Research article

Effect of lung function disorders and physical activity on smoking and non-smoking students

AMELIA LORENSIA[1], CYNTHIA MARISCA MUNTU[2], RIVAN VIRLANDO SURYADINATA[3], ROSLIN SEPTIANI[4]
[1] Department of Clinical-Community Pharmacy, Faculty of Pharmacy, Universitas Surabaya (UBAYA), Indonesia;
[2] Department of Pharmaceutical, Faculty of Pharmacy, Universitas Surabaya (UBAYA), Indonesia;
[3] Department of Public Health, Faculty of Biotechnology, Universitas Surabaya (UBAYA), Indonesia;
[4] Bachelor Student of Faculty of Pharmacy, Faculty of Pharmacy, Universitas Surabaya (UBAYA), Indonesia

Keywords

Physical activity • Lung function • Smokers • Non-smokers • Spirometry

Summary

Background. *The number of young smokers is increasing, and hence their risk of respiratory problems. This risk is exacerbated by their low level of physical activity, which also reduces lung function. This study aimed to determine differences in lung function and levels of physical activity between smokers and non-smokers.*
Method. *This research was conducted from October 2019 to January 2020. The research design was cross-sectional, and a purposive sampling method was used. Pulmonary function was measured by means of spirometry, while physical activity was measured through a modified International Physical Activity Questionnaire (IPAQ).*
Results. *We enrolled 124 university students: 62 smokers and 62 non-smokers. A significant difference in lung function values (< 70 vs ≥ 70) was observed between smokers and non-smokers (p = 0.00). No difference (p = 0.907) in the level of physical activity was seen between smokers and non-smokers, with most subjects in both groups displaying moderate levels.*
Conclusions. *Students who smoked had more respiratory problems than those who did not. Although the level of physical activity did not correlate with respiratory problems, these problems were more common in the vigorous catgory.*

Introduction

Lung dysfunction is one of the top five causes of death due to non-communicable diseases in Indonesia [1]. Lung function disorders are closely related to smoking. Indonesia has the third largest cigarette consumption in the world [2], and smoking is common among people of all ages, especially the young ones. Most teenagers have already consumed cigarettes, and many are habitual smokers [3]. Students who smoke admit that they are aware of the harmful effects of smoking on health, but they still ignore these effects, claiming to be "less certain" of the dangers of smoking.
Cigarettes contains nicotine, tar and carbon monoxide [4]. Nicotine and carbon monoxide in the bloodstream thicken the blood and narrow the arteries. Moreover, the tar contained in cigarettes can coat the lung tissues and reduce the elasticity of the air sacs, making breathing difficult [5]. Lung volume is measured to evaluate the normality of respiratory function [3]. A tool that is commonly used for this purpose is spirometer, which measures the forced expiratory volume in the first second (FEV1) and the forced vital capacity (FVC) [6].
Many students say that they do not have enough time to do physical activities, as they think that the time devoted to such activities would reduce the time available for learning. What they do not realize, however, is that physical exercise can have beneficial effects on their cognitive ability (attention, memory, concentration) and maintain mental health [7, 8]. In 2013, 26.1% of Indonesians were classified as having an insufficient level of physical activity. By 2018, this percentage had risen to an estimated 33.5%. Similarly, in East Java, the prevalence of people who did not do physical activity was around 28.5%. Various studies have reported that people of all ages in almost all countries are too sedentary [9]. According to Basic Health Research, the prevalence data show that many people do not engage in physical activity, despite its importance for health. Physical activities have beneficial effects on the respiratory system [10], improving lung function [11] and increasing the vital capacity. Indeed, an individual who takes regular physical exercise can train the respiratory muscles, with the result that a greater volume of oxygen can enter the pulmonary capillaries, and lungs capacity increases [12-14]. Moreover, intense physical activity can reduce systemic and bronchial inflammation, improving both lung function and quality of life [15].
Previous studies have found that smokers are physically less active than non-smokers [16, 17]. The present study investigated the effect of impaired lung function and physical activities in smoking and non-smoking students. The questionnaire used to measure physical activities was adapted from the International Physical Activity Questionnaire (IPAQ) [18, 19]. In order to measure lung function, a handheld spirometer was used. A handheld device was chosen because it was light and easy to carry, and because the results would be immediately available. Previous research conducted in Jordan by Banur et al. [20] and Nawafleh et al. [21] found that smokers and non-smokers differed in terms of their lung function (FEV1/FVC).

Method

Research design

The research design was cross-sectional. Data were collected through questionnaires administered from November 2019 to January 2020 in Surabaya. The ethics committee of the University of Surabaya approved the study protocols (No. 120/KE/XII/2019).

Research variable

In this study, the independent variables were smokers and non-smokers, while the dependent variables were lung function and physical activities. Impaired lung function was defined as an FEV1/FVC value less than 0.7 [22]. Lung function was tested by means of the Contec SP10 Spirometer.

Physical activity is any activity or movement carried out by the body as a result of energy expenditure by the skeletal muscles [23]. The questionnaire referred to physical activity carried out during the course of a week. Respondents were divided into categories according to their physical activity: Mild Physical Activity (< 600 METs), Moderate Physical Activity (600-1,500 METs), and Vigorous Physical Activity (> 1,500 METs) [24]. In this study, the intensity of physical activity was measured in METs (metabolic equivalents of task). Physical activities were calculated by means of the METs level (physical activity intensity) multiplied by the length of time (minutes) spent on the activity in a week [18, 19].

Population and sample research

The study population consited of male students attending a private university in Rungkut sub-district, Surabaya. The inclusion criteria were: age > 18 years and absence of respiratory or cardiovascular diseases which might affect the measurement of lung function and physical activities. A purposive sampling method was used.

Data collection

Subjects who stated that they were willing to participate in the study and filled in the informed consent form were immediately asked to complete a physical activity questionnaire consisting of the modified IPAQ questions; their lung function was then measured by means of spirometry.

Data analysis

Differences in lung function and physical activity between smokers and non-smokers were determined by means of the chi-square test. Subjects were described in terms of age and body mass index (BMI).

Results

Subjects were grouped according to sex, age and treatment history. Table I shows the number of respondents (124), subdivided into non-smokers (62) and smokers (62).

In the group of smokers, the degree of smoking was assessed by means of the Brinkman index, which is calculated by multiplying the number of cigarettes smoked per day by the duration of smoking in years [26]. The index has 3 categories: light smokers (0-199), moderate smokers (200-600), and heavy smokers (> 600) [26]. All our smokers fell into the light category and smoked filter cigarettes of various brands (62 of 62).

The results of lung function testing are shown in Table II. Most of the subjects (42 of 62 smokers and 60 of 62 non-smokers) did not experience respiratory problems, though the results of the chi-square test revealed a significant difference ($p = 0.00$) between the two groups.

The profile of the physical activities carried out by the subjects is shown in Table III. Physical activity was divided into 3 categories: mild (< 600 MET-minutes/week), moderate (600-1500 MET-minutes/week) and vigorous (> 1,500 MET-minutes/week). Most of the subjects (26 smokers and 27 non-smokers) reported moderate levels of physical activity. The chi-square test results showed no difference ($p = 0.907$) in the level of physical activity between smokers and non-smokers (Tab. IV).

Tab. V shows that almost one third of the smokers (20/62) had respiratory problems, and that more than half of these (11/20) engaged in moderate physical activity. Only 2 of the non-smokers had respiratory problems, both of whom were in the light activity category).

Tab. I. Frequency distribution of characteristics.

Respondents' characteristics		Smokers (n: 62)		Non-smokers (n: 62)	
		Number	Percentage (%)	Number	Percentage (%)
Age (years)	18-19	8	12.90	12	19.35
	20-21	17	27.42	21	33.87
	22-23	22	35.48	25	40.33
	24-25	15	24.20	4	6.45
BMI (kg/m^2) [25]	Underweight (< 18.5)	10	16.31	9	14.52
	Normal (18.5 ≤ 25)	47	75.81	45	72.58
	Overweight (25 ≤ 27)	3	4.84	2	3.23
	Overweight (≥ 27)	2	3.23	6	9.68

BMI: Body Mass Index.

Tab. II. Lung function values in smokers and non-smokers.

Lung function value		Smoker group (n: 62)		Non-smoking group (n: 62)		P value
		Frequency	Percentage (%)	Frequency	Percentage (%)	
FEV1/FVC value (%)	< 70 (with respiratory problems)	20	32.26	2	3.23	0.00
	≥ 70 (without respiratory problems)	42	67.74	60	96.77	

Tab. III. Profile of type of physical activity.

N.	Type of physical activity	Duration (minutes)	Smokers (n: 62)		Non-smokers (n: 62)	
			Number	Percentage (%)	Number	Percentage (%)
1	Walking 100 m	5	3	4.84	1	1.61
		10	5	8.06	3	4.84
		15	7	11.30	26	41.94
		20	3	4.84	2	3.23
		30	26	41.94	11	17.74
		40	1	1.61	0	0
		60	17	27.42	16	25.81
		Not done	0	0	3	4.84
2	Walking > 100 m	10	1	1.61	5	8.06
		15	6	9.68	11	17.74
		30	18	29.03	13	20.97
		40	1	1.61	0	0
		45	2	3.23	1	1.61
		60	23	37.10	23	31.10
		120	2	3.23	0	0
		Not done	9	14.52	9	14.52
3	Driving vehicles (cars, motorbikes)	10	1	1.61	0	0
		15	5	8.06	2	3.23
		20	1	1.61	5	8.06
		30	6	9.68	6	9.68
		35	3	4.84	0	0
		60	21	33.87	19	30.64
		120	10	16.13	13	20.97
		180	3	4.84	7	11.29
		240	6	9.68	4	6.45
		Not done	6	9.68	3	4.84
4	Cycling	10	2	3.23	1	1.61
		30	2	3.23	3	4.84
		60	4	6.45	1	1.61
		120	1	1.61	2	3.23
		180	2	3.23	1	1.61
		Not done	51	82.26	54	87.10
5	Cooking	10	4	6.45	10	16.13
		15	3	4.84	7	11.29
		30	7	11.29	6	9.68
		60	3	4.84	4	6.45
		Not done	45	72.58	35	56.45
6	Washing	5	1	1.61	3	4.84
		10	2	3.23	6	9.68
		15	6	9.68	3	4.84
		30	10	16.13	13	20.98
		60	10	16.13	8	12.90
		120	2	3.23	3	4.84
		Not done	31	50.00	26	41.93

Continues

Follows

Tab. III. Profile of type of physical activity.

N.	Type of physical activity	Duration (minutes)	Smokers (n: 62)		Non-smokers (n: 62)	
			Number	Percentage (%)	Number	Percentage (%)
7	Sweeping, cleaning room /house	5	6	9.68	6	9.68
		10	11	17.74	11	17.74
		15	4	6.45	6	9.68
		30	5	8.06	21	33.87
		60	10	16.13	4	6.45
		120	1	1.61	3	4.84
		Not done	25	40.32	11	17.74
8	Carrying water	1	0	0	11	17.74
		2	24	38.71	14	22.58
		4	0	0	11	17.74
		10	8	12.90	8	12.90
		Not done	30	48.39	18	29.03
9	Playing football	10	1	1.61	0	0
		30	1	1.61	4	6.45
		45	1	1.61	0	0
		60	17	27.42	5	8.06
		120	10	16.13	8	12.90
		Not done	32	51.61	45	72.58
10	Playing volleyball	60	2	3.23	4	6.45
		120	2	3.23	1	1.61
		Not done	58	93.53	57	91.94
11	Playing badminton	60	9	14.52	5	8.06
		120	1	1.61	5	8.06
		180	2	3.23	2	3.23
		Not done	50	80.64	50	80.64
12	Swimming	30	2	3.23	4	6.45
		60	1	1.61	0	0
		120	5	8.06	5	8.06
		Not done	54	87.10	53	85.48
13	Cleaning the garden, burning trash	10	1	1.61	5	8.06
		20	2	3.23	0	0
		30	2	3.23	2	3.23
		60	1	1.61	2	3.23
		120	2	3.23	1	1.61
		Not done	54	87.10	52	83.87
14	Playing musical instrument	15	1	1.61	1	1.61
		30	7	11.29	2	3.23
		60	4	6.45	3	4.84
		120	1	1.61	1	1.61
		180	1	1.61%	0	0
		Not done	48	77.42	53	85.48
15	Gymnastics/aerobics	10	0	0	1	1.61
		25	0	0	1	1.61
		30	0	0	5	8.06
		60	0	0	1	1.61
		90	0	0	1	1.61
		120	0	0	2	3.23
		150	0	0	1	1.61
		Not done	62	100	50	80.165

Discussion

Most subjects, whether smokers or non-smokers, did not experience respiratory problems (Tab. II). This was probably due to their young age, in that their exposure to cigarette smoke had not yet impaired their lung function. Nevertheless, a significant difference ($p = 0.00$) was seen between the two groups in terms of lung function values. The results of the present study are similar to those of the research conducted in Jordan by Banur et al. [20] and

Tab. IV. Physical activity of smokers and non-smokers.

Physical activity classification		Smokers (n:62)		Non-smokers (n:62)		P value
		Number	Percentage (%)	Number	Percentage (%)	
Category	Light	14	22.58	12	19.35	0.907
	Moderate	26	41.94	27	43.55	
	Vigorous	22	35.48	23	37.10	
Total	62	100	62	100		

Tab. V. Cross-tabulation of lung function values and physical activity levels in smokers and non-smokers.

Physical activity classification		Smokers (n: 62)		Non-smokers (n: 62)		Total
		With respiratory problems	Without respiratory problems	With respiratory problems	Without respiratory problems	
Category	Light	9	5	10	2	26
	Moderate	15	11	27	0	53
	Vigorous	18	4	23	0	45
Total		42	20	60	2	124

Nawafleh et al. [21], who also observed differences in lung function (FEV1/FVC) between smokers and non-smokers. Cigarettes contain harmful chemicals, such as carbon monoxide, which can enter the bloodstream and bind hemoglobin. Hemoglobin should bind to oxygen. However, when the carbon monoxide content exceeds that of oxygen, it binds the hemoglobin. This can disrupt the pulmonary blood vessels, which become narrower and less elastic, causing the lungs to expand [27]. In this study, lung function was measured by means of hand-held spirometers, which are small, portable and inexpensive. Moreover, spirometry results can be screened simply and accurately [22].

Several factors can affect lung function:

- *age*: lung function tends to decline with aging [28]. Lung function continues to increase up to the age of 25 years, and then remains stable for approximately 5-10 years. Subsequently, lung function begins to decrease after the age of about 40 years [29, 30]. Indeed, with aging, the muscles of the diaphragm decrease, and the lung tissue that helps keep the ducts open can lose elasticity, reducing the caliber of the airways [31];
- *gender*: pulmonary development continues throughout childhood and adolescence [32]. Women's lungs are smaller than men's, and have fewer bronchioles [33]. For this reason, and because most smokers are male [34], we enrolled only male subjects in the present study;
- *smoking*: cigarette smoke contains around 4,000 chemical compounds, more than 100 of which are carcinogenic and mutagenic and harmful to health [35]. The damage caused depends on the length of exposure; the longer the exposure, the greater the effect will be [36]. Thus, over time, the lung function of a smoker will deteriorate in comparison with that of a non-smoker [37]. According to some studies, many people think that light smoking has no harmful effects. In one such study, however, it was found that former smokers and those who smoked less than 5 cigarettes per day had already done moderate damage to their lungs, and that, in two-thirds of cases, chronic obstructive pulmonary disease (COPD) could well ensue [38]. Light smoking can impair lung function within 1 year, while heavy smokers can suffer the same effect within 9 months.
  The respondents involved in this study smoked filter cigarettes of different brands and with different levels of nicotine and tar. However, the cigarette brand did not affect the results of the study. Indonesian Government Regulation number 81 of 1999, regarding smoking and health, states that cigarettes are allowed to contain no more than 1.5 mg of nicotine and 20 mg of tar. The filters used in cigarettes can significantly reduce the tar and nicotine content of the smoke. According to previous research, the nicotine content in unfiltered cigarette smoke is greater than that of filtered cigarette smoke [38, 39];
- *physical activity*: regular physical activity increases respiratory efficiency, improving the functioning both of the lungs and of the other organs of the body. Swimming and gymnastics are particularly beneficial, the latter being an aerobic exercise that can easily be performed [40, 41].

This study involved respondents aged 18-25 years, which means that their lung function was still maturing [30]. If smoking begins at that age or less, it can have serious consequences and may be a risk factor for COPD [42]. In the present study, all subjects were less than 60 years old, and none were classified as geriatric (Tab. I). Thus, the age factor did not affect our results. BMI can also affect the functioning of the lung, and respiratory dysfunction due to obesity can affect FVC and FEV1 [43]. However, as most of our respondents had normal BMI values (Tab. I), the BMI factor did not affect this study.

The study involved 124 subjects, who were equally divided into 2 groups: smokers and non-smokers. We chose to enroll male students, since previous research has indicated that men are physically more active than women [44]. As shown in Tables IV and V, 26 smokers (41.94%) engaged in moderate physical activity; 22 (35.48%) in vigorous activity, and 14 (22.58%) in light activity. Similarly, 27 non-smokers (43.55%) engaged in moderate physical activity, 23 (37.10%) in vigorous activity, and 10 (19.35%) in light activity. Research conducted by Kwan et al. [45] has shown that physical activity tends to decline among young adults, particularly university students.

Physical activity has various beneficial effects on health, such as maintaining/losing body weight, strengthening bones and muscles, and reducing depression and stress. It can also prevent several diseases, including heart disease and stroke, and reduce the risk of high blood pressure, diabetes and several cancers, such as breast and colon cancers [46, 47].

The five physical activities most frequently carried out by the participants in our study were: walking more than 100 m; driving vehicles (cars, motorbikes); washing; sweeping and cleaning rooms/houses; carrying water. This study involved respondents aged 18-25 years. They can at least perform physical activities for 150 minutes at moderate intensity throughout the week, or perform physical activities for 75 minutes with heavy intensity throughout the week, or a combination of moderate activity and strenuous activity (Not clear. Perhaps you mean: The WHO recommends that such subjects carry out moderate-intensity physical activity for at least 150 minutes per week, or strenuous activity for 75 minutes, or a combination of moderate and strenuous activity) [23]. In the present study, the physical activity carried out by both smokers and non-smokers was of moderate intensity. Several factors can act upon a person's physical activity [48], including:

- *intrinsic factors*: these refer to the person's internal motivation, and are often connected with the good or bad feelings elicited by physical activity;
- *environmental factors*: the individual's surroundings, including the weather, can encourage or discourage physical activity;
- *physical considerations*: those who take regular physical exercise tend both to look and to feel good; they will therefore be motivated to continue their physical activity. Conversely, tiredness and lack of fitness will discourage physical activity;
- *routine factors*: the routine necessities of everyday life will obviously impact on the time and energy that an individual is able or willing to devote to physical activities.

Physical activity can be measured by means of accelerometers and pedometers and through self-report questionnaires (IPAQ-S, RPAQ, PAR). In this study, we used only self-report questionnaires, which have the advantage of being economical and easy to administer; admittedly, however, the data obtained will depend on what respondents remember [49].

The present study has some limitations. Firstly, the sample was relatively small. Secondly, smoking habits and the intensity and duration of the various physical activities were referred subjectively. However, the answers to types of physical activity such as carrying water were clear, i.e. lifting large 19 L water containers or medium-sized 10 L containers. Finally, in establishing the exclusion criteria, information on medical history was provided only by the respondents themselves and a complete medical examination was not carried out.

Conclusions

Most subjects (60/62 non-smokers and 42/62 smokers) had no respiratory problems, though the chi-square test results showed a significant difference ($p = 0.00$) between the two groups in terms of lung function values (< 70 vs ≥ 70). Most subjects (26/62 smokers and 27/62 non-smokers) had moderate levels of physical activity. The chi-square test results showed no difference ($p = 0.907$) between smokers and non-smokers in terms of their level of physical activity.

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Conflicts of interest statement

The authors declare no conflict of interest.

Authors' contributions

All authors discussed the results and contributed to the final manuscript.

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Correspondence: Amelia Lorensia, Fakultas Farmasi Universitas Surabaya (UBAYA), Jl. Raya Kalirungkut Surabaya 60293, Indonesia - E-mail: amelia.lorensia@gmail.com - amelia.lorensia@staff.ubaya.ac.id

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