerning sex, age, and height (for the subsequent calculation of body mass index [BMI]), degree, number of years of smoking, and weekly cigarette consumption, categorized as very low (1-5 cigarettes), low (6-10), medium (11-15), high (16-20), or very high (21 or more). Descriptive statistics for these variables are presented in [Tables 1 and 2](#).

Table 2. Statistical descriptive. Qualitative variables

Variable	n	%
Gender		
Male	11	50.0
Female	11	50.0
Physical activity level		
Active	9	40.9
Sedentary	13	59.1
Bachelor		
Audiovisual communication	1	4.5
Physical activity and sport sciences	10	45.5
Chemical engineering	1	4.5
Applied languages	1	4.5
Education	1	4.5
Human nutrition and dietetics	2	9.1
Psicology	5	22.7
Advertising and public relations	1	4.5
Tobacco consumption		
Very high (21-25)	1	4.5
High (16-20)	1	4.5
Moderate (11-15)	2	9.1
Low (6-10)	6	27.3
Very low (1-5)	12	54.5

n: number of subjects; %: percentage of total subjects.

Cumulative smoking exposure was quantified using pack-years, calculated as (cigarettes per day/20) × years smoked. When cigarette consumption was recorded in categories, the midpoint of each category was used to estimate daily cigarette intake (1–5→3; 6–10→8; 11–15→13; 16–20→18; 21–25→23 cigarettes/day).

In addition, this form included the International PA Questionnaire to divide the study participants into active or SGs,²⁸ considering the World Health Organization's weekly PA recommendations.²⁹ For the second part of the questionnaire, related to respiratory symptoms and consisting of metric variables, the Saint George Respiratory Questionnaire (SGRQ), specific to respiratory health, was used. This questionnaire is validated for the general population and provides scores, in addition to the total score, on the perception of respiratory symptoms in different subscales: symptoms (frequency and severity of symptoms), activity

(limitation of daily or sports activities due to dyspnea), and impact (psychological and social functioning impairments).³⁰ To calculate the perception of respiratory symptoms for the subjects, both the total score and the three subscales into which the tool is divided, the scoring algorithm available in the SGRQ mobile application was used. Scores are expressed as a percentage of overall impairment, where 100 represents the worst possible health status and 0 the best.³¹

Second, different physiological tests were conducted on the participants. The tests were performed in the following order: evaluation of respiratory function through forced spirometry using a portable COPD 6 spirometer (Vitalograph, London, UK), validated for detecting airway obstruction in comparison to conventional spirometry by Represas et al.²³ The variables resulting from this test are the volume of air exhaled during the first second of the forced vital capacity expressed in liters (FEV1), the FEV6, and the ratio between them (FEV1/FEV6). The test was conducted following the procedure of Rosero-Arenas et al.³²

The evaluation of exercise capacity was measured through the 6MWT, following the recommendations of Gochicoa-Rangel et al.³³ and using the distance covered in meters during the test as a reference. This test, a predictor of mortality that expresses an individual's ability to perform at submaximal intensities, has been validated by Cheng et al.²⁴

Data analysis

Given that the objective of this study is to compare pulmonary function and perceived respiratory symptoms in smoking university students based on their level of PA (and other variables of interest), the following analyses were conducted.

First, a correlation matrix was created to examine the pairwise relationships between the main quantitative variables, with a particular focus on exploring the relationship between the perception of respiratory symptoms and measured pulmonary function.

Second, a mean difference test was performed to determine if there are significant differences in both respiratory symptoms (SGRQ) and pulmonary function (spirometric values and 6MWT) between physically active and inactive subjects. For respiratory symptoms, the alternative hypothesis used, considering the range of variable values, was: $H_1: \mu_{\text{ACTIVE}} < \mu_{\text{SEDENTARY}}$, which can be interpreted as respiratory symptoms being lower in active subjects. On the other hand, the hypothesis test for variables related to pulmonary function was: $H_1:$

Table 3. Matrix of correlations between perception of respiratory symptomatology and measured lung function

Variable	Symptoms (%)	Activities (%)	Impact (%)	% Total	FEV1	FEV6	FEV1/FEV6	6MWT distance
% Symptoms	1.00							
% Activities	0.09	1.00						
% Impact	0.78 [†]	0.32	1.00					
% Total	0.70 [†]	0.72 [†]	0.88 [†]	1.00				
FEV1	0.05	−0.38	−0.14	−0.26	1.00			
FEV6	0.02	−0.22	−0.19	−0.21	0.92 [†]	1.00		
FEV1/FEV6	0.13	−0.48	0.04	−0.20	0.46*	0.07	1.00	
6MWT distance	−0.19	−0.14	−0.17	−0.08	0.20	0.20	0.07	1.00

* $p < 0.05$.[†] $p < 0.001$.

FEV1: forced expiratory volume in one second; FEV6: forced expiratory volume in six seconds; 6MWT: Six-minute walk test.

$\mu_{\text{ACTIVE}} > \mu_{\text{SEDENTARY}}$, based on the plausible assumption that pulmonary function is higher in active subjects. The test statistics considered were both parametric (t-test) and non-parametric (Welch's test and Mann-Whitney U test) to enhance the robustness of the results.

Third, analysis of variance (ANOVA) tables were constructed for the variables of interest, considering two classification groups: levels of PA (active/sedentary) and sex (male/female). The purpose of this analysis is to jointly compare whether the behavior between the groups differs in respiratory symptoms and pulmonary function.

In addition, cumulative smoking exposure (pack-years) was examined as a potential confounding variable. Normality of pack-years was assessed using the Shapiro-Wilk test. Given the non-normal distribution of this variable ($p < 0.001$), differences in cumulative smoking exposure across PA levels were analyzed using the Kruskal-Wallis test.

Finally, a regression analysis was performed using a generalized fixed-effects model. These models are used to capture the average variability between different levels of grouping. Similar to the ANOVA table, this model includes categorical variables for the level of PA and sex as predictors, as well as the interaction effect between both factors. The model used is represented by equation (1): $Y_{ij} = \beta_0 + \beta_1 (\text{Level}_{\text{PA}})_i + \beta_2 (\text{Sex})_i + \beta_3 (\text{Level}_{\text{PA}})_i \times (\text{Sex})_i + \varepsilon_i$, where $i = 1, \dots, 22$, and $j = 1, \dots, 8$, (1), where Y_{ij} is the dependent variable, and the subscript j denotes each of the eight quantitative variables included in the study to capture respiratory symptoms and pulmonary function. $(\text{Level}_{\text{PA}})_i$ is the binary variable representing the PA level of the subject, $(\text{Sex})_i$

is also a dichotomous variable denoting sex, and $(\text{Level}_{\text{PA}})_i \times (\text{Sex})_i$ represents the interaction effect. Finally, β_0 is the constant term, and ε_i is the error term.

The validation measures for model (1) are the coefficient of determination (R^2), which explains the percentage of variance explained by the model, and the global significance test, showing the F-statistic and its p-value. The statistical analysis was conducted using version 4.4.1 of the free software R.

Results

The correlation matrix shown in Table 3 reveals generally weak relationships between perceived respiratory symptoms and measured pulmonary function. Strong correlations were observed among SGRQ dimensions, particularly between impact and total scores ($r = 0.88$, $p < 0.001$). Among physiological variables, FEV1 and FEV6 were strongly correlated ($r = 0.92$, $p < 0.001$). A moderate inverse correlation was observed between the FEV1/FEV6 ratio and the activity dimension of the SGRQ ($r = -0.48$, $p < 0.05$), indicating lower perceived activity-related symptoms with higher ventilatory ratios. No significant correlations were observed between 6MWT distance and perceived respiratory symptoms or spirometric variables.

Cumulative smoking exposure, expressed as pack-years, showed a non-normal distribution (Shapiro-Wilk $p < 0.001$). As shown in Table 1, the mean cumulative exposure was 1.6 ± 1.95 pack-years. No significant differences in pack-years were observed across PA levels (Kruskal-Wallis $\chi^2(2) = 1.26$, $p = 0.531$, $\varepsilon^2 = 0.06$), indicating comparable smoking intensity among active and sedentary participants.

Table 4. Contrast of the mean difference of SGRQ respiratory symptom perception.

Variable	n	Mean	Std. Dev.	t-test	Welch	U Man-Withney
Symptoms (%)						
Active	9	19.34	11.82	0.37	0.37	0.47
Sedentary	13	21.08	12.67			
Activities (%)						
Active	9	14.13	9.89	0.22	0.21	0.39
Sedentary	13	18.59	15.06			
Impact (%)						
Active	9	3.88	5.96	0.07*	0.07*	0.05 [†]
Sedentary	13	8.30	7.19			
Total (%)						
Active	9	9.55	5.41	0.11	0.10*	0.11
Sedentary	13	13.54	8.43			

$H_a: \mu_{Active} < \mu_{Sedentary}$

* $p < 0.1$.

[†] $p \leq 0.05$.

SGRQ: Saint George respiratory questionnaire; Std. Dev.: standard deviation.

Table 5. Contrast of the mean difference of physiological variables

Variable	n	Mean	Std. Dev.	t-test	Welch	U Man-Withney
FEV1						
Active	9	3.56	0.76	0.53	0.53	0.50
Sedentary	13	3.58	1.09			
FEV6						
Active	9	4.38	0.90	0.21	0.21	0.25
Sedentary	13	4.03	1.06			
FEV1/FEV6						
Active	9	0.82	0.09	0.96	0.96	0.96
Sedentary	13	0.88	0.08			
6MWT distance						
Active	9	572	93.1	0.95	0.94	0.95
Sedentary	13	648	118			

$H_a: \mu_{Active} > \mu_{Sedentary}$.

FEV: forced expiratory volume; 6MWT: Six-minute walk test; Std. Dev.: standard deviation.

Regarding perceived respiratory symptoms ([Table 4](#)), sedentary participants reported higher mean scores across all SGRQ dimensions. Statistically significant differences were observed in the impact dimension, with higher values in sedentary students ($8.30 \pm 7.19\%$) compared with those of active students ($3.88 \pm 5.96\%$; $p = 0.05$, Mann-Whitney U). The total SGRQ score was also higher in the SG ($13.54 \pm 8.43\%$ vs. $9.55 \pm 5.41\%$),

although this difference did not reach conventional levels of statistical significance.

With respect to physiological variables ([Table 5](#)), no statistically significant differences were observed between active and sedentary participants in forced spirometry parameters. Mean FEV1 values were 3.56 ± 0.76 L in active students and 3.58 ± 1.09 L in sedentary students, whereas mean FEV6 values were 4.38

Table 6. ANOVA table of symptoms and respiratory physiological variables for PA level and gender groups

Variable	PA level	Gender	Mean	p-value (PA level)	p-value (gender)
Symptoms (%)	Active	Male	17.00	0.76	0.80
		Female	21.20		
	Sedentary	Male	24.30		
		Female	17.30		
Activities (%)	Active	Male	12.20	0.32	0.07*
		Female	15.70		
	Sedentary	Male	10.90		
		Female	27.50		
Impact (%)	Active	Male	4.32	0.17	0.99
		Female	3.53		
	Sedentary	Male	7.96		
		Female	8.70		
Total (%)	Active	Male	8.82	0.22	0.41
		Female	10.10		
	Sedentary	Male	11.60		
		Female	15.80		
FEV1	Active	Male	4.19	0.73	< 0.001 [†]
		Female	3.05		
	Sedentary	Male	4.33		
		Female	2.72		
FEV6	Active	Male	5.05	0.16	< 0.001 [†]
		Female	3.84		
	Sedentary	Male	4.68		
		Female	3.26		
FEV1/FEV6	Active	Male	0.83	0.08*	0.08*
		Female	0.81		
	Sedentary	Male	0.93		
		Female	0.83		
6MWT	Active	Male	650.00	0.13	0.87
		Female	646.00		
	Sedentary	Male	577.00		
		Female	564.00		

*p < 0.1.

[†]p < 0.001.

FEV1: forced expiratory volume in one second; FEV6: forced expiratory volume in six seconds; 6MWT: Six-minute walk test; ANOVA: analysis of variance; PA: physical activity.

± 0.90 L and 4.03 ± 1.06 L, respectively. The FEV1/FEV6 ratio was slightly lower in active participants (0.82 ± 0.09) compared with sedentary participants (0.88 ± 0.08), without statistical significance. Similarly, no significant differences were observed in functional

capacity, with mean 6MWT distances of 572 ± 93 m in active students and 648 ± 118 m in sedentary students.

The two-way ANOVA results are presented in Table 6. No statistically significant main effects of PA level were

Table 7. Fixed effects model

Variable	Variable	Estimate	Std. Dev.	p-value
Symptoms (%)	Constant	19.96	2.74	< 0.001 [†]
	PA Level	1.70	5.48	0.76
	Gender	-1.44	5.48	0.80
	PA Level × Gender	-11.14	10.96	0.32
	0.07			
F-test	0.45	0.72		
Activities (%)	Constant	16.59	2.61	< 0.001 [†]
	PA Level	5.29	5.22	0.32
	Gender	10.02	5.22	0.07*
	PA Level × Gender	13.16	10.45	0.22
	0.28			
F-test	2.37	0.10		
Impact (%)	Constant	6.13	1.54	< 0.001 [†]
	PA Level	4.40	3.08	0.17
	Gender	-0.02	3.08	0.99
	PA Level × Gender	1.53	6.17	0.81
	0.11			
F-test	0.71	0.56		
Total (%)	Constant	11.59	1.64	< 0.001 [†]
	PA Level	4.23	3.29	0.22
	Gender	2.79	3.29	0.41
	PA Level × Gender	2.95	6.57	0.66
	0.13			
F-test	0.86	0.48		
FEV1	Constant	3.57	0.14	< 0.001 [†]
	PA Level	-0.10	0.28	0.73
	Gender	-1.38	0.28	< 0.001 [†]
	PA Level × Gender	-0.47	0.56	0.41
	0.60			
F-test	9.09	< 0.001		
FEV6	Constant	4.21	0.16	< 0.001 [†]
	PA Level	-0.47	0.33	0.16
	Gender	-1.32	0.33	< 0.001 [†]
	PA Level × Gender	-0.20	0.65	0.76
	0.51			

(Continues)

Table 7. Fixed effects model (*Continued*)

Variable	Variable	Estimate	Std. Dev.	p-value
F-test	6.24	0.00		
FEV1/FEV6	Constant	0.85	0.02	< 0.001 [†]
	PA Level	0.06	0.03	0.08*
	Gender	−0.06	0.03	0.08*
	PA Level × Gender	−0.07	0.07	0.27
	0.35			
F-test	3.26	0.05		
6MWT	Constant	563.70	48.90	< 0.001 [†]
	PA Level	82.69	66.20	0.227
	Gender	13.29	62.30	0.833
	PA Level × Gender	−9.68	99.20	0.923
	0.126			
F-test	0.867	0.476		

*p < 0.1.

†p < 0.01.

FEV1: forced expiratory volume in one second; FEV6: forced expiratory volume in six seconds; 6MWT: Six-minute walk test; PA: physical activity.

observed for perceived respiratory symptoms, spirometric variables, or 6MWT distance.

Gender-related differences were more pronounced for spirometric outcomes. Men showed significantly higher mean values for FEV1 and FEV6 compared with women ($p < 0.001$ in both cases). For the activity dimension of the SGRQ, women exhibited higher mean scores than men, with a non-significant trend observed for gender ($p = 0.07$).

For the FEV1/FEV6 ratio, non-significant trends were observed for both PA level and gender ($p = 0.08$ in both cases). No significant interaction effects were identified for any outcome.

Fixed-effects regression models including PA level, gender, and their interaction were estimated for perceived respiratory symptoms and physiological variables (Table 7).

For perceived respiratory symptoms, PA level was not independently associated with any SGRQ dimension after adjustment for gender and the interaction term. For the activity dimension of the SGRQ, higher values were observed in women compared with men ($\beta = 10.02$, $p = 0.07$), whereas no independent associations were observed for the symptoms, impact, or total SGRQ scores. The interaction between PA level and gender was not statistically significant for any SGRQ dimension, and the global model tests did not reach statistical significance.

Regarding pulmonary function, gender was independently associated with spirometric outcomes. Lower values were observed in women for FEV1 ($\beta = -1.38$, $p < 0.001$) and FEV6 ($\beta = -1.32$, $p < 0.001$). PA level and the interaction term were not independently associated with these variables. For the FEV1/FEV6 ratio, PA level ($\beta = 0.06$, $p = 0.08$) and gender ($\beta = -0.06$, $p = 0.08$) were not statistically significant predictors, and the interaction term was not significant. The global model test for this outcome was at the threshold of statistical significance ($F = 3.26$, $p = 0.05$), with an explained variance of $R^2 = 0.35$.

In the regression model for functional capacity, PA level ($\beta = 82.69$, $p = 0.227$), gender ($\beta = 13.29$, $p = 0.833$), and their interaction ($\beta = -9.68$, $p = 0.923$) were not independently associated with 6MWT distance. The explanatory power of this model was limited ($R^2 = 0.126$), and the global model test did not reach statistical significance ($F = 0.867$, $p = 0.476$).

Discussion

The objective of this study was to compare pulmonary function and perceived respiratory symptoms in smoking university students based on their level of PA and gender. Considering this, and following the analysis conducted: First, the study observed significant

differences both in the category related to the impact of respiratory symptoms from the SGRQ questionnaire and in its total score, with higher averages for the group of university students who do not engage in PA compared to those who do.

In addition, no statistically significant differences were observed in the distance covered during the 6MWT test between active and sedentary participants. Although the AG showed a tendency to cover greater distances, this difference did not reach statistical significance. Therefore, while sedentary students reported worse perceived respiratory symptoms, this was not accompanied by significant differences in pulmonary function or functional exercise capacity. These findings suggest that the relationship between PA and objective pulmonary capacity may be less evident in young smokers, despite the well-established association between regular exercise and improved physical condition and respiratory efficiency.³⁴

The data from this study, while focusing on perceived symptoms and exercise capacity, are consistent with findings by Garcia-Aymerich et al.,³⁵ who followed a group of smokers for 19 months, identifying those who maintained an active lifestyle and finding that their forced spirometry results were better compared to those who did not maintain an active lifestyle. However, in the present study, conducted in young smokers with low cumulative tobacco exposure, no statistically significant differences were observed in forced spirometry parameters according to PA level. Thus, although scientific evidence supports the benefits of regular PA on pulmonary function, the present findings suggest that these effects may be less evident at early stages of tobacco exposure, primarily due to the negative effects of sedentary behavior, which cause significant physiological changes, accelerating pulmonary function deterioration and increasing the risk of developing respiratory diseases.³⁶⁻³⁹

Specifically, regarding the 6MWT, it is known that the distance covered can be related to the risk of hospitalizations, exacerbations, mortality, and survival in COPD.^{40,41} In the present study, although active participants showed higher mean values in the 6MWT compared to sedentary participants, these differences did not reach statistical significance. Other studies, such as Ben Cheikh Rejbi et al.²⁵ have observed that patients without pathologies cover a greater distance compared to patients diagnosed with COPD. Although the variables analyzed in this study do not account for whether participants engage in exercise, it could be important

for interpreting results since the primary cause of COPD is tobacco consumption.⁴² Therefore, the absence of significant differences in the 6MWT in this young smoking population may reflect an early stage of functional impairment, in which differences related to PA are not yet clearly detectable, in contrast to findings reported in clinical populations such as those described by Ben Cheikh Rejbi et al.²⁵

On the other hand, the tendency toward lower performance in the 6MWT test among sedentary smokers, although not statistically significant in the present study, might be related to alterations in walking patterns aimed at minimizing energy expenditure and maintaining lower limb stability, similar to what has been described in patients diagnosed with COPD.⁴³ It has been shown that COPD patients exhibit various clinical features, including reduced lower limb muscle strength⁴⁴ and impaired balance,⁴⁵ which affect walking patterns during the 6MWT test in both healthy smokers and those with COPD.⁴⁶

Second, regarding gender-related differences in the average percentage of the activity dimension of the SGRQ and in the spirometric variables analyzed (FEV1, FEV6, and FEV1/FEV6), a tendency toward higher values was observed in women for the activity dimension of the SGRQ, while statistically significant differences were identified in spirometric variables, particularly FEV1 and FEV6. Although there are no significant differences between men and women when considering the variable related to PA, women consistently exhibited lower pulmonary capacity as measured by the portable spirometer. This behavior shows that, regardless of exercise, women's pulmonary capacity is lower than men's, and it may also be lower if women are sedentary. The results suggest that women who perceive worse respiratory health may be more susceptible to tobacco use, largely due to the smaller size of their airways.⁴⁷ Furthermore, the spirometric values, also lower in women, indicate that men have greater inspiratory muscle strength compared to women, mainly due to differences in weight and height between sexes, and consequently, differences in bronchial number, alveolar surface area, and airway diameter.⁴⁸

Regarding spirometric variables, the data from this study align with findings from other studies, which highlight that men have greater expiratory flow than women.^{49,50} and that women have smaller airways and lung volumes, resulting in lower expiratory flow values.⁵¹

Finally, in general terms, the results of this study did not reveal consistent correlations between perceived

respiratory symptoms and pulmonary function measured by spirometric tests and the 6MWT test. Only a moderate inverse association was observed between the FEV1/FEV6 ratio and the activity dimension of the SGRQ, while no significant correlations were identified for the remaining variables. Therefore, spirometric measurements seem to be more effective in analyzing respiratory health, similar to COPD diagnosis.⁵² However, the issue of performing these maneuvers by non-expert professionals has been addressed, showing that FEV6 represents a reliable and valid indicator for detecting obstructive airway changes.⁵³

Conclusions

The results obtained do not show a strong or consistent correlation between pulmonary function and perceived respiratory symptoms in smoking individuals according to their level of PA. However, the findings highlight differences in perceived respiratory symptom impact and gender-related differences in pulmonary function, underscoring the importance of considering lifestyle factors in respiratory health, even in young smokers.

In addition, the negative effect of tobacco use, particularly evident in women through lower spirometric values, suggests that PA may play a complementary role in this population. Finally, when assessing pulmonary function in smokers, it seems more acceptable to use spirometric variables and/or pulmonary capacity tests compared to self-reported respiratory health questionnaires.

Limitations of the study

Regarding the limitations of the study, it is important to consider the relatively young age of the sample, which may account for the lack of significant differences in many of the analyzed variables. Another important limitation is the sample size, which is relatively small and therefore limits the statistical power and generalizability of the findings. Furthermore, the low cumulative exposure to tobacco observed in this population may have reduced the ability to detect objective alterations in lung function or exercise capacity.

Funding

None.

Conflicts of interest

None.

Ethical considerations

Protection of humans and animals. The authors declare that the procedures followed complied with the ethical standards of the responsible human experimentation committee and adhered to the World Medical Association and the Declaration of Helsinki. This study complies with the Declaration of Helsinki for research involving human subjects and was approved by the Ethics Committee of the European University of the Atlantic (Spain) (ID: CEI16/2024).

Confidentiality, informed consent, and ethical approval. The authors have followed their institution's confidentiality protocols, obtained informed consent from patients, and received approval from the Ethics Committee. The SAGER guidelines were followed according to the nature of the study.

Declaration on the use of artificial intelligence. The authors declare that no generative artificial intelligence was used in the writing of this manuscript.

References

1. González EM, Oliva DA. Tabaquismo y su relación con las enfermedades cardiovasculares. *Rev Habanera Cien Méd.* 2018;17:225-35.
2. Rey-Brandariz J, Ruano-Ravina A, Isolina Santiago-Pérez M, Varela-Lema L, Guerra-Tort C, Montes A, et al. Evolution of smoking prevalence in Spain and its 17 autonomous regions (1987-2020). *Med Clin (Barc).* 2024;162:417-24.
3. Brime B, García N, León L, Llorens N, Tristán C, Sánchez E. Informe 2022: Alcohol, Tabaco y Drogas Ilegales en España; 2022. Available from: <https://pnsd.sanidad.gob.es/profesionales/sistemasinformacion/informesestadisticas/pdf/2022oeda-informe.pdf>
4. Ling PM, Glantz SA. Why and how the tobacco industry sells cigarettes to young adults: evidence from industry documents. *Am J Public Health.* 2002;92:908-16.
5. Abdulghani HM, Alrowais NA, Alhaqwi AL, Alrasheedi A, Al-Zahir M, Al-Madani A, et al. Cigarette smoking among female students in five medical and nonmedical colleges. *Int J Gen Med.* 2013;6:719-27.
6. Wolfson M, McCoy TP, Sutfin EL. College students' exposure to second-hand smoke. *Nicotine Tob Res.* 2009;11:977-84.
7. Celli BR, MacNee W, Agustí A, Anzueto A, Berg B, Buist AS, et al. Standards for the diagnosis and treatment of patients with COPD: a summary of the ATS/ERS position paper. *Eur Respir J.* 2004;23:932-46.
8. Vázquez Rosa A, Tárraga Marcos A, Tárraga Marcos ML, Romero De Ávila M, Tárraga López PJ. Enfermedad pulmonar obstructiva crónica y comorbilidad. *J Negat No Posit Results.* 2020;5:1195-220.
9. Miravittles M, Worth H, Soler Cataluña JJ, Price D, De Benedetto F, Roche N, et al. Observational study to characterise 24-hour COPD symptoms and their relationship with patient-reported outcomes: results from the ASSESS study. *Respir Res.* 2014;15:122.
10. Crotty Alexander LE, Shin S, Hwang JH. Inflammatory diseases of the lung induced by conventional cigarette smoke: a review. *Chest.* 2015;148:1307-22.
11. Kou YR, Kwong K, Lee LY. Airway inflammation and hypersensitivity induced by chronic smoking. *Respir Physiol Neurobiol.* 2011;178:395-405.
12. Madani A, Alack K, Richter MJ, Krüger K. Immune-regulating effects of exercise on cigarette smoke-induced inflammation. *J Inflamm Res.* 2018;11:155-67.

13. Twisk JW, Staal BJ, Brinkman MN, Kemper HC, Van Mechelen W. Tracking of lung function parameters and the longitudinal relationship with lifestyle. *Eur Respir J*. 1998;12:627-34.
14. Martínez Hernández JA, Varo Cénarrubaleitia JJ, Martínez González MÁ. Beneficios de la actividad física y riesgos del sedentarismo. *Med Clin*. 2003;121:665-72.
15. Lei Y, Zou K, Xin J, Wang Z, Liang K, Zhao L, et al. Sedentary behavior is associated with chronic obstructive pulmonary disease: a generalized propensity score-weighted analysis. *Medicine (Baltimore)*. 2021;100:e25336.
16. Arocha Rodulfo JI. Sedentary lifestyle a disease from xxi century. *Clin Investig Arterioscler*. 2019;31:233-40.
17. Holmen TL, Barrett-Connor E, Clausen J, Holmen J, Bjørner L. Physical exercise, sports, and lung function in smoking versus nonsmoking adolescents. *Eur Respir J*. 2002;19:8-15.
18. Holmen TL, Barrett-Connor E, Clausen J, Holmen J, Bjørner L. Physical exercise, sports, and lung function in smoking versus nonsmoking adolescents. *Eur Respir J*. 2002;19:8-15.
19. Fanelli A, Cabral AL, Neder JA, Martins MA, Carvalho CR. Exercise training on disease control and quality of life in asthmatic children. *Med Sci Sports Exerc*. 2007;39:1474-80.
20. Krüger K, Seimetz M, Ringseis R, Wilhelm J, Pichl A, Couturier A, et al. Exercise training reverses inflammation and muscle wasting after tobacco smoke exposure. *Am J Physiol Regul Integr Comp Physiol*. 2018;314:R366-76.
21. Mapel DW, Dalal A, Blanchette CM, Petersen H, Ferguson GT. Severity of COPD at initial spirometry-confirmed diagnosis: data from medical charts and administrative claims. *Int J Chron Obstruct Pulmon Dis*. 2011;6:573-81.
22. Agustí A. Una Guía Para Profesionales de la Asistencia Sanitaria: Guía de Bolsillo Para el Diagnóstico, Manejo y Prevención de la EPOC. Edición de 2022. Global Initiative for Chronic Obstructive Lung Disease; 2021. Available from: https://goldcopd.org/wp-content/uploads/2022/01/guidasgold2022_xxxxxv2_es-pocket.pdf
23. Represas Represas C, Botana Rial M, Leiro Fernández V, Isabel A, Del Campo V, Fernández-Villar A. Validación del dispositivo portátil COPD-6 para la detección de patologías obstructivas de la vía aérea. *Arch Bronconeumol*. 2010;46:426-32.
24. Cheng DK, Nelson M, Brooks D, Salbach NM. Validation of stroke-specific protocols for the 10-meter walk test and 6-minute walk test conducted using 15-meter and 30-meter walkways. *Top Stroke Rehabil*. 2019;27:251-61.
25. Ben Cheikh Rejbi I, Trabelsi Y, Chouchene A, Ben Turkia W, Ben Saad H, Zbidi A, et al. Changes in six-minute walking distance during pulmonary rehabilitation in patients with COPD and in healthy subjects. *Int J Chron Obstruct Pulmon Dis*. 2010;5:209-15.
26. Rodríguez DA, Kortianou EA, Alison JA, Casas A, Giavedoni S, Barبران-García A, et al. Heart rate recovery after 6-min walking test predicts acute exacerbation in COPD. *Lung*. 2017;195:463-7.
27. Zhao D, Abbasi A, Casaburi R, Adami A, Tiller NB, Yuan W, et al. Identifying a heart rate recovery criterion after a 6-minute walk test in COPD. *Int J Chron Obstruct Pulmon Dis*. 2021;16:2545-60.
28. Meh K, Jurak G, Sorić M, Rocha P, Sember V. Validity and reliability of IPAQ-SF and GPAQ for assessing sedentary behaviour in adults in the European Union: a systematic review and meta-analysis. *Int J Environ Res Public Health*. 2021;18:4602.
29. Bull FC, Al-Ansari SS, Biddle S, Borodulin K, Buman MP, Cardon G, et al. World Health Organization 2020 guidelines on physical activity and sedentary behaviour. *Br J Sports Med*. 2020;54:1451-62.
30. Ferrer M, Villasante C, Alonso J, Sobradillo V, Gabriel R, Vilagut G, et al. Interpretation of quality of life scores from the St George's respiratory questionnaire. *Eur Respir J*. 2002;19:405-13.
31. Jones PW, Quirk FH, Baveystock CM. The St George's respiratory questionnaire. *Respir Med*. 2022;85:25-31; discussion 33-7.
32. Rosero Arenas MÁ, García García MÁ, Briones Uriaga MM, Martínez Cornejo A. Utilidad del miniespirómetro COPD-6 en el diagnóstico precoz de EPOC. *Open Respir Arch*. 2020;2:132-40.
33. Gochicoa-Rangel L, Mora-Romero U, Guerrero-Zúñiga S, Silva-Cerón M, Cid-Juárez S, Velázquez-Uncal M, et al. Prueba de caminata de 6 minutos: recomendaciones y procedimientos. *Neumol Cir Torax*. 2015;74:127-36.
34. Pelkonen M, Notkola IL, Lakka T, Tukiainen HO, Kivinen P, Nissinen A. Delaying decline in pulmonary function with physical activity. *Am J Respir Crit Care Med*. 2003;168:494-9.
35. García-Aymerich J, Lange P, Benet M, Schnohr P, Antó JM. Regular physical activity modifies smoking-related lung function decline and reduces risk of chronic obstructive pulmonary disease: a population-based cohort study. *Am J Respir Crit Care Med*. 2007;175:458-63.
36. Anderson GP. COPD, asthma and C-reactive protein. *Eur Respir J*. 2006;27:874-6.
37. Dogra S, Good J, Gardiner PA, Copeland JL, Stickland MK, Rudoler D, et al. Effects of replacing sitting time with physical activity on lung function: an analysis of the Canadian longitudinal study on aging. *Health Rep*. 2019;30:12-23.
38. Edwards MK, Loprinzi PD. Systemic inflammation as a function of the individual and combined associations of sedentary behaviour, physical activity and cardiorespiratory fitness. *Clin Physiol Funct Imaging*. 2016;38:93-9.
39. Truba TN, Doan J, Currie CL, Copeland JL. Short-term changes in daily movement behaviour influence salivary C-reactive protein in healthy women. *Appl Physiol Nutr Metab*. 2018;43:854-6.
40. Cahalin LP, Arena R, Labate V, Bandera F, Lavie CJ, Guazzi M. Heart rate recovery after the 6 min walk test rather than distance ambulated is a powerful prognostic indicator in heart failure with reduced and preserved ejection fraction: a comparison with cardiopulmonary exercise testing. *Eur J Heart Fail*. 2013;15:519-27.
41. Groepenhoff H, Vonk-Noordegraaf A, Van De Veerdonk MC, Boonstra A, Westerhof N, Bogaard HJ. Prognostic relevance of changes in exercise test variables in pulmonary arterial hypertension. *PLoS One*. 2013;8:e72013.
42. Hopkinson NS. COPD, smoking, and social justice. *Lancet Respir Med*. 2022;10:428-30.
43. Donelan JM, Kram R, Kuo AD. Mechanical and metabolic determinants of the preferred step width in human walking. *Proc Biol Sci*. 2001;268:1985-92.
44. Seymour JM, Spruit MA, Hopkinson NS, Natanek SA, Man WD, Jackson A, et al. The prevalence of quadriceps weakness in COPD and the relationship with disease severity. *Eur Respir J*. 2009;36:81-8.
45. Smith MD, Chang AT, Seale HE, Walsh JR, Hodges PW. Balance is impaired in people with chronic obstructive pulmonary disease. *Gait Posture*. 2010;31:456-60.
46. Kuo AD, Donelan JM. Dynamic principles of gait and their clinical implications. *Phys Ther*. 2010;90:157-74.
47. Leynaert B, Sunyer J, García-Esteban R, Svanes C, Jarvis D, Cerveri I, et al. Gender differences in prevalence, diagnosis, and incidence of allergic and non-allergic asthma: a population-based cohort. *Thorax*. 2012;67:625-31.
48. Townsend EA, Miller VM, Prakash YS. Sex differences and sex steroids in lung health and disease. *Endocr Rev*. 2012;33:1-47.
49. Lee SH, Yim SJ, Kim HC. Aging of the respiratory system. *Kosin Med J*. 2016;31:11.
50. Sharma G, Goodwin J. Effect of aging on respiratory system physiology and immunology. *Clin Interv Aging*. 2006;1:253-60.
51. Talaminos Barroso A, Márquez Martín E, Roa Romero LM, Ortega Ruiz F. Factors affecting lung function: a review of the literature. *Arch Bronconeumol (Engl Ed)*. 2018;54:327-32.
52. Toda R, Hoshino T, Kawayama T, Imaoka H, Sakazaki Y, Tsuda T, et al. Validation of "lung age" measured by spirometry and handy electronic FEV1/FEV6 meter in pulmonary diseases. *Intern Med*. 2009;48:513-21.
53. Jing JY, Huang TC, Cui W, Xu F, Shen HH. Should FEV1/FEV6 replace FEV1/FVC ratio to detect airway obstruction? A metaanalysis. *Chest*. 2009;135:991-8.