Original Article

Correlation of Smoking with Carbon Monoxide Level and Peak Expiratory Flow Rate in High School Students Banda Aceh

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Abstract

Background: Indonesia has the highest number of adolescent smokers in the world. Carbon monoxide (CO) is a by-product of tobacco smoking and is inhaled into the lungs. A smokerlyzer can monitor its level. Cigarette smoke also causes inflammation that affects airflow in the airways and can be detected by measuring the peak expiratory flow rate (PEFR). This study aims to determine the relationship between smoking and CO levels and PEFR in high school students in Banda Aceh City.

Methods: This quantitative study uses an analytical observational approach with a cross-sectional design. This study involved 300 students from five senior high schools in Banda Aceh. The data were analyzed using the Mann-Whitney and Spearman correlation with a significance value $P<0.05$.

Results: CO levels of the smoker students were higher (12.61±3.342 ppm) than nonsmoker students (2.46±0.569 ppm), $P=0.0001$. The mean PEFR for smoking students was lower than nonsmokers (61.11±9.163%) than for non-smoking students (78.48±6.804 %), $P=0.0001$. Duration of smoking in smoking students was also strongly associated with CO levels (r=0.749; $P=0.0001$) and PEFR (r= -0.560; $P=0.0001$).

Conclusion: There is a relationship between smoking and CO levels and PEFR in senior high school students in Banda Aceh.

Keywords: Banda Aceh, CO levels, PEFR, senior high school student, smoker student

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Submitted: November 25th, 2021
Accepted: March 28th, 2023
Published: July 28th, 2023

J Respirol Indones. 2023
Vol. 43 No. 3: 204–9
https://doi.org/10.36497/jri.v43i3.294

INTRODUCTION

Worldwide, smoking is the most common cause of preventable death.[1] Based on a World Health Organization (WHO) report, 1 billion active smokers worldwide consume about 6 trillion cigarettes annually.[2] Six percent cause of death in women and 12% the cause of death in men are the results of tobacco use and exposure to cigarette smoke.[2]

The analysis of Baseline Health research in Indonesia year 2013 showed that the proportion of people who smoked every day from 2007 to 2013 slightly increased (23.7–24.3%).[3] In 2014, the Global Youth Tobacco Survey (GYTS) found that Indonesia has the highest number of adolescent smokers worldwide.[4] The main findings of GYTS in 2019 were that 19.2% of students, 38.3% of boys, and 2.4% of girls currently smoke cigarettes. Up to 57.8% of students were exposed to tobacco smoke at home, and 66.2% smoke inside an enclosed public place.[5]

Aceh is one of Indonesia's provinces with the highest smoking rate. The proportion of smokers in Aceh is 29.3% or 25% active smokers, 4.3% light smokers, 2.5% former smokers, and 6.2% nonsmokers. Baseline Health research in Indonesia year 2013 reported that the prevalence of smokers in Aceh province for the ≥10-years-old population, according to smoking habits, that is, daily smokers up to 25% and occasional smokers up to 4.3%, with an mean number of cigarettes smokers at age ≥10 years in Aceh are 15.3 rods. Even Aceh is included in the province, with a high percentage of smokers who start smoking at 15 to 19 years old.[3]

Smoking is one of the significant resources of carbon monoxide (CO). The body will absorb Carbon monoxide through the lung when inhaling cigarette smoke. CO infiltrates the blood vessels through the lung and then bindings with hemoglobin in the blood to form carboxyhemoglobin (COHb). Furthermore, the CO in the blood will re-enter the alveolus due to

the concentration gradient so that the CO will come out along with the exhaled air. The levels of CO at the time of expiration can be measured to determine a person's smoking status. Many researchers used CO measurements to determine tobacco exposure among cigarette smokers since measuring CO level is a simple and noninvasive procedure.[6]

Cigarette smoke increases inflammation by increasing the production of pro-inflammatory cytokines and accumulating immune cells within the respiratory tract.[7] The chronic inflammatory process in the respiratory tract will disturb the airflow, which leads to decreased lung function in smokers. When assessing lung function, three parameters are commonly used: forced vital capacity (FVC), forced expiratory volume in one second (FEV_1), and the peak expiratory flow rate (PEFR). Based on studies on smokers, the value of FVC, FEV_1, and PEFR is lower than nonsmokers.[8]

This study aimed to determine the relationship between smoking and CO levels and PEFR values in Banda Aceh City high school smokers and the relationship between smoking duration and CO levels and PEFR values.

METHODS

This type of research is a study with a cross-sectional design. The research was conducted from April to October 2021 in five high schools or the equivalent in Banda Aceh City. School selection is performed using simple random sampling techniques. At each school that has been determined, students are selected using a random sampling technique, where the researcher determines the number of students from every school, as many as 60 people, who meet the inclusion and exclusion criteria so that they can represent the population.

The inclusion criteria for this study were male students in grades 10, 11, and 12 at the upper secondary level or equivalent, aged 16–18 years, and willing to participate. Exclusion criteria were students with asthma, heart disease, or other congenital diseases and students absent on the day of measurement due to illness or permission.

Eligible samples complete a basic questionnaire containing students' personal information and smoking status. CO levels were measured using a CO smokerlyzer, while PEFR values were measured using a peak flow meter.

Statistical analysis was performed to examine the relationship between smoking and CO levels and PEFR values using the Mann-Whitney test. Spearman correlation the relationship between smoking duration with CO levels and PEFR values. Relationships were considered significant if $P<0.05$.

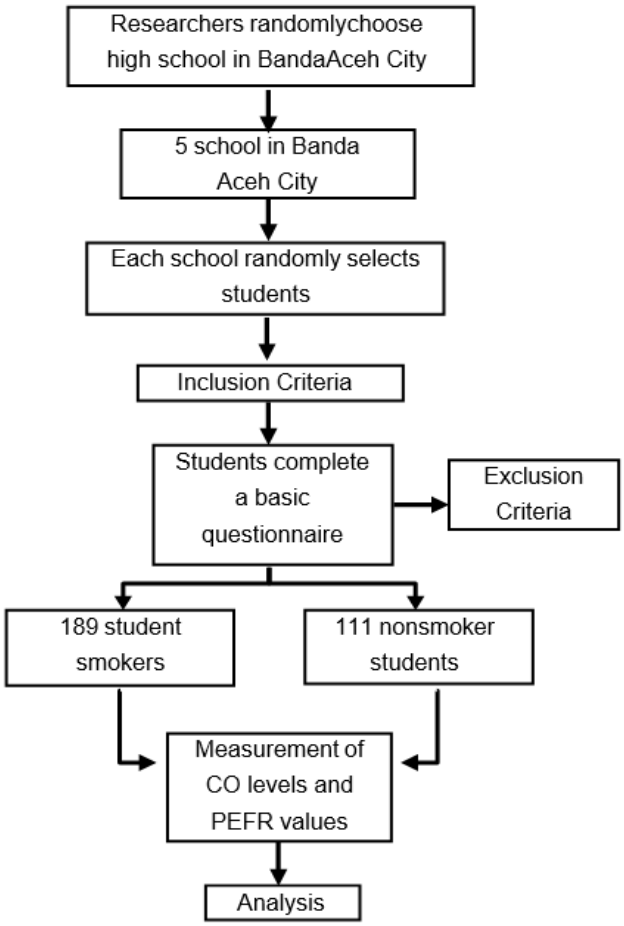

Figure 1. Research flow chart.

RESULTS

According to the inclusion criteria, this study was conducted in five high schools with 300 suitable students. The prevalence of smokers, age, age at smoking initiation, smoking duration, mean CO levels, and PEFR values among high school students in Banda Aceh City are shown in Table 1.

Table 1. Sample characteristics

Variable	Smoking status	
	Smoker (n=189)	Non-smoker (n=111)
Age (years)		
Mean±SD*	17.55±0.738	17.61±0.676
Median (min-max)**	18 (16–19)	18 (16–19)
Age at smoking initiation (years)		
Mean±SD*	13.5±0.926	---
Median (min-max)**	13 (12–16)	---
Smoking duration (years)		
Mean±SD*	4.04±1.166	---
Median (min-max)**	4 (1–7)	---
CO level (ppm)		
Mean±SD*	12.61±3.342	2.46±0.569
Median (min-max)	13 (5–21)	2 (2–4)
PEFR value (L/min)		
Mean±SD*	317.77±47.650)	408.10±35.381
Median (min-max)	300 (200–400)	400 (250–450)

In the group of students who smoke, 140 students (74.1%) have parents who smoke, and 118 students (62.4%) have non-parental families who smoke. In the nonsmokers' group, 92 (82.9%) students had parents who smoke, and 76 (68.5%) students had families other than their smoking parents. The normality test results using the Kolmogorov-Smirnov test showed that the CO levels and PEFR values were not normally distributed. The results of the Mann-Whitney test show a relationship between smoking with CO levels and PEFR scores in high school students in Banda Aceh City, as shown in Table 2.

Table 2. The relationship between smoking status and CO levels

Smoking status	CO Levels (ppm)		PEFR value (ppm)	
	Mean±SD	*P*	Mean±SD	*P*
Smoker	12.61±3.342	0.0001*	317.77±47.650	0.0001*
Non-smoker	2.46±0.569		408.10±35.381	

Note: *Mann-Whitney test

Based on the Spearman correlation, a relationship exists between smoking duration with CO levels and PEFR values, as shown in Table 3.

Table 3. The relationship between smoking duration with CO levels and PEFR values

Variable	Correlation coefficient	*P*
CO level	0.749	0.0001*
PEFR value	-0.554	0.0001*

Note: *Spearman correlation

DISCUSSION

The results of this study showed that the number of students in Banda Aceh City who smoke is higher than nonsmokers, which is 63%. This result is consistent with Baseline Health research in Indonesia year 2013 that as many as 64.9% of men over 15 years are smokers.[3] Research conducted by Sari in Padang showed that 59.1% of high school students in Padang were smokers.[9] Based on the 2013 Global Youth Tobacco Survey report, the proportion of smokers aged 15–19 years was 56.9%.[4] This age group is the age of high school students in Banda Aceh City.

Adolescence is the transition period from childhood to adulthood, characterized by physical, mental, and emotional changes. Adolescence is also a period where the environment and peers influence attitudes and behavior more.[10] One study showed a relationship between peer interaction and family interaction with smoking behavior in adolescents.[11]

The results of this study also indicated a relationship between smoking status and CO levels among high school students in Banda Aceh City. The CO levels of the student who smoke were 10.15 ppm higher than those of the nonsmokers. The result aligns with a study by Paskaria that showed higher CO levels in Purwakarta student smokers than in non-smoking students.[11] Another study of workers and visitors to the Persahabatan Hospital in Jakarta showed the same results, the CO levels in the smoker group were higher than the CO levels in the nonsmoker group.[12]

Aside from Indonesia, a study in Thailand of respondents aged 16–70 years showed that smokers had an mean expiratory CO level of 11.24 ppm. This value is significantly higher than for nonsmokers with an mean expiratory CO level of 2.25 ppm.[13] In study involving healthy respondents of Turkish smokers and nonsmokers, Deveci et al noted that CO levels were higher in smokers than nonsmokers (17.13 vs. 3.61). They even compared the CO levels of active smokers with those of passive smokers. As a result, CO levels are higher in active smokers than in passive smokers.[14] The finding of Hrabovsky et al also showed that smokers had higher expiratory CO levels than nonsmokers.[15]

Carbon monoxide is the main constituent of

cigarette smoke.[16] Carbon monoxide gas inhaled with cigarette smoke absorbs by the blood vessels and then binds to hemoglobin in the blood, forming carboxyhemoglobin (COHb), which will bind oxygen more efficiently than hemoglobin.[17] Smokers can have COHb levels as high as 5.6%, while smokers with lung disease have COHb levels above 10%.[18] COHb levels in the blood correlate well with expiratory CO levels and have a very high sensitivity. Therefore, the results of measuring the CO levels in this study also correlate very well with smoking status in students.[18]

The PEFR value in this study also has a significant relationship with smoking status. For smoking students, the mean PEFR value is lower than the mean PEFR value for nonsmokers, with a difference of 90.33 L/minute. In their study involving intermediate students in Bandar Lampung, Soemarwoto et al noted that student smokers (both active and passive) had lower PEFR scores than nonsmokers.[19] According to a Faqilah study in Bogor, adolescent smokers aged 15–19 years had higher PEFR values than nonsmokers in the same age range (470.22 L/min vs. 500.87 L/min). This is due to inflammation, fibrosis, goblet cell metaplasia, and smooth muscle hypertrophy in the airways of smokers, resulting in the narrowing of the airways.[20]

Age and smoking habits are several aspects that influence the PEFR value. From childhood to adolescence, 22–24 years of age, there is a development of pulmonary function, which an increase in the value of PEFR can assess. The PEFR value describes the function of the airways and lung tissue. Smoking can affect the function of the respiratory tract and lung tissue, affecting the PEFR value. The study included the age of student smokers into adolescence, with an mean smoking duration of 4 years, so the damage to the respiratory tract was not too severe. [21]

The mean PEFR value of non-smoking students in this study was 408.10 L/min, which was lower than the results of previous studies in the nonsmoker group.[19] This may be due to exposure to tobacco smoke from the environment, especially the environmental families. The study found that 82.9% and 68.5% of parents and families smoked in groups of nonsmokers, respectively.[21]

CO levels and PEFR values in this study were also strongly correlated with smoking duration (r=0.749 for CO levels, r= -0.554 for PEFR values). The more extended period of smoking is consistent with the higher CO level and the lower PEFR value. This is consistent with studies by Hilyah et al and Sukreni et al, who also mentions a strong relationship between smoking duration and CO and PEFR levels.[22,23] The longer a person smokes, the more frequently he will be exposed to CO gas from cigarette smoke, and therefore more CO gas will bind to hemoglobin than oxygen. This can be detected by measuring CO levels in the exhaled air.[24] The effects of smoking will be seen if the smoking duration was longer than two years, i.e., the PEFR values decreased due to airway changes caused by inflammatory processes.[25]

LIMITATION

Several limitations of this study were the cross-sectional design, where it could only be observed and measured at one time, so the course of smoking on increasing CO levels and decreasing PEFR values could not be seen. In addition, PEFR measurements were performed in a sitting position, not a standing one. Another limitation is that this study did not consider factors that cause high CO levels or low PEFR values in the student group of smokers since living environment factors can also influence CO levels and PEFR values.

CONCLUSION

From this study, it can be concluded that there is a relationship between smoking, CO levels, and PEFR values. High levels of CO and low PEFR values in the student who is a smokers are influenced by the length of time they smoke. Environmental factors can influence CO levels and PEFR of both smoker and nonsmoker students, that is, exposure to CO gas from smoking parents or families. Therefore, it is necessary to advise students, parents, and immediate family about the dangers of smoking.

Another thing that needs to be done is further research is needed to identify other factors that affect smoking behavior, CO levels, and PEFR levels in Banda Aceh students.

ACKNOWLEDGMENTS

None.

CONFLICT OF INTEREST

None.

FUNDING

None.

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