ORIGINAL ARTICLE

Effect of Intensity of Cigarette Smoking on Leukocytes among Adult Men and Women Smokers in Bangladesh

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Abstract

Background: Smoking is one of the preventable causes of disease in middle and low-income countries. This study was conducted in smokers and non-smokers to observe the changes in total count of leukocytes in cigarette smokers in relation to body mass index (BMI) and blood pressure (BP).
Methods: The study populations were from different sources including diagnostic center and general hospital, and consisted of 58 smokers and 77 non-smokers, with a broad range of age groups. The variables considered for this study were the smoking status of current smokers and non-smokers, and blood samples of the subject, anthropometric data and also blood pressure data.
Results: Total leukocytes in smokers were found to be higher than the non-smokers along with the increasing of lymphocytes. Leukocytes were also found to be increased with intensity of smoking in adult men and women. The BMI of the smokers showed decreasing trend compared to non-smokers. The relation between blood pressure and smoking was not well established, as there were only little changes on systolic blood pressure (SBP) of smokers found according to smoking intensity.
Conclusion: Cigarette smoking has negative effects on leukocytes both in men and women smokers in terms of certain anthropometric parameters.

Keywords: Blood Pressure; BMI; Leukocytes; Smoking

How to cite this article: Shipa SA, Rana MM, Miah MF, Alam MJ, Mahmud MGR. Effect of Intensity of Cigarette Smoking on Leukocytes among Adult Men and Women Smokers in Bangladesh. *Asia Pac J Med Toxicol* 2017;6:12-7.

INTRODUCTION

Due to civilization, people are more concerned about their health status and thus the importance of avoidable causes of disease become on top priority of fitness. Nearly 4 million people died every year due to smoking and about 8.8% of worldwide deaths were caused by tobacco (1). According to the World Health Organization (WHO), if the current tobacco trends continue, 8 million deaths could be caused annually (more than 80% of in low- and middle-income countries) by the year 2030 (2). Several studies provide the evidence that tobacco is strongly responsible for the alteration of the normal status of the lipid profile and moreover, cigarette smoking is an important and independent risk factor for atherosclerosis, coronary artery disease, peripheral vascular disorders, etc. (3). Smoking is also known to decrease the immune function and cause rheumatoid arthritis (4). There is hardly any organ which is not affected by smoking. In 2004, the Surgeon General released a comprehensive report on smoking and its health consequences, revealing for the first time that smoking causes diseases in every organ of the body. About 2.4 billion people worldwide have consumed tobacco in several forms like smoking, chewing, snuffing or dipping where tobacco-related deaths were recorded around 6.4 million in 2015, and it is assumed that, deaths will rise 8.3 million in 2030 and one billion deaths during the 21st century (5). With the increase of population, the percentages of smoking are also predicted to be high. People are getting more addicted with the smoking while majority of whom are young community. To solve this critical situation, along with the improvement of consciousness, the other damages that occur due to the smoking (i.e., elevated WBC) need to know for the better knowledge and treatment of the health problems that are caused by smoking.

Cross sectional study of eighty subjects (40 cigarette smokers and 40 non-smokers in the age range of 25 to 40 years) were done to observe the effect of smoking and its intensity on hematological and lipid parameters and it was found that the total leukocyte count increased with specific increase in neutrophils (3). In a relative study with 70 healthy male volunteers (35 healthy smokers and 35 healthy non-smokers), it was found that the volunteers 18-25 years of age had significantly higher leukocytes with specific increase in lymphocytes among the smokers, compared to non-smokers (6). In another study, relationship between WBC count and smoking, and between smoking and lung function in healthy

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Received 17 January 2017, Accepted 4 March 2017

men and women across several ages were analyzed and it was found that the total WBC was significantly higher in both sexes of smokers than non-smokers and the non-smokers had higher BMI compared to smokers (7). However, in a study of observing the relationship between WBC and hypertension in Chinese adults, the study concluded that the white blood cell count could independently predict hypertension in Chinese adults (8). Substantial proportion of premature deaths in the Bangladeshi population, especially among men, was caused by tobacco (2). Thus, this study was undertaken with the people of Bangladesh to explain the harmful effect of tobacco on human blood leukocytes. The present study was undertaken to elucidate the effects of smoking on WBC of the Bangladeshi individuals considering the age, BMI and BP variables.

METHODS

Design and setting

In this study, the subjects were selected from two different sources. One of them is the students of Shahjalal University of Science and Technology with the age range of 18-25 years who were separated based on minimum 1 year of smoking. Another source of the subjects was collected from Pathological Laboratory, Habiganj Diabetic and General Hospital, Habiganj, Bangladesh. Subjects from the second source were selected with a wide range of ages. The study was conducted by manual process as follows: total leukocytes count was done by Neubauer chamber and differential count was done by Leishman staining.

Study subject

A total 335 subjects were examined from whom 92 were excluded for not responding to the personal interview questionnaire and 73 subjects were rejected for having a disease history and/or taking antibiotic drugs. Another 35 subjects were excluded because of their alcoholic habit. Among the rest of the total sample population, 58 smokers (49 male and 9 female) and 77 non-smokers (55 male and 22 female) were taken as control. Due to cultural and traditional reasons, female subjects were limited in number and for this the analysis was done in combination of male and female. They were also subjected for a personal interview.

Variables

The variables of this study interest were mainly focused on smoking status (current smoker or nonsmoker), and blood for leukocytes analysis. The other variables for the analysis were anthropometric data (weight, height, body mass index [BMI] calculated as kg/m^2), and the blood pressure. 'Pack-years' of cigarette consumption was calculated for all smokers by the following formula:

Pack-years = (number of cigarettes smoked per day × number of years smoked)/20.

Statistical analysis

In this study, data were expressed as mean±standard deviation (SD). The comparisons between the parameters of the control group and the experimental group were statistically analyzed by using unpaired Student T Test and ANOVA for F test. P value < 0.05 was considered for being statistically significant.

RESULTS

Analysis of different types of WBC helps to analyze the effect of smoking on the blood. Total and differential counts of white blood cells were performed among the 77 non-smokers and 58 smokers along with the percentage (Table 1). Quantitative analysis of different types of WBC clearly indicated that there is a relationship between leukocytes and lymphocytes. Lymphocytes increased with the increasing of leukocytes in the smokers compared with non-smokers ($p<0.05$).

The leukocytes were increased more than 500 cells/mm^3 with the intensity of smoking (Table 2). The total leukocytes were 8163 cells/mm^3 in mild smokers, where moderate and heavy smokers have 8737 cells/mm^3 and 9356 cells/mm^3, respectively. In case of lymphocytes, heavy smokers have higher value of 32.9 cells/mm^3 than mild (31.53 cells/mm^3) and moderate smokers (32.42 cells/mm^3).

General anthropometric characteristics of 135 smoker and non-smoker subjects were kept into concern for this study (Table 3). The mean age of smokers and non-smokers was observed 33.5 years and 40.03 years, respectively. However, smokers have significantly lower weight (mean weight 70.33 kg) compared to non-smokers (mean weight 72.17 kg). But in case of the parameter of height of all subjects, no significant difference was found. However, BMI of smokers has lower value compared to non-smokers. In order to validate this result of BMI, the further analysis of BMI of the subjects was analyzed according to the age groups.

Table 1. Different types of white blood cells (WBCs) in healthy population.

Parameter	Non-smokers (Mean±SD)			Smokers (Mean±SD)		
	Male (n=55)	Female (n=22)	All (n=77)	Male (n=49)	Female (n=9)	All (n=58)
WBC (cells/mm^3)	6920 ± 1075.9	7056.36 ± 970.22	6958.96 ± 1042.32	8804 ± 1146.91	8822.22 ± 1019.53	8806.90±1119.66*
Neutrophils (%)	61.09 ± 5.42	60.64 ± 5.30	60.96 ± 5.36	59.59 ± 5.46	59.78 ± 5.89	59.62 ± 5.48
Eosinophils (%)	2.87 ± 0.98	3.09 ± 0.87	2.94 ± 0.95	2.29 ± 0.84	2.78 ± 0.83	2.36 ± 0.85
Lymphocyte (%)	30.27 ± 4.41	29.77 ± 3.64	30.13 ± 4.19	32.43 ± 4.75	31.56 ± 6.41	32.29 ± 4.99*
Monocyte (%)	5.42 ± 1.46	5.91 ± 1.69	5.56 ± 1.53	5.51 ± 1.70	5.67 ± 1.41	5.53 ± 1.65
Basophils (%)	0.45 ± 0.50	0.41 ± 0.55	0.44 ± 0.50	0.20 ± 0.41	0.33 ± 0.5	0.22 ± 0.42

***** Statistically significant differences between smokers and non-smokers (t test for independent groups, $P < 0.05$).

Table 2. Different white blood cells in smokers (mild, moderate and heavy).

Parameter	Mild smokers (Pack years 0.1-5) (Mean ± SD)	Moderate smokers (Pack years 6-15) (Mean ± SD)	Heavy smokers (Pack years > 15) (Mean ± SD)
WBC (cells/mm^3)	8163 ± 1226.65	8737 ± 955.23*	9356 ± 1078.73*
Neutrophils (%)	60.05 ± 4.80	59.95 ± 7.11	58.9 ± 4.40
Eosinophils (%)	2.32 ± 0.89	2.32 ± 0.89	2.45 ± 0.83
Lymphocyte (%)	31.53 ± 4.55	32.42 ± 5.87*	32.9 ± 4.62*
Monocyte (%)	5.74 ± 1.66	5.21 ± 1.44	5.65 ± 1.84
Basophils (%)	0.42 ± 0.51	0.16 ± 0.34	0.1 ± 0.31

***** Statistically significant differences between smokers and non-smokers (f test for independent groups, $P < 0.05$).

Table 3. Anthropometric values of the healthy population.

Parameter	Non–smokers (Mean ± SD)			Smokers (Mean ± SD)		
	Male (n=55)	Female (n=22)	All (n=77)	Male (n=49)	Female (n=9)	All (n=58)
Age (years)	40.05 ± 19.12	39.95 ± 15.12	40.03 ± 17.97	33.22 ± 13.10	35 ± 14.56	33.5 ± 13.22*
Weight (kg)	76.49 ± 7.24	61.36 ± 6.65	72.17 ± 9.84	72.27 ± 9.26	59.78 ± 8.33	70.33 ± 10.13*
Height (m)	1.66 ± 0.06	1.58 ± 0.12	1.63 ± 0.09	1.66 ± 0.05	1.61 ± 0.05	1.66 ± 0.06
BMI (kg/m^2)	27.92 ± 2.53	25.25 ± 5.70	27.16 ± 3.87	26.16 ± 3.65	23.17 ± 3.55	25.70 ± 3.77*

***** Statistically significant differences between smokers and non-smokers (t test for independent groups, $P < 0.05$).

Based on five different age groups of study subjects, WBC was counted and it was concluded that smokers have higher leukocytes than non-smokers ($p<0.05$) of the same age group (Table 4). Smokers have 1000 cells/mm^3 more leukocytes than non-smokers in almost every age group.

Comparative study of BMI in different age groups of both smokers and non-smokers was brought into concern to observe the effect of smoking on BMI scale. It was observed that BMI of non-smokers was statistically higher than that of smokers among all age groups by more than 1kg/m^2 (Table 5)**.** From this comparative analysis of BMI, it could be concluded that smoking affects the BMI of the individuals independently.

To evaluate the relation between blood pressure (BP) and smoking, BPs of non-smokers and smokers were measured in this study. The mean BPs did not differ importantly among never, mild, moderate and heavy smokers, even though a small significant difference was observed in mean SBP between never smokers (132.18 mm Hg) and moderate (133.74 mm Hg) and heavy smokers (135.05 mm Hg) ($P<0.05$) (Table 6). In case of diastolic blood pressure(DBP), no significant difference was found between non-smokers and smokers. Moreover, higher level of SBP was observed among the >40-year-old subjects (not shown).

Morphological observation of white blood cell

Through the analysis of different white blood cell types, no significant morphological differences have been observed among healthy population. Thus, it would be said that there is no morphologically change occurred in the white blood cells due to smoking.

Table 4. WBC of healthy population on the basis of different age groups.

Age (years)	Non-smokers (Mean±SD)	Smokers (Mean±SD)
18-25	6373.08 ± 981.65	8821.74 ± 1042.27*
26-35	6243.75 ± 613.15	8735.71 ± 970.02*
36-45	7418.18 ± 936.82	8880 ± 1595.69*
46-55	7714 ± 490.99	8783.33 ± 1318.21*
56-above	7964.29 ± 448.26	8820 ± 947.10*

***** Statistically significant differences between smokers and non-smokers (t test for independent groups, $P < 0.05$).

DISCUSSION

In this study, the influence of smoking on hematological, particularly the white blood cells, and other physiological parameters (age, BMI and blood pressure) was observed. Since smoking causes several health damages, the impact of smoking was taken for statistical analysis on human health compared to non-smoker subjects. The white blood cell is a very important component of the human health condition which makes harmful implications to the human health through causing different diseases if abnormally present in human blood. This study showed an elevated white blood cells count in smokers compared to non-smokers at different ages and different smoking levels. The mean difference between the white blood cell of the smokers and non-smokers was about 1800 cells/mm^3 in the study. Recent studies on

Table 5. BMI of smokers and non-smokers at different age groups.

Age (years)	Non-smokers (Mean±SD)	Smokers (Mean±SD)
18-25	26.25 ± 3.56	24.45 ± 3.55*
26-35	28.23 ± 3.79	25.42 ± 4.20*
36-45	28.13 ± 3.94	27.66 ± 1.78*
46-55	29.03±4.76	28.14 ± 4.09*
56-above	25.52 ± 3.08	25.36 ± 4.45*

***** Statistically significant differences between smokers and non-smokers (t test for independent groups, P < 0.05).

Japanese people suggested that WBC counts were significantly increased in heavy (7500 ± 324/µl, $p< 0.001$) or light (6829 ± 352/µl, $p = 0.001$) smoking groups as compared to non-smokers (5590 ± 178/µl) (9). Recently, in a study of 6902 male and 8405 female smokers sample, higher WBC counts were demonstrated (10). In relation to a WBC count over 6000 cells/ml, mortality found to be higher in one recent cohort study (11). Not only traditional smoking, but also current cigarette smoking was associated with elevated counts of all WBC differentials (12). Research carried out on 105 adult populations showed that smokers had significantly (P<0.001) higher WBC counts than non-smokers. In addition, WBC count was found increased with intensity of smoking (13). Some other studies also showed the positive relationship between WBC and male smokers (3, 6, 14-16).

Again, when it comes to the differential count of white blood cells, they also have an important role in human health because all types of white blood cells (neutrophils, eosinophils, lymphocytes, monocytes and basophils) have an individual role in human immune system. In this study, we found statistically significant (p<0.05) higher lymphocyte count in smokers over non-smokers. The mean lymphocyte of smokers was 32.29% while this mean value was lowered to 30.13% in non-smokers. But other than lymphocytes, no significant differences were found in other cell types in this study. In a study conducted by Schwartz and Weiss on smokers, a similar increase in neutrophil count was noticed (17). However, in a previous study (18), smokers have an increased trend in WBC, neutrophils, lymphocytes and basophils. Another study found an increase in neutrophil and eosinophil count (19). Recently, it was found that the lymphocyte count was higher while the neutrophil count was lower in smokers (20).

When the smokers' WBC was compared on the basis of smoking intensity, with the increase of smoking intensity an increase in WBC was also found. The total WBC count in moderate and heavy smokers was significantly higher than that of the mild smokers. This is consistent with the study that showed the effect of smoking and its intensity on hematological and lipid parameters (3). For that count in the present study, the increase of WBCs in smokers compared to the non-smokers was confirmed. Nicotine-induced release of catecholamines might be the reason of increased leukocyte number in the smokers. For the higher WBCs in smokers, the irritant effect of cigarette smoke that causes the inflammation on respiratory tract might be a contributory factor. It should be noted that inflammatory stimulation was caused because of smoking and resulted in chronic bronchitis, which may increase inflammatory indicators in blood (6). Smoking also causes the generation of free radicals that are consistently associated with different markers of inflammation such as C-reactive protein and WBCs. It has been reported that chronic bronchitis or leukocytes released from lymphoid organs to the periphery were two major causes for the increasing of total leukocyte count in smokers (21). Bronchial tract inflammation could be an increasing factor of leukocytes that leads to chronic bronchitis.(6). The effect of nicotine that evokes discharge of catecholamines from the adrenal medulla could be another mechanism for increase in leukocyte count by changing distribution of leukocyte from marginal pool into circulating pool (6). It was found that moderate and heavy smokers have higher lymphocyte content than mild smokers.

The effect of cigarette smoking on differential leukocyte count is controversial. In the present study, a significant increase in the lymphocyte count in smokers as compared to non-smokers was observed. The increase in the number of lymphocytes in smokers might be due to the stimulating effect of nicotine on lymphocytes. The mechanism by which nicotine influences lymphocyte count is still not known. It might be in accordance with the findings noted by other researchers (22), who investigated the effect of cigarette smoking on T cell subsets, reporting that current smokers had a significantly higher absolute lymphocyte count than non-smokers. The proportion of CD4 lymphocyte was significantly increased in smokers as compared to non-smokers. They also found that the percentage of CD4 cells tends to increase with the number of cigarettes smoked per day. These studies reported that the mechanisms responsible for this effect were obscured. Increase in lymphocyte count obtained in the present study can be attributed to the stimulating effect of nicotine on lymphocytes. Disturbance in

Table 6. Blood pressure of smokers and non-smokers.

Blood Pressure (mmHg)	Non-smokers (Mean±SD)	Smokers (Mean±SD)		
		Mild Smokers	Moderate Smokers	Heavy Smokers
SBP	132.18 ± 12.98	132.05 ± 11.06	133.74 ± 10.95*	135.05 ± 11.34*
DBP	81.10 ± 9.91	80.58 ± 6.96	81.05 ± 8.69	81.2 ± 8.70

* Statistically significant differences between smokers and non-smokers (f test for independent groups, P < 0.05).

the function of adrenal gland under influence of a stress factor like smoke might play a significant role in elevating the lymphocyte count. The irritant effect of cigarette smoke on respiratory tree, resulting in chronic inflammation must be another reason for increased release of lymphocytes from lymphoid organs. However, the limitation of this study was that CD4 count and animal experiments have not been done in this study.

In this study, the general characteristics of smokers and non-smokers were also measured. The mean weight and BMI of the smokers were showing significant difference of being lower in smokers than non-smokers (23). It might be possible that lower BMI of the subjects is also an important factor in smoking. For this, the number of WBC and BMI of different age groups were analyzed between the smokers and non-smokers to predict the relation among smoking, BMI and WBCs. Also, it showed the difference in WBC number of smokers and non-smokers among the age groups. In the present study, there was no significant difference between the height of the smokers and non-smokers, whereas some studies showed that current and former smokers were also taller than non-smokers, but most have a conflict on findings (24-26). On the other hand, some do not have confliction with their studies (27).

The number of WBC showed higher value in all age groups of smokers than non-smokers. In addition, on an average, nearly more than 1000 cells/mm^3 leukocytes were found in smokers compared to non-smokers in all age groups. From our observation, we concluded that smoking affects WBC count regardless of age. This finding is consistent with a widely reported dose–response effect of smoking (9, 17, 28).

BMI is an important factor for human health condition and it has been shown in this study that the BMI of the smokers was lower than the same age group of non-smoker subjects and this shows an inverse relation between smoking and BMI. In 18-25 years of age groups of the study, the mean BMI of the non-smoker subjects were 26.25 kg/m^2. In contrast, smokers have 24.45 kg/m^2. In all other age groups, there were similar significant differences obtained. These findings are consistent with the other findings that showed decreased BMI in smokers compared to non-smokers (7). However, this decreasing might be harmful for human health. An inverse relationship between smokers and BMI was also subjected (29), and it was found that the increased mortality observed among lean individuals is because of smoking rather than normal leanness. This was also concluded in some other previous studies. Thus, the health benefit of being a nonsmoker is that they have a healthy BMI.

Blood pressure is associated with major human health impact as well. One previous study suggested that the white blood cell count could independently predict hypertension in Chinese adults (8). A previous study suggested that hypertension is an inflammatory disease based on the finding of significantly higher levels of inflammatory markers, including total leukocyte and neutrophil counts, in hypertensive patients (30). For this, in the present study, the blood pressure of the smokers and non-smokers has been shown to make the conclusion of the fact that the blood pressure was either associated with smoking or not. From this study, it was observed that there are little differences between the SBP of moderate and heavy smokers compared to that of the mild and never smokers. In addition, high ranges of SBP were found in the aged subjects. For this, it is hard to conclude that the SBP is either independently associated with the smoking or not. In contrast, no significant difference was found in the DBP between the smokers and non-smokers.

LIMITATIONS

This study was conducted among the patients within a region of the country, so the results cannot be generalized. However, another limitation could be the poor documentation of the patients' information because of the lack of well-trained staff in the hospital and diagnostic center.

CONCLUSION

This present study revealed that continuous cigarette smoking has severe adverse effects on WBC count in the human body as WBC number is significantly higher in smokers compared with non-smokers. Too many blood cells in the blood can make the smokers' blood more viscous. When so, the blood does not flow efficiently and this can contribute to the formation of clots which can increase the risk of clotting complications such as stroke, deep vein thrombosis, pulmonary embolism, and so on. This study suggests that the biomarker (i.e., WBC) might be associated with a greater risk for developing atherosclerosis, polycythemia vera, chronic obstructive pulmonary disease or cardiovascular diseases in smokers rather than non-smoker individuals. The implications of these relationships range from helping to guide the medical work-up in a smoker with leukocytosis to broadening our understanding of how smoking leads to these life-threatening diseases. This study also revealed the strong relationship between smoking and different physiological parameters of the human body. Additional research is clearly necessary to determine that to what extent smoking needs to be reduced for health benefit. This should be a good stepping stone for individuals who are resistant to quitting.

ACKNOWLEDGEMENT

We are very much grateful to the authority of Pathological Laboratory, Habiganj Diabetic and General Hospital, Habiganj, Bangladesh for their support during data collection.

Conflict of interests: None to be declared.

Funding and support: Laboratory of Animal Biotechnology as well as Biochemistry and Molecular Biology, Department of Genetic Engineering and Biotechnology, Shahjalal University of Science and Technology, Sylhet, Bangladesh.

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