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Exploring the impacts of smoking, nutrition and physical activity on pulmonary functions

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Abstract. *Study Objectives:* The study aimed to explore the impacts of smoking, poor nutrition, and physical activity on pulmonary functions. *Methods:* We obtained the data regarding the participants' consisted of 93 (50.5%) males and 91 (49.5%) females and smoking, nutrition, and physical activity status through focus group interviews. We recruited them to pulmonary function tests through ergospirometry twice. The results were evaluated by a specialist physician on expected and measured values of the FVC, FEV1, FEV1/FVC, PEF, and MEF25-75 measurements. We analyzed the data using independent and dependent samples t-tests and logistic regression analysis on SPSS 22. *Results:* According to the findings of the Kolmogorov-Smirnov test, the research data showed a normal distribution ($p > 0.05$). Thus, we compared the dichotomous variables using Paired Samples t-test. We performed a logistic regression analysis to explore the predictive impact of smoking, poor nutrition, and physical activity on the parameters of the pulmonary test. The findings revealed that smoking significantly predicted FVC ($p = 0.008$), FEV1 ($p = 0.001$), and MEF25-75 ($p = 0.000$). Yet, it was not the case for FEV1-FVC ($p = 0.059$) and PEF ($p = 0.433$). On the other hand, physical activity significantly predicted FVC ($p = 0.000$), FEV1 ($p = 0.000$), FEV1-FVC ($p = 0.06$, and MEF25-75 ($p = 0.000$). However, we could not suggest that physical activity predicts PEF ($p = 0.062$) significantly. *Conclusion:* We concluded that smoking, and had positive predictive impacts on pulmonary functions and that nutrition did not have any predictive effects on pulmonary functions.

Key words: physical activity, pulmonary functions, sports, nutrition

Introduction

Cigarette or tobacco smoking undoubtedly leads to particularly pulmonary diseases by disrupting the oxidant/antioxidant balance in favor of oxidants (1-2), as well as cerebrovascular diseases (3-4). The previous research documented that about 1.2 billion people worldwide smoke cigarettes or tobacco (5-6) and that smoking causes 700,000 deaths per year in the European Union (5) and accounts for approximately 80% of chronic obstructive pulmonary disease (COPD) in the United States (7). Smoking-related diseases progress from small airways to larger ones (8) (Juusela et al., 2013). Airway obstruction and inflammatory changes, characterizing COPD, can be attributed to smoking and exert the same impacts on the respiratory system, regardless of ethnicity (9). Besides, both active and second-hand smoking causes significant failures in the respiratory system (4).

Exposure to tobacco smoke affects the airways and lungs, especially of young people, resulting in higher rates of asthma and reduced pulmonary functions (10-11). Moreover, tobacco smoke was shown to be the most prevalent cause of COPD and chronic respiratory symptoms (e.g., chronic cough, increased sputum production, wheezing, and shortness of breath) in healthy adults (12). In other words, smoking is the primary risk factor in many respiratory system diseases such as COPD, asthma, and bronchiectasis. As smokers get older and have reduced lung flexibility, they are at greater risk of developing pulmonary diseases (13).

A review of the medical literature suggests that healthy eating and physical activity bring numerous benefits to health, reduce the risk of morbidity and mortality from many diseases, and help individuals maintain and/or improve their independence and functional capacities (7, 14-15). Previous cohort studies documented that regular physical activity may effectively initiate the prevention and treatment of chronic respiratory diseases, including asthma and COPD (16). In addition, despite controversial findings (17), it was previously confirmed that healthy eating and physical activity were positively associated with spirometric parameters (18-19).

It is often anticipated that smokers and secondhand smokers will have lower activity capacity. As a critical cardiovascular risk factor, smoking causes damage to the vascular endothelial tissue, which contributes to decreased physical activity and fitness capacity. Besides, vasoconstriction occurs in the vascular endothelium due to smoking, leading to a reduced functional physical capacity. Such adverse situations appear at various rates in different social and occupational groups (20).

Epidemiological studies by Saadeh et al. (21) showed that fruit intake was associated with a low prevalence of wheezing and that cooked green vegetable intake was associated with a low prevalence of wheezing and asthma in school children aged 8–12 years old. Studies by Grieger et al. (22) on the heterogeneous nature of the data describing fruit and vegetable intake and lung function, with one study showing no effect on lung function of higher fruit and vegetable intake over 10 years (23), yet in another study, increased fruit intake over 2 years was associated with increased FEV1 (23), while another study showed that a large decrease in fruit intake over 7 years was associated with decreased FEV1 (24) in adults.

Since smoking and physical activity seem largely maladaptive behavior regarding their impacts on bodily functions (25), their concurrent effects on pulmonary functions among the young remain unclear (26-28). Therefore, the present study attempted to explore the effects of smoking, nutrition, and physical activity on pulmonary function.

Materials and Methods

We included 184 voluntary participants aged 18 years and above in focus group interviews to know about their demographic characteristics and smoking, nutrition, and physical activity status of the patients who came to the Chest Polyclinic of Sakarya Training and Research Hospital. We then recruited them to pulmonary function tests through ergospirometry (Quark PFT, Cosmed, Italy) twice and utilized the result of the most efficient test. Ergospirometry is a fundamental procedure to examine pulmonary functions and is needed to diagnose and monitor pulmonary diseases (29). In this study. A specialist physician evaluated the test results by the FVC, FEV1, FEV1/FVC, PEF, and MEF25-75 measurements. Finally, we compared the expected and observed values of the specified parameters. We analyzed the data using independent and paired samples t-tests and logistic regression analysis on SPSS.

Note: According to the Body Mass Index (BMI), the participant's height and weight were measured and information about healthy nutrition was evaluated. In addition, the participants were asked whether they exercised regularly, whether they smoked, and whether they ate regularly during the day.

The parameters in the pulmonary function test are summarized below.

i. Forced Vital Capacity (FVC) is the volume of air exhaled with forced, rapid, and deep expiration after deep inspiration. Its difference from VC is characterized by a swift maneuver. Indeed, FVC should be equal to VC in ordinary people. FVC becomes lower in airway obstruction due to bronchiolar collapse caused by forced expiration.
ii. Forced Expiratory Volume (FEV1) is the volume of air exhaled in the first second of forced expiration. Typically, 80% of the air volume is exhaled in the first second. It often implies the situation in larger airways.

iii. FEV1/FVC ratio (Tiffeneau ratio) is often over 75% in young adults and decreases with age and is used to distinguish between obstructive and restrictive pathologies. It may appear as < 70% in the presence of any airway obstruction. Although it helps diagnose mild to moderate obstruction, it may not be sensitive enough to grade the severity of obstruction.

iv. Mid-Expiratory Flow (MEF25-75) is the flow rate measured during the period in which 25% to 75% of air volume is exhaled with forced expiration. It is related to the flow from the middle and small airways. It becomes reduced in the early stages of obstructive diseases and sometimes shows a decrease in restrictive conditions. The rate is calculated on the curve with the highest sum of FEV1 and FVC. It is affected by the efficiency of the forced expiratory maneuver and the strength of the expiratory effort.

v. Peak Expiratory Flow (PEF) represents the highest flow during the FVC maneuver.

Results

Of the 184 participants, 93 (50.5%) were male, 91 (49.5%) were female, and the mean age was 50 years. Some sociodemographic characteristics of the study group are presented in Table 1.

Normality of distribution

According to the findings of the Kolmogorov-Smirnov test, the research data showed a normal distribution ($p > 0.05$). Thus, we compared the dichotomous variables using a Paired Samples t-test.

Expected and observed values in the pulmonary test

As in Table 3, we found significant differences between FVC observed (M = 3.28) and FVC expected ($M = 3.71$) values ($p = 0.00$), between FEV1 observed ($M = 2.78$) and FEV1 expected ($M = 3.08$) values ($p = 0.00$), between FEV1-FVC observed ($M = 82.17$) and FEV1-FVC expected ($M = 78.76$) values ($p = 0.00$), between PEF observed ($M = 6.63$) and PEF expected ($M = 8.27$) values ($p = 0.00$), and between MEF25-75 observed ($M = 3.09$) and MEF25-75 expected

Table 1. Distribution of Participant's by demographic characteristics

Characteristics		N	%
Height	150 – 160 cm	32	17.4
	161 – 170 cm	82	44.6
	171 cm and above	70	38.0
Age	20 – 40 years	59	32.1
	41 years and above	125	67.9
Sex	Male	93	50.5
	Female	91	49.5
Smoking	Yes	93	50.5
	No	91	49.5
Physical Activity	Yes	94	51.1
	No	90	48.9
Smoking duration	Less than 2 years	93	50.5
	More than 2 years	91	49.5
Weight	40 – 70 kg	60	32.6
	71 – 100 kg	105	57.1
	101 kg and above	19	10.3

Table 2. Findings of the Kolmogorov-Smirnov Test

Parameters	n	*p*
FVC	184	.052
FEV1	184	.074
FEV1/FVC	184	.050
PEF	184	.053
MEF25-75	184	.200

Table 3. Expected and Observed Values in the Pulmonary Test

	M	N	SD	*p*
FVC Observed	3.28	184	1.18	0,001
FVC Expected	3.71	184	0.97	
FEV1 Observed	2.73	184	1.08	0,001
FEV1 Expected	3.08	184	0.80	
FEV1-FVC Observed	82.17	184	11.36	0,001
FEV1-FVC Expected	78.76	184	8.45	
PEF Observed	6.63	184	9.03	0,001
PEF Expected	8.27	184	7.66	
MEF25-75 Observed	3.09	184	1.59	0,001
MEF25-75 Expected	3.76	184	0.91	

(*M* = 3.76) values (*p* = 0.00). Thus, we further investigated the significant difference between the observed and expected values of the parameters in the pulmonary test. We initially hypothesized that such significant differences may be associated with smoking and physical activity. In this regard, we performed a logistic regression analysis to explore the predictive impact of smoking status and physical activity on the findings of the pulmonary test.

Correlation analysis between expected and measured values

In Table 4, the relationship between expected and observed values for the FVC in the patient was examined. Accordingly, it is seen that there is a significant positive relationship between the expected and observed values (p=0.00>0.01). Considering the level of this relationship between them, it can be said that there is a 68% relationship. In this case, the reliability of the measurements for FVC was also found.

In Table 5, the relationship between expected and observed values for the FEV1 in the patient was examined. Accordingly, it is seen that there is a significant positive relationship between the expected and observed values (p=0.00>0.01). Considering the level of this relationship between them, it can be said that there is a 68% relationship. In this case, the reliability of the measurements for FEV1 was also found.

In Table 6, the relationship between expected and observed values for the FEV1-FVC in the patient was examined. Accordingly, it is seen that there is a significant positive relationship between the expected and observed values (p=0.00>0.01). Considering the level of this relationship between them, it can be said that there is a 68% relationship. In this case, the reliability of the measurements for FEV1-FVC was also found.

In Table 7, the relationship between expected and observed values for the PEF in the patient was examined. Accordingly, it is seen that there is a significant positive relationship between the expected and observed values (p=0.00>0.01). Considering the level of this relationship between them, it can be said that

Table 4. Relationship between Expected and Observed Values for FVC in the Pulmonary Test

Correlations			
		FVC Observed	**FVC Expected**
FVC Observed	relationship level	1	,834**
	p		,001
	N	184	184
FVC Expected	relationship level	,834**	1
	p	,001	
	N	184	184

**. significance level 0,01

Table 5. Relationship Between Expected and Observed Values for FVC1 in the Pulmonary Test

Correlations			
		FEV1 Observed	**FEV1 Expected**
FEV1 Observed	relationship level	1	,826**
	p		,001
	N	184	184
FEV1 Expected	relationship level	,826**	1
	p	,001	
	N	184	184

**. significance level 0,01

Table 6. Relationship Between Expected and Observed Values for FEV1-FVC in the Pulmonary Test

Correlations			
		FEV1-FVC Observed	**FEV1-FVC Expected**
FEV1-FVC Observed	relationship level	1	,433**
	p		,001
	N	184	184
FEV1-FVC Expected	relationship level	,433**	1
	p	,001	
	N	184	184

**. significance level 0,01

Table 7. Relationship between Expected and Observed Values for PEF in the Pulmonary Test

		PEF Observed	**PEF Expected**
PEF Observed	relationship level	1	,981**
	p		,001
	N	184	184
PEF Expected	relationship level	,981**	1
	p	,001	
	N	184	184

**. significance level 0,01

there is a 68% relationship. In this case, the reliability of the measurements for PEF was also found.

In Table 8, the relationship between expected and observed values for the MEF25-75 in the patient was examined. Accordingly, it is seen that there is a significant positive relationship between the expected and observed Values (p=0.00>0.01). Considering the level of this relationship between them, it can be said that there is a 68% relationship. In this case, the reliability of the measurements for MEF25-75 was also found.

Relationship between smoking and results of the pulmonary test

We performed a logistic regression analysis to explore the predictive impact of smoking on the parameters of the pulmonary test. The findings revealed that smoking significantly predicted FVC ($p = 0.008$), FEV1 ($p = 0.001$), and MEF25-75 ($p = 0.000$). Yet, it was not the case for FEV1-FVC ($p = 0.059$) and PEF ($p = 0.433$). Overall, smoking had a negative predictive effect on the participants' findings on the pulmonary test (Table 9).

Relationship between smoking and results of the pulmonary test

We performed another logistic regression analysis to explore the predictive effect of physical activity on the parameters of the pulmonary test. Accordingly, physical activity significantly predicted FVC ($p = 0.000$), FEV1 ($p = 0.000$), FEV1-FVC ($p = 0.06$, and MEF25-75 ($p = 0.000$). However, we could not find the physical activity to predict PEF ($p = 0.062$) significantly. In general, engaging in physical activities had a positive predictive effect on the participants' findings of the pulmonary test (Table 10).

Table 8. Relationship between Expected and Observed Values for MEF25-75 in the Pulmonary Test

Correlations			
		MEF25-75 Observed	**MEF25-75 Expected r**
MEF25-75 Observed	relationship level	1	,683**
	p		,001
	N	184	184
MEF25-75 Expected	relationship level	,683**	1
	p	,001	
	N	184	184

**. significance level 0,01

Table 9. Relationship between smoking and results of the pulmonary test

Independent variable	**Constant**	**α**	***p***	**Dependent variable**
FVC	3.512	-0.461	0.008	Smoking
FEV1	2.983	-0.511	0.001	
FEV1-FVC	83.73	-3.166	0.059	
PEF	7.151	-1.08	0.433	
MEF25-75	3.51	-0.864	0.001	

Table 10. Relationship between smoking and results of the pulmonary test

Independent variable	**Constant**	**α**	**p**	**Dependent variable**
FVC	2.807	0.974	0.001	Physical activity
FEV1	2.241	1.00	0.001	
FEV1-FVC	79.166	6.145	0.001	
PEF	5.415	2.48	0.062	
MEF25-75	2.234	1.342	0.001	

Discussion

We carried out the present study to explore the effects of smoking and healthy nutrition – physical activity on pulmonary function. One's pulmonary functions may severely be damaged when being exposed to tobacco smoke throughout their life (30), and the adverse impacts may vary by the type and severity of smoke exposure (31). The first years of life represent a critical developmental period in which smoke inhalation can significantly affect the development of pulmonary functions (32). Moreover, while adult smoking is typically associated with a rapid decline in FEV1 (33), smoking during adolescence may interfere with the final stages of lung development that affect both FEV1 and FVC (34) Several studies on young smokers concluded a reduction in their lung capacity compared to non-smokers. Merghany and Saeed (35) studied 9-14-year-old 153 male adolescents exposed to smoking in Sudan and found that FEV1 and FVC in the experimental group were significantly lower than in the non-smoking control group (35). Similar findings were obtained in a sample of 300 students (137 boys) aged 13-15 years in Juárez in the study by Bird and Staines-Orozco (36). In that study, young non-smokers exhibited significantly higher values (FEV1, FEV1/FVC, and FEV 25%-75%) than both passive and second-hand smokers. Vianna et al. (37) examined the effects of smoking on the pulmonary functions of 2,063 young people with a mean age of 24 years in Brazil and found a significant relationship between smoking and the FEV1/FVC (32)36. A similar study in Spain with 2,647 young people (1,275 males) with a mean age of 32 (38) reported significantly lower values of FEV1, FEV1/FVC, and FEF 25%-75% among the smokers (38). However, none of the mentioned studies considered physical activity an influencing factor on pulmonary functions in young people.

The previous research reported a positive association between physical activity performance and spirometric parameters (18-19, 27,34) Holmen et al. (27) carried out a study with 13-18-years-olds and found a significant relationship between lung capacity (FVC and FEV1) and physical activity level among non-smokers, but it was not the case among those smoking occasionally. Michalak et al. (28) investigated the impacts of physical activity on young smokers and non-smokers aged 19-24 years for 10 months and observed improvements in FVC and FEV1 of both groups (28). Campbell Jenkins et al. (26) explored an association between physical inactivity and smoking in a cohort of 5,301 African-American adults aged 21-95 years and concluded that physically active smokers had improved pulmonary functions than sedentary smokers (26).

Only limited data are available on the effects of physical activity on pulmonary functions. Nystad et al. (39) showed that a high level of physical activity may compensate for a typical decline of approximately 3-5 years in FEV1 (30 ml/year) and, thus, may overcome the disadvantages of the decrease in FEV1 due to increasing age (39). Our findings revealed that the physical activity significantly predicted the FVC (p = 0.000), FEV1 (p = 0.000), FEV1-FVC (p = 0.059), and MEF25-75 (p = 0.000) measurements of the pulmonary function test. Yet, we could not find a significant predictive effect of physical activity on PEF (p = 0.062).

On the other hand, smoking brings various negative effects on the pulmonary system of smokers, which triggers undesirable symptoms (5). Smoking is a risk factor for bronchial hyperresponsiveness, asthma, COPD, and lung cancer (8). In this study, we found that smoking was a significant predictor of the FVC (p = 0.008), FEV1 (p = 0.001), and MEF25-75 (p = 0.000) measurements of the pulmonary function test. However, our findings revealed that smoking was not a significant predictor of two parameters, FEV1-FVC (p = 0.059) and PEF (p = 0.433). Twisk et al. (14) reported that smoking reduces FVC and FEV1, while physical activity improves FVC. Holmen et al. (27) found that FEV1 and FVC are significant predictors of good lung functions (27).

A lot of research has been done on whether dietary nutrients are beneficial for patients with COPD. While creatinine, found in meat and fish, does not contribute to rehabilitation, sulforaphane, found in broccoli and wasabi, and curcumin, the pigment in turmeric, may have beneficial antioxidant properties (40–42). In COPD, branched chain amino acid supplementation is associated with positive outcomes, including increases in whole body protein synthesis, body weight, lean mass, and arterial blood oxygen levels (43,44). Malnutrition is not a major problem in asthma. In this case, supports our observation that nutrition has no predictive effect on pulmonary functions.

A study of how smoking and physical activity affect pulmonary functions can be expected to find that smoking adversely affects pulmonary functions while it is vice versa for physical activity. Overall, our findings confirm the idea above and overlap the findings in the literature.

The present study is not free from a few limitations. First, it was a cross-sectional study; therefore, it only dealt with the associations between the variables, not causality. In addition, we retrospectively examined the randomly selected data of those admitted to the pulmonology clinic for their complaints or follow-up purposes. Thus, our findings were not generalizable to patient populations in different regions. However, the idea of contributing to the health status of individuals was the primary motivation for this study. The findings also displayed initial changes to pulmonary functions triggered by tobacco use and physical activity, which may reinforce discouraging smoking. In conclusion, this study confirmed poor pulmonary functions without physical activity. Moreover, the results support that physical activity is positively associated with improved pulmonary functions in both smokers and non-smokers.

Conclusion

The field of nutrition and respiratory diseases continues to develop and expand, but in this study, we observed no predictive effect of nutrition on pulmonary functions. however, more studies are needed in the form of randomized controlled dietary manipulation studies using whole foods to ensure that evidence-based recommendations for the management of respiratory conditions are provided.

Conflicts of interest: Each author declares that he or she has no commercial associations (e.g. consultancies, stock ownership, equity interest, patent/licensing arrangement, etc.) that might pose a conflict of interest in connection with the submitted article.

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