

# Effects of smoking and physical exercise on respiratory function test results in students of university

## A cross-sectional study

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### Abstract

We explored the effects of smoking and exercise on pulmonary function (PF) in young adults.

This was a 2-year, prospective cross-sectional study on university students. We recorded age, gender, weight, height, pulmonary symptoms, smoking status, and sports habits. Spirometry was used to evaluate lung function; we recorded the forced expiratory volume in 1 second (FEV<sub>1</sub>), the forced vital capacity (FVC), and the FEV<sub>1</sub>/FVC ratio.

A total of 1014 (552 female, 464 male) subjects were included. Smokers reported significantly more wheezing and sputum production than nonsmokers, but exhibited better FVC and FEV<sub>1</sub> values. Those who smoked less than half a pack/d had significantly poorer FVC and FEV<sub>1</sub> levels than nonsmokers. Smokers exhibited significantly lower FEV<sub>1</sub>/FVC ratios than nonsmokers. Overall, those who exercised exhibited better FEV<sub>1</sub> and FVC levels, but this was attributable entirely to females.

The spirometric percentile data were adjusted for gender, age, and height, and used as indicators of health status (good: >90; average: 25–90, poor <25). In males, PF was associated with regular exercise (good: 7.8, average: 6.5, poor: 14.2,  $P = .02$ ). The smoking rate was higher in the “good” group (males: good: 31.3, average: 30, poor: 17.9,  $P = .02$ /females: good: 22.4, average: 17.9, poor: 10.4,  $P = .02$ ).

On multivariate regression analysis, above-average PF test results were associated with age (1.32 [1.04–1.69]) and exercising at least once per week (4.06 [1.16–14.20]) in males. In females, above-average results were associated with irregular exercise (2.88 [1.36–6.09]), age (1.85 [1.44–2.37]), and exercising until palpitations developed (0.18 [0.04–0.88]).

Smoking improves lung function in young adults; these are “healthy smokers.” Physical activity did not improve lung function, but the absence of physical activity significantly worsened lung function.

**Abbreviations:** FEV<sub>1</sub> = forced expiratory volume in 1 second, FVC = the forced vital capacity, PF = pulmonary function, PFT = pulmonary function test.

**Keywords:** lung function, physical activity, spirometry, tobacco-smoking

## 1. Introduction

Smoking is a public health problem that causes various diseases. Approximately 1.2 billion people smoke worldwide.<sup>[1–3]</sup> Smoking is the leading cause of preventable death. In the European Union, smoking is responsible for 700,000 deaths annually.<sup>[1]</sup> Diseases closely associated with tobacco-smoking include cardiovascular, respiratory, oncological, and cerebrovascular

conditions.<sup>[4,5]</sup> The human respiratory system is the system most significantly affected by smoking; disease spreads from the smaller to the larger airways.<sup>[6]</sup> In the United States, smoking is responsible for about 80% of chronic airway disease cases.<sup>[7]</sup> The airway obstruction and inflammatory changes characteristic of chronic obstructive lung diseases are attributable to smoking. The respiratory system is equally affected in all races; no variation by ethnicity is evident.<sup>[8]</sup> Both active and passive smoking (the latter especially in childhood) trigger significant impairments.<sup>[5]</sup>

Exercise benefits health.<sup>[7,9]</sup> However, the effects of physical activity on pulmonary function (PF) have not been well-described. Only limited data are available on the effect of physical activity on PF, especially in heavy/young smokers.<sup>[7]</sup> A study of how smoking and physical activity affect PF may be expected to find that smoking negatively affects, and physical activity positively affects PF. Here, we examined the effects of smoking and exercise on the PF of young adults.

## 2. Materials and methods

We performed a prospective cross-sectional study in the Hacettepe University Faculty of Medicine between 2001 and 2003 (2 years). The study protocol was approved by our ethics board and university students were enrolled. Informed consent

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**Table 1**  
Mean age, smoking amount, and age of first smoking tobacco of the study subjects.

	Age (mean ± SD yr)	Age of first smoking tobacco (mean ± SD yr)	Smoking amount (box/d)			Total	Nonsmoker
			(<1/2)	(1/2–1)	(>1)		
Male (n=462)	19.42 ± 1.28	16.71 ± 1.9	54	48	21	123 (26, 6%)	339 (73, 4%)
Female (n=552)	19.33 ± 1.25	17.3 ± 2.5	57	28	1	86 (15, 6%)	466 (84, 4%)
Total (n=1014)	19.37 ± 1.27		111	76	22	209 (42.2%)	805 (100%)
<i>P</i> *		>.005				$\chi^2$ :18.746, <i>P</i> .000	

SD = standard deviation.

\* Pearson Chi-square test.

was obtained from all subjects. Those aged less than 18 years, and those who were unwilling to participate, were excluded, as were subjects with airway obstruction (forced expiratory volume in 1 second/forced vital capacity [FEV1/FVC] < 80%) and those with a history of chest or abdominal surgery, current chest pain, or a history of stroke or a heart attack. Pulmonary symptoms, smoking status, and sports participation were recorded for in subjects (Appendix), in addition to age, gender, weight, and height. We recorded wheezing in the past 12 months, current sputum production, and current cough, as well as age of smoking onset, number of cigarettes smoked daily (less than half a pack, half-to-1 pack, more than 1 pack), current passive smoking status, and any passive smoking history in childhood. In terms of physical activity, we recorded current exercise status, exercise intensity (once a week, a few days a week, every day, irregular), and mean duration of exercise (<30, 30–60, 60–90, 90–120, or >120 minutes). Height, weight, and PF test (PFT) results were recorded by a trained nurse. Test data included the FEV1, FVC, and FEV1/FVC ratio. Males and females were grouped separately by height quartile. We used PFT data to categorize health status, as follows:

- Good: PFT in the 90% percentile;
- Average: PFT in the 26% to 90% percentile;
- Poor: PFT in the 25% percentile.

We divided all subjects into smokers and nonsmokers and compared their demographic data, pulmonary symptoms and PFT results. We used regression analysis to determine factors affecting the PFT results.

### 2.1. Statistical analysis

All data were analyzed using SPSS for Windows software (ver. 21.0; SPSS Inc, Chicago, IL). Demographic data are reported as

means ± standard deviation. The FEV1, FVC, and FEV1/FVC ratio are presented as geometric means. We compared 2 groups using Pearson chi-squared test. If more than 2 groups were compared, we employed the independent *t* test. We performed multivariate regression analysis to determine factors predicting average and above-average PFT status. A *P*-value <.05 was considered to reflect statistical significance.

## 3. Results

We enrolled 1014 students (462 males, 552 females) (Table 1) with a mean age of 19.37 ± 1.27 years (range: 18–25 years). Significantly more males were smokers (26.6% vs 15.6% of females;  $\chi^2$ : 18.746, *P* = .000). The mean time since starting smoking was 2.9 ± 1.9 years; the mean age at smoking onset did not differ by gender (*P* > .005).

### 3.1. Smoking status and PF

The frequency rates of wheezing and sputum production in the past 12 months differed significantly between smokers and nonsmokers (wheezing: 45.9% of smokers and 20.2% of nonsmokers,  $\chi^2$ : 57.554, *P* = .000; sputum production: 49.8% of smokers and 28.2% of nonsmokers,  $\chi^2$ : 35.084, *P* = .000). Cough frequency did not differ between smokers and nonsmokers (73.3% of smokers and 66.7% of nonsmokers, *P* > .05). No significant gender differences were seen (Table 2). The FEV1, FVC, and FEV1/FVC values in smokers were significantly higher than in nonsmokers (FEV1, *t* = 4.130, *P* = .000; FVC, *t* = 5.336, *P* = .000; FEV1/FVC, *t* = 4.049, *P* = .000). Smokers exhibited better FEV1 and FVC values, but nonsmokers showed better FEV1/FVC ratios. Significant differences were also seen between smokers and nonsmokers when considering males and females separately (FEV1, *t* = 2.112, *P* = .035; FVC, *t* = 3.338, *P* = .001;

**Table 2**  
Effects of smoking habits on pulmonary symptoms and spirometry findings (FEV1 values, FVC values, and FEV1/FVC ratio).

	Smoker			Nonsmoker			<i>P</i> *
	Male (n=123)	Female (n=86)	Total (n=209)	Male (n=339)	Female (n=466)	Total (n=805)	
Pulmonary symptoms							
Wheeze	54 (43.9%)	42 (48.8%)	<b>94 (45.9%)</b>	66 (19.5%)	97 (20.8%)	<b>163 (20.2%)</b>	( $\chi^2$ : 57.554 <i>P</i> .000)
Sputum	68 (55.3%)	36 (41.9%)	<b>104 (49.8)</b>	95 (28.0%)	132 (28.3%)	<b>227 (28.2%)</b>	( $\chi^2$ : 35.084, <i>P</i> 0.000)
Cough	90 (73.2%)	64 (74.4%)	<b>154 (73.7)</b>	208 (61.4%)	329 (70.6%)	<b>537 (66.7%)</b>	<i>P</i> > .05
Spirometry							
FEV <sub>1</sub>	99.72	98.33	<b>99.15</b>	97.45	94.62	<b>95.80</b>	<i>t</i> 4.130 <i>P</i> 0.000
FVC	92.89	92.42	<b>92.70</b>	89.18	87.66	<b>88.33</b>	<i>t</i> 5.336, <i>P</i> 0.000
FEV1/FVC	91.39	93.47	<b>92.23</b>	93.24	94.66	<b>94.06</b>	<i>t</i> 4.049, <i>P</i> .000

FEV1 = forced expiratory volume in 1 second, FVC = forced vital capacity.

\* Pearson Chi-square test.

**Table 3****Comparison of FEV1 values, FVC values, and FEV1/FVC ratio according to exercise status between smoker and nonsmoker groups.**

	In all groups			Smoker			Nonsmoker		
	Male (n=462)	Female (n=552)	Total (n=1014)	Male (n=123)	Female (n=86)	Total (n=209)	Male (n=339)	Female (n=466)	Total (n=805)
Exercise + (n=762)	82.7%	68.8%	74.2%	26.7%	17.1%	21.9%	73.3%	82.9%	78.1%
FEV <sub>1</sub>	98.24	96.05	97.14	99.40	100.16	99.70	97.83	95.23	96.45
FVC	90.22	89.35	89.78	92.68	94.23	93.28	89.33	88.37	88.82
FEV1/FVC	92.83	94.30	93.56	91.30	93.32	92.08	93.39	94.51	93.97
Exercise – (n=252)	17.3%	31.2%	25.8	26.3%	12.2%	16.7%	73.8%	87.8%	83.3%
FEV <sub>1</sub>	93.35	93.35	94.51	101.27	92.92	97.00	95.69	93.39	94.04
FVC	89.86	86.32	87.44	93.88	87.07	90.40	88.39	86.22	86.83
FEV1/FVC	92.32	94.88	94.06	91.70	93.95	92.83	92.53	95.01	92.53
<i>P</i> *	<i>P</i> >.005 for FEV1,FVC and FEV1/FVC com- parisons	FEV1, <i>t</i> 2.879 <i>P</i> : .004; FVC, <i>t</i> 3.161, <i>P</i> : .002; FEV1/FVC, <i>P</i> >.005	FEV <sub>1</sub> , <i>t</i> 3.519 <i>P</i> : .000; FVC, <i>t</i> 3.099, <i>P</i> : .002; FEV1/FVC, <i>P</i> >.005	<i>P</i> >.005 for FEV1,FVC and FEV1/FVC comparisons	FEV1, <i>t</i> 3.137 <i>P</i> : .002; FVC, <i>t</i> 3.183, <i>P</i> : .002; FEV1/FVC, <i>P</i> >.005	<i>P</i> >.005 for FEV1,FVC and FEV1/FVC com- parisons	<i>P</i> >.005 for FEV1,FVC and FEV1/FVC com- parisons	FEV1, <i>P</i> >.005; FVC, <i>t</i> 2.077, <i>P</i> : .038;FEV1/ FVC, <i>P</i> >.005	(FEV1, <i>t</i> 2.933 <i>P</i> : .003; FVC, <i>t</i> 2.359, <i>P</i> : .019 FEV1/FVC, <i>P</i> >.005)

FEV1 = forced expiratory volume in 1 second, FVC=forced vital capacity.

\*Independent groups *t* test.

and FEV1/FVC,  $t = -3.090$ ,  $P = .002$  for males; and FEV1,  $t = 3.021$ ,  $P = .003$ ; FVC,  $t = 3.810$ ,  $P = .000$ ; and FEV1/FVC,  $t = -2.001$ ,  $P = .046$  for females; Table 2).

According to daily smoking amount, the mean FEV1, FVC, and FEV1/FVC values were 99.18, 92.23, and 93.41, respectively, in those who smoked less than half a pack; 100.11, 94.16, and 91.48 in those who smoked half-to-1 pack; and 101.27, 96.00, and 90.36 in those who smoked more than a pack. Duncan test revealed a significant difference in the FEV1/FVC ratio between those who smoked less than half versus more than 1 pack. Of all subjects, 61.1% (males, 56.1%, females, 65.4%) had been exposed to passive smoking during childhood. The FEV1, FVC, and FEV1/FVC values of the exposed subjects were 96.00, 88.94, and 93.62, respectively, and the values for those not exposed were 97.25, 89.57, and 93.77; the differences were not significant (all  $P > .005$ ).

### 3.2. Smoking and exercise

Table 3 shows the FEV1, FVC, and FEV1/FVC values of smokers and nonsmokers who did and did not exercise. Of all subjects, 74.2% ( $n = 752$ ) exercised (82.7% of males and 68.8% of females); the difference was significant ( $\chi^2: 25.808$ ,  $P = .000$ , Table 3). Of those who exercised, 21.9% smoked; 16.7% of those who did not exercise smoked. The male and female smoking rates were 26.7% and 17.1%, respectively, among those who exercised. The rates in males and females who did not exercise were 26.3% and 12.2%, respectively. The smoking rates of subjects who exercised and those who did not overall and by gender, did not differ significantly ( $P > .005$ ). Of the male subjects, 34.6% exercised regularly, and 65.4% irregularly. Of the female subjects, 32.9% exercised regularly and 67.1% irregularly; no between-gender difference was apparent ( $P > .005$ ). In terms of exercise duration, 19.9% of males exercised for <30 min/wk, 10.2% for 30 to 60 minutes, 38.5% for 60 to 90 minutes, 13.9% for 90 to 120 minutes, and 17.5% for >120 minutes. In females, the figures were 22.9%, 29.2%, 25.8%, 9.2%, and 12.9% respectively. On average, males exercised for

more than 60 minutes and females for less than 60 minutes; the difference was significant (Pearson chi-squared test,  $\chi^2: 51.572$ ,  $P = .000$ ).

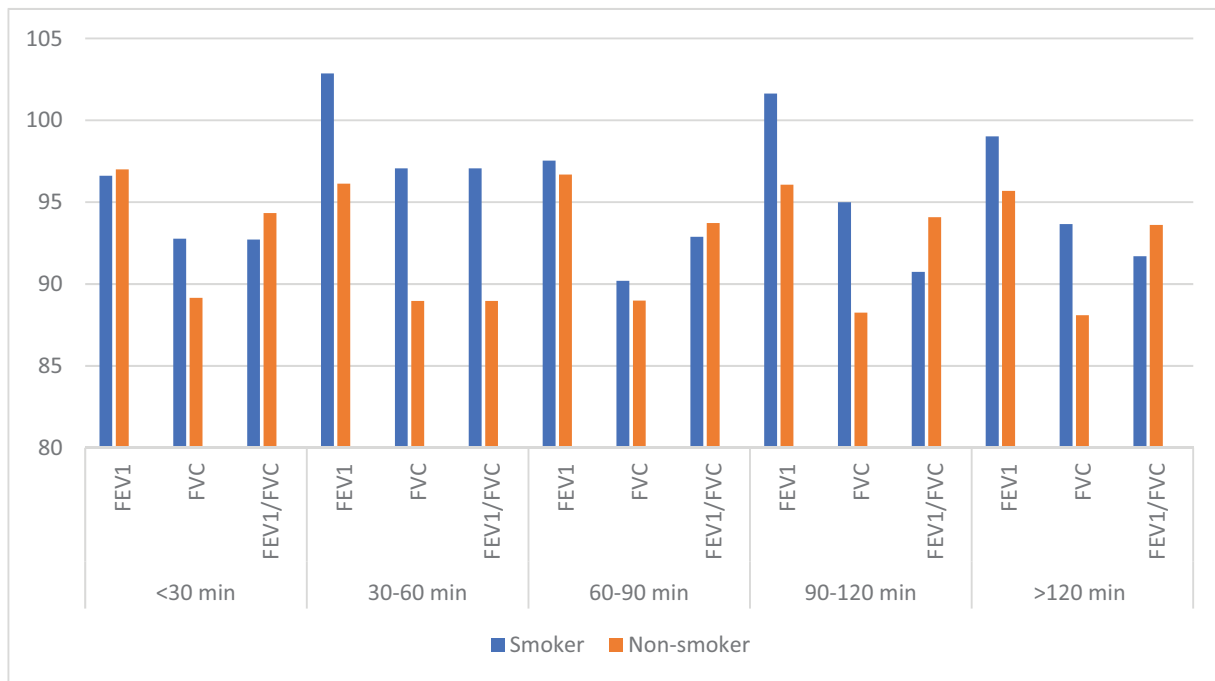
### 3.3. Exercise and PF

When the exercise and nonexercise groups were compared, the FEV1, FVC, and FEV1/FVC values differed significantly; the FEV1 and FVC values were higher in those who exercised (FEV1,  $t = 3.519$ ,  $P = .000$ ; FVC,  $t = 3.099$ ,  $P = .002$ ) but the FEV1/FVC ratios did not differ significantly. The FEV1, FVC, and FEV1/FVC values of males who exercised did not differ significantly from those of males who did not exercise. The FEV1 and FVC values of females who exercised were significantly higher than those of females who did not exercise (FEV1,  $t = 2.879$ ,  $P = .004$ ; FVC,  $t = 3.161$ ,  $P = .002$ ), but the FEV1/FVC ratios were not.

### 3.4. Exercise, smoking, and PF

The FEV1, FVC, and FEV1/FVC values of the smokers who exercised and those who did not showed no significant differences (all  $P > .005$ ). The independent *t* test showed that the FEV1 and FVC values of nonsmokers who exercised and those who did not differed significantly (FEV1,  $t = 2.933$ ,  $P = .003$ ; FVC,  $t = 2.359$ ,  $P = .019$ ) but the FEV1/FVC ratios did not. In males, the FEV1, FVC, and FEV1/FVC values of smokers who exercised and those who did not showed no significant differences (all  $P$ -values  $> .005$ ). The same was true of nonsmokers who exercised and those who did not (all  $P > .005$ ).

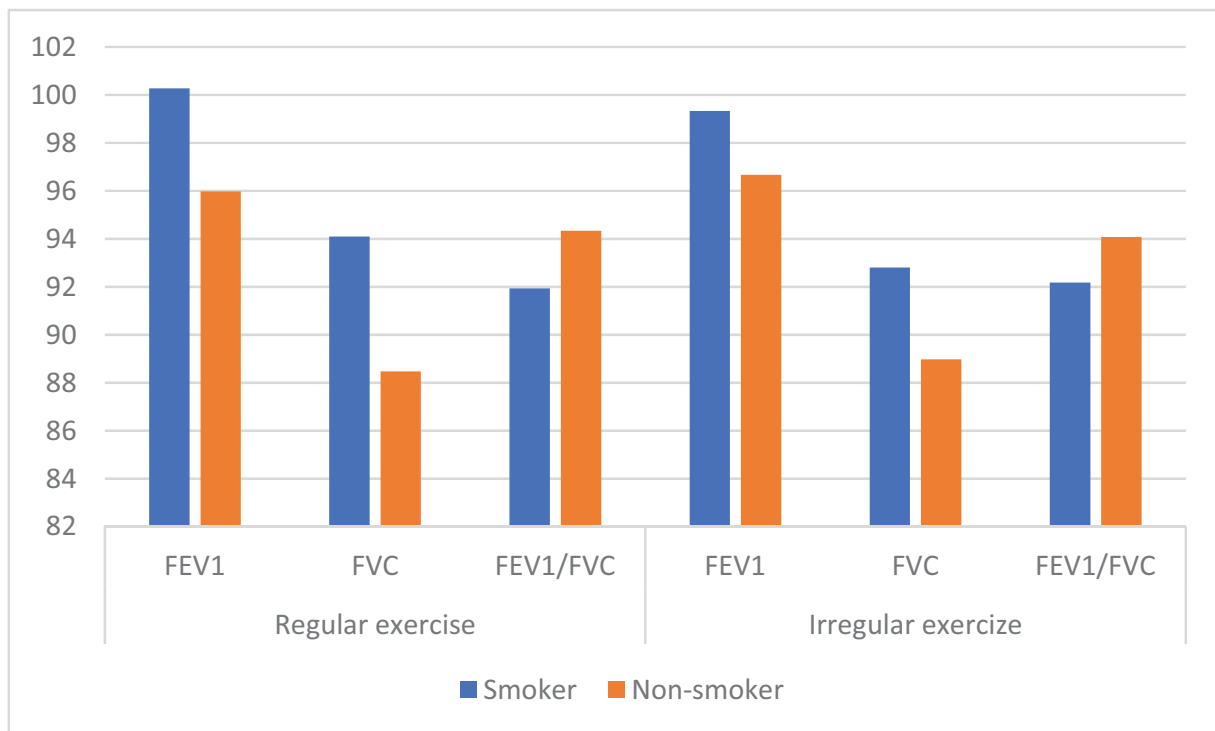
In females, the FEV1 and FVC values of smokers who exercised and those who did not differed significantly (FEV1,  $t = 3.137$ ,  $P = .002$ ; FVC,  $t = 3.183$ ,  $P = .002$ ). The FEV1/FVC ratios did not differ. The FVC values of nonsmokers who exercised and those who did not differed significantly ( $t = 2.077$ ,  $P = .038$ ) but the FEV1 and FEV1/FVC values did not. In terms of exercise (regular/irregular), the FEV1, FVC, and FEV1/FVC values did not differ by smoking status, or exercise frequency or duration (all  $P > .005$ ; Figs. 1 and 2).



**Figure 1.** FEV1, FVC, and FEV1/FVC ratio values by exercise duration in smokers and nonsmokers. FEV1 =forced expiratory volume in 1 second, FVC=forced vital capacity.

Spirometric percentile data adjusted for gender, age, and height were used as indicators of health status (good: >90; average: 25–90, poor <25). In males, the spirometric category differed by regular exercise (good: 7.8, average: 6.5, poor: 14.2,  $P = .02$ ). The

smoking rate was higher in the “good” PFT groups (males: good: 31.3, average: 30, poor: 17.9,  $P = .02$ /females: good: 22.4, average: 17.9, poor: 10.4,  $P = .02$ ). Multivariate regression analysis showed that above-average PFT results differed by age



**Figure 2.** FEV1, FVC, and FEV1/FVC ratio values by regular exercise status in smokers and nonsmokers. FEV1 =forced expiratory volume in 1 second, FVC=forced vital capacity.

**Table 4**

**Multinomial logistic regression analysis of health status that was described by PFT levels with sporting attitude and sporting habits in male and female students.**

Frequency of sports habits	PFT average		PFT Above average	
	Male	Female	Male	Female
>1/wk	1.36 (0.70–2.67)	1.34 (0.77–2.34)	1.16 (0.41–3.35)	1.45 (0.53–4.01)
1/wk	3.37 (1.27–8.90)*	2.28 (0.95–5.47)	4.06 (1.16–14.20)*	1.92 (0.35–10.5)
Irregular	1.88 (1.06–3.34)*	1.24 (0.81–1.92)	1.90 (0.81–4.46)	2.88 (1.36–6.09)**
No exercise	Reference ( $P=$ **)	Reference ( $P=$ >.05)	Reference ( $P=$ >.05)	Reference ( $P=$ ***)
Age (1 yr increase)	1.11 (0.93–1.34)	1.07 (0.90–1.27)	1.32 (1.04–1.69)*	1.85 (1.44–2.37)**
Smoking	1.89 (1.10–3.25)*	1.68 (0.92–3.04)	1.68 (0.81–3.47)	1.17 (0.48–2.83)
Exercising till palpitation	0.48 (0.25–0.92)*	1.10 (0.58–2.08)	0.72 (0.30–1.75)	0.18 (0.04–0.88)*

PFT below average group was reference group.

PFT=pulmonary function test.

\* $P < .05$ .

\*\* $P < .01$ .

\*\*\*\* $P < .0001$ .

(1.32 [1.04–1.69]) and once-weekly exercise status in males (4.06 [1.16–14.20]). In females, above-average PFT results differed by irregular exercise status (2.88 [1.36–6.09]), age (1.85 [1.44–2.37]), and exercising until experiencing palpitations (0.18 [0.04–0.88]) (Table 4).

#### 4. Discussion

Lung function is an indicator of all-cause morbidity/mortality; studies on the effects of smoking and exercise, especially on young adults, provide useful data. We found that 26.6% of male and 15.6% of female students smoked. Males started smoking at a mean age of  $16.71 \pm 1.9$  years, and females at  $17.3 \pm 2.5$  years. Juusela et al reported that most active smokers start smoking between 15 and 19 years of age.<sup>[6]</sup>

Smoking exerts various effects on the human pulmonary system and symptoms eventually develop.<sup>[1]</sup> Smoking is a risk factor for bronchial hyperresponsiveness, asthma, chronic obstructive pulmonary disease, and lung cancer.<sup>[6]</sup> We found that smokers wheeze more and produce more sputum than nonsmokers. We used the FEV1, FVC, and FEV1/FVC values to explore PF; all 3 parameters were affected by both smoking and exercise. Twisk et al reported that smoking decreased the FVC and FEV1, while physical activity increased the FVC.<sup>[9]</sup> Holmen et al found that the FEV1 and FVC were predictors of good lung function<sup>[10]</sup> We found that smokers had better FVC and FEV1 levels than nonsmokers, but those who smoked less than half a packet daily had poorer FVC and FEV1 levels than nonsmokers. These findings are consistent with literature data. The term “healthy smoker” was first coined by Becklake and Laloo in 1990,<sup>[11]</sup> the concept is allied to the “healthy worker” descriptor. The idea is that those who function well keep working; similarly, smokers with better lung function will continue to smoke, quitting only when lung function deteriorates.<sup>[10]</sup> We excluded subjects with airway obstruction ( $FEV1/FVC < 80\%$ ); we studied only spirometry-proven healthy lungs. Smokers had a significantly lower FEV1/FVC ratio than nonsmokers. Thus, even though the FVC and FEV1 values were better in smokers, the lower FEV1/FVC ratio may be a predictor of obstructive lung disease. Smoking affects the FEV1 more so than the FVC.

Males engaged in more intense physical activity than females. Good exercise habits benefit health; Pelkonen et al evaluated 429 males and reported that physical activity reduced mortality and slowed the decline in PF measured using the FEV1.<sup>[12]</sup> Overall, we

recorded better FEV1 and FVC levels in subjects who played sports. Neither exercise duration nor exercise regularity affected the outcomes. Although FEV1 and FVC values in males did not differ significantly by sports participation status, females who played sports had higher values. It remains unclear how activity affects the FEV1. It has been suggested that physical activity reduces obesity, changes the adipose tissue profile, and improves ventilator muscle function.<sup>[13]</sup> We found that the FEV1, FVC, and FEV1/FVC values were, respectively, 97.14, 89.78, and 94.51 in those who exercised regularly, thus higher than in those who did not exercise regularly; the differences in FEV1 and FVC were significant ( $FEV1 P = .000$ ;  $FVC P = .002$ ) but the difference in FEV1/FVC ratio was not. Lazovic et al evaluated adaptive respiratory changes in those who played various sports; the FEV1, FVC, and FEV1/FVC values of male players were good, but baseline data were lacking<sup>[14]</sup>; our results were similar. Spirometric and adaptive respiratory changes may vary by sporting activity, reflecting improvements in ability, strength, or endurance. In this study, we evaluated the duration, and not the type, of sports, and found no correlation between sports duration and spirometric values. This may have been a limitation of our study.

#### 5. Conclusion

We studied healthy young subjects with a 3-year mean smoking history. Smoking improves lung function in early life; such smokers are classified as “healthy smokers.” Physical activity did not affect smoker lung function, but the absence of physical activity significantly worsened lung function.

#### Author contributions

**Conceptualization:** Esra Dugral.

**Data curation:** Esra Dugral.

**Formal analysis:** Esra Dugral.

**Supervision:** Dicle Balkancı.

**Writing – original draft:** Esra Dugral.

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**Appendix A. Appendix: Survey of pulmonary symptoms, smoking status, and sports habits.**

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Q1.	Age	. . . . .	
..Q2.	Gender	Male	Female
Q3.	Place of birth	. . . . .	
Q4.	Current residence	. . . . .	
Q5.	Have you experienced wheezing in the past 12 months?	Yes ( )	No ( )
Q6.	Do you produce sputum?	Yes ( )	No ( )
Q7.	Do you have a cough?	Yes ( )	No ( )
Q8.	Do you smoke tobacco?	Yes ( )	No ( )
(if your answer is no please go to Q 12)	Yes ( )	No ( )	
Q9.	Age when you started smoking	( . . . . . ) age	
Q10.	Number of cigarettes smoked	(a) less than half a pack/d (b) half to 1 pack/d (c) >1 pack/d	
Q11.	If you quit smoking, when did you do that?	( . . . . . ) age	
Q12.	As a child, were you exposed to smoke at home?	Yes ( )	No ( )
Q13.	Do you experience passive smoking in your present living environment?	Yes ( )	No ( )
Q14.	Are you disturbed by passive smoking?	Yes ( )	No ( )
Q15.	Do you engage in sports/exercise?	Yes ( )	No ( )
Q16.	How often do you exercise?	(a) Once a week (b) A few days a week (c) Every day (d) Irregularly	
Q17.	Mean duration of exercise?	(a) <30 minutes (b) 30–60 minutes (c) 60–90 minutes	
(d) 90–120 minutes (e) >120 minutes			
Q18.	Do you exercise regularly?	Yes ( )	No ( )
Q19.	What sports do you engage in?		

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