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Saliva as a Surrogate for Blood in Electrolyte Monitoring: A Cross-Sectional Study Among Healthy Individuals

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ABSTRACT

Background: Electrolytes such as sodium, potassium, and chloride are essential for maintaining fluid balance, nerve function, and cellular homeostasis. Blood-based electrolyte testing is the standard diagnostic approach but its invasiveness may pose challenges. Saliva has emerged as a potential non-invasive alternative biofluid for clinical monitoring. This study aimed to evaluate and compare the levels of sodium, potassium, and chloride in saliva and blood among apparently healthy students, and to assess the correlation between concentrations in both biofluids.

Methods: A cross-sectional study was conducted involving 60 apparently healthy students residing in Port Harcourt. Blood and unstimulated saliva samples were collected and analyzed using standard colorimetric and turbidimetric methods. Statistical analysis was performed using SPSS version 21.0. Paired t-tests and Pearson's correlation were used to assess differences and relationships, respectively, with significance set at $p < 0.05$.

Results: Mean concentrations of sodium and chloride were significantly higher in blood (127.7 mmol/L and 97.6 mmol/L, respectively) than in saliva (49.8 mmol/L and 16.8 mmol/L, respectively), while potassium was higher in saliva (37.9 mmol/L) compared to blood (3.0 mmol/L). Only sodium showed a statistically significant inverse correlation between blood and salivary levels ($r = –0.39$, $p < 0.05$). Potassium and chloride did not show significant correlations.

Conclusion: Saliva contains measurable levels of sodium, potassium, and chloride, but only salivary sodium demonstrated a meaningful correlation with its blood counterpart in healthy individuals. While salivary sodium may hold potential as a non-invasive diagnostic marker, further studies are needed to validate its utility, particularly in clinical populations.

Keywords: *Electrolytes, Saliva, Sodium, Potassium, Chloride, Non-invasive biomarkers, Renal function, Blood–saliva correlation*

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INTRODUCTION

Electrolytes are inorganic substances that dissociate into ions in biological fluids and are essential for maintaining several physiological processes such as fluid balance, acid-base homeostasis, nerve conduction, and muscle contraction. Among the key electrolytes—sodium, potassium and chloride; each serves a distinct but interrelated function. Sodium is the principal extracellular cation involved in osmoregulation and volume control; potassium is the predominant intracellular cation critical for maintaining resting membrane potential; and chloride is the major extracellular anion that contributes to electrical neutrality and pH regulation [5].

The kidneys play a central role in the regulation of electrolyte levels by filtering and selectively reabsorbing or excreting these ions through various transport mechanisms in the nephrons. Hence, abnormalities in serum electrolyte concentrations often serve as early indicators of renal dysfunction, including acute kidney injury (AKI) and chronic kidney disease (CKD). Routine measurement of serum electrolytes is a cornerstone in the diagnosis and management of renal diseases. However, the conventional practice of venous blood collection can be painful, invasive, and inconvenient, especially in resource-limited settings or when dealing with pediatric, elderly, or chronically ill patients.

Saliva has emerged in recent years as a promising alternative biological fluid for diagnostic purposes due to its non-invasive nature, ease of collection, and reduced need for specialized personnel or infrastructure [6][7]. Salivary diagnostics are increasingly gaining recognition not only in oral health but also in the monitoring of systemic conditions, including endocrine, metabolic, and renal disorders. Electrolytes are secreted into saliva through active transport mechanisms across salivary gland epithelia. Although these mechanisms differ somewhat from renal excretion pathways, various studies have demonstrated that salivary electrolyte concentrations may reflect systemic physiological and pathological states [6][8].

Studies in patients with renal disease have shown altered salivary concentrations of sodium, potassium, and chloride, suggesting the possibility of their use as surrogate indicators for blood-based electrolyte measurements [1][2]. However, the data remain conflicting, especially in healthy individuals, where correlations between serum and salivary electrolytes are not always statistically significant. Factors such as circadian rhythm, salivary flow rate, glandular function, hydration status, and psychological stress are known to influence salivary composition and may account for the observed variations [8]. Nonetheless, the prospect of employing salivary electrolyte analysis in clinical practice —especially in settings with limited access to laboratory facilities—makes this line of inquiry both timely and valuable.

In Nigeria, the burden of renal disorders is on the rise, yet diagnosis is frequently delayed due to logistical challenges associated with blood-based testing and limited access to care. Non-invasive methods such as saliva testing may enhance early detection and monitoring of renal dysfunction, particularly in underserved populations. Despite its promise, salivary electrolyte analysis remains underexplored in the Nigerian context, and there is a paucity of data regarding the normal ranges and diagnostic accuracy of salivary electrolytes in healthy individuals.

This study was therefore designed to evaluate and compare the levels of sodium, potassium, and chloride in both saliva and blood samples among apparently healthy students residing in Port Harcourt. By investigating the relationship between these electrolytes Across the two biofluids, this study aims to determine whether saliva could serve as a reliable, non-invasive alternative for electrolyte monitoring and possibly as a preliminary screening tool for renal health.

MATERIALS AND METHODS

Study Design: This study employed a cross-sectional analytic design to assess and compare the levels of selected electrolytes—sodium (Na^+), potassium (K^+), and chloride (Cl^-)—in blood and saliva samples among apparently healthy university students. The study aimed to investigate whether salivary concentrations of these electrolytes correlate significantly with their blood levels.

Study Area: The research was conducted among students residing in Owerri, Imo State.

Study Population: A total of 60 apparently healthy undergraduate students residing in Port Harcourt were enrolled in the study through simple random sampling. Participants were aged 18 years and above, with no known history of renal, cardiovascular, oral, hepatic, or metabolic diseases.

Inclusion Criteria: Apparently healthy students aged 18 years and above and students who provided informed consent

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Exclusion Criteria: Individuals with systemic diseases such as diabetes, kidney, liver, or cardiovascular diseases were excluded. Individuals with oral infections or smokers and those who declined to provide informed consent were excluded. The design of the study was focused on health subjects not on unhealthy subjects, thus participants with diseases that affect blood vessels were excluded since impaired blood vessels can affect how substances in blood are filtered or diffused in saliva. Subjects with such diseases were captured using questionnaire.

Sample Size Estimation: The sample size of 60 was used for this study. The size of the sample used was determined using Cochrane formula at P equal to 4%.

Sampling Methodology: A cross-section of healthy adult volunteers was recruited from the Federal University Teaching Hospital, Owerri. To ensure a representative sample while minimizing confounding factors that affect electrolyte balance, a purposive sampling approach was utilized.

Ethical Consideration: This study was conducted in strict accordance with the ethical principles outlined in the Declaration of Helsinki. Prior to recruitment and the collection of any data, the study protocol was reviewed and approved by the Ethics Committee of the Federal Teaching Hospital, Owerri, Imo State with the Ethical number FTH/OW/HREC/VOL.1/279. In line with these ethical standards, informed written consent was obtained from all participating authors prior to their recruitment and enrollment in the study. All participant data were anonymized to ensure confidentiality.

Sample Collection

Saliva Collection: Unstimulated whole saliva samples were collected using the passive drool method. Participants were asked to avoid eating or drinking for at least one hour before sample collection. With the head tilted slightly downward, each participant expectorated approximately 4–5 mL of saliva into a sterile, open-mouthed universal container. Samples were centrifuged at 3,000 rpm for 10 minutes, and the supernatant was aliquoted into plain sample tubes and stored at 4°C until analysis.

Blood Collection: Venous blood (5 mL) was drawn from the antecubital vein using sterile syringes and transferred into plain tubes. The samples were allowed to clot and then centrifuged at 3,000 rpm for 10 minutes to obtain serum. The serum was separated and stored at 4°C until analysis.

Analytical Methods: Sodium Estimation (Colorimetric Method) Sodium ions reacted with a chromogen to produce a colored complex whose absorbance was measured at 630 nm. The concentration was determined using Beer-Lambert's Law.

Potassium Estimation (Turbidimetric Tetraphenylborate Method): Potassium ions reacted with tetraphenylborate under alkaline conditions to form a turbid complex. The increase in turbidity was measured at 578 nm, and potassium concentration was calculated using Beer-Lambert's equation.

Chloride Estimation (Colorimetric Method): Chloride ions displaced thiocyanate from mercuric thiocyanate. The released thiocyanate reacted with ferric ions to form a red complex measured at 500 nm. Chloride concentrations were derived from a standard calibration curve.

All tests were conducted in duplicate, and mean values were recorded for each analyte.

Quality Assurance: All reagents used were quality-controlled commercial kits. Calibration and blank readings were performed with each batch of samples. Control samples were included to ensure validity and reproducibility of the assays.

Statistical Analysis: Data were entered into Microsoft Excel and analyzed using IBM SPSS version 21.0. Descriptive statistics (mean and standard deviation) were used to summarize the data. Independent sample t-tests were used to compare mean concentrations between blood and saliva samples. Pearson's correlation coefficient was used to determine the strength and significance of the relationship between blood and salivary electrolyte levels. A p-value of less than 0.05 was considered statistically significant.

RESULTS

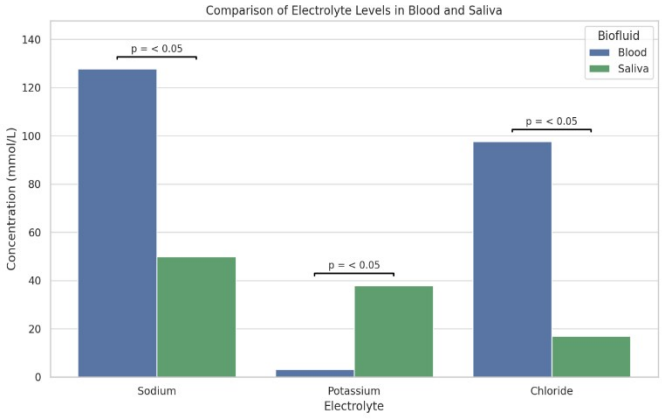

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Figure 1: Comparison of Electrolyte Levels in Blood and Saliva

Figure 1 is the bar chart visualizing the mean concentrations of sodium, potassium, and chloride in blood and saliva. The p-values above the bars indicate that the differences between blood and salivary concentrations for each electrolyte are statistically significant (p < 0.05).

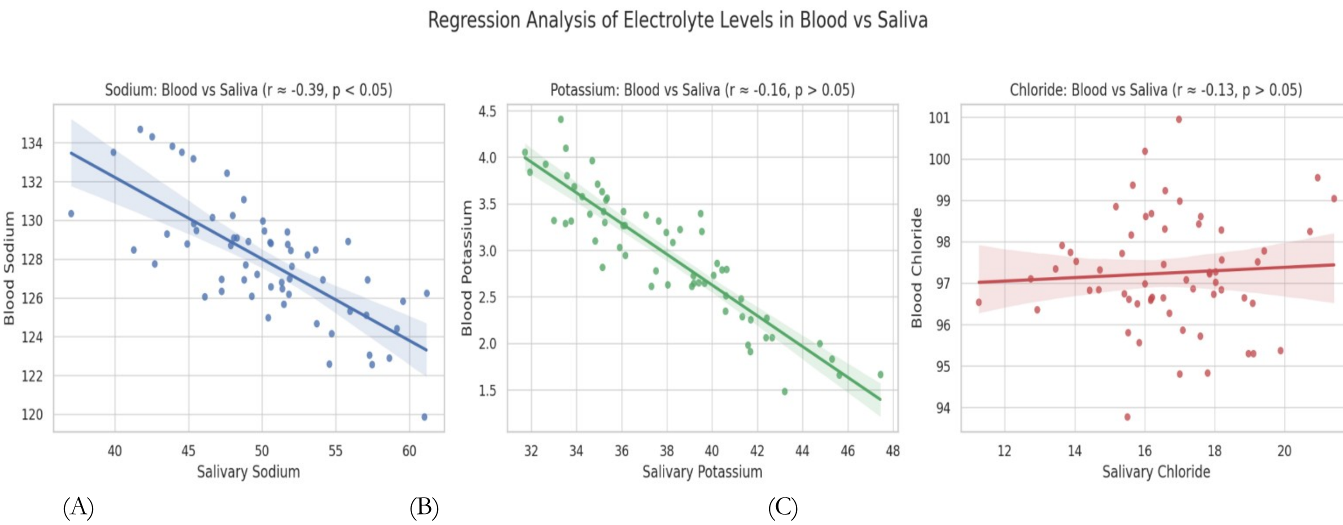

Figure 2: Regression Analysis of Electrolytes (Sodium, Potassium and Chloride) in Blood and Saliva

Figure 2 presents scatter plots with regression lines showing the relationship between salivary and blood concentrations of sodium, potassium, and chloride among study participants. (A) The first panel shows the association between salivary and blood sodium concentrations. Data points are distributed with a mild inverse trend, and a linear regression line is plotted. (B) The second panel illustrates the relationship between salivary and blood potassium levels. The distribution of data points is wider, with a slight negative slope observed in the regression line. (C) The third panel depicts the correlation between salivary and blood chloride levels. Data points are moderately scattered around the regression line, which also trends slightly downward.

Discussion

This study evaluated the levels of sodium, potassium, and chloride in saliva and blood, and assessed their correlation among apparently healthy university students. The goal was to explore the potential of using saliva as a non-invasive alternative for electrolyte monitoring, particularly in the context of renal health.

The results revealed statistically significant differences between salivary and blood concentrations of all three electrolytes assessed. Sodium and chloride were significantly more concentrated in blood compared to saliva, whereas potassium was markedly higher in saliva than in blood. These findings are consistent with earlier reports that suggest distinct transport mechanisms and secretory behavior of salivary glands compared to renal excretion [6][9].

The observed lower salivary sodium levels relative to blood may be attributed to the reabsorption of sodium ions during saliva formation in the striated ducts of salivary glands. This aligns with findings from previous studies that describe saliva as hypotonic to plasma, especially at low flow rates (Iorgulescu, 2009). Furthermore, the inverse correlation observed between blood and salivary sodium concentrations ($r = -0.39$, $p < 0.05$) suggests that salivary sodium levels, although lower, may reflect systemic sodium balance under certain physiological conditions.

In contrast, the markedly elevated salivary potassium concentration observed in this study compared to blood may reflect the active secretion of potassium into the salivary ducts. This phenomenon has been documented

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in prior studies and is thought to result from sodium–potassium exchange mechanisms within the salivary glands [1]. Despite the significant difference in concentrations, the absence of a statistically significant correlation between salivary and blood potassium levels ($r = –0.16$, $p > 0.05$) limits its immediate utility as a surrogate for blood potassium measurement.

Similarly, chloride was significantly more concentrated in blood than saliva, but no significant correlation was found between the two compartments ($r = –0.13$, $p > 0.05$). This is in line with existing research that highlights variable chloride secretion influenced by glandular function, salivary flow rate, and systemic acid-base status [2].

Overall, only sodium demonstrated a statistically significant correlation between its salivary and blood concentrations. The weak or non-significant correlations for potassium and chloride suggest that, in healthy individuals, salivary electrolyte concentrations may be influenced more by local glandular activity and physiological variability than by systemic electrolyte levels alone. These results are consistent with previous studies which found stronger correlations in patients with advanced renal disease but less so in healthy populations [9].

While the findings of this study support the presence of electrolytes in saliva and demonstrate their measurable differences compared to blood, caution must be exercised in interpreting their diagnostic relevance. The variable correlation patterns indicate that salivary electrolyte testing may not be a reliable substitute for serum analysis in general populations. However, the significant correlation seen in sodium suggests it could have potential for further exploration, particularly in conditions affecting systemic sodium balance or in populations where blood sampling is difficult.

Limitations of this study include its restriction to a healthy population, relatively small sample size, and the absence of clinical renal function markers such as glomerular filtration rate (GFR) for comparative analysis. Future studies involving larger and more diverse populations—including patients with varying degrees of renal impairment—are needed to clarify the diagnostic value of salivary electrolytes.

Implications of the Findings of the Study

Further research is needed to explore the diagnostic relevance of salivary electrolytes, particularly in individuals with renal or electrolyte disorders. Future studies should include larger and more diverse populations, incorporate additional renal function markers, and consider the influence of salivary flow rate and stimulation on electrolyte levels.

CONCLUSION

This study confirms that sodium, potassium, and chloride are present in both saliva and blood, with significant differences observed between their concentrations across the two biofluids. While sodium and chloride levels were higher in blood, potassium was notably elevated in saliva. Among the three, only sodium showed a statistically significant correlation between blood and salivary levels, suggesting limited but promising potential for salivary sodium as a non-invasive marker for systemic electrolyte status in healthy individuals. However, the weak correlations seen for potassium and chloride highlight the need for cautious interpretation when considering salivary electrolytes for clinical use.

Declarations

Authors' contribution: OJU did the study and analysed the samples under OCG supervision
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Funding: Personal funds
Conflicts of Interest: Nil conflict of interest
Disclosure in AI use: None

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