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Evaluation of Hemoglobin and Red Blood Cells Parameters among Smokers in Shendi Town

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Research Article

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Abstract

Background

Cigarette smoking is associated with several chronic diseases, particularly cardiovascular disease and lung cancer. It may also affect hematological parameters through oxidative tissue damage.

Objective

To evaluate hematological parameters, including hemoglobin concentration, hematocrit (HCT), red blood cell (RBC) indices, and red cell distribution width (RDW), among smokers, and to assess the effects of smoking duration and intensity on these parameters.

Methods

This comparative cross-sectional study was conducted at Shendi University and included 50 smokers and a healthy control group. Complete blood count (CBC) parameters were measured using an automated hematology analyzer (Mindray BC-3000). Data were analyzed using SPSS version 26.

Results

Smokers showed significantly higher mean values of hemoglobin concentration, hematocrit, RBC indices, and RDW compared with controls ($p < 0.05$). Increased smoking intensity was associated with higher mean values of hemoglobin (HB), hematocrit (HCT), mean corpuscular volume (MCV), mean corpuscular hemoglobin concentration (MCHC), and RDW. No significant association was found between smoking duration and hematological parameters. Among cigarette smokers, increased smoking intensity was associated with higher HCT, MCV, and RDW-SD values, while among hookah smokers it was associated with increased HB and HCT values.

Conclusion

Smoking significantly affects hematological parameters, particularly hemoglobin concentration, hematocrit, RBC indices, and RDW. Smoking intensity appears to have a greater effect than smoking duration.

1. Introduction

1.1 Background

Smoking is a process in which tobacco is burnt and smoke is inhaled by different ways i.e. cigarette, cigar, biri and pipe. It gives sense of pleasure and satisfaction to the smoker. It is complex external and internal stimulus consisting of visual, tactile, mechanical (mouth movement), gustatory, olfactory and irritating factor[1] .The average per capita cigarette consumption in hungry is among the highest in the world (WHO)[2] . Cigarette smoking is one of the 10 leading health indicators that reflect the major health concerns in the USA[3] .

Although the percentage of the population that smokes has declined in the USA and other industrialized countries. It is increasing in developing countries[4]. According to the WHO smoking diseases are set to become a greater problem in these countries than communicable diseases and malnutrition[5]. Tobacco use is one of the chief preventable causes of death in the world[6] . Nearly 50,000 deaths annually are attributed to tobacco and in Islamic Republic of Iran it is estimated that the figure will reach about 200,000 annual deaths due to smoking in 20 years time[7] .

Numerous throughout the world have examined the risk factors for cigarette smoking. Some of these include: genetic and demographic factors, social norms, peer influences and parental attitudes and behavior [8] . Cigarette smoking is considered a “gateway” drug in as its use often precedes use of alcohol, marijuana or other illicit drugs [9]. During the last 20 years the amount of tar and Nicotine content delivered by cigarette made by United States has decreased more than 50% [10] .

WHO estimates that by the decade 2020- 2030 tobacco will be responsible for 10 million deaths per year, with 70% occurring in developing countries [11] . In Thailand Prevalence of current smoker has been reported to be greater than 9 million or 19.5% of 49.4 million, in 2005 [12] . It generates many toxic and carcinogenic compounds harmful to health, such as nicotine, NO, CO, hydrogen Cyanide and free radicals [13] . About1.3 billion people are regular smoker and every day between 8,200 and 9,900 young people start to smoke, risking rapid addiction to nicotine [14] . tobacco smoking in pregnancy exerts a negative effect on the environment iwhich the fetus develops, and consequently, on the health of newborn babies [15] . The aim of this study was to examine agerelated change and cigarette smoking in the strength of the association of RBCs count, hemoglobin concentrations, Red Cell Indices to create awareness in public and plan launching anti-smoking campaigns.

1.2 Rationale

Smoking is a well-known risk factor for a wide range of diseases, particularly those affecting the respiratory and cardiovascular systems. However, its effects on hematological parameters, especially hemoglobin concentration and red blood cell indices, have received limited attention in recent local studies. Therefore, this study was conducted to evaluate hemoglobin concentration and red blood cell parameters among smokers and to assess the relationship between smoking habits and hematological changes

1.3 Objectives

1.3.1 General Objective

- To evaluate hemoglobin concentration and red blood cell parameters among smokers in Shendi town.

1.3.2 Specific Objectives

- To determine the relationship between the type of smoking and hematological changes in hemoglobin concentration and RBC parameters.
- To determine the relationship between the duration of smoking and hematological changes in hemoglobin concentration and RBC parameters.
- To determine the relationship between the amount of smoking and hematological changes in hemoglobin concentration and RBC parameters.

2. Materials and Methods

2.1 Study Design

This was a comparative cross-sectional study conducted to evaluate hemoglobin levels and red blood cell parameters among smokers.

2.2 Study Area

The study was conducted at Shendi University, located in Shendi town, Sudan. Shendi is a town in northern Sudan situated on the eastern bank of the River Nile, approximately 150 km northeast of Khartoum (16°41'N, 33°25'E).

2.3 Study Duration

The study was conducted in Shendi town from January 2024 to April 2024.

2.4 Study Population

The study population included cigarette and hookah smokers.

2.5 Inclusion Criteria

The study included 50 smokers and 25 non-smokers as a control group.

2.6 Exclusion Criteria

Participants with diseases that could affect hemoglobin concentration and red blood cell parameters were excluded.

2.7 Study Sample

Venous blood samples were collected from participants.

2.8 Sample Size

The sample size was initially calculated using the formula:

$N = Z^2 p(1 - p) / e^2$

$N = (1.96)^2 \times 0.5 \times (1 - 0.5) / (0.05)^2 = 384$

However, due to limited study duration and financial constraints, the final sample consisted of 75 participants.

2.9 Study Variables

The study variables included type, duration, and amount of smoking.

2.10 Data Collection Tools

Primary data were collected using a structured questionnaire.

2.11 Sample Processing

A total of 2.5 mL of venous blood was collected from participants and transferred into EDTA tubes. Samples were analyzed within 3–6 hours of collection.

Hematological parameters including red blood cell (RBC) count, hemoglobin (Hb), hematocrit (HCT), and RBC indices (MCV, MCH, MCHC), as well as red cell distribution width (RDW-CV and RDW-SD), were measured using an automated hematology analyzer (Mindray BC-3000) through standard laboratory procedures.

2.12 Materials

Cotton, EDTA tubes, disinfectant (Dettol), blood samples, and a hematology analyzer were used.

2.13 Method

2.13.1 Hematological Analysis

Hematological parameters were measured using the Mindray BC-3000 Hematology Analyzer.

2.13.1.1 Principle

Blood cells are classified into red blood cells, white blood cells, and platelets. The analyzer determines cell counts and differentiates cell types based on size using the sheath flow direct current (DC) detection

method. Electrical resistance changes as blood cells pass through an aperture are measured to determine cell volume.

The instrument operates using RF/DC detection, hydrodynamic focusing, and the sodium lauryl sulfate (SLS) hemoglobin method. The RF/DC method detects blood cell volume based on changes in electrical resistance as cells pass through the detection aperture [16].

2.13.1.2 Procedure

Approximately 2.5 mL of venous blood was collected from participants and transferred into EDTA tubes. Samples were analyzed within 3–6 hours of collection for RBC count, hemoglobin concentration, hematocrit, and RBC indices (MCV, MCH, MCHC), as well as RDW parameters. The analysis was performed according to the manufacturer's instructions. The analyzer was calibrated using normal, high, and low control samples. EDTA blood samples were aspirated automatically, and results were generated within approximately 20 seconds. Blood smears were also prepared from all samples for quality assessment [16].

2.14 Data Analysis and Presentation

Data were analyzed using SPSS version 26. The chi-square test was used to assess associations between categorical variables. Results were presented in tables, and outliers were evaluated and reported where necessary.

2.15 Ethical Considerations

The venous blood sampling procedure was explained to all participants. Participants were informed about the study objectives and procedures, and verbal consent was obtained prior to participation. Confidentiality and privacy of all participants and their results were strictly maintained.

3. Results

Demographic data:

This study conducted to evaluate the effect of smoking on hemoglobin and the RBCs parameters, 50 whole blood sample was collected from cigarette and hookah smokers, the participants of these study are: cigarette smokers comprise (50%) and hookah smokers comprise (50%) of smokers, cigarette smokers which smoke less than 10 years comprise(68%) while cigarette smokers which smoke more than 10 years comprise (32%) as shown in table no (3 – 1).

Table {3.1} Show the distribution of duration of smoking among cigarette smokers:

Duration	Frequency	Percent
Less than 10 years	17	68%
More than 10 years	8	32%
Total	25	100%

Cigarette smokers which smoke less than 10 cigarette per day comprise (32%) while cigarette smokers which smoke more than 10 per day cigarette comprise(68%) as shown in table no (3 – 2).

Table {3.2} Show the distribution of amount of smoking per day among cigarette smokers:

Amount	Frequency	Percent
Less than 10 cigarettes	8	32%
More than 10 cigarettes	17	68%
Total	25	100%

Hookah smokers which smoke less than 10 years comprise(40%) while hookah smokers which smoke more than 10 years comprise(60%) as shown in table (3–3).

Table {3.3} Show the distribution of duration of smoking among hookah smokers:

Duration	Frequency	Percent
Less than 10 years	10	40%
More than 100 years	15	60%
Total	25	100%

Hookah smokers which smoke less than 5 times per day comprise (48%) while hookah smokers which smoke more than 5 times per day comprise(52%) as shown in table (3.4).

Table {3.4} Show the distribution of amount of smoking per day among hookah smokers:

Amount	Frequency	Percent
Less than 5 times	12	48%
More than 5 times	13	52%
Total	25	100%

Table (3.5) Show comparison the mean of Hb and RBCs parameters between case group(cigarette and hookah smokers) and control group, there was significant increase in the mean of (Hb, HCT,MCV, MCH,

MCHC, RDW-CV ,RDW-SD) in smokers.

Parameters	Type	N	Mean	P.value
HB	Case	50	16.972	0.000
	Control	25	14.560	
RBCs	Case	50	4.7496	0.557
	Control	25	4.6840	
HCT	Case	50	46.636	0.000
	Control	25	42.440	
MCV	Case	50	97.356	0.000
	Control	25	88.880	
MCH	Case	50	35.404	0.000
	Control	25	29.880	
MCHC	Case	50	36.416	0.000
	Control	25	33.720	
RDW-CV	Case	50	16.900	0.000
	Control	25	14.160	
RDW-SD	Case	50	52.028	0.000
	Control	25	44.760	

Table (3.6) Show comparison the mean of Hb and RBCs parameters between case group(cigarette smokers) and control group, there was significant increase in the mean of (Hb, HCT,MCV, MCH, MCHC, RDW-SD) in cigarette smokers.

Parameters	Type	N	Mean	P.value
HB	Case	25	16.096	0.000
	Control	25	14.560	
RBCs	Case	25	4.448	**0.190**
	Control	25	4.684	
HCT	Case	25	44.152	0.030
	Control	25	42.440	
MCV	Case	25	97.976	0.000
	Control	25	88.880	
MCH	Case	25	35.520	0.000
	Control	25	29.880	
MCHC	Case	25	36.520	0.001
	Control	25	33.720	
RDW-CV	Case	25	14.480	0.296
	Control	25	14.160	
RDW-SD	Case	25	52.320	0.000
	Control	25	44.760	

Table (3.7) Show comparison the mean of Hb and RBCs parameters between case group(hookah smokers) and control group, there was increase in the mean of HB and RBCs parameters except in RDW-CV in hookah smokers:

Parameters	Type	N	Mean	P.value
HB	Case	25	17.848	0.000
	Control	25	14.560	
RBCs	Case	25	5.051	0.011
	Control	25	4.684	
HCT	Case	25	49.120	0.000
	Control	25	42.440	
MCV	Case	25	96.736	0.000
	Control	25	88.880	
MCH	Case	25	35.288	0.000
	Control	25	29.880	
MCHC	Case	25	36.312	0.000
	Control	25	33.720	
RDW-CV	Case	25	19.320	**0.300**
	Control	25	14.160	
RDW-SD	Case	25	51.736	0.000
	Control	25	44.760	

4. Discussion

Carbon monoxide (CO), a major constituent of cigarette smoke, exhibits an affinity for hemoglobin that is approximately 245 times greater than that of oxygen [(17)]. Consequently, CO competitively binds to hemoglobin, displacing oxygen and forming carboxyhemoglobin [(18)]. .This complex lacks oxygen-carrying capacity [(19)], thereby impairing oxygen delivery to peripheral tissues and contributing to a state of relative tissue hypoxia. In response, a compensatory physiological mechanism is activated, characterized by increased erythropoietin secretion, which stimulates erythropoiesis in the bone marrow. This adaptive response leads to elevated hemoglobin concentration and hematocrit levels.

Furthermore, CO exposure has been reported to increase capillary permeability, which may result in plasma volume reduction and a hemoconcentration effect that can physiologically mimic polycythemia [(18)].

In the present study, statistical analysis demonstrated a significant difference in the mean values of hemoglobin (Hb), hematocrit (HCT), mean corpuscular volume (MCV), mean corpuscular hemoglobin

(MCH), mean corpuscular hemoglobin concentration (MCHC), and red cell distribution width (RDW) between smokers and the control group ($p < 0.05$). In contrast, no statistically significant differences were observed in these hematological parameters among smokers with respect to the duration of smoking ($p > 0.05$).

Moreover, subgroup analysis revealed significant variations in HCT, MCV, and RDW-SD among cigarette smokers based on smoking intensity (≥ 10 cigarettes/day). Similarly, in hookah smokers, significant differences were observed in Hb and HCT according to smoking frequency (> 5 sessions), with statistical significance ($p < 0.05$).

The findings of the present study are consistent with previously published literature. In agreement with our results, earlier studies have reported significantly elevated hemoglobin and hematocrit levels in smokers compared with non-smokers [(20)].. Similarly, concordant findings have been documented for Hb, HCT, and MCH, where smokers exhibited significantly higher values of hemoglobin concentration, packed cell volume (PCV), and MCH [(21)]. Furthermore, our results are in line with another study reporting significant increases in MCV, MCH, RDW, hematocrit, and hemoglobin among smokers, while RBC count showed no statistically significant difference between smokers and non-smokers [(22)].

5. Conclusion

Based on the findings of this study, the following conclusions can be drawn:

- Smokers exhibited significantly higher mean values of hemoglobin (Hb), hematocrit (HCT), mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC), and red cell distribution width (RDW) compared to non-smokers.
- No significant association was observed between hematological parameters and the duration of smoking, suggesting that chronicity alone may not be a strong determinant of these alterations.
- An increase in smoking intensity was associated with significant elevations in HCT, MCV, and RDW-SD among cigarette smokers.
- Similarly, higher frequency of hookah smoking was associated with significant increases in Hb and HCT levels.

Overall, these findings indicate that smoking exerts a measurable effect on red blood cell indices, with stronger alterations observed in relation to the intensity rather than the duration of exposure.

Declarations

Competing Interests:

The authors declare that they have no relevant financial or non-financial competing interests to disclose.

Funding:

This study did not receive any financial support from any organization. No funding was obtained for the design, data collection, analysis, interpretation, or preparation of this manuscript.

Ethical Approval:

This study was conducted in accordance with the ethical standards of the Declaration of Helsinki. Ethical approval was obtained from the Health Research Ethics Committee at the University of Shendi (or relevant local health authority).

Informed Consent:

Informed consent was obtained from all individual participants included in the study. Participants were fully informed about the purpose of the study, and confidentiality of their data was strictly maintained.

Data Availability:

The datasets generated and/or analyzed during the current study are available from the corresponding author upon reasonable request.

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