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SMOKING AND HUMAN BODY ELECTROLYTE LEVELS? EVALUATING WITH AUTOMATED ATELLICA CH ANALYZER

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Abstract

Smoking is a leading preventable cause of morbidity and mortality, yet its effects on electrolyte balance remain underexplored. By examining how smoking affects the body's levels of important electrolytes, sodium, potassium, and lithium, this study fills a scientific vacuum by collecting data from Karachi, Pakistan. Blood samples from smokers and non-smokers were analyzed using the Atellica CH Analyzer to determine the electrolyte concentrations. The findings showed that compared to non-smokers, smokers had considerably higher sodium and lower potassium levels while lithium levels remained the same, indicating a substantial disturbance in electrolyte balance. Additionally, the study discovered a relationship between the degree of these imbalances and the intensity of smoking, indicating that heavier smokers may be more susceptible to electrolyte disruptions. These findings have significant clinical relevance, emphasizing the necessity for physicians and other healthcare professionals to keep an eye on smoker electrolyte levels and to think about dietary recommendations to reduce health risks. This study advances the knowledge of the biochemical effects of smoking. It emphasizes the significance of treating electrolyte imbalances in public health campaigns meant to lessen the health risks associated with smoking.

INTRODUCTION

Globally, smoking is the leading behavioural risk factor for mortality, accounting for more than 175 million deaths and countless years of life lost from past two decades [1]. It usually involves breathing in smoke from burning tobacco through the mouth and typically into the lungs [2]. Cigarettes are the most used product to smoke, although other products are also used including cigars, pipes, vapes, etc. Recent studies indicated that it has negative impacts on cardiovascular, respiratory, renal, reproductive, and nervous system. Significant health problems, such as heart arrhythmias, muscular weakness, and neurological disorders, can result from imbalances in vital ions [3, 4].

Smoking effects on electrolyte balance have not been well investigated in surveys [5]. Electrolytes i.e. sodium (Na), potassium (K), and lithium (Li), are essential for preserving fluid equilibrium, general metabolic activities, and cellular function. Human body utilizes sodium, and potassium, as its primary electrolytes in the extracellular and intracellular fluid compartment. It oversees controlling the cell membrane potential and preserving the extensiveness of fluid component [6]. According to a study, serum sodium, and potassium are the factors determining the cardiac membrane's electrophysiological characteristics [7]. Hyponatremia is known to be the most recurrent electrolyte abnormality while hypernatremia is less common. It is diagnosed when the sodium level in serum is less than 136 mmol/L [8]. When potassium levels in the serum are lower than 3.5 mmol/L, it results in hypokalemia. Serum potassium imbalances may lead to arrhythmias of the heart [6, 9]. Muscle twitching, cramps, and fatigue or generalized weakness are signs of hypo and hyperkalemia [10, 11]. Lithium has distinct, independent, and demonstrated anti-suicide action in addition to its mood-stabilizing properties. Compared to placebo, treatment with Lithium could lower the probability of death and suicide in patients with mood disorders by up to half percentage, according to a review [12]. It has also been linked to remarkable neuroprotective and antiviral properties, evident from literature [13, 14]. Furthermore, it has recently been suggested that lithium be used as a possible treatment for CoViD-19 [15]. Therefore, understanding the effects of smoking on these vital electrolytes provides critical insights into the mechanisms underlying smoking-related diseases.

This observational cross-sectional study aims to examine or investigate how smoking effects body electrolyte levels, with a particular focus on key electrolytes including sodium, potassium, and Lithium utilizing automated atellica CH analyzer. This machine has been well optimized for assessing and evaluating clinical lab parameters and toxicology. Our goal is to give an extensive overview of how smoking influences body homeostasis, determine health outcome, and proposed the evidence or recommendations for clinicians to gauge and control its optimum level. By achieving these objectives, the study seeks to improve understanding of the biochemical effects, underlying mechanisms, guide medical procedures or interventions, and endorse public health initiatives that will reduce the health consequences associated with smoking.

MATERIALS AND METHODS

MATERIALS USED

In this study, various materials and equipment were utilized to ensure accurate and reliable results. To accurately assess the effects of smoking on electrolyte levels, high quality equipment was employed along with maintaining strict protocols. Key materials that were utilized during the execution of study are:

Disposable gloves, single-use disposable syringes for blood samples, collection tubes containing anti-coagulant, centrifuge machine, ion selective electrodes, calibration solutions, phosphate-buffered saline, and the primary equipment Atellica CH Analyzer.

DESIGN OF STUDY

The study uses an observational cross-sectional methodology to look at how smoking affects an adult's electrolyte levels. The population, which was included consists of both smokers and non-smokers and is aged from 18 to 50 above. The purpose was to compare these two groups electrolyte levels and pinpoint any notable variations.

ELIGIBILITY CRITERIA

An extensive survey form was created to record patient data. The form contains:

- ➢ Details about age, and gender.
- ➢ Current smoking status (smoker or non-smoker)
- ➢ Smoking duration and intensity (pack-years)
- ➢ Medical history (drugs, chronic illnesses)

SAMPLE COLLECTION

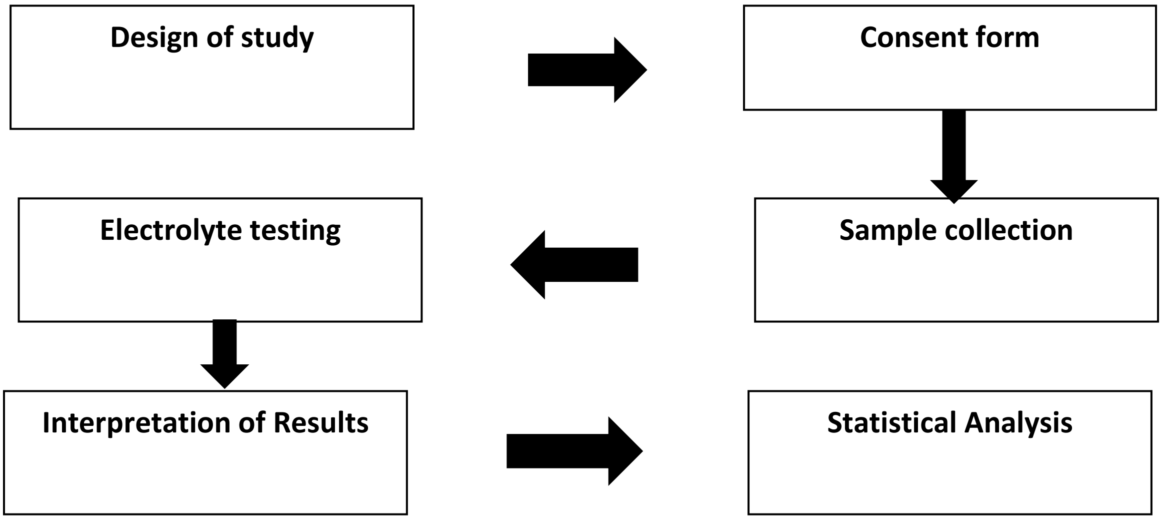
Participants had venous blood samples taken to verify baseline electrolyte levels were assessed. To prevent contamination, aseptic procedures was followed correctly and labeled with distinctive IDs.

ELECTROLYTES TESTING

An automated electrolyte analyzer, Atellica CH module, was used to measure the electrolyte levels. Key electrolyte concentrations, such as those of sodium (Na^+), potassium (K^+), and lithium (Li) were measured by this apparatus.

INTERPRETATION OF RESULTS

Quantitative information on each electrolyte's concentration in the blood samples was provided by the test findings.



PROCEDURE

The blood samples for electrolyte levels were tested using the Atellica CH Analyzer which is an advanced clinical chemistry analyzer. This provided crucial information for this investigation into how smoking affects electrolyte homeostasis. To achieve accurate and trustworthy data, this analyzer uses advanced methods like spectrophotometry and ion-selective electrodes (ISE). Spectrophotometry is the process of passing light through a sample to measure the transmission or absorbance at particular wavelengths, which corresponds to the analyte's concentration. The analyzer uses ion-selective electrodes to measure electrolytes such as lithium, potassium, and sodium. These electrodes are sensors that respond only to the ion of interest, enabling precise and direct measurements [16].

To guarantee accuracy and consistency, the Atellica CH Module electrolyte level testing process consists of multiple phases. First, participants blood samples were taken using normal phlebotomy techniques. After that, the samples were centrifuged to extract the serum or plasma, which is needed for analysis, from the blood cells. To ensure precise tracking and analysis, these prepared samples were fed onto the analyzer using sample tubes. The analyzer was then configured with the sample identification and test settings. The accurate reagents needed for every particular test, including those for determining the levels of sodium, potassium, and lithium, were automatically dispensed by the analyzer.

Using ion-selective electrodes for sodium, potassium, and lithium, the analyzer conducts the required tests during the measurement procedure. Using pre-calibrated algorithms, the light absorbance or electrode response was monitored and translated into electrolyte concentrations. The raw data was then processed by the Atellica CH Analyzer, which also performs periodic internal quality control sample runs to verify performance and reliability. The appropriate calibrations and quality control checks were applied to assure accuracy [70].

The effect of smoking on electrolyte balance was evaluated by comparing the measured electrolyte levels between smokers and non-smokers. To evaluate the clinical implications and the significance of the results, statistical analysis was done. This research guarantees excellent accuracy, dependability, and efficiency in electrolyte level measurement by employing the Atellica CH Module, offering solid information to comprehend the biochemical effects of smoking on human health.

FIGURE 1: THE AUTOMATED ATELLICA CH ANALYZER MACHINE

ETHICAL FRAMEWORK

The study protocol received ethical approval from the **Ethical Institutional Review Board (EIRB)** of Sir Syed University of Engineering and Technology, Karachi, under approval dated April 04, 2024. The investigation was conducted in full compliance with the ethical principles of the Declaration of Helsinki. Data confidentiality was ensured by anonymizing all identifiable patient information prior to analysis, and all records were securely stored with access limited to the research investigators.

STATISTICAL ANALYSIS

Statistical analysis was carried out using IBM SPSS version 26. Descriptive statistics (mean and standard deviation) to summarize the categorical variable data, such as gender, sample of electrolytes (Na, K, Li) in smokers, and non-smokers utilizing frequency tables were executed. Gender was analyzed as a grouped variable to examine distribution patterns across different cohorts. Comparative analysis across all sample groups and gender categories was conducted using chi-square tests, and a p-value of less than 0.05 was considered statistically significant. No imputation for missing data was necessary, as incomplete records were excluded from the dataset prior to analysis. No sensitivity analyses or adjustments for confounders were performed, as the study design was observatory in nature and based solely on descriptive and univariate comparisons. Finding meaningful changes in electrolyte levels between smokers and non-smokers was the main goal of the interpretation. The investigation also looks at the potential roles that smoking-related electrolyte imbalances may have in the development of disease.

RESULTS

Samples of smokers and non-smokers in both males and females from all age groups starting from 18 to 50 above were taken for testing *(Table 1).* Our cross-sectional survey, revealed that there were fewer female smokers than males. We accurately measure the concentrations of important electrolytes, such as lithium, potassium, and sodium, in the blood samples of smokers compared to non-smokers.

TABLE 1: OVERALL RESULTS OF SMOKERS AND NON-SMOKERS IN BOTH GENDERS.

Gender	**Mean Sodium Levels**	**Mean Potassium Levels**	**Mean Lithium Levels**
Male Non-Smokers	140.35 mEq/l	4.32 mEq/l	<0.10 mEq/l
Female Non-Smokers	140.75 mEq/l	4.23 mEq/l	<0.10 mEq/l
Male Smokers	143.56 mEq/l	3.82 mEq/l	<0.10 mEq/l
Female Smokers	144.4 mEq/l	3.91 mEq/l	<0.10 mEq/l

ELECTROLYTE LEVEL OF NON-SMOKERS

The data shows that electrolyte levels mostly stay within the expected normal ranges for both male and female non-smokers. In particular, potassium levels in non-smoking males fall between 3.7 and 5.0 mEq/L and sodium levels range between 136 and 145 mEq/L. Similar trends are seen in female non-smokers, whose potassium and sodium levels range from 3.6 to 5.0 mEq/L and 136 to 146 mEq/L, respectively ***(Figure 2 and 3).*** All samples have lithium concentrations that are consistently less than 0.10 mEq/L, suggesting that these people do not significantly contain lithium ***(Supplementary table 1 and 2)***. The regularity of potassium and sodium levels within the normal ranges implies that nonsmokers typically keep their electrolyte profiles in balance. The fact that there are no notable departures from the normal range and no corresponding medical conditions or comorbid supports the notion that a nonsmoking lifestyle supports stable electrolyte levels. This stability supports appropriate cellular activity, fluid balance, and nerve transmission, all essential for general health.

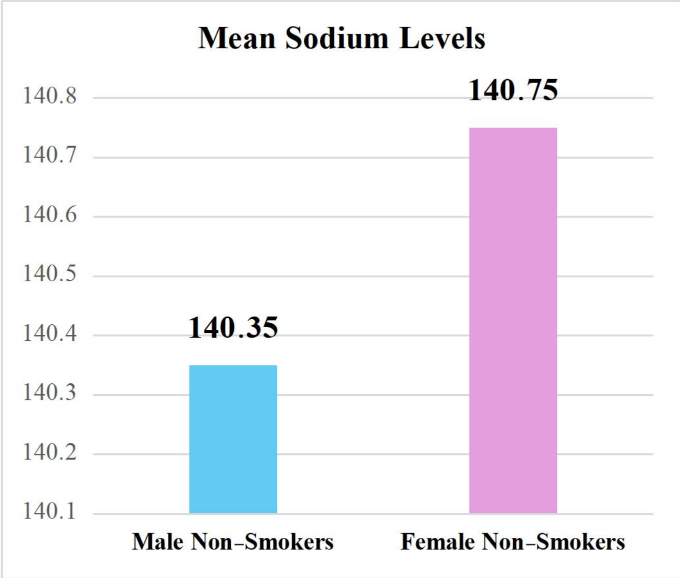


FIGURE 2: MEAN SODIUM LEVELS OF NON-SMOKERS IN BOTH GENDERS.

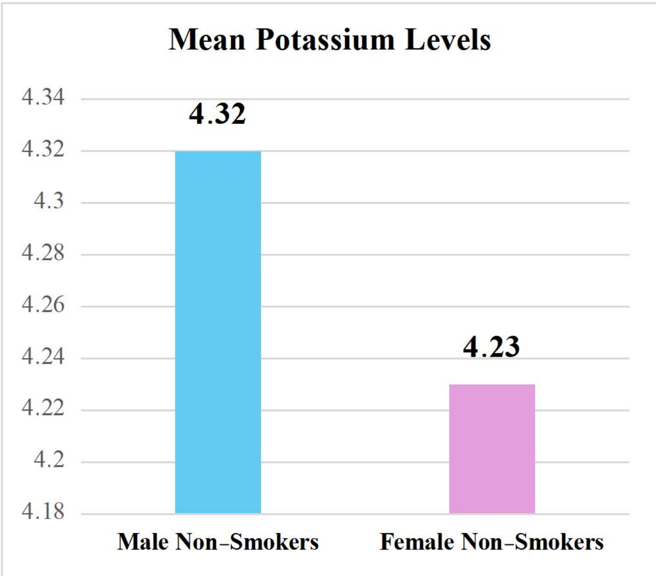


FIGURE 3: MEAN POTASSIUM LEVELS OF NON-SMOKERS IN BOTH GENDERS.

ELECTROLYTE LEVEL OF SMOKERS

The medical histories and electrolyte levels of 25 male smokers are summarised in (*Table 2*). Sample 1 demonstrates balance with potassium at 3.1 mEq/L and sodium at 146 mEq/L, but lithium is still low (<0.10 mEq/L); the patient has diabetes. Sample 2 has balanced sodium (142 mEq/L) and potassium (3.9 mEq/L) levels with average lithium levels. Sample 3, on the other hand, has high sodium (149 mEq/L) and potassium (3.1 mEq/L) levels combined with low lithium levels. Sample 4 had balanced sodium (140 mEq/L) but uneven potassium (2.9 mEq/L); the patient has both TB and hypertension. Sample 5 shows a patient with hypertension who has low lithium, balanced sodium (140 mEq/L), and imbalanced potassium (3.1 mEq/L). Samples 6 and 7 sustain low lithium with balanced potassium and sodium levels. Sample 8 exhibits low lithium with abnormal potassium (5.8 mEq/L) and sodium (149 mEq/L) levels, suggesting kidney problems. Sample 9 exhibits balanced sodium (136 mEq/L) and potassium (3.7 mEq/L) levels with average lithium levels. Sample 10 shows anomalies in potassium (5.4 mEq/L) and sodium (152 mEq/L) in addition to low lithium in a patient with renal and diabetes. Lithium levels in other samples remain variable, and several patients have kidney issues, diabetes, and high blood pressure.

TABLE 2: LEVELS OF ELECTROLYTES IN MALE SMOKERS

No. of Samples	Sodium Levels	Potassium Levels	Lithium Levels
Sample 1	146 mEq/l	**3.1 mEq/l**	<0.10 mEq/l
Sample 2	142 mEq/l	3.9 mEq/l	<0.10 mEq/l
Sample 3	**149 mEq/l**	**3.1 mEq/l**	<0.10 mEq/l
Sample 4	140 mEq/l	**2.9 mEq/l**	<0.10 mEq/l
Sample 5	140 mEq/l	**3.1 mEq/l**	<0.10 mEq/l
Sample 6	137 mEq/l	4.1 mEq/l	<0.10 mEq/l
Sample 7	143 mEq/l	4.1 mEq/l	<0.10 mEq/l
Sample 8	**149 mEq/l**	**5.8 mEq/l**	<0.10 mEq/l
Sample 9	136 mEq/l	3.7 mEq/l	<0.10 mEq/l
Sample 10	**152 mEq/l**	**5.4 mEq/l**	<0.10 mEq/l
Sample 11	**150 mEq/l**	4.0 mEq/l	<0.10 mEq/l
Sample 12	139 mEq/l	**3.3 mEq/l**	<0.10 mEq/l
Sample 13	**150 mEq/l**	**3.0 mEq/l**	<0.10 mEq/l
Sample 14	**151 mEq/l**	**3.4 mEq/l**	<0.10 mEq/l
Sample 15	139 mEq/l	4.8 mEq/l	<0.10 mEq/l

Sample 16	**155 mEq/l**	**3.1 mEq/l**	<0.10 mEq/l
Sample 17	136 mEq/l	3.9 mEq/l	<0.10 mEq/l
Sample 18	**149 mEq/l**	**5.5 mEq/l**	<0.10 mEq/l
Sample 19	**153 mEq/l**	**2.0 mEq/l**	<0.10 mEq/l
Sample 20	146 mEq/l	**3.2 mEq/l**	<0.10 mEq/l
Sample 21	137 mEq/l	4.5 mEq/l	<0.10 mEq/l
Sample 22	**150 mEq/l**	**2.8 mEq/l**	<0.10 mEq/l
Sample 23	140 mEq/l	3.4 mEq/l	<0.10 mEq/l
Sample 24	**131 mEq/l**	3.4 mEq/l	<0.10 mEq/l
Sample 25	**129 mEq/l**	**2.0 mEq/l**	<0.10 mEq/l

Comparing the electrolyte levels of 15 female smokers, (***Table 3)*** reveals that their lithium levels are consistently low, usually less than 0.10 mEq/L. Sample 1: The patient has osteoporosis and hypertension; potassium is 2.8 mEq/L (imbalanced) and sodium is 145 mEq/L (balanced). Sample 2 has balanced potassium (5.0 mEq/L) and sodium (141 mEq/L) levels along with average lithium values. Sample 4 shows an unbalanced potassium level of 5.9 mEq/L, an average sodium level of 150 mEq/L, and a patient with both hypertension and diabetes. Sample 11: This patient has kidney problems; low lithium, balanced potassium (3.8 mEq/L), and imbalanced sodium (154 mEq/L).

TABLE 3: LEVELS OF ELECTROLYTES IN FEMALE SMOKERS

No. of Samples	Sodium Levels	Potassium Levels	Lithium Levels
Sample 1	145 mEq/l	**2.8 mEq/l**	<0.10 mEq/l
Sample 2	141 mEq/l	5.0 mEq/l	<0.10 mEq/l
Sample 3	**148 mEq/l**	**3.1 mEq/l**	<0.10 mEq/l
Sample 4	**150 mEq/l**	**5.9 mEq/l**	<0.10 mEq/l
Sample 5	140 mEq/l	4.5 mEq/l	<0.10 mEq/l
Sample 6	137 mEq/l	4.2 mEq/l	<0.10 mEq/l
Sample 7	139 mEq/l	4.3 mEq/l	<0.10 mEq/l

Sample 8	140 mEq/l	3.9 mEq/l	<0.10 mEq/l
Sample 9	138 mEq/l	4.0 mEq/l	<0.10 mEq/l
Sample 10	146 mEq/l	4.7 mEq/l	<0.10 mEq/l
Sample 11	**154 mEq/l**	3.8 mEq/l	<0.10 mEq/l
Sample 12	139 mEq/l	3.7 mEq/l	<0.10 mEq/l
Sample 13	136 mEq/l	3.9 mEq/l	<0.10 mEq/l
Sample 14	**148 mEq/l**	**3.1 mEq/l**	<0.10 mEq/l
Sample 15	140 mEq/l	3.7 mEq/l	<0.10 mEq/l

Overall, electrolyte levels of smoker vary significantly; male values range from 2.0 to 5.8 mEq/L for potassium and from 129 to 155 mEq/L for sodium. The range of sodium and potassium levels in females is 136–154 mEq/L and 2.8–5.9 mEq/L, respectively *(Figure 4 and 5*). Numerous of these anomalies are connected to underlying illnesses such as kidney problems, diabetes, and hypertension. However aberrant potassium and sodium levels can also arise in the absence of clear-cut illnesses, indicating that smoking may be a factor in these imbalances. This emphasizes how smoking may affect the body's capacity to control salt and potassium, which may have serious consequences for the health of the kidneys and heart. This revised version is shorter without sacrificing any of the original meaning.

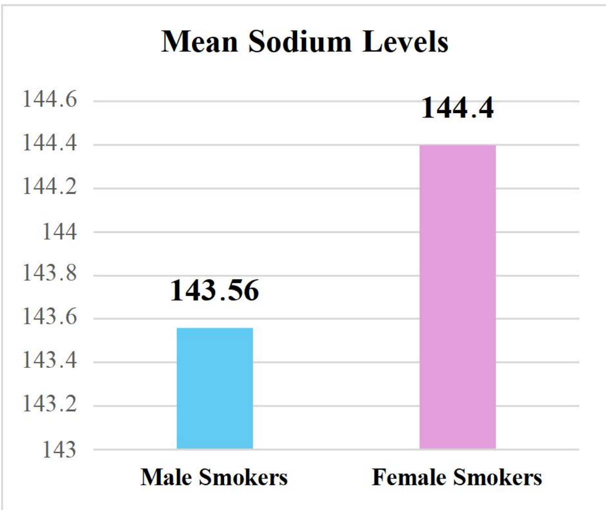


FIGURE 4: MEAN SODIUM LEVELS OF SMOKERS IN BOTH GENDERS.

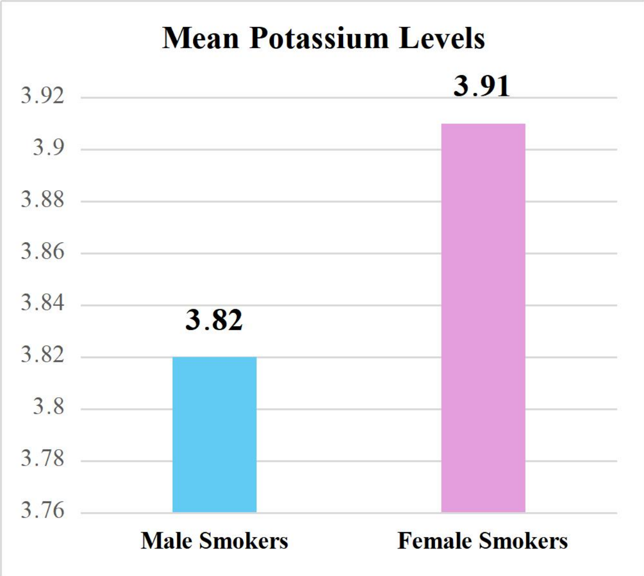


FIGURE 5: MEAN POTASSIUM LEVELS OF SMOKERS IN BOTH GENDERS

COMPARATIVE ANALYSIS OF SMOKERS AND NON-SMOKERS

There is a noticeable variation between the average electrolyte levels of smokers and non-smokers. The average potassium level in male non-smokers is 4.32 mEq/L while the average sodium level is 140.35 mEq/L. The average values for potassium and sodium in non-smoking females are 4.23 mEq/L and 140.75 mEq/L, respectively. These averages, which fall between the expected ranges, point to a steady electrolyte balance among nonsmokers. However, the average potassium level of male smokers falls to 3.82 mEq/L, while their average sodium level is greater at 143.56 mEq/L. With an average potassium level of 3.91 mEq/L and a sodium level of 144.4 mEq/L, female smokers exhibit a similar tendency. These higher sodium and lower potassium values suggest that smoking may be a factor in an electrolyte imbalance, depicted by STD results *(Supplemental Figure 1).* While smokers' decreased potassium levels may raise their risk of cardiovascular illnesses, their greater salt levels may be linked to an increased risk of hypertension. The study shows that smoking affects electrolyte balance in a significant way and may have negative health effects. This emphasizes how critical it is to comprehend smoking's wider health effects, especially concerning electrolyte management, which is essential to many physiological functions.

DISCUSSION

This study examined the effects of cigarette smoking on serum electrolyte levels (sodium, potassium, lithium) in adults aged 18–50 years using the automated Atellica CH Analyzer. Our findings revealed that, smokers across both the gender group exhibited significantly higher mean serum sodium levels (males: 143.56; females: 144.4) mEq/L and lower mean serum potassium levels (males: 3.82; females: 3.91) mEq/L compared to non-smokers (sodium: males 140.35, females 140.75; potassium: males 4.32, females 4.23) mEq/L. Lithium levels remained consistently low (< 0.10) mEq/L across both the groups. A dose-response relationship emerged, with heavier smokers demonstrating more pronounced electrolyte imbalances. Comorbidities such as hypertension, diabetes, and kidney disease were frequently associated with aberrant electrolyte levels in smokers.

The elevated serum sodium observed in smokers aligns with some prior studies such as, Eliasson et al. found significantly higher serum sodium in chronic smokers than in non-tobacco users [18]. Similarly, animal study reported hypernatremia i.e., increased sodium levels, associated with tobacco exposure [19]. Furthermore, chronic smoking stimulates vasopressin secretion, promoting renal water retention and concentrated sodium levels as evident from a study [20]. However, this finding contrasts with epidemiological study [21], which found virtually identical mean serum sodium levels in smokers and non-smokers probably attributed to syndrome of inappropriate antidiuretic hormone (SIADH) [20]. The discrepancy may stem from methodological differences.

In contrast to sodium, serum potassium was significantly lower in smokers in our data. The lower potassium levels in smokers support prior evidence of smoking-induced hypokalemia. Catecholamine release from nicotine or etomidate present in electronic cigarettes activates Na^+ /K^+ -ATPase, shifting potassium intracellularly and depleting serum levels as evident from literature [22]. Moreover, nicotine activates the renin-angiotensin-aldosterone system (RAAS), increasing urinary potassium excretion. Opposite to our finding, Das and Saha (2022) reported higher serum potassium in smokers, albeit in patients with myocardial infarction [23]. This justifies that the level can be altered when its measured during medical emergencies. The severity of hypokalemia in our cohort exceeded prior reports, potentially due to the high prevalence of hypertension, and concomitant diuretic use, which synergistically exacerbate potassium loss [24, 25].

Unlike sodium and potassium, lithium levels were undetectable (<0.10 mEq/L) in all participants, showing no smoking-related variation. This is not surprising, since lithium (at trace dietary levels) is not tightly regulated. Enderle et al. (2020) reported that even in habitual populations, physiological plasma lithium is about 1000-fold lower than therapeutic levels [26]. Our null finding suggests that lithium is not physiologically relevant in smoking-related electrolyte dynamics. In context, interest in lithium and smoking has focused on hypotheses for example, smokers inhale trace lithium from tobacco, potentially affecting Parkinson and melanoma risk [27], but our data indicate any such exposure produces only the expected negligible blood levels, highlighting a need for further research on cellular lithium flux in smokers.

We also observed gender disparities in electrolyte levels. In our cohort, men tended to have slightly higher potassium than women, and sodium values were essentially equivalent between sexes. These differences reflect known physiological patterns: in a large US population sample [21]. Similarly, our male smokers had marginally higher potassium levels than female smokers, paralleling that trend. The reasons are likely due to demographic. Males typically have greater muscle mass [28] and different hormonal status [29], which influence electrolyte distribution. Importantly, the sex differences we saw were generally in the same direction in smokers and non-smokers alike, implying that smoking did not reverse or eliminate normal gender effects. For example, the higher potassium in men occurred in both smoking and non-smoking subgroups. Thus, while our primary focus was on smoking status, these sex-related findings highlight that male/female physiology modulates electrolyte levels and should be considered in interpreting results. In practice, however, the sex differences were minor compared to the overall smoking and non-smoking cohorts.

Furthermore, the pronounced electrolyte imbalances in smokers with Comorbidities like; hypertension, diabetes, or renal disease (e.g., Sample 10 of diabetic smoker) suggest synergistic pathology. Smoking exacerbates oxidative stress and endothelial dysfunction, impairing renal electrolyte regulation in comorbid individuals [30]. While Al-harbi (2012) also reported similar trends in students [31], our study demonstrates this interaction in a broader age cohort, highlighting high-risk subgroups needing targeted clinical monitoring. We excluded participants with acute illnesses, whereas prior work included hospitalized patients with comorbid like SIADH triggers. By using an automated Atellica CH Analyzer in a broad cohort of healthy subjects, our study adds precision and generalizability. The concordance with earlier findings suggests that our result reflects a true association rather than an artifact. The machine high reliability and robust stratification, may have improved detection of this modest difference, offering a novel perspective on how smoking chronically influences electrolytes balance.

This study has several limitations. First, its cross-sectional design, we cannot infer causation from the observed associations. We measured each subject only once and did not follow electrolyte changes over time, so we cannot determine whether smoking led to these electrolyte differences or vice versa. Potential confounders were not fully controlled: dietary sodium or potassium intake, hydration status, alcohol use, or unrecognized health conditions (such as hypertension or renal impairment) could have influenced electrolyte levels. Our exclusion criteria removed overt comorbidities, but subtle medical issues may remain. The focus on sodium, potassium, and lithium excludes other electrolytes such as; calcium, magnesium potentially affected by smoking. The sample was geographically restricted to Karachi, Pakistan, limiting generalizability to other populations with different dietary or environmental exposures. Finally, lithium levels near the assay's detection limit complicate interpretations of subtle variations. Despite these caveats, the clear patterns we observed – particularly the higher sodium and lower potassium in smokers – suggest real effects of tobacco use on electrolyte balance. Future longitudinal or interventional studies could clarify the mechanisms and clinical relevance.

CONCLUSION

This observational cross-sectional study demonstrated that chronic smoking significantly disrupts electrolytes homeostasis, as evidenced by elevated sodium and reduced potassium levels in smokers compared to non-smokers, while lithium concentrations remained unaffected. The findings, derived from precise measurements via the automated Atellica CH Analyzer. The observed dose-response relationship between smoking intensity and electrolyte imbalances underscores the cumulative physiological toll of tobacco use and are exacerbated by comorbidities such as hypertension and diabetes. Therefore, the findings underscore the need for clinical attention to such imbalances. Regular monitoring of sodium and potassium levels in smokers could help identify individuals at greater risk for smoking-related cardiovascular and metabolic complications, and public health initiatives might incorporate electrolyte screening and targeted dietary guidance into tobacco cessation and prevention programs to mitigate these effects. Future studies should extend these findings by examining other relevant electrolytes (calcium, magnesium etc), employing longitudinal designs to assess the progression and reversibility of changes, conducting high quality intervention trials (for example, dietary modifications or cessation efforts) to correct imbalances, and validating the associations in larger and more diverse populations.

REFERENCES

1. Bryazka D, Reitsma MB, Abate YH, Abd Al Magied AH, Abdelkader A, Abdollahi A, Abdoun M, Abdulkader RS, Zuñiga RA, Abhilash ES, Abiodun OO. Forecasting the effects of smoking prevalence scenarios on years of life lost and life expectancy from 2022 to 2050: a systematic analysis for the Global Burden of Disease Study 2021. The lancet Public health. 2024 Oct 1;9(10):e729-44. https://doi.org/10.1016/s2468-2667(24)00166-x.
2. West R. Tobacco smoking: Health impact, prevalence, correlates and interventions. Psychology & health. 2017 Aug 3;32(8):1018-36. https://doi.org/10.1080/08870446.2017.1325890.
3. Caralis PV, Perez-Stable E. Electrolyte abnormalities and ventricular arrhythmias. Drugs. 1986 Jun;31:85-100. https://doi.org/10.2165/00003495-198600314-00011.
4. Ghoshal S. Renal and Electrolyte disorders and the nervous system. CONTINUUM: Lifelong Learning in Neurology. 2023 Jun 1;29(3):797-825. https://doi.org/10.1212/con.0000000000001286.
5. Al-harbi W. Electrolytes changes in cigarette smoking male students. Pakistan Journal of Pharmacology. 2012 Jan;29(1):33-8.
6. Cevc G. Membrane electrostatics. Biochimica et Biophysica Acta (BBA)-Reviews on Biomembranes. 1990 Oct 8;1031(3):311-82. https://doi.org/10.1016/0304-4157(90)90015-5.
7. Kughapriya P, Evangeline J. Evaluation of serum electrolytes in Ischemic Heart Disease patients. Natl J Basic Med Sci. 2016;6(4):1-4.
8. Miller NE, Rushlow D, Stacey SK. Diagnosis and management of sodium disorders: hyponatremia and hypernatremia. American family physician. 2023 Nov;108(5):476-86.

9. Helfant RH. Hypokalemia and arrhythmias. The American journal of medicine. 1986 Apr 25;80(4):13-22. https://doi.org/10.1016/0002-9343(86)90336-0.
10. Viera AJ, Wouk N. Potassium disorders: hypokalemia and hyperkalemia. American family physician. 2015 Sep 15;92(6):487-95.
11. Weir CB, Jan A. BMI classification percentile and cut off points. StatPearls. Treasure Island. 2023.
12. Cipriani A, Hawton K, Stockton S, Geddes JR. Lithium in the prevention of suicide in mood disorders: updated systematic review and meta-analysis. Bmj. 2013 Jun 27;346. https://doi.org/10.1136/bmj.f3646.
13. Post RM. The new news about lithium: an underutilized treatment in the United States. Neuropsychopharmacology. 2018 Apr;43(5):1174-9. https://doi.org/10.1038/npp.2017.238.
14. Murru A, Manchia M, Hajek T, Nielsen RE, Rybakowski JK, Sani G, Schulze TG, Tondo L, Bauer M, International Group for The Study of Lithium Treated Patients (IGSLi). Lithium's antiviral effects: a potential drug for CoViD-19 disease?. International Journal of Bipolar Disorders. 2020 Dec;8:1-9. https://doi.org/10.1186/s40345-020-00191-4.
15. Györfi I, Pál K, Mănescu IB, Oprea OR, Dobreanu M. Atellica CH 930 chemistry analyzer versus Cobas 6000 c501 and Architect ci4100-a multi-analyte method comparison. Revista Romana de Medicina de Laborator. 2021 Oct 22;29(4):421-38. https://doi.org/10.2478/rrlm-2021-0027.
16. Lippi G, Salvagno GL, Poli G, Gelati M, Favaloro EJ. Assessment of plasma sample quality on Siemens Atellica COAG 360 System. InSeminars in Thrombosis and Hemostasis 2019 Apr (Vol. 45, No. 03, pp. 315-318). Thieme Medical Publishers. https://doi.org/10.1055/s-0037-1621718.
17. Eliasson M, Hägg E, Lundblad D, Karlsson R, Bucht E. Influence of smoking and snuff use on electrolytes, adrenal and calcium regulating hormones.

European Journal of Endocrinology. 1993 Jan;128(1):35-40. https://doi.org/10.1530/acta.0.1280035.

18. Nwaji AR, Inwang U, Nwoke FA, Ante I. Changes in serum electrolytes, urea and creatinine in nicotiana tabacum-treated rats. Nigerian Journal of Physiological Sciences. 2022 Jun 30;37(1):153-6. https://doi.org/10.54548/njps.v37i1.19.
19. Choi KH, Park MS, Kim JA, Lim JA. Associations between excessive sodium intake and smoking and alcohol intake among Korean men: KNHANES V. International Journal of Environmental Research and Public Health. 2015 Dec;12(12):15540-9. https://doi.org/10.3390/ijerph121215001.
20. Overwyk KJ, Pfeiffer CM, Storandt RJ, Zhao L, Zhang Z, Campbell NR, Wiltz JL, Merritt RK, Cogswell ME. Serum sodium and potassium distribution and characteristics in the US population, national health and nutrition examination survey 2009–2016. The journal of applied laboratory medicine. 2021 Jan;6(1):63-78. https://doi.org/10.1093/jalm/jfaa127.
21. Wu W, Xia C, Gan L, Liao S, Yan Y. Etomidate-induced hypokalemia in electronic cigarette users: Two case reports and literature review. Frontiers in Endocrinology. 2024 May 30;15:1321610. https://doi.org/10.3389/fendo.2024.1321610.
22. Das S, Saha SN. A study of serum sodium and potassium levels in subjects of acute myocardial infarction in a tertiary care hospital in Eastern India. International Journal of Basic & Clinical Pharmacology. 2022 May;11(3):223. https://dx.doi.org/10.18203/2319-2003.ijbcp20221036.
23. Lin Z, Wong LY, Cheung BM. Diuretic-induced hypokalaemia: an updated review. Postgraduate Medical Journal. 2022 Jun;98(1160):477-82. https://doi.org/10.1136/postgradmedj-2020-139701.
24. Fan P, Lu YT, Yang KQ, Zhang D, Liu XY, Tian T, Luo F, Wang LP, Ma WJ, Liu YX, Zhang HM. Apparent mineralocorticoid excess caused by novel compound heterozygous mutations in HSD11B2 and characterized by

early-onset hypertension and hypokalemia. Endocrine. 2020 Dec;70:607-15. https://doi.org/10.1007/s12020-020-02460-9.

25. Enderle J, Klink U, di Giuseppe R, Koch M, Seidel U, Weber K, Birringer M, Ratjen I, Rimbach G, Lieb W. Plasma lithium levels in the general population: a cross-sectional analysis of metabolic and dietary correlates. Nutrients. 2020 Aug 18;12(8):2489. https://doi.org/10.3390/nu12082489.
26. Guttuso Jr T. High lithium levels in tobacco may account for reduced incidences of both Parkinson's disease and melanoma in smokers through enhanced β-catenin-mediated activity. Medical Hypotheses. 2019 Oct 1;131:109302. https://doi.org/10.1016/j.mehy.2019.109302.
27. Nuzzo JL. Narrative review of sex differences in muscle strength, endurance, activation, size, fiber type, and strength training participation rates, preferences, motivations, injuries, and neuromuscular adaptations. The Journal of Strength & Conditioning Research. 2023 Feb 1;37(2):494-536. https://doi.org/10.1519/jsc.0000000000004329.
28. Hiller-Sturmhöfel S, Bartke A. The endocrine system: an overview. Alcohol health and research world. 1998;22(3):153.
29. Ghoshal S. Renal and Electrolyte disorders and the nervous system. CONTINUUM: Lifelong Learning in Neurology. 2023 Jun 1;29(3):797-825. https://doi.org/10.1212/con.0000000000001286.
30. Al-harbi W. Electrolytes changes in cigarette smoking male students. Pakistan Journal of Pharmacology. 2012 Jan;29(1):33-8.