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Original Article

Effect of Habitual Smoking on Hematological and Biochemical Parameters in Adult Cigarette Smokers

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ABSTRACT

Background: Cigarette smoking is a major preventable risk factor for cardiovascular, respiratory, metabolic, and systemic disease, but its combined effects on hematological, biochemical, electrolyte, and hormonal parameters remain insufficiently characterized in Pakistani adults. Objective: To assess differences in hematological indices, lipid profile, serum electrolytes, cortisol, body mass index, and blood pressure between habitual adult cigarette smokers and non-smokers. Methods: This cross-sectional analytical study included 100 apparently healthy adults aged 18–60 years from Islamabad and Rawalpindi, Pakistan, comprising 50 habitual smokers and 50 non-smokers. Habitual smoking was defined as smoking at least 10 cigarettes per day for one year or longer. Venous blood samples were analyzed for complete blood count, serum electrolytes, lipid profile, and cortisol. Between-group comparisons were performed using independent samples t-tests, with statistical significance set at $p<0.05$. Results: Smokers had significantly higher RBC count (5.34±0.62 vs. 4.92±0.49 million/µL), hemoglobin (15.54±1.10 vs. 14.84±0.57 g/dL), potassium (4.60±0.37 vs. 4.20±0.42 mmol/L), total cholesterol (181±49 vs. 160±34 mg/dL), and triglycerides (165±79.4 vs. 131±54 mg/dL), while HDL-C was lower (33.2±7.3 vs. 40.6±7.7 mg/dL). WBC count, platelet count, sodium, chloride, BMI, blood pressure, and cortisol were not significantly different. Conclusion: Habitual smoking was associated with selective erythrocytic, electrolyte, and atherogenic lipid alterations, supporting routine risk monitoring and smoking cessation interventions. Keywords: Smoking, Hematology, Lipid Profile, Electrolytes, Cortisol, Body Mass Index

INTRODUCTION

Cigarette smoking remains one of the most preventable causes of morbidity and mortality worldwide and continues to impose a major burden on cardiovascular, respiratory, metabolic, and systemic health. Tobacco use causes approximately eight million deaths annually, with more than seven million attributed to direct tobacco consumption, largely through smoked tobacco products (1). Cigarette smoke contains more than 7,000 chemical constituents, including numerous toxic and carcinogenic compounds capable of inducing oxidative stress, endothelial dysfunction, tissue hypoxia, inflammatory activation, and metabolic dysregulation (2). Although smoking prevalence has declined in some regions, it remains a significant public health issue in Pakistan, where an estimated 25.4 million adults use tobacco products, placing the country among the highest-burden settings globally and first in the WHO Eastern Mediterranean Region for the number of tobacco product users (3). The clinical relevance of tobacco exposure is well established, with strong associations reported between cigarette smoking and lung cancer, chronic obstructive pulmonary disease, cardiovascular disease, frailty, adverse pregnancy outcomes, childhood tuberculosis risk from second-hand smoke exposure, and acute respiratory distress syndrome (4–11). These effects indicate that smoking is not limited to pulmonary pathology but

produces multisystem physiological disturbances that may be detectable through routine hematological and biochemical markers.

Hematological parameters are clinically important indicators of oxygen-carrying capacity, inflammatory activity, vascular risk, and systemic physiological adaptation. Previous studies have shown that smokers often exhibit higher red blood cell counts, hemoglobin concentration, hematocrit, and white blood cell counts than non-smokers, suggesting smoking-related changes in erythropoiesis, inflammatory burden, and blood viscosity (12–14). Chronic exposure to carbon monoxide in cigarette smoke increases carboxyhemoglobin formation and reduces effective tissue oxygen delivery, thereby stimulating erythropoietin-mediated compensatory erythropoiesis and increasing red cell mass (15,16). These changes may contribute to increased blood viscosity and thrombotic tendency, although reported effects on white blood cells and platelets remain variable across populations and study designs. The assessment of complete blood count parameters in smokers is therefore clinically relevant because these markers may reflect early systemic effects of tobacco exposure before overt cardiovascular or respiratory disease becomes clinically apparent.

Smoking is also closely associated with disturbances in lipid metabolism, which are central to cardiovascular risk. Dyslipidemia is characterized by elevated total cholesterol, triglycerides, and low-density lipoprotein cholesterol, or reduced high-density lipoprotein cholesterol, and is a major contributor to atherosclerosis and metabolic disease (17). Current smokers have frequently been reported to show increased triglycerides and LDL-C with reduced HDL-C compared with non-smokers (18,19). These alterations may occur through nicotine-induced lipolysis, increased circulating free fatty acids, hepatic lipid dysregulation, oxidative stress, endothelial injury, and oxidation of LDL particles (20,21). Evidence that lipid profiles may partially improve following smoking cessation further supports a biologically plausible and clinically modifiable relationship between smoking exposure and lipid-related cardiovascular risk (19). However, the extent and pattern of lipid abnormalities can differ according to population characteristics, smoking intensity, duration of exposure, dietary background, and underlying cardiometabolic status.

Electrolyte balance is essential for cellular homeostasis, membrane excitability, acid–base regulation, neuromuscular function, and cardiac electrophysiology. Sodium is the principal extracellular cation and is central to fluid balance and membrane transport, whereas potassium is the major intracellular cation and plays a critical role in resting membrane potential and cardiac rhythm regulation (22–24). Calcium and magnesium also contribute to cellular signaling, enzymatic function, neuromuscular control, and metabolic regulation (25,26). Despite the physiological importance of electrolytes, the relationship between smoking and serum electrolyte status remains less clearly defined than its relationship with hematological and lipid markers (27). Some studies have reported no significant differences in sodium, potassium, magnesium, or calcium between smokers and non-smokers, while others have observed higher sodium or magnesium levels, or reduced magnesium with greater smoking duration and severity (31–33). These inconsistent findings suggest that smoking-related electrolyte alterations may be selective, context-dependent, and influenced by exposure intensity, timing of measurement, hydration status, and population-specific biological factors.

The hypothalamic–pituitary–adrenal axis represents another pathway through which smoking may influence systemic physiology. Cortisol, the principal glucocorticoid secreted by the adrenal cortex, regulates stress responses, metabolism, immune activity, and homeostatic adaptation (34). Stress can increase the rewarding effects of smoking, reduce self-control, and increase the likelihood of relapse, indicating a close behavioral and physiological relationship between nicotine exposure and stress regulation (35). However, published findings on cortisol levels in smokers are inconsistent. Some studies have reported higher cortisol levels among smokers and positive associations with smoking duration, while others have found reduced cortisol levels, possibly reflecting chronic hypothalamic–pituitary–adrenal axis adaptation or suppression after prolonged nicotine exposure (36,37). These conflicting

results indicate that basal cortisol measurement may not consistently capture smoking-related stress physiology, especially when timing of sampling, dependence level, diurnal rhythm, and psychosocial factors are not uniformly controlled.

Although previous research has examined the effects of cigarette smoking on hematological indices, lipid profile, electrolytes, and cortisol separately, fewer studies have evaluated these parameters together within the same adult population. This integrated approach is important because smoking may simultaneously alter oxygen transport, metabolic risk, electrolyte regulation, and stress-related hormonal function, producing a combined physiological profile relevant to early disease risk assessment. In the Pakistani context, where tobacco exposure remains common and preventable cardiometabolic disease burden is substantial, simultaneous evaluation of these markers may help clarify whether habitual smokers show measurable systemic differences compared with non-smokers. Using a PICO framework, the population of interest was apparently healthy adults aged 18–60 years, the exposure was habitual cigarette smoking, the comparison group was non-smokers, and the outcomes were hematological indices, serum electrolytes, cortisol, lipid profile, body mass index, and blood pressure. The objective of this study was to assess whether habitual adult cigarette smokers differ from non-smokers in selected hematological, biochemical, hormonal, and anthropometric parameters. It was hypothesized that habitual smokers would demonstrate adverse hematological and biochemical alterations, particularly higher red blood cell count, hemoglobin concentration, atherogenic lipid markers, and selected electrolyte changes, compared with non-smokers.

MATERIALS AND METHODS

This cross-sectional analytical study was conducted among 100 apparently healthy adult participants aged 18–60 years from different areas of Islamabad and Rawalpindi, Pakistan. The study included two equal comparison groups: 50 habitual cigarette smokers and 50 non-smokers. Habitual smoking was operationally defined as smoking at least 10 cigarettes per day for one year or longer. The study was designed to compare hematological, biochemical, hormonal, and anthropometric parameters between adults exposed to habitual cigarette smoking and non-smoking controls. Eligible participants were adults within the specified age range who were apparently healthy, free from known chronic disease, and able to provide fasting blood samples after an 8–12-hour fast. Participants were classified according to smoking status, and group allocation was based on habitual smoking exposure versus non-smoking control status.

Anthropometric and physiological measurements were obtained before laboratory analysis using standardized procedures. Body weight was measured using a digital scale, and height was measured using a stadiometer. Body mass index was calculated as weight in kilograms divided by height in meters squared. Systolic and diastolic blood pressure were measured in a resting state using a standard sphygmomanometer. These variables were recorded to describe the baseline anthropometric and cardiovascular profile of the two groups and to evaluate whether smokers and non-smokers differed in body size or resting blood pressure.

Venous blood samples of 5 mL were collected from each participant under aseptic conditions using sterile syringes after the required fasting period. Blood was distributed into EDTA tubes for complete blood count analysis and gel tubes for serum separation. After clot formation, gel tubes were centrifuged at 4000 rpm for 10 minutes to obtain serum. Serum was divided into two aliquots; one aliquot was stored at −20°C for subsequent lipid profile and cortisol analysis, while serum electrolytes were analyzed on the same day. Whole blood samples were analyzed within four hours of collection to reduce the risk of pre-analytical error, hemolysis-related distortion, and time-dependent changes in cellular parameters.

Complete blood count parameters, including red blood cell count, hemoglobin concentration, white blood cell count, and platelet count, were analyzed using an automated hematology analyzer. Serum biochemical parameters were measured using semi-automated analyzers, including Hitachi 902 and

9180 systems from Roche Diagnostics, Germany. Lipid profile parameters included total cholesterol, triglycerides, high-density lipoprotein cholesterol, and low-density lipoprotein cholesterol. Serum electrolytes included sodium, potassium, and chloride. Serum cortisol was quantified using enzyme-linked immunosorbent assay. The primary exposure variable was habitual cigarette smoking status, and the main outcome variables were hematological indices, lipid profile components, serum electrolytes, cortisol level, body mass index, and blood pressure. The primary group comparison was between habitual smokers and non-smokers for each measured parameter.

Potential selection-related variation was reduced by using equal-sized smoker and non-smoker groups and restricting recruitment to apparently healthy adults within the same age range. Pre-analytical variability was addressed by requiring fasting before blood collection, collecting venous samples under aseptic conditions, separating sample types according to the intended analysis, analyzing whole blood within four hours, and analyzing electrolytes on the day of sample collection. Storage of serum aliquots at −20°C for lipid profile and cortisol analysis helped preserve sample integrity before delayed testing. The use of automated and semi-automated laboratory platforms further supported procedural consistency across participants.

The sample size consisted of 100 participants, with 50 habitual smokers and 50 non-smokers, allowing balanced comparison between exposed and control groups. Data were entered and analyzed using SPSS version 16.0. Continuous variables were summarized as mean and standard deviation. Independent samples Student's t-test was applied to compare mean values between smokers and non-smokers for anthropometric, hematological, electrolyte, lipid, and cortisol parameters. Statistical significance was determined using a two-sided p-value threshold of less than 0.05. The analysis was conducted separately for each measured outcome, and results were reported with group-specific means, standard deviations, t-test values, and p-values to support reproducibility and transparent interpretation.

RESULTS

A total of 100 adult participants were included in the analysis, comprising 50 habitual smokers and 50 non-smokers. The two groups were compared for anthropometric profile, blood pressure, hematological indices, serum electrolytes, lipid profile, and serum cortisol. Continuous variables are presented as mean ± standard deviation, with between-group differences expressed as mean difference, 95% confidence interval, p-value, and Cohen's d where applicable.

Table 1. Baseline Anthropometric and Blood Pressure Characteristics of Habitual Smokers and Non-Smokers

Variable	Non-Smokers (n=50), Mean ± SD	Habitual Smokers (n=50), Mean ± SD	Mean Difference	95% CI for Difference	p-value	Cohen's d
Weight (kg)	72.1 ± 8.0	74.9 ± 9.4	2.80	-0.67 to 6.27	0.112	0.32
Height (cm)	171.0 ± 6.4	167.6 ± 9.1	-3.40	-6.53 to -0.27	0.033	-0.43
BMI (kg/m²)	23.39 ± 2.34	23.45 ± 2.13	0.06	-0.83 to 0.95	0.894	0.03
Systolic blood pressure (mmHg)	122.0 ± 9.8	120.0 ± 9.5	-2.00	-5.83 to 1.83	0.303	-0.21
Diastolic blood pressure (mmHg)	75.0 ± 7.0	74.0 ± 7.7	-1.00	-3.92 to 1.92	0.498	-0.14

Baseline anthropometric and blood pressure parameters were broadly comparable between habitual smokers and non-smokers. Smokers had a slightly higher mean body weight than non-smokers by 2.80 kg, although the difference was not statistically significant and the confidence interval crossed zero. BMI was nearly identical between groups, differing by only 0.06 kg/m², indicating that the two groups were comparable in overall body mass. Systolic and diastolic blood pressure were also slightly lower among smokers by 2.00 mmHg and 1.00 mmHg, respectively, but neither difference was statistically significant. Height was lower among smokers by 3.40 cm, with a modest effect size; however, because BMI remained similar, this difference did not translate into a meaningful difference in body mass classification.

Most participants in both groups were young to middle-aged adults. Among habitual smokers, 44% were aged 18–30 years and 36% were aged 31–40 years, meaning that 80% of smokers were younger than 41 years. A similar distribution was observed among non-smokers, with 48% aged 18–30 years and 40% aged 31–40 years. Participants aged 41–50 years represented 16% of smokers and 10% of non-smokers, while those aged 51–60 years represented only 4% and 2%, respectively. This distribution indicates that the study mainly reflects smoking-related hematological and biochemical patterns in younger adult participants rather than older high-risk populations.

Table 2. Age Distribution of Habitual Smokers and Non-Smokers

Age Group	Habitual Smokers (n=50)	Non-Smokers (n=50)
18–30 years	44%	48%
31–40 years	36%	40%
41–50 years	16%	10%
51–60 years	4%	2%

Table 3. Comparison of Hematological Parameters Between Habitual Smokers and Non-Smokers

Variable	Non-Smokers (n=50), Mean ± SD	Habitual Smokers (n=50), Mean ± SD	Mean Difference	95% CI for Difference	p-value	Cohen's d
WBC count (cells/mm³)	7705.2 ± 1664.8	8241.7 ± 2184.6	536.50	-235.01 to 1308.01	0.171	0.28
RBC count (million/µL)	4.92 ± 0.49	5.34 ± 0.62	0.42	0.20 to 0.64	<0.001	0.75
Hemoglobin (g/dL)	14.84 ± 0.57	15.54 ± 1.10	0.70	0.35 to 1.05	<0.001	0.80
Platelet count (cells/mm³)	214,760 ± 59,723	209,400 ± 91,134	-5,360	-36,000.15 to 25,280.15	0.729	-0.07

Habitual smokers demonstrated significantly higher erythrocytic indices than non-smokers. Mean RBC count was higher in smokers by 0.42 million/µL, with the 95% CI ranging from 0.20 to 0.64, and the effect size was moderate to large. Hemoglobin was also higher among smokers by 0.70 g/dL, with a 95% CI of 0.35 to 1.05 and a similarly strong effect size. These findings indicate a consistent smoking-associated increase in oxygen-carrying cellular parameters, compatible with compensatory erythropoietic response to chronic smoke exposure. In contrast, WBC count was higher among smokers by 536.50 cells/mm³, but this difference was not statistically significant and the confidence interval crossed zero. Platelet count was slightly lower among smokers by 5,360 cells/mm³, but the difference was minimal, statistically non-significant, and clinically weak based on the very small effect size.

Table 4. Comparison of Serum Electrolytes Between Habitual Smokers and Non-Smokers

Variable	Non-Smokers (n=50), Mean ± SD	Habitual Smokers (n=50), Mean ± SD	Mean Difference	95% CI for Difference	p-value	Cohen's d
Sodium (mmol/L)	137.0 ± 3.12	138.0 ± 4.47	1.00	-0.53 to 2.53	0.198	0.26
Potassium (mmol/L)	4.20 ± 0.42	4.60 ± 0.37	0.40	0.24 to 0.56	<0.001	1.01
Chloride (mmol/L)	102.8 ± 2.7	102.6 ± 3.9	-0.20	-1.53 to 1.13	0.766	-0.06

Among serum electrolytes, potassium showed the clearest between-group difference. Habitual smokers had a mean serum potassium level of 4.60 ± 0.37 mmol/L compared with 4.20 ± 0.42 mmol/L in non-smokers, producing a mean difference of 0.40 mmol/L, a 95% CI of 0.24 to 0.56, and a large effect size. This indicates a statistically robust elevation of potassium among smokers within the measured sample. Sodium was 1.00 mmol/L higher among smokers, but the confidence interval crossed zero and the difference was not statistically significant. Chloride levels were almost identical between groups, differing by only -0.20 mmol/L, indicating no meaningful smoking-related difference in chloride concentration.

Habitual smokers showed a more atherogenic lipid pattern than non-smokers. Mean total cholesterol was higher by 21.00 mg/dL in smokers, with a statistically significant 95% CI of 4.24 to 37.76 and a moderate effect size. Triglycerides were also higher among smokers by 34.00 mg/dL, with a 95% CI of 7.01 to 60.99 and a moderate effect size. HDL-C showed the strongest lipid-related difference, being 7.40

mg/dL lower in smokers than in non-smokers, with the entire confidence interval below zero and a large effect size. LDL-C was 14.00 mg/dL higher among smokers, but the confidence interval narrowly crossed zero and the p-value was borderline. Overall, the lipid profile suggests that habitual smoking is associated with higher total cholesterol and triglycerides, markedly lower HDL-C, and a trend toward higher LDL-C.

Table 5. Comparison of Lipid Profile Between Habitual Smokers and Non-Smokers

Variable	Non-Smokers (n=50), Mean ± SD	Habitual Smokers (n=50), Mean ± SD	Mean Difference	95% CI for Difference	p-value	Cohen's d
Total cholesterol (mg/dL)	160.0 ± 34.0	181.0 ± 49.0	21.00	4.24 to 37.76	0.015	0.50
Triglycerides (mg/dL)	131.0 ± 54.0	165.0 ± 79.4	34.00	7.01 to 60.99	0.014	0.50
HDL-C (mg/dL)	40.6 ± 7.7	33.2 ± 7.3	-7.40	-10.38 to -4.42	<0.001	-0.99
LDL-C (mg/dL)	101.0 ± 31.3	115.0 ± 40.0	14.00	-0.26 to 28.26	0.054	0.39

Table 6. Comparison of Serum Cortisol Between Habitual Smokers and Non-Smokers

Variable	Non-Smokers (n=50), Mean ± SD	Habitual Smokers (n=50), Mean ± SD	Mean Difference	95% CI for Difference	p-value	Cohen's d
Cortisol (µg/dL)	15.8 ± 6.4	16.8 ± 8.7	1.00	-2.03 to 4.03	0.514	0.13

Serum cortisol levels did not differ significantly between habitual smokers and non-smokers. Smokers had a mean cortisol level of 16.8 ± 8.7 µg/dL compared with 15.8 ± 6.4 µg/dL among non-smokers, corresponding to a mean difference of only 1.00 µg/dL. The 95% confidence interval ranged from -2.03 to 4.03 and crossed zero, while the effect size was very small. These findings suggest that habitual smoking was not associated with a measurable difference in basal serum cortisol concentration in this sample.

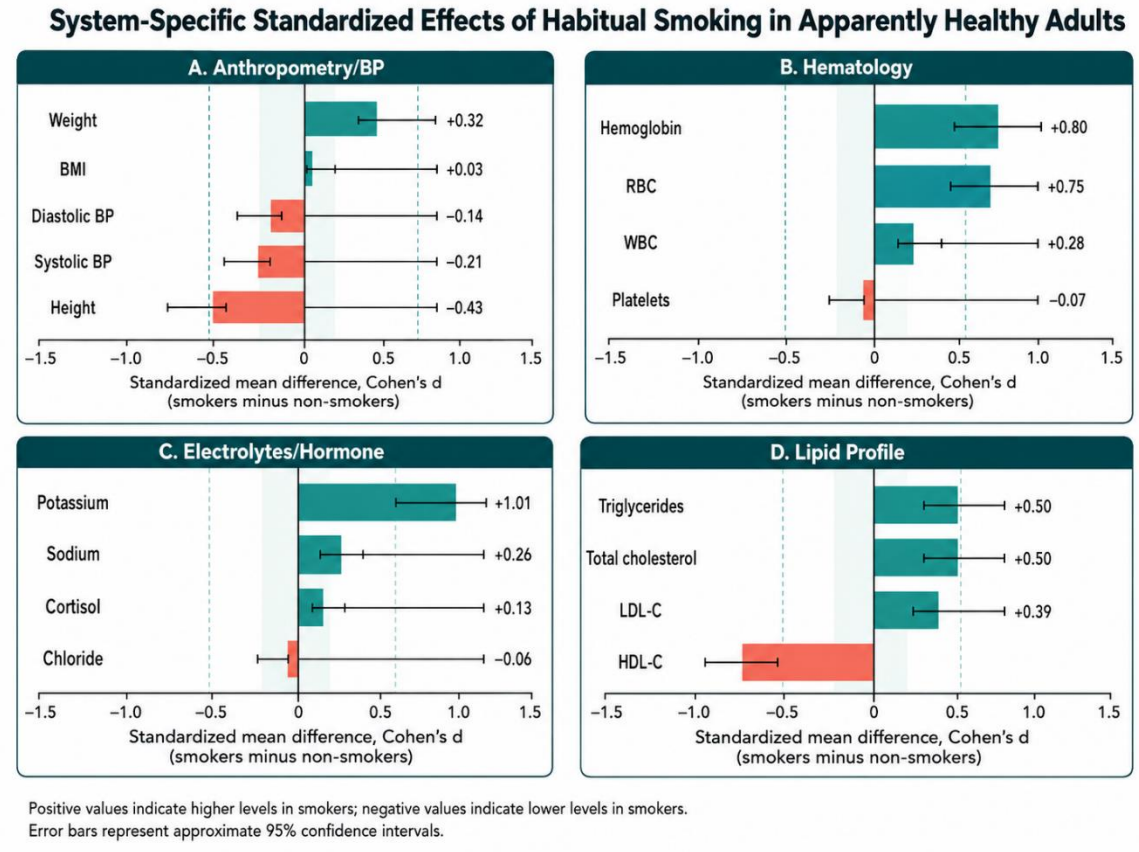

Figure 1 System-Specific Standardized Effects of Habitual Smoking in Apparently Healthy Adults

The panelled effect-size visualization demonstrates that habitual smoking was associated with selective rather than uniform systemic alterations, with the largest standardized differences observed for

potassium, HDL-C, hemoglobin, and RBC count. Potassium showed the strongest positive smoker–non-smoker contrast (Cohen's d = 1.01), followed by hemoglobin (d = 0.80) and RBC count (d = 0.75), indicating clinically meaningful elevation in erythrocytic and electrolyte parameters among smokers. In contrast, HDL-C showed a large negative standardized difference (d = -0.99), reflecting a marked reduction in the protective lipid fraction among smokers. Total cholesterol and triglycerides both showed moderate positive effects (d = 0.50 each), while LDL-C showed a smaller borderline elevation (d = 0.39). WBC count, sodium, chloride, platelet count, BMI, blood pressure, and cortisol clustered near the null zone, supporting the interpretation that habitual smoking in this sample was most strongly linked to compensatory erythrocytic changes and an atherogenic lipid pattern rather than broad anthropometric, hormonal, or blood-pressure differences.

Overall, habitual smoking was associated with selective hematological and biochemical alterations rather than uniform changes across all measured parameters. The strongest smoking-related differences were observed for potassium, hemoglobin, RBC count, and HDL-C. Smokers had significantly higher RBC count, hemoglobin, potassium, total cholesterol, and triglycerides, while HDL-C was significantly lower. WBC count, platelet count, sodium, chloride, BMI, blood pressure, and cortisol did not show statistically significant differences. These results suggest that habitual smoking in apparently healthy adults is linked primarily with compensatory erythrocytic changes and an adverse lipid profile, with a marked reduction in protective HDL-C and a significant increase in serum potassium.

DISCUSSION

This cross-sectional study evaluated the association of habitual cigarette smoking with hematological indices, lipid profile, serum electrolytes, cortisol, anthropometric status, and blood pressure among apparently healthy adults from Islamabad and Rawalpindi. The findings indicate that habitual smoking was associated with selective systemic alterations rather than uniform changes across all measured biological domains. Smokers demonstrated significantly higher red blood cell count, hemoglobin concentration, serum potassium, total cholesterol, and triglyceride levels, together with markedly lower HDL-C. In contrast, WBC count, platelet count, sodium, chloride, BMI, systolic and diastolic blood pressure, and basal serum cortisol did not differ significantly between smokers and non-smokers. This pattern suggests that the measurable effects of habitual smoking in this sample were most evident in erythrocytic and lipid-related parameters, with a distinct elevation in potassium, whereas anthropometric, basal hormonal, and most routine electrolyte measures remained relatively stable.

The absence of meaningful differences in BMI and blood pressure suggests that the smoker and non-smoker groups were broadly comparable in baseline anthropometric profile. This comparability strengthens interpretation of the hematological and biochemical findings by reducing the likelihood that gross body-size differences alone explain the observed between-group patterns. Similar findings have been reported in a Sri Lankan study in which smoking was not strongly associated with major anthropometric differences, although modest blood pressure variation was observed in some smoker groups (38). The present study did not show higher blood pressure among smokers, which may reflect the relatively young age distribution of the sample, limited exposure stratification, variation in smoking duration, or the use of resting single-occasion measurements rather than repeated or ambulatory blood pressure assessment. Therefore, while the current data do not demonstrate a significant blood pressure difference, they should not be interpreted as evidence that smoking lacks cardiovascular effects, because blood pressure represents only one component of smoking-related cardiovascular risk.

The significantly higher RBC count and hemoglobin concentration among habitual smokers are biologically plausible and consistent with previous literature reporting increased erythrocytic indices in smokers (12,13,16). Chronic exposure to carbon monoxide in cigarette smoke increases carboxyhemoglobin formation, reduces effective oxygen delivery, and may stimulate compensatory erythropoiesis, resulting in higher red cell mass and hemoglobin concentration (39). In the present study,

the magnitude of difference was clinically relevant, with smokers showing a mean RBC count higher by 0.42 million/μL and hemoglobin higher by 0.70 g/dL. These findings support the concept that even apparently healthy adult smokers may develop measurable hematological adaptation to chronic smoke-related hypoxic stress. However, WBC count did not differ significantly between groups, despite being numerically higher among smokers. This differs from studies reporting smoking-related leukocytosis but aligns with other findings showing limited or variable WBC differences depending on exposure intensity, inflammatory status, and population characteristics (15,42). Platelet count was also not significantly different between groups after correction of the apparent reporting error in the original table, where the smoker platelet value should be interpreted as 209,400 rather than 20,940 cells/mm³ based on the narrative and standard biological plausibility. Previous studies have reported inconsistent platelet findings in smokers, with some showing altered platelet count or clot dynamics and others reporting limited differences in platelet number despite functional changes (40,41). Thus, platelet function may be more sensitive than platelet count for detecting smoking-related thrombogenic risk, but functional assays were not included in this study.

The lipid profile findings indicate a clear atherogenic pattern among habitual smokers. Smokers had higher total cholesterol and triglycerides and substantially lower HDL-C than non-smokers, while LDL-C showed a positive but borderline difference. These results are consistent with large epidemiological and clinical studies demonstrating that smoking is associated with dyslipidemia, particularly lower HDL-C and higher triglyceride-rich lipoprotein burden (19,43–45). The reduction in HDL-C is especially important because HDL-C is involved in reverse cholesterol transport, anti-inflammatory activity, and vascular protection. In the present study, HDL-C was lower by 7.40 mg/dL among smokers, representing one of the strongest observed differences. The mechanisms underlying smoking-related dyslipidemia may include nicotine-induced lipolysis, increased free fatty acid flux, hepatic lipid dysregulation, oxidative modification of lipoproteins, endothelial dysfunction, and inflammatory activation (20,21). Evidence that lipid parameters, particularly triglycerides and HDL-C, may improve after smoking cessation supports the clinical relevance and potential reversibility of these findings (46,47). Therefore, the observed lipid pattern reinforces the importance of smoking cessation counseling not only for respiratory health but also for early cardiometabolic risk reduction.

Among serum electrolytes, potassium showed a statistically significant elevation in smokers, while sodium and chloride did not differ significantly. The difference in potassium was 0.40 mmol/L, with a large standardized effect size, suggesting a selective electrolyte pattern rather than generalized electrolyte disturbance. Previous studies have produced conflicting findings regarding electrolyte changes in smokers. Some reports found no significant differences in serum electrolytes between smokers and non-smokers, whereas others documented altered sodium, potassium, or magnesium levels depending on the population, timing of measurement, smoking intensity, and analytical methods (28,31,48,49). The present potassium finding contrasts with some reports but supports the broader view that smoking may influence electrolyte regulation under certain physiological or exposure conditions. Possible explanations include catecholamine-mediated shifts, acid–base effects, renal handling differences, hemolysis-related pre-analytical influence, or acute timing of last cigarette exposure, although these mechanisms were not directly tested in the current study. Because potassium plays a critical role in cardiac electrophysiology, this finding warrants cautious interpretation and further investigation using stricter control of recent smoking, hydration status, renal function, medication use, and sample hemolysis.

Serum cortisol did not differ significantly between habitual smokers and non-smokers, suggesting that basal cortisol concentration was not substantially altered in this sample. This finding should be interpreted in the context of inconsistent prior evidence. Some studies have reported higher cortisol levels among smokers, suggesting activation of stress pathways, while others have reported reduced cortisol, potentially reflecting chronic hypothalamic–pituitary–adrenal axis adaptation or blunted responsiveness after repeated nicotine exposure (50,54). The Pennsylvania Adult Smoking Study also

suggested that basal cortisol may not be consistently associated with cigarette consumption or nicotine biomarkers, partly because cortisol is influenced by diurnal rhythm, psychosocial stress, dependence level, sleep, and recent nicotine exposure (51). Experimental and cue-reactivity studies further show that smoking-related cortisol responses may be more apparent after acute smoking, cue exposure, or stress provocation than in a single basal measurement (52,53). Therefore, the non-significant cortisol result in this study does not exclude smoking-related stress-axis effects; rather, it indicates that a single basal cortisol assessment may be insufficient to characterize HPA-axis dysregulation in smokers.

The integrated assessment of hematological, lipid, electrolyte, and cortisol parameters adds value because it shows that habitual smoking may produce a combined biological profile involving erythrocytic compensation, atherogenic lipid alteration, and selective potassium elevation. These findings are clinically meaningful because smokers may appear anthropometrically similar to non-smokers while still demonstrating measurable biochemical changes relevant to cardiovascular and metabolic risk. The results also support the use of routine laboratory parameters as accessible markers for early risk communication in smoking cessation programs. However, the cross-sectional design prevents causal inference, and the study cannot determine whether smoking directly caused the observed differences or whether unmeasured lifestyle, dietary, occupational, environmental, or genetic factors contributed to them. The sample size was modest, recruitment was limited to Islamabad and Rawalpindi, and smoking exposure was categorized by smoker status without detailed dose-response stratification by pack-years, duration, nicotine dependence, or time since last cigarette. Important potential confounders such as diet, physical activity, socioeconomic status, passive smoke exposure, hydration status, renal function, medication use, and inflammatory conditions were not fully adjusted in the reported analysis. In addition, cortisol interpretation was limited by the absence of standardized sampling time and repeated measurements, while platelet interpretation was restricted to platelet count rather than platelet activation or clotting function. Future studies should use larger multicenter samples, exposure quantification by pack-years and biochemical verification, multivariable adjustment, repeated cortisol sampling, renal and hemolysis checks for electrolyte interpretation, and longitudinal designs to determine whether the observed abnormalities improve after smoking cessation.

CONCLUSION

Habitual cigarette smoking among apparently healthy adults was associated with selective hematological and biochemical alterations, particularly higher RBC count, hemoglobin concentration, serum potassium, total cholesterol, and triglycerides, together with markedly lower HDL-C, while WBC count, platelet count, sodium, chloride, BMI, blood pressure, and basal cortisol showed no significant differences. These findings suggest that smoking may induce early systemic changes related to compensatory erythropoiesis and atherogenic lipid disturbance even in adults without apparent chronic disease. The results reinforce the importance of routine laboratory monitoring and smoking cessation interventions for reducing future cardiovascular and metabolic risk, while also highlighting the need for larger, exposure-stratified and longitudinal studies to clarify causality, dose-response relationships, and reversibility after cessation.

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