Frontiers in Health Informatics
ISSN-Online: 2676-7104
www.healthinformaticsjournal.com
2024; Vol-13: Issue 8 Open Access

Establishing baseline standards for blood's physical characteristics in healthy individuals: a pilot study.

***Dr. Vijay Singh Yadav, **Dr. Sisir Kumar Mandal, ***Dr. Produyt Dhar, ****Rohit Rai**

*PhD Scholar, Vikriti Vigyan Department, Faculty of Ayurveda IMS, BHU. Mail id- drvijays.yadav09@gmail.com

**Professor, Vikriti Vigyan Department, Faculty of Ayurveda IMS, BHU. Mail id- todrskmandal@gmail.com

***Assistant Professor, Bio-Chemical Engineering, IIT, BHU. Mail id- prodyut.bce@iitbhu.ac.in

****PhD Scholar, Bio-Chemical Engineering, IIT, BHU. Mail id- rohitrai.rs.bce20@itbhu.ac.in

Corresponding Address

Dr. Vijay Singh Yadav, *PhD Scholar, Vikriti Vigyan Department, Faculty of Ayurveda IMS, BHU. Mail id- drvijays.yadav09@gmail.com

Cite this paper as: Dr. Vijay Singh Yadav, Dr. Sisir Kumar Mandal, Dr. Produyt Dhar, Rohit Rai (2024). Establishing baseline standards for blood's physical characteristics in healthy individuals: a pilot study. Frontiers in Health Informatics, Vol. 13, No.8, 7158-7172

ABSTRACT

Introduction: Blood is a complex biological fluid that plays a critical role in maintaining various physiological functions in the human body. Understanding its physical properties in healthy individuals is crucial for establishing baseline standards, which can be used to interpret clinical findings, improve diagnostic accuracy, and enhance therapeutic interventions. While much is known about the biochemical composition of blood, less attention has been given to the standardization of its key physical properties, such as pH, viscosity, moisture content, specific gravity, and foam formation. This pilot study was designed to standardize these critical physical characteristics of blood in healthy volunteers to provide essential baseline data. **Methods**: This study involved 30 healthy adult volunteers, selected based on strict inclusion and exclusion criteria to ensure a homogeneous sample. Blood samples were collected under standardized conditions and subjected to laboratory analysis. Key physical properties, including pH, viscosity, moisture content, specific gravity, and foam formation, were measured using validated instruments and protocols. **Results**: The findings of the study revealed that the blood pH in healthy volunteers ranged from 7.35 to 7.45, consistent with the normal physiological range. Viscosity values averaged at 5.06 cP, with a slight variation between individuals. Specific gravity of the blood samples was stable at approximately 0.9561 across all participants. The moisture content of the blood averaged around 80%, confirming the high water content of the fluid. Foam formation was consistently observed in all samples within minutes of agitation, with the foam demonstrating stability for several minutes. These results provide foundational data for these critical parameters in healthy individuals. **Discussion**: This pilot study has successfully established standard reference values for important physical characteristics of blood in healthy volunteers. These values will serve as baseline data for future research and clinical applications, particularly in monitoring deviations in blood properties associated with disease states. **Conclusion**: In conclusion, this study provides valuable reference values for key physical properties of blood in healthy individuals. These findings offer a baseline for clinical and research purposes, supporting the development of more accurate diagnostic techniques and enhancing therapeutic strategies.

KEYWORDS: Baseline, Blood, Foam, Moisture, Viscosity

INTRODUCTION

1. Blood: A Vital Fluid

Blood is one of the most critical components of the human body, facilitating essential functions such as oxygen and nutrient transport, immune responses, temperature regulation, and waste elimination. Its unique physical properties not only play a pivotal role in these functions but also serve as crucial biomarkers for assessing an individual's overall health. Despite the considerable advances in medical research, there remains a limited understanding of the standardized physical properties of blood in healthy individuals. Standardizing these properties, including pH, viscosity, moisture content, specific gravity, and foam formation, is crucial for enhancing diagnostic accuracy, guiding therapeutic interventions, and ensuring more effective clinical practices. This pilot study sets out to fill this gap by establishing baseline values for these key physical parameters in healthy volunteers.[1]

2. The Need for Standardization

The physical characteristics of blood are dynamic and can vary across individuals and populations due to various factors, such as age, sex, genetics, diet, lifestyle, and environmental influences. These properties are critical for various clinical processes, including diagnosis, treatment planning, and monitoring disease progression. However, there is often a lack of standardized reference values for these properties, especially when it comes to understanding the normal range of blood characteristics in a healthy population. While biochemical markers in blood have been extensively studied, fewer studies have focused on its physical properties. By standardizing these properties in healthy individuals, clinicians can establish a reliable baseline, which can then be compared to pathological values, improving diagnostic efficiency and therapeutic outcomes.[2]

3. The Physical Properties of Blood

The physical properties of blood refer to characteristics that determine its flow behavior and its ability to function effectively within the circulatory system. These include viscosity, pH, specific gravity, moisture content, and foam formation. Understanding these properties is essential for the following reasons:

- **pH**: The pH of blood is crucial for maintaining acid-base balance within the body. A normal blood pH range of 7.35 to 7.45 is tightly regulated by various buffering systems in the body. Any deviation from this range can indicate underlying conditions such as acidosis or alkalosis, which can have serious health implications.
- **Viscosity**: Blood viscosity refers to its thickness and resistance to flow. It is a critical factor in determining blood circulation and is influenced by factors such as hematocrit, plasma protein concentration, and red blood cell deformability. High viscosity can lead to cardiovascular complications, while low viscosity can result in insufficient oxygen delivery to tissues.

- **Specific Gravity**: The specific gravity of blood is a measure of its density relative to water. This value can provide insight into the concentration of blood components and is influenced by the balance of plasma, red blood cells, and other cellular elements in the bloodstream. Specific gravity is a key parameter in assessing the efficiency of blood circulation and its ability to transport oxygen and nutrients.
- **Moisture Content**: The moisture content of blood is largely determined by its plasma composition, which is predominantly water. This parameter can indicate the hydration status of an individual and is important in assessing conditions like dehydration or fluid overload.
- **Foam Formation**: Foam formation in blood occurs when blood is agitated, resulting in the formation of bubbles or froth. The stability and volume of foam can provide indirect information about the blood's protein content, particularly the levels of lipoproteins, and can be used as a simple diagnostic indicator for lipid-related disorders.[3,4,5]

4. Relevance to Clinical Medicine

Standardizing the physical characteristics of blood is highly relevant to clinical medicine. In routine clinical practice, blood is often used as a medium for diagnostic testing, with parameters such as pH, viscosity, and specific gravity providing valuable insights into an individual's health. For example, the measurement of blood viscosity can aid in diagnosing conditions like polycythemia, anemia, and certain hematological disorders. Similarly, abnormal pH levels are frequently associated with metabolic disorders, kidney disease, and respiratory conditions. However, the interpretation of these parameters requires a reliable baseline, which can be derived from healthy populations. Establishing standard values for these blood characteristics will not only improve diagnostic accuracy but also enhance the precision of treatments, leading to better clinical outcomes.[5,6]

5. Understanding Variability in Blood Characteristics

The variability in blood's physical characteristics can be attributed to multiple factors. These include:

- **Age and Gender**: Blood viscosity, pH, and other properties can vary across different age groups and between males and females. For instance, children may have different blood viscosity compared to adults, and elderly individuals may show variations due to changes in their circulatory and metabolic systems.
- **Genetic Factors**: Genetic variations can influence the concentration of plasma proteins, red blood cell morphology, and the body's ability to regulate blood pH. Inherited conditions, such as sickle cell anemia or hemophilia, can also alter the physical properties of blood.
- **Diet and Lifestyle**: Nutrition and lifestyle choices, including hydration, alcohol consumption, exercise, and smoking, can have significant effects on blood characteristics. For example, dehydration increases blood viscosity, while regular physical activity can improve circulation and reduce blood viscosity.
- **Health Conditions**: Certain health conditions, such as diabetes, cardiovascular diseases, and kidney disorders, can affect blood's physical properties. For instance, high blood sugar levels can alter blood viscosity, while kidney diseases can lead to changes in blood pH and specific gravity.[7,8]

6. Objectives of the Study

The primary objective of this pilot study is to establish standard reference values for key physical characteristics of blood in a healthy adult population. Specifically, the study aims to:

1. Measure and standardize the pH, viscosity, moisture content, specific gravity, and foam formation of blood in healthy volunteers.
2. Identify the normal ranges for these properties to serve as a reference for clinical comparison.
3. Evaluate the reliability and consistency of the measurement techniques used for each parameter.
4. Provide baseline data that can be used in future studies and clinical practice to enhance the understanding of blood's physical properties in both healthy and diseased states.

7. Significance of the Study

The significance of this pilot study lies in its potential to provide critical baseline data on the physical properties of blood in healthy individuals. By standardizing these properties, healthcare providers can enhance diagnostic accuracy and treatment precision.

MATERIALS AND METHODS

Study Design and Participants

This pilot study aimed to standardize various physical characteristics of blood in healthy adult volunteers. A total of 30 healthy volunteers were enrolled in this study, aged between 18 and 30 years, without any history of cardiovascular, hematological, metabolic, or kidney diseases. Participants were selected based on a questionnaire (*Charak Viman* 8/89). The inclusion criteria required that all volunteers be non-smokers, not on any chronic medications, and without a history of chronic diseases such as hypertension or diabetes. Individuals who were pregnant, obese (BMI over 30), or had undergone any recent surgery were excluded from the study.

All participants provided informed consent prior to their enrollment in the study, and the ethical guidelines for human research were strictly followed. The study received approval from the institutional review board of the research institution.[9,10]

Blood Collection and Preparation

Blood samples were collected in the morning after an overnight fast to minimize the potential influence of food intake on the results. A trained phlebotomist collected venous blood from each participant using sterile techniques. Blood was drawn into 5 mL vial containing EDTA as an anticoagulant to prevent clotting. After collection, the samples were immediately transported to the laboratory for analysis. Blood samples were processed and stored under controlled conditions to maintain their integrity and ensure accurate measurements. All tests were conducted within two hours of collection to avoid potential degradation or alteration of the blood components.[11,12,13]

Measurement of Physical Characteristics

The study measured a range of blood's physical characteristics, as outlined below:

1. pH Measurement

Principle: The pH of blood is a critical indicator of its acid-base balance, reflecting the overall metabolic and respiratory status. Normal blood pH ranges from 7.35 to 7.45, and deviations from this range may indicate underlying conditions such as acidosis or alkalosis.

Methodology:

The pH of the blood samples was measured using a calibrated digital pH meter (e.g., Mettler

Toledo Seven Excellence). A 3 mL aliquot of blood was carefully pipetted into a clean beaker, and the pH probe was immersed into the sample. The measurement was taken after a stable reading was obtained. The results were recorded for each sample.

2. Viscosity Measurement

Principle: Blood viscosity is the measure of blood's internal friction as it flows. It is influenced by factors such as hematocrit (the proportion of red blood cells in blood), plasma proteins, and red blood cell deformability. Increased viscosity can result in slower blood flow, which may contribute to cardiovascular diseases.

Methodology:

Blood viscosity was measured using a viscometer (e.g., Brookfield viscometer or a rotational viscometer). A sample of 0.5 mL of blood was placed in the sample chamber, and the viscometer was set to a controlled speed (30 RPM for 30 second) to measure the resistance to flow. The unit of viscosity measurement used was Centipoise (cP). To ensure consistent results, viscosity measurements were taken at 37°C, the normal body temperature, to prevent temperature-related variations.

Precision and Accuracy: The viscometer was calibrated using standard fluids with known viscosities. Repeated measurements were taken for each sample to ensure precision, and the average value was reported.

3. Moisture Content Measurement

Principle: The moisture content of blood reflects its hydration status. Water is a significant component of blood plasma, and its levels can affect the blood's flow properties and the overall fluid balance in the body.

Methodology:

Moisture content was determined by drying a known volume of blood (approximately 100 µL) in an oven at 40°C for 24 hours, until the sample reached a constant weight. The blood was placed in a pre-weighed drying container, and the weight of the dried blood was recorded. The moisture content was calculated as the percentage difference between the initial and final weights.

4. Spectrophotometric Analysis

Principle: Spectrophotometry is used to measure the absorption of light by blood, which is typically used to assess the hemoglobin concentration. The absorption spectrum of blood can provide insights into its molecular composition.

Methodology:

A sample of blood (10 µL) was diluted with saline (2990 ml) to ensure that the absorbance falls within the measurable range. Spectrophotometric measurements were taken at wavelengths corresponding to the peak absorption of hemoglobin (around 540 nm) using a UV-Vis spectrophotometer. The hemoglobin concentration was calculated based on Beer-Lambert's law, which relates absorbance to concentration.

5. Specific Gravity Measurement

Principle: Specific gravity is the ratio of the density of blood to the density of water. It provides information about the overall composition of blood, including the concentrations of plasma proteins and red blood cells.

Methodology:

Collect a sample of blood in a clean, dry container. Weight the container with the blood sample using an analytical balance. Carefully pour the blood sample into a graduated cylinder or container of known volume. Record the volume of the blood sample in millilitres (mL). Calculate the density of the blood sample by dividing its weight by its volume: Density (g/mL) = weight (g)/ Volume (mL). Compare the density of the blood sample to the density of water at the same temperature. The density of water is approximately 1 g/mL at room temperature. To calculate the specific gravity of the blood sample, divide the density of the blood sample by the density of water at the same temperature:

Specific gravity = Density of blood sample (g/mL) / Density of water (1 g/mL).

Specific gravity = Density = W/V

6. Clotting Time (CT) and Bleeding Time (BT)

Principle: Clotting time (CT) and bleeding time (BT) are indicators of blood's ability to coagulate. Abnormal clotting or bleeding times can be indicative of underlying disorders such as hemophilia, platelet dysfunction, or other coagulopathies.

Methodology:

- **Clotting Time (CT)**: Clean the finger with alcohol 70% and allow to dry. Prick the finger by lancet. Draw blood up in the capillary glass tube. Start the stopwatch. After one minute start breaking small pieces of the capillary tube every 30 second until a fibrin thread is seen between the two broken ends. Calculating the clotting time by: (The waiting time after the glass tube is filled no. of capillary tubes breaks × 30 second).
- **Bleeding Time (BT)**: Bleeding time was measured using the Duke method. A small incision (about 1-2 mm) was made on the volunteer's earlobe or fingertip. The time it took for bleeding to stop was recorded using a stopwatch.

7. Foam Formation

Principle: Foam formation in blood occurs when the blood is agitated. This property is linked to the lipid and protein content in blood, and foam stability can be used as an indirect indicator of these components.

Methodology:

A 1 mL sample of blood was placed in a test tube, and the blood was vigorously shaken for 30 seconds. The volume of foam produced and its stability were observed. The foam height and duration were recorded at intervals (e.g., at 0 hr. and at 1 hr.). Foam formation was categorized as stable, moderate, or unstable based on the height and persistence of foam.

8. Contact Angle Measurement

Principle: The contact angle measures the interaction between blood and surfaces, providing insight into its tendency to adhere or spread. It is relevant in understanding clot formation and blood's interaction with vascular surfaces.

Methodology:

Contact angle of EDTA blood was carried out using a goniometer (contact angle meter, model DMs-401, Kyowa Interface Science Co. Ltd., Japan). A 5µL sessile drop of EDTA blood was placed on the clean surface of Teflon slide. The value of contact angle was obtained with the in-built software FAMAS.

9. Body Mass Index (BMI)

Principle: BMI is a commonly used measure of general health, reflecting body weight relative to height. It provides an indication of whether an individual is underweight, normal weight, overweight, or obese, and can impact blood properties such as viscosity and hydration.

Methodology:

BMI was calculated using the formula:

$$BMI = \frac{\text{weight (kg)}}{\text{height (m)}^2}$$

Height and weight were measured for each participant using a calibrated stadiometer and weighing scale. Participants were asked to remove shoes and heavy clothing before measurements were taken.

Statistical Analysis

Data analysis was performed using statistical software (e.g., SPSS, R). Descriptive statistics, including means, standard deviations, and ranges, were used to summarize the measurements for each blood characteristic. Variations in parameters were analyzed, and any significant differences between the measures were tested using appropriate statistical tests (e.g., ANOVA or t-tests).

OBSERVATION AND RESULTS

In this pilot study, the physical characteristics of blood were measured in 30 healthy volunteers to establish baseline values. These characteristics included pH, viscosity, moisture content, specific gravity, clotting time (CT), bleeding time (BT), foam formation, contact angle, and body mass index (BMI). The results from this study offer valuable insights into the normal ranges for these parameters in healthy individuals, providing reference values that can be useful for clinical diagnostics and therapeutic interventions.

The mean and standard deviation (SD) for each parameter were calculated and are presented in the table below. These results offer a comprehensive understanding of the variability and central tendency for each parameter.

Mean and Standard Deviation Summary

Parameter	Mean	Standard Deviation (SD)
Age	22.27	± 1.46
pH	7.39	± 0.44
Viscosity	5.06 cP	± 0.46
Moisture	79.57%	± 0.028
Spectrophotometer	0.4022	± 0.083
Specific Gravity	0.9561	± 0.10
CT	303 Second	± 54.27
BT	113 Seconds	± 33.12
Foam 0	4.1mm	± 0.99
Foam 1	3.31	± 0.88
Contact Angle	84.61	± 5.01
BMI	21.02	± 3.86

The following sections discuss the results in greater detail, focusing on the key findings for each parameter, the significance of these results, and potential implications for clinical practice.

1. Age

- **Mean Age**: 22.27 years
- **Standard Deviation**: ± 1.46 years

The age of participants in this study was relatively uniform, with a mean of 22.27 years and a standard deviation of 1.46 years. This range ensures that the sample is representative of young, healthy adults, minimizing the variability that may be introduced by age-related changes in blood properties. Age is a crucial factor in many physiological parameters, and by selecting a narrow age group, we ensured that the effects of aging on blood properties were not confounding factors.

2. pH

- **Mean pH**: 7.39
- **Standard Deviation**: ± .044

The mean blood pH measured in the study was 7.17, which is similar to the typical reference range of 7.35-7.45 for normal blood pH. This result is likely due to variations in the individual responses of the participants and the relatively small sample size. The standard deviation of ± 0.044 suggests a considerable variation in pH values across the participants. This variation may be influenced by factors such as diet, hydration status, or minor metabolic imbalances that do not manifest as clinical symptoms but still affect blood pH. In clinical practice, monitoring pH levels is crucial, as deviations from normal pH can be indicative of underlying conditions such as respiratory or metabolic acidosis/alkalosis.

3. Viscosity

- **Mean Viscosity**: 5.06 cP.
- **Standard Deviation**: ± 0.46 cP.

Viscosity is a measure of blood's "thickness" or resistance to flow. The mean viscosity in the sample population was 4.93 cP., with a standard deviation of ± 0.46, suggesting moderate variation across participants. Viscosity is significantly influenced by hematocrit (the proportion of red blood cells in blood), plasma protein concentration, and blood volume. Higher viscosity can be associated with cardiovascular diseases, as it leads to greater resistance to blood flow and requires the heart to work harder to pump blood. In contrast, low viscosity may suggest issues with red blood cell production or other hematological disorders. While the values observed here fall within normal ranges, further studies with larger sample sizes and broader population demographics are necessary to refine these baseline measurements.

4. Moisture Content

- **Mean Moisture Content**: 79.57%
- **Standard Deviation**: ± 0.028

The moisture content of blood, which reflects its water concentration, is crucial for maintaining proper circulation and homeostasis. The mean moisture content was 79.57%, with a relatively low standard deviation of ± 0.028, indicating a consistent level of hydration across participants. Hydration status is a key determinant of blood properties, particularly viscosity and circulation efficiency. Lower hydration levels may lead to increased blood viscosity and reduced blood flow, while higher hydration levels can improve circulation and enhance the delivery of nutrients and oxygen. This value aligns with the known high water content of blood plasma, further corroborating the hydration status of the participants.

5. Spectrophotometer Reading

- **Mean Spectrophotometer Value**: 0.4022
- **Standard Deviation**: ± 0.083

The spectrophotometer reading indicates the absorbance of light by blood, which can provide valuable information about hemoglobin concentration. A mean value of 0.4022 suggests an average concentration of hemoglobin in the blood, although this value is somewhat dependent on the specific equipment and calibration methods used. Spectrophotometric analysis is commonly used in clinical labs to estimate hemoglobin levels and assess oxygen-carrying capacity. The standard deviation of ± 0.083 indicates a moderate consistency in the hemoglobin levels among participants, which is expected in a relatively healthy population.

6. Specific Gravity

- **Mean Specific Gravity**: 0.9561
- **Standard Deviation**: ± 0.101

Specific gravity reflects the density of blood relative to water, providing insights into blood composition. The mean specific gravity was 0.9561, which is typical for healthy blood, as it indicates a balanced proportion of red blood cells, plasma, and other cellular elements. A high or low specific gravity could indicate issues like dehydration (increased specific gravity) or anemia (decreased specific gravity). The standard deviation of ±0.101 suggests some variability, which could be attributed to individual differences in blood composition, hydration status, or other underlying factors.

7. Clotting Time (CT)

- **Mean Clotting Time**: 303 seconds
- **Standard Deviation**: ± 54.27 seconds

Clotting time is a critical measure of blood's ability to form clots, which is essential for wound healing and preventing excessive bleeding. The mean clotting time in this study was ± 303 second, which is within the normal range for healthy individuals. A standard deviation of ± 54.27 indicates some variability in clotting times, which could be influenced by genetic factors or slight variations in blood coagulation factors. Prolonged clotting time could suggest a clotting disorder, while a very short clotting time could point to hypercoagulability, both of which require medical attention.

8. Bleeding Time (BT)

- **Mean Bleeding Time**: 113 seconds
- **Standard Deviation**: ±33.12 seconds

Bleeding time refers to the time it takes for bleeding to stop after a standardized incision is made in the skin. The mean bleeding time of ± 33.12 minutes is within the normal range, which typically falls between 60 seconds to 180 seconds for healthy adults. A shorter bleeding time could suggest hyperactive platelet function, while a longer bleeding time could indicate platelet dysfunction or other coagulation issues. The standard deviation of ± 33.12 seconds suggests that the variability in bleeding times among the participants.

9. Foam Formation (Foam 0 and Foam 1)

- **Mean Foam 0**: 4.1mm
- **Mean Foam 1**: 3.31mm
- **Standard Deviation (Foam 0)**: ± 0.99
- **Standard Deviation (Foam 1)**: ± 0.88

Foam formation in blood occurs when the blood is agitated, and it provides an indirect measure of the blood's lipid and protein content. The results show that foam formation in response to agitation (Foam 0) had a mean value of 4.1 mm, with a standard deviation of ± 0.99. Foam stability (Foam 1) had a mean value of 3.31 mm, with a standard deviation of ± .88. These results suggest that the blood of most participants formed stable foam, indicating a normal lipid and protein concentration. Excessive foam formation can be linked to lipid disorders, while low foam formation could suggest a deficiency in plasma proteins.

10. Contact Angle

- **Mean Contact Angle**: 84.61°
- **Standard Deviation**: ± 5.01°

The contact angle measures blood's ability to interact with surfaces, particularly in relation to clot formation. The mean contact angle of 84.61° suggests that the blood had moderate adhesiveness to the surface, which is typical for healthy individuals. The standard deviation of ± 5.01° indicates considerable variability in how blood interacted with surfaces, which could be influenced by factors such as the presence of clotting factors, hydration, and the composition of plasma proteins.

11. Body Mass Index (BMI)

- **Mean BMI**: 21.02
- **Standard Deviation**: ± 3.86

The body mass index (BMI) is an indicator of overall body health and weight status. A mean BMI of 21.02 suggests that the participants were within the normal weight range (18.5–24.9). BMI can have an indirect effect on blood properties such as viscosity and circulation. A higher BMI can lead to increased blood viscosity and associated cardiovascular risks. The relatively low standard deviation of ± 3.86 indicates a fairly consistent body mass index across the participants.

The results from this study provide valuable baseline data on the physical characteristics of blood in healthy individuals. Understanding the normal range for parameters such as pH, viscosity, clotting time, and foam formation is essential for clinicians to identify deviations that may indicate underlying health conditions.

- **Viscosity and Hydration**: The viscosity values observed suggest that the participants had normal blood flow characteristics, which is crucial for efficient oxygen and nutrient delivery to tissues. Variations in viscosity can have significant implications for cardiovascular health, as higher viscosity increases the workload on the heart.
- **Clotting and Bleeding Times**: The clotting time and bleeding time results were within the normal range, indicating that the participants had a healthy coagulation system. This is vital for wound healing and preventing excessive blood loss.
- **pH**: The slightly lower mean pH suggests that there may be some minor deviations in acid-base balance. While still within the normal range, further studies could explore the factors influencing pH variability in healthy individuals.
- **Foam Formation**: Foam formation offers a simple method for assessing lipid and protein concentrations in the blood. The stable foam formation observed in the majority of participants is a positive indicator of normal lipid metabolism.

DISCUSSION

This pilot study aimed to standardize the physical characteristics of blood in healthy volunteers to establish baseline values that could serve as reference points for clinical diagnostics and therapeutic interventions. The results presented above provide valuable insights into various blood parameters, including pH, viscosity, moisture content, specific gravity, clotting time (CT), bleeding time (BT), foam formation, contact angle, and body mass index (BMI). The mean and standard deviation (SD) for each parameter reveal crucial information about the consistency and variability of these characteristics in healthy individuals.[14]

pH of Blood

The pH of blood plays a pivotal role in maintaining the body's acid-base balance, and any deviations from the normal range (7.35–7.45) can indicate underlying metabolic or respiratory conditions. In this study, the mean pH value was 7.39, which falls within a normal range. While the value is still within an acceptable range, the standard deviation (SD = ± 0.044) indicates that there is some variability among participants. This variability could be attributed to several factors, including diet, hydration status, or other metabolic influences that may not be apparent in a clinical setting.[15]

In clinical practice, blood pH is a key parameter in assessing patients' acid-base balance. Deviations in pH can signal the presence of conditions like acidosis or alkalosis, which can have serious implications for organ function. However, it is important to note that slight variations in blood pH may not always be clinically significant in the absence of other symptoms. The findings of this study highlight the need for more research to refine these baseline values in a broader population, particularly considering different age groups, genders, and health conditions.[16]

Blood Viscosity

Blood viscosity is an essential physical property that significantly impacts blood flow and circulation. It is influenced by factors such as the concentration of red blood cells (hematocrit), plasma proteins, and the ability of blood components to flow through the circulatory system. The mean viscosity value obtained in this study was 5.06 cP, which is within the expected range for healthy adults. The standard deviation of ± 0.46 indicates a moderate variability in viscosity among the participants, which could be attributed to individual differences in hematocrit levels and plasma protein concentrations.

Increased blood viscosity can result in poor blood circulation, putting additional strain on the heart and increasing the risk of cardiovascular diseases, such as hypertension and atherosclerosis. Conversely, low viscosity could indicate conditions like anemia, where there is a reduced number of red blood cells, or other hematological disorders. The values observed in this study fall within the typical range for healthy individuals, which is reassuring. However, future studies with larger sample sizes could help determine more precise reference ranges for viscosity in different populations, including those with underlying medical conditions.

Moisture Content of Blood

The moisture content of blood, primarily composed of water in the plasma, plays a crucial role in maintaining blood circulation and overall fluid balance in the body. The mean moisture content in this study was 79.57%, with a standard deviation of ± 0.028. This indicates that most participants had similar hydration levels, which aligns with the fact that blood plasma is typically composed of around 90% water.[17]

Hydration status can affect the viscosity of blood, with dehydration leading to thicker blood and increased resistance to flow. The relatively low standard deviation in the moisture content suggests that participants were generally well-hydrated. This is important because maintaining optimal hydration is crucial for ensuring proper circulation, tissue perfusion, and the efficient transport of oxygen and nutrients. Dehydration, even at mild levels, can cause blood to become more viscous and less able to circulate efficiently. The results from this study suggest that hydration status is an important factor to consider when interpreting blood's physical properties.

Spectrophotometric Analysis

Spectrophotometric analysis is often used to assess the concentration of hemoglobin in the blood, as it provides an indirect measure of oxygen-carrying capacity. In this study, the mean spectrophotometer reading was 0.4022, with a standard deviation of ± 0.083. This value indicates that the hemoglobin levels in the blood samples were within the normal range, suggesting that participants had adequate levels of this essential protein.

The standard deviation, though small, suggests that there is some variability in the hemoglobin concentrations among participants. This is to be expected, as hemoglobin levels can vary slightly based on factors such as genetics, nutritional status, and overall health. In clinical practice, spectrophotometry is used to assess conditions such as anemia or polycythemia, which can affect hemoglobin levels. Although the spectrophotometer reading in this study suggests normal hemoglobin concentrations, further research with a larger sample size and diverse population is needed to confirm these findings and establish more specific reference ranges.[18]

Specific Gravity

Specific gravity is a measure of the density of blood relative to water and can provide insight into blood composition. The mean specific gravity in this study was 0.9561, which is consistent with the expected range for healthy blood. The standard deviation of ± 0.101 indicates some variability, which may be influenced by factors such as plasma protein concentration, hydration status, and hematocrit levels.

Specific gravity is an important indicator of blood's ability to transport oxygen and nutrients throughout the body. Higher specific gravity may suggest an increased concentration of red blood cells or plasma proteins, while lower specific gravity could indicate anemia or other blood disorders. The results from this study suggest that the participants had a normal balance of red blood cells and plasma components, but further investigation is needed to determine how specific gravity might vary in different populations or in individuals with specific medical conditions.

Clotting Time (CT) and Bleeding Time (BT)

Clotting time and bleeding time are key indicators of blood's ability to form clots and stop bleeding, respectively. The mean clotting time was 303 seconds, while the mean bleeding time was 113 seconds. Both of these values fall within the normal reference ranges for healthy adults. The standard deviations for both parameters (± 54.27 for CT and ± 33.12 for BT) indicate moderate variability, which is typical in a healthy population.

In clinical practice, abnormal clotting or bleeding times can be indicative of coagulation disorders, such as hemophilia or platelet dysfunction. Prolonged clotting times can lead to excessive bleeding, while shorter clotting times may be associated with increased risk of thrombosis. The normal clotting and bleeding times observed in this study suggest that the participants had normal coagulation function, but it is important to consider the potential influence of individual variations in clotting factor levels or platelet function.

Foam Formation

Foam formation is a qualitative indicator of the lipid and protein content in blood. In this study, the mean foam formation for Foam 0 was 4.10 mm, and for Foam 1, it was 3.31 mm. These results suggest that the participants had a normal lipid and protein profile, with stable foam formation under stress. The standard deviations for both Foam 0 and Foam 1 (± 0.99 and ± 0.88, respectively) indicate that there was some variability in foam formation, which is expected due to differences in lipid metabolism and plasma protein levels among individuals. Excessive foam formation can be linked to lipid-related disorders, such as hyperlipidemia or hypercholesterolemia, while low foam formation could suggest deficiencies in plasma proteins or lipoproteins. The results from this study suggest that the participants generally had normal lipid and protein levels. However, further studies with larger sample sizes and more diverse populations are necessary to establish more definitive reference values for foam formation and its relationship to blood lipid and protein content.[19]

Contact Angle

The contact angle is a measure of blood's ability to interact with surfaces, which is relevant for clot formation and other physiological processes. The mean contact angle in this study was 84.61°, with a standard deviation of ± 5.01°. This suggests that blood from the participants had moderate adhesiveness to surfaces, which is typical for healthy individuals.

The contact angle can be influenced by a variety of factors, including the presence of clotting factors, plasma proteins, and other molecules involved in blood coagulation. A higher contact angle may indicate better clotting potential, while a lower contact angle could suggest issues with clot formation or platelet function. The moderate contact angle observed in this study suggests that the participants had normal clotting function, but further research is needed to understand the full implications of contact angle measurements in blood.

Body Mass Index (BMI)

BMI is a widely used indicator of overall health, and it has a significant impact on blood viscosity and circulation. The mean BMI in this study was 21.02, which places the participants in the normal weight range. The relatively low standard deviation (± 3.86) indicates that the participants had a fairly consistent body composition.

A higher BMI can increase blood viscosity, putting additional strain on the cardiovascular system, while a lower BMI could be associated with malnutrition or other health issues. The results from this study suggest that the participants were generally healthy with a normal BMI, which is important for ensuring optimal blood flow and reducing the risk of cardiovascular diseases. However, further studies with a broader range of BMI values are needed to understand how BMI may influence blood properties across different populations.[20]

CONCLUSION

This pilot study aimed to establish baseline reference values for various physical characteristics of blood in healthy volunteers. By measuring parameters such as pH, viscosity, moisture content, specific gravity, clotting time (CT), bleeding time (BT), foam formation, contact angle, and body mass index (BMI), the study provides valuable insights into the normal range for these characteristics in healthy individuals. These baseline values are critical for enhancing diagnostic accuracy, improving therapeutic interventions, and fostering a better understanding of blood's role in overall health.

The study's findings revealed that the participants generally exhibited normal blood properties. For instance, the mean blood pH (7.39) was within an acceptable range, though similar the typical physiological range of 7.35–7.45. This suggests some variability in blood pH among healthy individuals, which could be influenced by factors such as diet, hydration status, and metabolic balance. Similarly, the mean viscosity of blood (5.06 cP) and specific gravity (0.95) were within expected ranges, reflecting normal blood flow characteristics and composition. These parameters are crucial for circulatory health, and maintaining their normal levels is essential for efficient oxygen and nutrient transport to tissues.

The study also highlighted the importance of hydration, as evidenced by the moisture content (mean = 79.57%) and the stable foam formation observed in most participants. These findings suggest that the volunteers were generally well-hydrated, which is essential for maintaining the fluidity and viscosity of blood. Furthermore, the results for clotting time (mean = 303 seconds) and bleeding time (mean = 113 seconds) were within normal ranges, indicating healthy coagulation function. Abnormalities in these times can signal clotting disorders or platelet dysfunction, making their normal values crucial for understanding overall blood health.

Foam formation, as an indirect measure of lipid and protein content in the blood, further corroborated the normal metabolic profile of the participants. The results showed that blood from healthy individual's forms stable foam, which is a positive indicator of balanced lipid and protein concentrations. Similarly, the contact angle (mean = 84.61°) provided insights into the blood's interaction with surfaces, relevant for understanding clot formation dynamics, with normal contact angle values suggesting proper clotting function.

BMI, as a general health indicator, showed that the participants were within the normal weight range (mean = 21.02), which is important for ensuring optimal blood circulation and reducing cardiovascular risks. The relatively low standard deviation in BMI further supports the overall health of the participants, as it indicates a consistent body composition among the sample group.

While the results of this study offer useful reference values, it is important to note that the sample size was small (30 participants), and these findings should be considered preliminary. Further research involving a larger, more diverse population would be valuable to refine these baseline values and explore how blood characteristics vary across different demographic groups, such as those with underlying medical conditions or specific lifestyle factors.

In conclusion, this pilot study provides essential baseline data on the physical characteristics of blood in healthy adults. The findings not only enhance our understanding of normal blood properties but also pave the way for more accurate clinical diagnostics and interventions. Establishing reliable reference values for these parameters can help clinicians detect early signs of health issues, monitor disease progression, and tailor treatments to individual patients. Further research is needed to confirm these results and expand our knowledge of how these blood characteristics relate to overall health and disease states.

REFERENCES

1. Brown JD, Smith AP, Jones RL. Physiological role of blood viscosity in human health. *J Clin Biochem*. 2017;33(2):120-8.
2. Kumar S, Agarwal P, Shukla N, et al. Study of blood pH variation and its clinical relevance. *Indian J Physiol Pharmacol*. 2019;63(4):334-41.
3. Kapoor A, Singh P. Assessment of blood viscosity and its clinical importance. *Clin Hemorheol Microcirc*. 2020;75(1):1-9.
4. Singh A, Singh V, Kumar R. Moisture content of blood and its influence on viscosity. *J Lab Med*. 2021;8(3):102-9.
5. Gupta R, Sharma M, Malhotra S. Blood properties in various health conditions: implications for diagnosis and treatment. *Med Res Arch*. 2020;8(4):205-14.

6. Bhatt M, Varma P, Tripathi N. Specific gravity and its relationship with blood composition in normal individuals. *Indian J Blood Transfus Immunohematol*. 2018;34(4):298-303.
7. Mishra A, Prakash B. Variability in clotting and bleeding times: An epidemiological study. *Blood Coagul Fibrinolysis*. 2019;30(2):156-62.
8. Reddy PV, Sharma S. Blood viscosity as a determinant of cardiovascular function. *J Cardiovasc Res*. 2020;14(2):81-6.
9. Gupta S, Kumar S, Verma P, et al. Foamy blood: A diagnostic tool for lipid and protein disorders. *Indian J Med Sci*. 2021;73(3):145-53.
10. Singh R, Virdi N, Yadav A, et al. Investigation of the contact angle of blood and implications for thrombosis. *Thrombosis J*. 2020;18(1):45-52.
11. Patil M, Deshpande V. A study on blood pH and its clinical implications. *Ind J Clin Biochem*. 2017;32(2):197-205.
12. Mehta P, Gupta R, Thakur S. Blood's interaction with surfaces: A study on contact angle measurements. *J Blood Res*. 2019;23(4):134-9.
13. Malik S, Kumar M, Sharma P. The role of hydration in blood viscosity and overall health. *Am J Physiol Circ Physiol*. 2018;315(6):1238-45.
14. Mehta S, Sharma G. Role of BMI in cardiovascular health: An integrated approach. *J Nutr Metab*. 2020;2020:784-91.
15. Mishra H, Kumar S, Singh B. The effect of body mass index on blood properties: An epidemiological analysis. *Obes Rev*. 2021;22(8):1820-6.
16. Nair K, Raju R. Spectrophotometric methods for the assessment of hemoglobin in blood. *J Clin Pathol*. 2019;12(4):89-95.
17. Kumar V, Singh R, Tripathi P. Determining blood viscosity in relation to lipid disorders. *Int J Clin Hemorheol*. 2021;55(3):213-21.
18. Bansal M, Tiwari S. Clotting time and its role in assessing bleeding disorders. *Hematol Oncol Clin North Am*. 2018;32(6):1087-95.
19. Joshi A, Jha A, Soni R, et al. Effect of hydration status on blood viscosity in healthy adults. *Clin Nutr*. 2017;36(3):833-40.
20. Verma K, Tyagi N, Gupta M. Blood pH and its clinical relevance in metabolic disorders. *J Clin Diagn Res*. 2019;13(1):12-18.