CHAPTER «BIOLOGICAL SCIENCES»

AGE-RELATED DYNAMICS OF BIOCHEMICAL MARKERS OF THE BLOOD SYSTEM

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Abstract. Abstract. The study of biochemical markers of the blood system provides essential insights into the functional state of the human organism and the early detection of pathological conditions. *The purpose* of this paper is to analyse the age-related dynamics of key biochemical blood indicators in adolescents and adults, based on a large dataset of laboratory diagnostics conducted in the city of Sumy. The research tasks determine the structure of the paper: systematisation of scientific data on the biochemical composition of blood and its regulatory mechanisms; analysis of the methods used in biochemical diagnostics; and a comparative assessment of glucose, creatinine, uric acid, and transaminase levels (AST, ALT) across age groups. *Methodology* of the study relies on general scientific approaches, including analysis, synthesis, comparison, and statistical generalisation of laboratory data from 1,886 individuals aged 17–18 and over 18. *Results* demonstrate significant age- and sex-related variations in biochemical markers: adults more frequently exhibit elevated glucose, creatinine, AST, and ALT levels, whereas adolescents show fluctuations primarily related to physiological growth processes. The obtained findings indicate that increased biochemical deviations in adults may be associated with metabolic disorders, impaired liver or kidney function, lifestyle factors, or chronic diseases. *Practical implications.* The results can be used to improve regional health monitoring, support preventive medical programs, and optimise diagnostic strategies for different age groups. *Value/originality.* This research provides one of the first comprehensive comparative analyses of biochemical blood parameters

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in adolescents and adults in the Sumy region, highlighting the relevance of age-related biochemical monitoring for public health assessment and early disease prevention.

1. Introduction

In the current context of prolonged crisis events, including the war and the COVID-19 pandemic, the issue of preserving and strengthening the health of the Ukrainian population has become particularly significant. Such circumstances create a considerable burden on the human body, causing chronic stress that may lead to alterations in blood biochemical parameters [17]. Blood biochemical indicators serve as an important measure of an individual's physiological state, as they reflect the functioning of organs and bodily systems. The study of changes in the biochemical composition of blood makes it possible to detect pathologies at early stages, which is crucial for timely diagnosis and treatment [10].

According to official statistics from the Public Health Center of the Ministry of Health of Ukraine (the most recent available report is from 2021), the morbidity rate in Sumy Oblast exceeds the national average [11]. In this regard, while examining the issue of increased morbidity in the region, it became necessary to analyze laboratory blood test results, particularly among residents of the city of Sumy. Laboratory diagnostics enable the assessment of biochemical blood parameters in individuals of different age groups and allow for a comprehensive evaluation of the population's health. Modern chemical analysis methods provide accurate and prompt determination of the concentrations of various substances in the blood, which is critically important for disease diagnosis and monitoring. Such studies make it possible to detect pathological changes in enzyme levels, hormones, and other biochemical indicators, contributing to timely responses to changes in patients' health status.

The events of recent years in Ukraine have only intensified scientific interest in assessing morbidity among Ukrainians and in studying the influence of various factors on health indicators [8; 9; 10; 14; 18]. Laboratory studies of blood parameters under the influence of different factors have been conducted by O. Andrushchenko, O. Dolzhykova, N. Hryhorova, A Pokalenko et al. (2021), Ye. Dolatkazina (2022), Ye. Yel'kiv (2025), among others [7].

Within the framework of research carried out by the Department of Human Biology, Chemistry, and Methods of Teaching Chemistry at A.S. Makarenko Sumy State Pedagogical University, a comprehensive study of biochemical blood parameters across various age groups was conducted. Based on these data, a comparative analysis of changes in biochemical blood indicators among different age categories (particularly adolescents and adults) was performed for the first time using laboratory test results provided by laboratories in the city of Sumy. Further development involves the study of age-related changes in blood parameters among residents of Sumy Oblast under the influence of various factors.

The application of research results on biochemical blood parameters across different age groups may be beneficial for evaluating the health status of adolescents and adults, both in terms of individual indicators (such as glucose, creatinine, uric acid levels, and enzymes) and through comparative analysis by age and gender. These findings may also support the implementation of various public health programs and initiatives in the city of Sumy.

The obtained data [14; 15; 16] may serve as a foundation for further scientific research on biochemical blood parameters across age groups, as well as for the development of new diagnostic, monitoring, and health assessment methods. Moreover, they may be used to raise public awareness about morbidity levels, particularly among residents of Sumy and Sumy Oblast, thus fostering a responsible attitude toward personal health and encouraging annual visits to clinical laboratories for health monitoring and disease diagnostics.

2. General information about blood composition and hematopoiesis

Cells, tissues, and organs of the human body can function normally only within an appropriate internal environment [12]. To maintain such an environment at a relatively constant level, the body regulates blood pressure, temperature, and the content of proteins, carbohydrates, sodium, potassium, and chloride ions, among other components. The preservation of the constancy of the internal environment is referred to as *homeostasis*.

The internal environment consists of blood, lymph, and interstitial fluid. Blood belongs to the integral systems of the body and is in direct contact with lymph and interstitial fluid, ensuring the exchange of substances between them [2].

Blood is one of the most important fluid tissues in the human body. It plays a decisive role in maintaining vital functions through a number of processes, including the transport of oxygen and nutrients, the removal of metabolic waste products, temperature regulation, immune responses, and others. Blood contains a wide variety of chemical compounds essential to the performance of these functions.

Some researchers refer to blood as "a living chemical medium that reflects the functioning and health status of the organism" [4]. For this reason, blood analysis is one of the most informative tools for diagnosing and assessing the condition of the human body. Laboratory blood tests make it possible to evaluate the functioning of organs and systems and to identify characteristics of various diseases.

The most common blood test is the ***complete blood count*** **(CBC)**, which every individual undergoes at least once. Based on the results of a CBC, it is possible to assess the number of blood cells (erythrocytes, leukocytes, and platelets), hemoglobin levels, and deviations from the norm [12]. Many diseases can be detected relatively quickly through changes in clinical blood parameters. For example, an increase in leukocyte count indicates the development of appendicitis, whereas bleeding decreases the number of erythrocytes and hemoglobin levels. Elevated glucose concentrations indicate impaired carbohydrate metabolism and the development of diabetes mellitus. Lipid metabolism is evaluated based on blood concentrations of cholesterol, lipoproteins, and triglycerides. Changes in phosphorus and calcium concentrations indicate disrupted mineral metabolism, which may occur in kidney disease, rickets, or certain hormonal disorders. Potassium, sodium, and chloride are also important indicators. Alterations in their levels negatively affect the functioning of internal organs, particularly the heart [2].

A ***biochemical blood test*** enables the assessment of metabolism and the functioning of internal organs such as the liver, kidneys, and pancreas. Therefore, the study of biochemical blood parameters, their dynamics, and their dependence on various factors is of great scientific interest.

An analysis of the literature and information sources indicates that the biochemical parameters of human blood are the subject of intensive research in medicine and biochemistry.

Numerous studies by T.Yu. Horpynich [9], N.M. Inshyna [13], V.A. Samchuk, O.I. Huzhva, and others confirm that biochemical blood parameters change with age. For example, the levels of specific proteins, enzymes, glucose, and other substances may increase or decrease depending on the age of the patients.

Understanding age-related changes in biochemical blood parameters is essential for assessing and predicting certain diseases. Factors influencing these age-related changes include heredity, sex, lifestyle, diet, and the presence of chronic diseases.

In recent years, scientific interest in assessing morbidity rates among Ukrainians and in evaluating various factors affecting health indicators has significantly increased [8 9; 10; 13; 14; 15; 17; 18]. For instance, laboratory studies of blood parameters in patient with COVID-19 were conducted by O.Ye. Andrushchenko, O.V. Dolzhykova, N.V. Hryhorova, A.O. Pokalenko, and others (2021) [10]. Researcher Ye. Dolatkazina presented findings on blood parameters and COVID-19 (2022) [17].

The study of biochemical blood indicators is crucial for understanding human health and identifying pathological conditions, enabling timely diagnosis and effective treatment. Modern laboratory diagnostic methods continue to advance and evolve.

Thus, after analyzing the literature regarding the study of age-related changes in biochemical blood indicators, we can confirm the relevance and multidimensional nature of such research. Previous scientific findings indicate the complexity and variability of changes observed in different age groups under the influence of various factors. All these aspects emphasize the importance of studying biochemical blood parameters for assessing the condition of the body, diagnosing diseases, and developing effective treatment methods.

Let us now consider the chemical composition and functions of blood.

Blood (*Latin: sanguis*) is a type of connective tissue. It consists of a liquid component – blood plasma – and formed elements, produced through the interaction of multiple organs and body systems. The formed elements of blood include erythrocytes (RBCs), leukocytes (WBCs), and platelets (PLTs). Formed elements account for approximately 40–45% of blood volume, while 55–60% is represented by the liquid component [5; 14].

Blood plasma is a complex biological medium closely interconnected with cerebrospinal and interstitial fluids. Plasma is a yellowish fluid composed of water (90–92%) and a dry residue (8-10%), which consists of organic and inorganic substances.

Inorganic substances constitute about 1% of plasma and mainly include cations (Na^+, Ca^{2+}, K^+, Mg^{2+}) and anions (Cl^-, HPO_4^{2-}, HCO_3^-). On average, blood volume constitutes 6–8% of total body weight; at a body mass of 70 kg, the blood volume is approximately 5 liters. Blood serves as a neurochemical medium that responds precisely to even minor physiological – and especially pathological – changes in the organism [4; 7].

The organic components of blood plasma are presented in Figure 1.

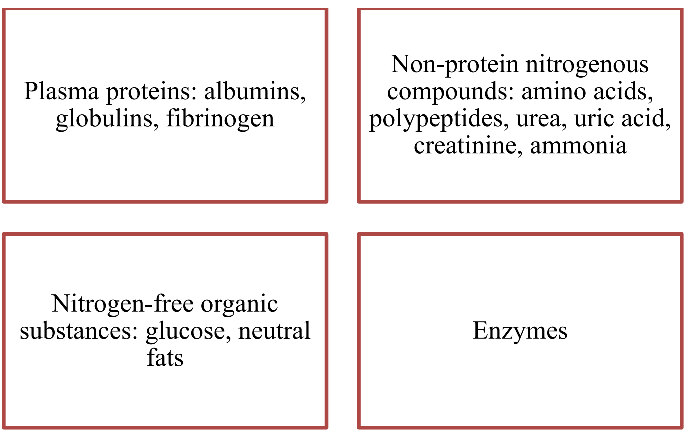


Figure 1. Organic substances of blood plasma

Blood contains approximately 20 essential trace elements. Many of them (iron, nickel, cobalt) participate in hematopoiesis. Therefore, alterations in the composition of blood plasma have a detrimental effect on the organism.

In addition to the formed elements and plasma, the blood system includes lymph, as well as the organs of hematopoiesis and immunopoiesis (red bone marrow, thymus, spleen, lymph nodes, and accumulations of lymphoid tissue). All components of the blood system are interconnected both histogenetically and functionally, and are governed by the general laws of neurohumoral regulation [4].

The chemical composition of blood determines its functions and affects human health [12]. The principal functions of blood include transport, respiratory, nutritive, excretory, water-balance regulation, regulatory, and protective functions.

Plasma is adapted to perform nutritive, excretory, regulatory, thermoregulatory, and homeostatic functions, whereas the formed elements of the blood ensure respiratory and protective functions.

Blood also influences the distribution and metabolism of pharmaceuticals within the body. Studying the chemical properties of blood helps elucidate how drugs interact with the blood and organs, which is essential for proper dosing and treatment safety.

Thus, blood consists of blood plasma (approximately 60% of its volume) and formed elements (blood cells: RBCs, WBCs, and platelets), which make up about 45% of its volume. Blood performs a number of vital functions (transport, respiratory, nutritive, excretory, regulatory, and protective, among others). Alterations in the chemical composition of blood may lead to various functional disorders in organs and systems and contribute to the development of certain diseases.

3. Key Indicators of Blood Biochemical Analysis

Biochemical blood analysis is a laboratory diagnostic method that examines various chemical components of the blood to assess the functions of organs and body systems, determine disease risks, and monitor the patient's health status. This type of analysis provides physicians with essential information about biochemical processes occurring in the body and serves as an important tool for diagnosing and monitoring diseases.

Blood for examination should be collected from a vein on an empty stomach, following prior medical recommendations [4].

Biochemical blood analysis makes it possible to determine the levels of various substances in the bloodstream, including electrolytes, proteins, enzymes, sugars, lipids, amino acids, transferases, and other chemical compounds [9]. The assessment of these parameters is important for the following aspects:

a) disease diagnosis – biochemical analysis helps detect various diseases such as diabetes, kidney, liver, and heart disorders, osteoporosis, thyroid abnormalities, and many others. Changes in the levels of certain substances may indicate pathological processes in the body;

b) evaluation of organ function – the analysis makes it possible to assess the functioning of different organs, particularly the kidneys, liver, and heart. For example, creatinine levels indicate kidney function, while enzymes such as AST and ALT may reflect liver function;

c(treatment monitoring – after diagnosis, biochemical blood tests can be used to monitor treatment effectiveness and determine the need for modifications to the treatment plan;

d) assessment of disease risk – certain substances and biochemical indicators may serve as markers of the risk of developing particular diseases. For instance, elevated cholesterol levels may be associated with cardiovascular disease risk;

e) evaluation of general health status – the analysis provides information about the patient's overall condition and helps detect abnormalities even in the absence of clinical symptoms.

Biochemical blood analysis usually includes numerous indicators, and interpretation of results requires appropriate medical expertise. This analysis may be conducted for medical check-ups, disease diagnosis, patient monitoring, and various other clinical purposes. Preparation depends on the specific indicators required. It is recommended to avoid physical exertion for 3–5 days before testing, refrain from consuming alcoholic beverages, avoid diuretic medications, and abstain from eating for 12 hours [2].

1) Non-Protein Nitrogenous Components of Blood Plasma

Non-protein nitrogenous components include urea (50%), uric acid (4%), amino acids (25%), creatine (5%), creatinine, ammonia, indican, bilirubin, and other compounds (Figure 2) [9; 12]**.**

Urea (*3,33-8,32 mmol/L*) is formed in the liver as the final product of ammonia detoxification. Urea itself is minimally toxic; however, when its concentration increases, edema of the tissues of parenchymal organs, the myocardium, and the central nervous system may occur. As a biochemical indicator, its level is determined primarily for the diagnosis of kidney diseases.

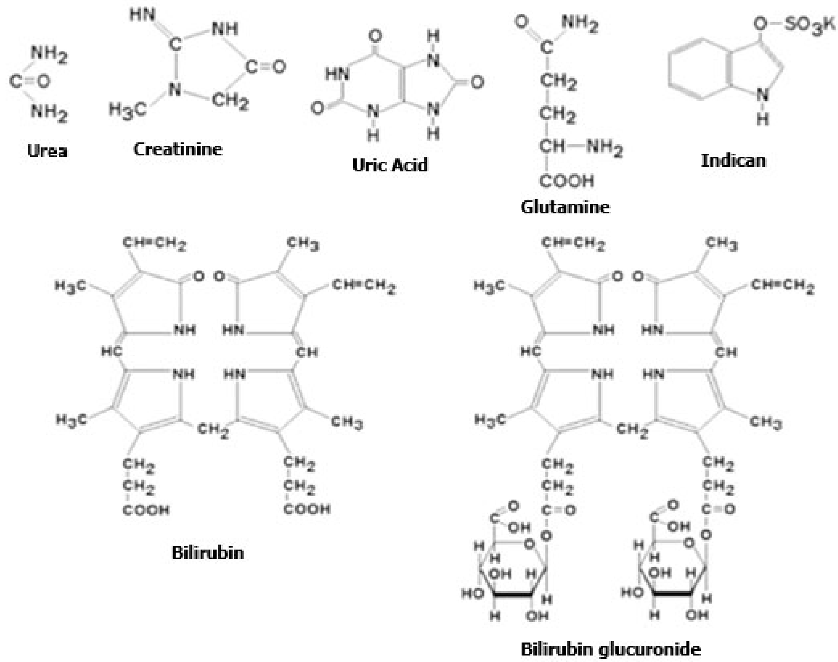


Figure 2. Non-protein nitrogenous components of blood plasma

Amino acids are essential components that enter the bloodstream either through absorption in the gastrointestinal tract or as a result of tissue protein degradation. In healthy individuals, alanine and glutamine predominate among the amino acids present in the blood. In addition to participating in protein biosynthesis, these amino acids serve as transport forms of ammonia.

Creatine is synthesized in the kidneys and liver and is converted in muscle tissue into creatine phosphate, an important energy source for muscle contraction. Normally, plasma creatine concentrations range from 15.3 to 45.8 μmol/L in men and from 45.8 to 76.3 μmol/L in women. Elevated creatine levels may be observed in muscle injuries, muscular dystrophy, poliomyelitis, starvation, burns, infections, diabetes mellitus, hyperthyroidism, acromegaly, leukemia, and other pathological conditions.

Indican (the potassium or sodium salt of indoxyl sulfate) is a compound formed in the liver as the detoxification product of indole–one of the putrefaction products of proteins in the intestine. Hyperindicanemia is observed in the early stages of renal insufficiency, in glomerulonephritis, pulmonary tuberculosis, and in conditions associated with increased intestinal protein putrefaction.

Bilirubin (direct and indirect) is a product of hemoglobin catabolism. Blood bilirubin levels increase in different types of jaundice: hemolytic (due to indirect bilirubin), obstructive (due to direct bilirubin), and parenchymal (due to increases in both fractions).

Ammonia (17–78 µmol/L) is the final product of protein metabolism. Its primary sources include deamination processes in tissues and the catabolism of nitrogen-containing compounds in the intestine by putrefactive bacteria. Elevated blood ammonia concentrations occur in hepatic coma, partial hepatectomy, hereditary enzyme deficiencies of the ornithine cycle, and other pathological conditions.

Thus, the non-protein nitrogen fraction of blood or serum includes nitrogen from urea, amino acids, uric acid, creatine, and other non-protein nitrogenous substances (polypeptides, nucleotides, nucleosides, glutathione, bilirubin, choline, histamine, etc.). Therefore, non-protein nitrogen consists mainly of the nitrogen of end-products of simple and complex protein metabolism.

Uric Acid ($C_5H_4N_4O_3$) (Figure 3) is an organic compound formed in the body as a result of the breakdown of purine compounds, particularly adenine and guanine. It is the final product of purine degradation within cells.

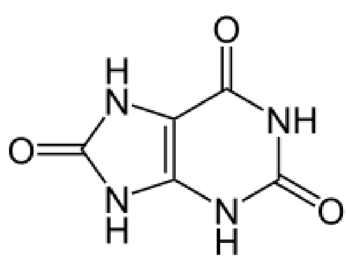


Figure 3. Chemical structure of uric acid

Uric acid possesses a nitrogen-containing heterocyclic ring framework that includes amino groups and a carboxyl group. Its chemical formula (Figure 1.3) indicates the presence of five carbon atoms, four nitrogen atoms, three oxygen atoms, and three hydrogen atoms.

Processes involving uric acid in the blood:

– During metabolic processes in the organism, adenine and guanine–components of cellular DNA and RNA–undergo degradation to form uric acid. This process occurs primarily in liver cells and other tissues.

– The uric acid produced in the body enters the bloodstream. It is subsequently filtered by the kidneys, where most of it is excreted from the body in the form of urine.

– The kidneys play a crucial role in regulating blood uric acid levels. When uric acid levels rise, the kidneys excrete more of it. Conversely, when uric acid levels decrease, the kidneys reabsorb a greater amount from the urine for reuse.

– Elevated uric acid levels may lead to the formation of uric acid crystals (urates), which can cause pathological conditions such as gout or urinary bladder stones.

– Uric acid levels vary throughout life. They are lowest in newborns and gradually increase with age. Higher uric acid levels are observed in adulthood due to growth, development, and hormonal influences.

Factors influencing blood uric acid levels – diet, hormones, genetics, namely:

– Consumption of purine-rich foods, such as red meat and fish, can increase uric acid levels.

– Hormonal fluctuations can affect uric acid synthesis.

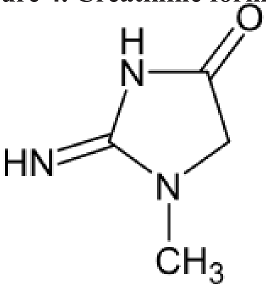
– Heredity may influence the body's ability to metabolize purines and eliminate uric acid.

Thus, uric acid is an important biochemical component formed as a result of purine degradation. Its blood concentration changes with age and is influenced by various factors, including diet, hormonal status, and genetic predisposition. Understanding this compound and its role in biochemical processes contributes to the comprehension of human physiology and may be valuable for the diagnosis and treatment of various diseases.

Creatinin – the final product of nitrogen metabolism is formed through the dephosphorylation of creatine phosphate in muscle tissues and is excreted from the body by the kidneys.

The chemical formula of creatinine is $C_4H_7N_3O$ (Figure 4). Creatinine contains an amide group and is a component of urea, a product of secondary nitrogen metabolism.

Figure 4. Creatinine formula



The blood creatinine level in newborns is usually very low, as their kidneys are not yet fully functional. Over time, as the child grows, the creatinine level increases because kidney function becomes more efficient. In adults, creatinine levels remain relatively stable but may vary depending on physical activity and other factors.

Creatinine is formed through the anhydrous transfer of guanidinoacetate with urea to form amidino-amino-creatine. This process occurs in muscle cells under the catalytic action of creatine kinase. Creatinine is excreted by the kidneys in the form of creatininuria. The chemical reactions associated with creatinine include its formation in muscle cells, metabolism, and renal excretion.

From a chemical perspective, creatinine formation in muscle cells results from the anhydrous transfer of guanidinoacetate with urea to amidino-amino-creatine. This reaction is catalyzed by the enzyme creatine kinase. Chemically, the reaction may be represented as follows:

Guanidinoacetate + Creatine ⇌ Creatinine + Urea

This reaction occurs in muscle cells and is essential for the creation and maintenance of the body's energy reserves. Creatinine is a by-product of creatine metabolism, which provides energy in muscle tissue. After entering the bloodstream, creatinine is transported to the kidneys, where it is filtered and excreted in urine. This process depends on kidney function and occurs without any changes to the chemical structure of creatinine.

Creatinine is eliminated by the kidneys in the form of creatininuria, meaning that creatinine passes from the blood into the urine and is excreted from the body. The urinary creatinine level is an important indicator of renal function and can be used to assess kidney performance. Creatinine represents an equilibrium between creatine and creatinine metabolism in muscle cells. Under normal conditions, the levels of creatine and creatinine remain stable. Alterations in this balance may indicate various pathological conditions, such as kidney diseases or muscle disorders.

2) Non-nitrogenous Organic Components of Blood Plasma

This group includes nutrients (carbohydrates and lipids) and their metabolic products (organic acids). In biochemical analysis, the most significant parameters are the blood levels of glucose, cholesterol, free fatty acids, ketone bodies, and lactic acid. The formulas of these compounds are presented in Figure 5.

Carbohydrates of blood plasma: blood plasma contains monosaccharides such as glucose, fructose, galactose, as well as lactic and pyruvic acids, ribose, and deoxyribose.

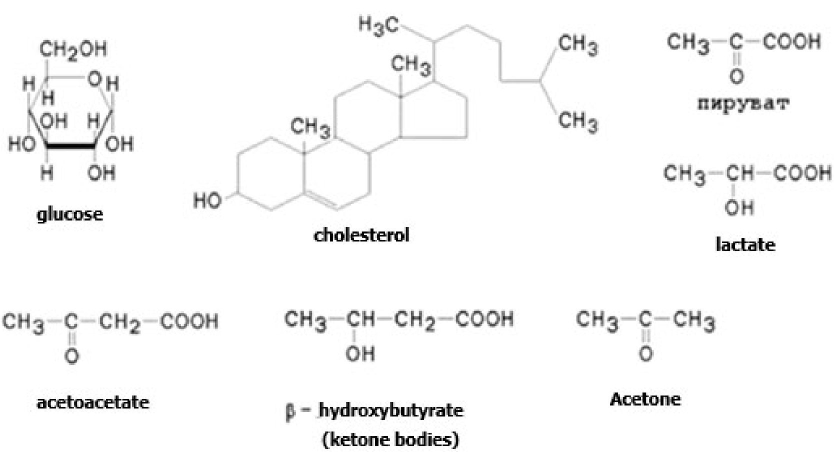


Figure 5. Non-nitrogenous Organic Components of Blood Plasma

Glucose is an essential biochemical compound and the principal energy source for the body's cells. Its concentration in the bloodstream is tightly regulated through complex mechanisms to ensure normal physiological functioning.

Below are the chemical properties of glucose, processes associated with increased or decreased blood glucose levels, and factors influencing these levels.

Glucose ($C_6H_{12}O_6$) (Figure 6) is a monosaccharide composed of six carbon atoms, twelve hydrogen atoms, and six oxygen atoms. It is the primary energy substrate for cells, supplied through oxidation in glycolysis and subsequent oxidative pathways.

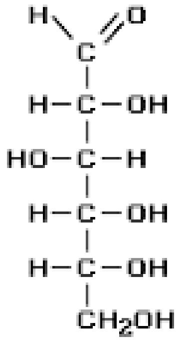


Figure 6. Glucose formula

Processes occurring in the blood at elevated glucose levels:

– Glucose is absorbed from the gastrointestinal tract after food intake and enters the bloodstream.

– Under the influence of insulin, a hormone secreted by the pancreas, glucose enters cells, where it can be utilized for energy production or stored as glycogen.

– When blood glucose levels rise (hyperglycemia), excessive blood sugar may lead to various complications, such as diabetes mellitus.

Processes occurring in the blood at decreased glucose levels:

– reduced blood glucose (hypoglycemia) may occur due to insufficient food intake or an excess of insulin relative to needs;

– hypoglycemia can impair energy supply to cells, leading to symptoms such as weakness, dizziness, and loss of consciousness.

Factors influencing blood glucose levels – diet, insulin, hormones, namely: carbohydrate intake significantly affects blood glucose concentration, regulates glucose uptake and utilization, glucagon, cortisol, and epinephrine also influence glucose levels.

Thus, blood glucose concentration is an essential biochemical indicator regulated by complex physiological processes. Both hyperglycemia and hypoglycemia may cause significant health problems, including diabetes or acute glucose deficiency. Regular monitoring of blood glucose and maintaining a healthy lifestyle are essential to ensure optimal physiological function.

Transaminases are key enzymes involved in vital biochemical processes. Below are the chemical properties, structure, and principal functions of transaminases, as well as their significance in blood biochemical indices.

Transaminases (aminotransferases) constitute a subclass of enzymes within the transferase class that catalyze transamination reactions, i.e., the transfer of an α-amino group from an amino acid to the α-carbon atom of an α-keto acid – the amino group acceptor. As a result, an α-keto analogue of the original amino acid and a new amino acid are formed [27].

Aminotransferases are complex protein enzymes whose prosthetic group consists of the coenzyme forms of vitamin B_6 (pyridoxine, pyridoxol) – pyridoxal phosphate (PLP) and pyridoxamine phosphate (PMP), the latter formed from PLP during the amino group transfer [31].

Transaminases exhibit extensive structural and substrate diversity. These enzymes contain active sites where the catalytic transfer of amino groups occurs. Most transaminases contain a pyridoxal–pyrimidine active center responsible for transferring amino groups between substrates.

Transaminases consist of protein units that may include one or more subunits, each contributing to the catalytic mechanism of amino group transfer.

In biochemical pathways, transaminases play crucial roles in the synthesis of amino acids, nucleotides, and other biomolecules. They help maintain amino acid balance within cells and support biosynthetic processes essential for proteins and other biochemical structures. Transaminases also participate in metabolic regulation and ensure optimal conditions for vital physiological processes.

Role in Biochemical Blood Markers

Transaminases are important indicators of tissue function, as changes in their concentrations may signal organ damage. For example, aminotransferases such as alanine aminotransferase (ALT) and aspartate aminotransferase (AST) are normally present in organs such as the liver, heart, and muscles. Elevated activity of these enzymes in the blood may indicate damage to these organs.

Aspartate Aminotransferase (AST) is an essential biochemical marker.

AST is a protein enzyme with an active site that catalyzes amino group transfer reactions between amino acids. AST is abundant in the liver, heart, skeletal muscles, and kidneys. A stereo image of ASAT is presented in Figure 7.

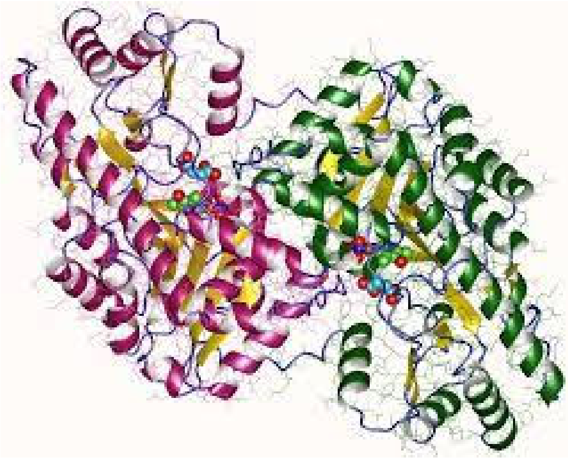


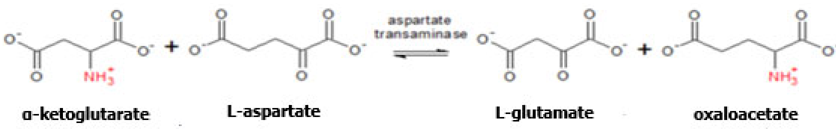
Figure 7. Stereostructure of AST

AST catalyzes the transfer of an amino group between aspartate and glutamate. A central biochemical reaction involving AST is the conversion of aspartate to oxaloacetate or the reverse reaction, the conversion of oxaloacetate to aspartate – processes vital for amino acid metabolism and overall biochemical balance [30].

Measurement of AST activity is widely used in medical diagnostics. Elevated AST levels may indicate damage to the liver, heart, or muscle tissue. For example, AST levels rise significantly during myocardial infarction due to cardiac muscle injury. Elevated AST may also be a marker of hepatitis or other liver diseases.

AST activity in blood may vary depending on several factors, including medication intake, alcohol consumption, and intense physical activity.

AST (also known as glutamate-oxaloacetate transaminase; L-aspartate: 2-oxoglutarate aminotransferase) catalyzes the reversible transfer of an α-amino group between aspartate and glutamate [27]:



Pyridoxal phosphate (vitamin B_6) serves as a cofactor for AST. The amino group transfer catalyzed by AST is essential in amino acid degradation and biosynthesis. The glutamate produced in this reaction undergoes oxidative deamination to yield ammonium ions, which are excreted as urea. In the reverse reaction, aspartate may be synthesized from oxaloacetate, a key intermediate of the citric acid (Krebs) cycle.

Alanine Aminotransferase (ALT) – also known as alanine transaminase, is a transaminase-class enzyme. ALT is a protein with an active site containing pyridoxal phosphate as a cofactor for amino acid exchange reactions [30].

Properties of ALT:

– ALT plays a key role in amino acid metabolism.

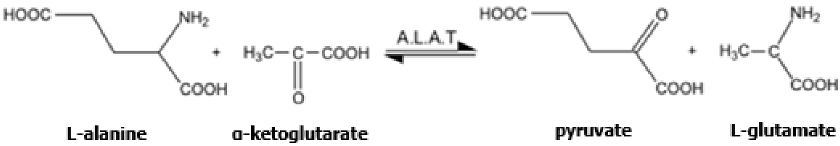
– It catalyzes the transfer of the amino group from L-alanine to α-keto acids, particularly pyruvate.

– ALT is essential for converting L-alanine into pyruvate – a critical step in glycolysis.

– ALT is abundant in tissues with high metabolic activity, such as the liver, heart, and muscles.

– ALT transfers an amino group from L-alanine to α-keto acids, producing pyruvate, making it central to glycolysis and other energy-related metabolic pathways [4].

Measurement of ALT levels is an important clinical tool for assessing liver function. Elevated ALT may indicate liver damage, including hepatitis or cirrhosis, or other pathological conditions [4].



Factors affecting ALT levels:

– Liver damage – inflammation or injury releases ALT into the bloodstream.

– Medications – certain drugs, such as acetaminophen, may increase ALT levels.

– Physical activity – intense exercise may also elevate ALT activity.

Thus, alanine aminotransferase (ALT) is a key biochemical enzyme in glycolysis and amino acid metabolism. ALT measurement plays an essential role in diagnosing liver diseases and other pathological conditions. Understanding the functions and regulation of this enzyme provides valuable insight into human health and supports effective treatment strategies.

Biochemical blood analysis is an essential laboratory method that determines the concentration of various chemical compounds in blood plasma. This method provides crucial information about the function of organs and systems such as the kidneys, liver, and heart, and enables early detection of numerous diseases. For example, liver disorders may be assessed through ALT, AST, and bilirubin levels, while kidney function is evaluated by measuring creatinine and urea [12].

This subsection discusses general methods and manual techniques used in biochemical blood analysis, their characteristics, and conditions of application.

Let's consider general methods of determination and manual methods of biochemical blood analysis, their features and conditions of use.

General Methods for Biochemical Blood Analysis

Laboratory tests allow for the determination of a wide range of biochemical blood parameters, such as proteins, enzymes, glucose, lipids, and others. Among the commonly used methods for assessing biochemical blood indicators, photometry and enzymatic methods are the most widely applied:

1. Photometry – used to determine proteins, glucose, bilirubin, and other substances.

Method features – the absorption of light by a blood sample is measured, which enables the determination of the concentration of chemical substances in blood plasma.

Application – photometry is widely used in biochemical analyzers for the automated measurement of chemical components in blood.

2. Enzymatic method (enzymatic assays):

Features – the activity of specific enzymes in the blood is measured, which correlates with the concentration of certain substances. For example, amylase activity reflects pancreatic function.

Application – enzymatic methods are used to determine enzyme activity and diagnose conditions such as pancreatic adenocarcinoma and other diseases.

Manual (bench) laboratory methods for determining biochemical blood parameters include laboratory procedures performed manually by technicians and are used to identify various chemical components of blood. These methods are applied in clinical laboratories for disease diagnosis and patient monitoring. Although manual methods can be labor-intensive and time-consuming, they may provide reliable and accurate results under certain conditions.

Using these diagnostic methods, important biochemical indicators of blood are determined, including glucose concentration, amylase, alanine aminotransferase (ALT), aspartate aminotransferase (AST), uric acid, and other chemical compounds. These methods enable diagnostic evaluation, monitoring, and investigation of various diseases and patient conditions.

Understanding the characteristics of each method allows us to draw the following conclusions:

– Methods for blood analysis, such as the determination of urea, uric acid, AST, ALT, and others, provide information about the composition of blood and its main cellular components.

– Measuring glucose, AST, ALT, creatinine, and other biochemical indicators makes it possible to assess the function of organs such as the liver, kidneys, and heart, and to detect various diseases at different stages of development.

– Manual and automated analytical methods are used in clinical laboratories for routine testing and diagnostics and allow for obtaining accurate and reliable results.

– Determining biochemical blood parameters is an essential part of medical practice and helps physicians make informed decisions regarding diagnosis and treatment.

Thanks to advances in chemical analysis methods, the determination of blood chemical indicators such as glucose levels, liver enzymes (ALT and AST), and creatinine levels has been improved. These indicators play a crucial role in diagnosing and monitoring diseases such as diabetes mellitus, liver disorders, and cardiovascular diseases.

4. Results of the Study of Key Biochemical Blood Parameters

Biochemical blood indicators serve as an essential tool for diagnosing and monitoring health status. The relevance of studying and understanding these parameters lies in their role as markers of various physiological and pathological conditions.

Through biochemical laboratory diagnostic methods, it is possible to analyze a wide range of blood components, including glucose, proteins, electrolytes, lipids, enzymes, and other indicators. The investigation of biochemical blood parameters is a crucial element in the detection and management of numerous diseases, such as diabetes mellitus, liver, kidney, and cardiovascular disorders, as well as rheumatoid arthritis and other pathologies. Changes in the concentrations of specific substances indicate physiological disturbances and form the basis for accurate diagnosis. Laboratory assessment of biochemical blood markers enables evaluation of an individual's general health status and facilitates early detection of disease development.

According to the results of laboratory diagnostics, biochemical blood parameters were monitored in *1,886 individuals* belonging to different age groups: *1,139 participants aged 17–18 years* and *747 adults*. Among them: 17-year-old males – 256 individuals; 17-year-old females – 287 individuals; 18-year-old males – 301 individuals; 18-year-old females – 295 individuals; adult males – 368 individuals; adult females – 379 individuals.

The study assessed several biochemical blood parameters in adolescents (males and females) and adults (men and women), namely: glucose, creatinine, uric acid, and transaminases (AST, ALT).

Below, we provide a more detailed analysis of the levels of these selected biochemical indicators in adolescents and adults, based on the processed laboratory diagnostic data.

Blood Glucose Level

In Ukraine, the number of patients diagnosed with diabetes mellitus increases every year. The number of people aged 20–79 years living with diabetes reaches 2,325,000, according to the 10th edition of the *Diabetes Atlas* of the International Diabetes Federation (2021) [6]. Diabetes screening is available free of charge [3].

Figure 8 presents the blood glucose levels in adolescents aged 17–18 years. According to the diagram, most individuals of this age group have glucose levels within the normal range. Elevated glucose levels were noted in: 17-year-old males – 48 individuals (19%); 17-year-old females – 53 individuals (18%); 18-year-old males – 25 individuals (8%); 18-year-old females – 30 individuals (10%).

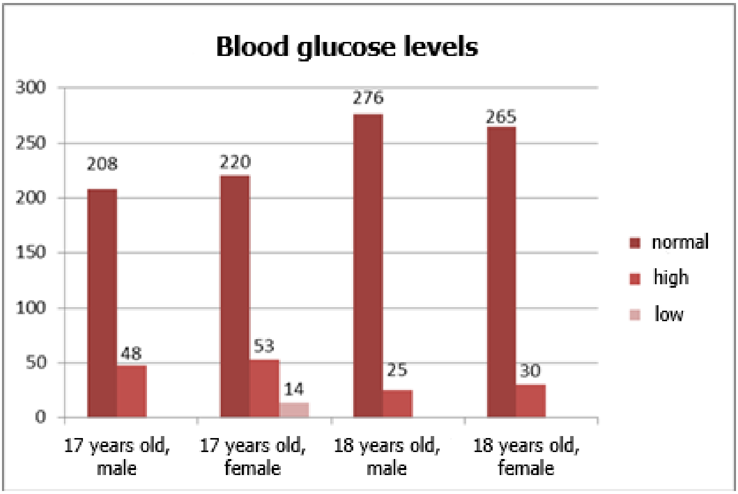


Figure 8. Blood glucose levels in adolescents aged 17–18 years

In adolescents, elevated glucose levels may be associated with physiological changes, especially the period of active growth and bodily development. Stress and emotional strain may also affect hormonal balance and lead to increased glucose levels. Figure 9 shows glucose levels in adults.

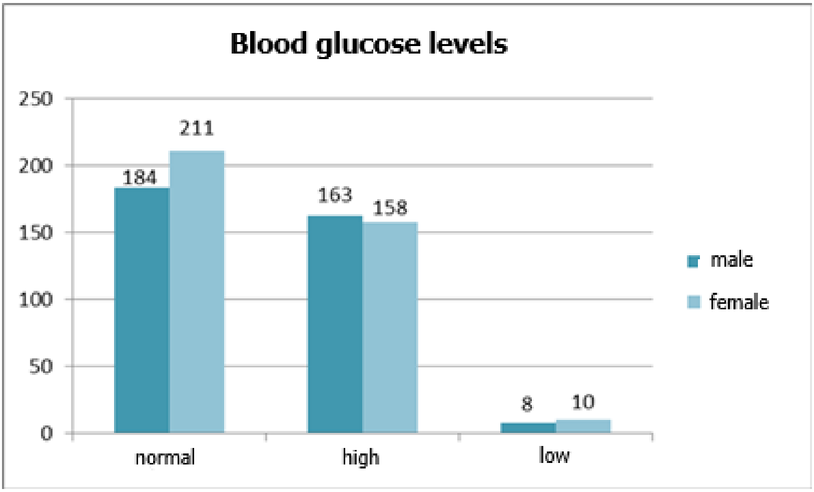


Figure 9. Blood glucose levels in adults

According to the chart, elevated glucose levels occur most frequently in adults, both in men (163 individuals) and women (158 individuals). Low glucose levels were detected in 8 men and 10 women. Possible causes include impaired carbohydrate metabolism, genetic predisposition (diabetes mellitus), stress, and physical exertion.

Blood Transaminase Levels

Transaminases are enzymes that play an essential role in the functioning of organs such as the liver and heart. The two main types of transaminases commonly measured in biochemical blood tests are aspartate aminotransferase (AST) and alanine aminotransferase (ALT). They are widely used as indicators of liver and cardiac function.

Figure 10 presents AST levels in adolescents.

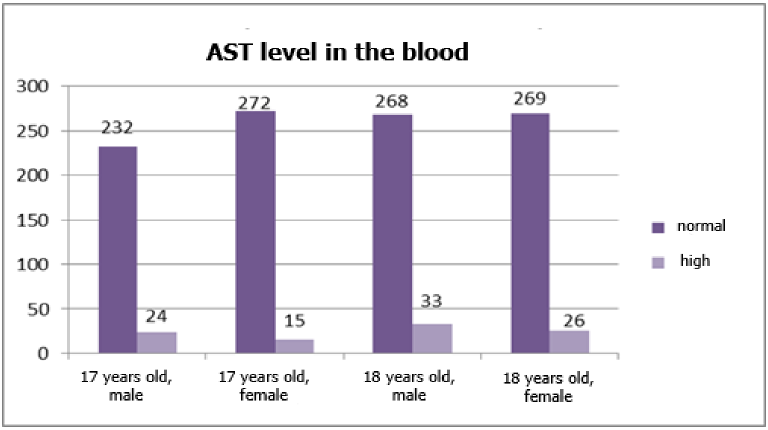


Figure 10. AST levels in adolescents aged 17–18 years

According to the chart, most adolescents – 1,041 out of 1,139 individuals (91%) have normal AST levels. Elevated AST levels were identified in: 17-year-old males – 24 individuals; 17-year-old females – 15 individuals; 18-year-old males – 33 individuals; 18-year-old females – 26 individuals.

Figure 11 presents AST levels in adults.

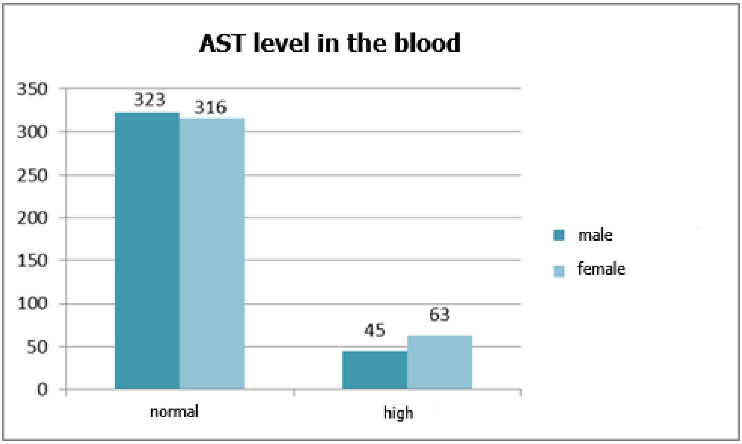


Figure 11. AST levels in adults

The chart shows that 639 men and women (85.5%) have AST levels within the normal range. However, elevated AST levels are present in both sexes, with the highest number among women – 63 individuals, compared with 45 men.

Figure 12. displays ALT levels in adolescents.

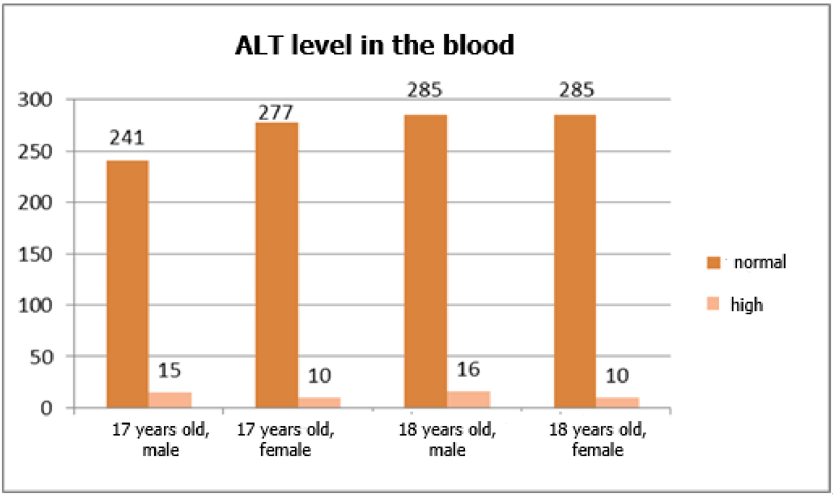


Figure 12. ALT levels in adolescents

The chart shows that ALT levels are normal in 1,088 adolescents, indicating normal liver function. Elevated ALT levels were found in: 17-year-old males – 15 individuals; 17-year-old females – 10 individuals; 18-year-old males – 16 individuals; 18-year-old females – 10 individuals.

Figure 13 shows ALT levels in adults.

According to the diagram, ALT levels are normal in 666 men and women (89%). Elevated ALT values are most frequent among women – 53 individuals, and among men – 28 individuals. Contributing factors may include genetic predisposition, hepatitis, liver damage, and others.

ALT is a more specific indicator of liver disease than AST because AST may also increase in conditions affecting other organs, such as myocardial infarction, acute pancreatitis, acute hemolytic anemia, severe burns, and acute diseases of the kidneys and musculoskeletal system.

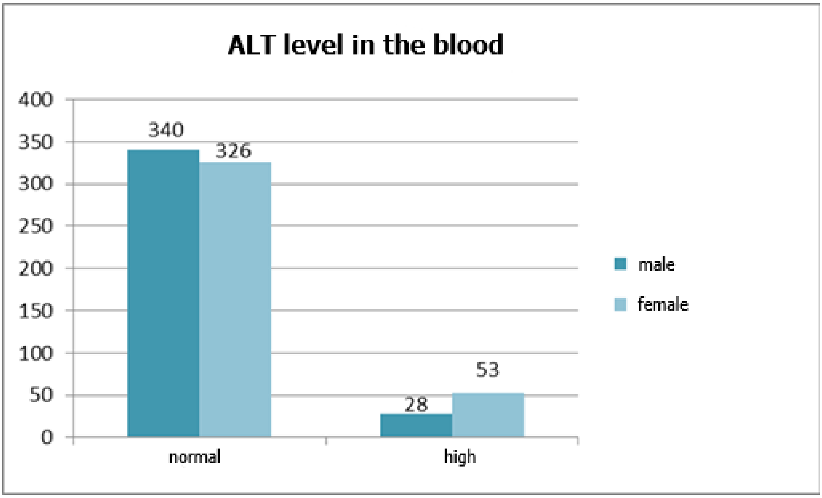


Figure 13. ALT levels in adults

Blood Uric Acid Level

Uric acid is formed as a result of oxidation of purine bases, such as adenine and guanine, primarily in the liver. Adenine undergoes oxidation and is converted into uric acid through several biochemical steps. Guanine can also be oxidized and transformed into uric acid.

Uric acid is excreted mainly by the kidneys, where it can be reabsorbed or eliminated in urine. Some uric acid is converted into urea after interacting with ammonia and subsequently excreted. Hormonal regulation (thyroid and parathyroid hormones) may also affect uric acid metabolism.

Figure 14 presents uric acid levels in adolescents aged 17–18 years.

According to the data, most adolescents (1,047 individuals, 92%) have normal uric acid levels. Elevated uric acid levels were observed in: 17-year-old males – 18 individuals; 17-year-old females – 23 individuals; 18-year-old males – 13 individuals; 18-year-old females – 14 individuals. Low uric acid levels were found in 17-year-old females – 14 individuals and 18-year-old males – 10 individuals.

Figure 15 presents uric acid levels in adults.

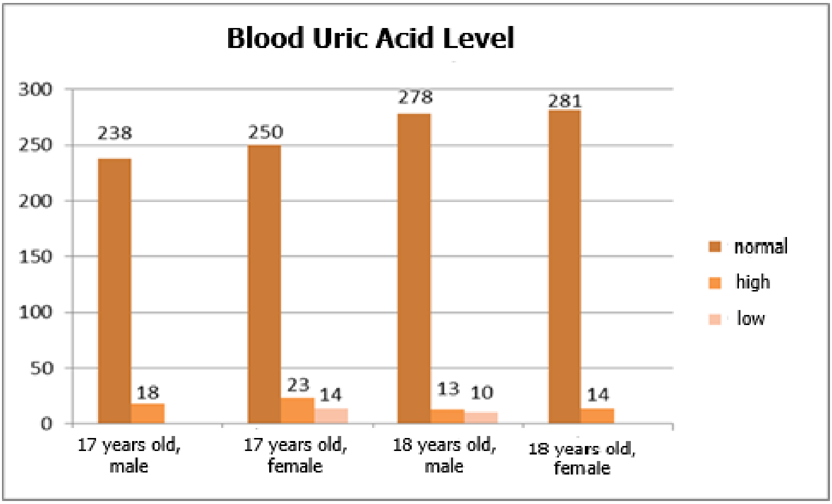


Figure 14. Uric acid levels in adolescents aged 17–18 years

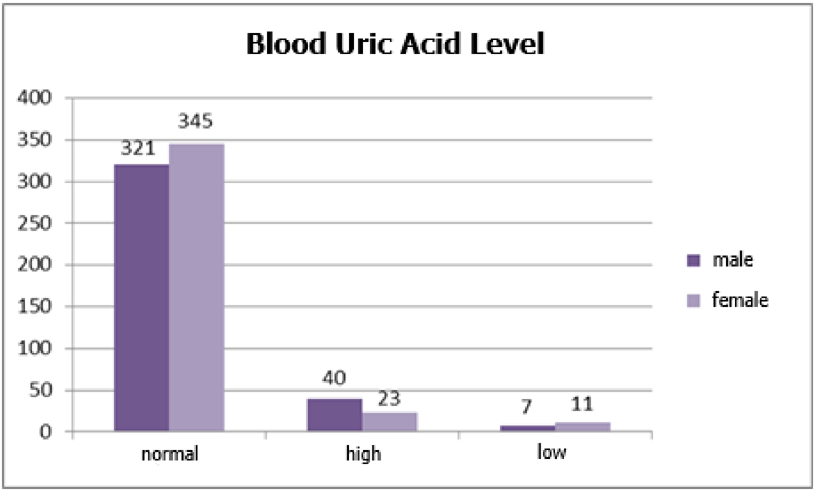


Figure 15. Uric acid levels in adults

According to the chart, 89% of adults have normal uric acid levels. Elevated levels were found in 40 men and 23 women, while low levels were recorded in 7 men and 11 women. A primary cause of elevated uric acid may be excessive consumption of purine-rich foods such as meat, seafood, and certain cheeses. Hormonal differences may also contribute to variations in uric acid metabolism.

Blood Creatinine Level

Creatinine is a metabolic byproduct formed during the breakdown of creatine in muscle tissue. It is a key biochemical marker used to assess kidney function. Its concentration reflects the balance between its production in muscles and renal filtration.

Figure 16 shows creatinine levels in adolescents aged 17–18 years.

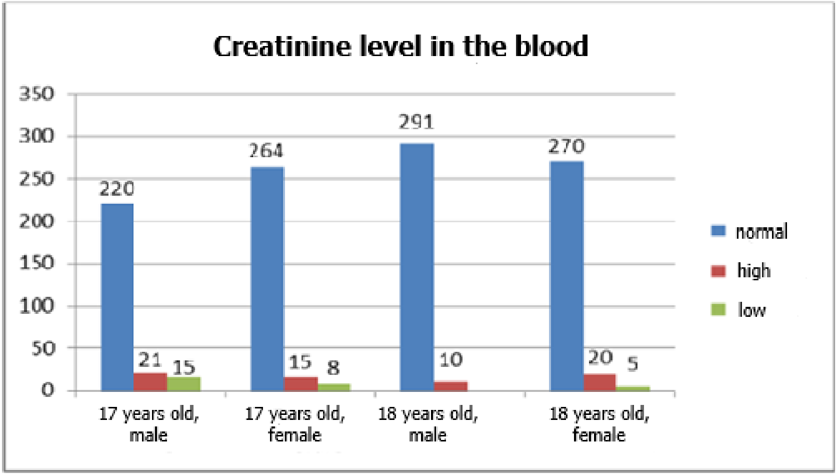


Figure 16. Creatinine levels in adolescents aged 17–18 years

The chart indicates that high creatinine levels are common among 17-year-olds of both sexes – 36 individuals, whereas 23 individuals show low levels. Among 18-year-olds, elevated levels were found in 30 individuals, and low levels in 5 individuals. Such changes may be related to active growth, increased muscle mass, diet, and physical activity.

Figure 17 presents creatinine levels in adults.

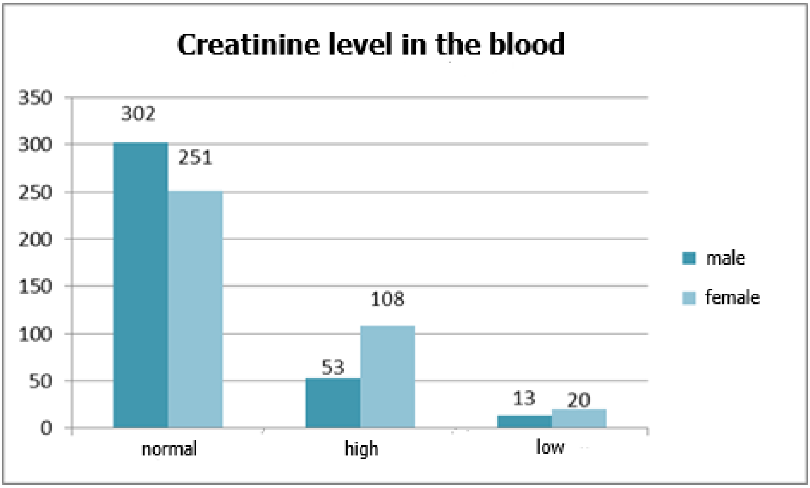


Figure 17. Creatinine levels in adults

Most adults (553 individuals, 74%) have creatinine levels within the normal range. High levels were found mainly in women – 108 individuals (28%), which may be related to diet, physical activity, and hormonal factors (thyroxine T4, triiodothyronine T3, aldosterone). In men, elevated creatinine was detected in 53 individuals (14% fewer than women).

Comparative Analysis of Biochemical Indicators

A biochemical blood test includes numerous indicators reflecting the function of various organs and systems across age groups. The following comparative analysis considers glucose, creatinine, uric acid, AST, and ALT levels.

Figure 18 illustrates blood glucose levels in adolescents and adults.

According to the chart, glucose levels are normal in 1,364 individuals (72%). Elevated glucose levels were found in: 17-year-old males – 48 individuals (19%); 17-year-old females – 53 individuals (18%); 18-year-old males – 25 individuals (8%); 18-year-old females – 30 individuals (10%); adult men – 163 individuals (17%); adult women – 158 individuals (41%). Low glucose levels were found in 17-year-old females – 14 individuals (5%) and adult women – 10 individuals (3%).

Figure 19 shows a comparative analysis of creatinine levels.

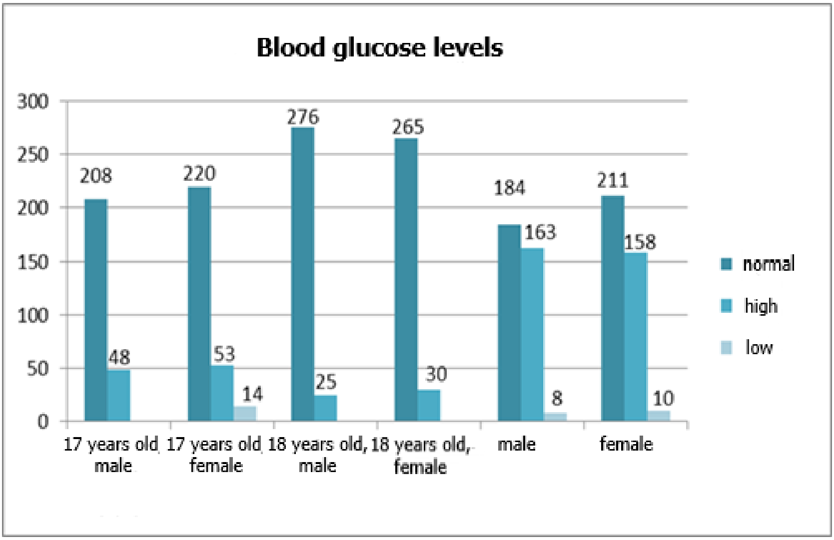


Figure 18. Blood glucose levels in adolescents and adults

Creatinine levels are normal in 1,598 individuals (85%). Elevated levels occur most frequently in: 17-year-old males – 21 individuals (8%); 17-year-old females – 15 individuals (5%); 18-year-old males – 10 individuals (3.3%); adult men – 14 individuals (5%); adult women – 108 individuals (28%).

Low levels occur in: 17-year-old males – 15 individuals (6%), adult men – 13 individuals (4%), and adult women – 20 individuals (5%).

Figure 20 presents uric acid levels.

Uric acid levels are normal in 1,713 individuals (90%). Elevated values were found in: 17-year-old males – 18 individuals (7%); 17-year-old females – 23 individuals (8%); 18-year-old males – 13 individuals (4%); 18-year-old females – 14 individuals (5%); adult men – 40 individuals (11%); adult women – 23 individuals (6%).

Figure 21 presents AST levels.

AST levels are normal in 1,680 individuals (89%). Elevated AST levels were detected in: 17-year-old males – 24 individuals (9%); 17-year-old females – 15 individuals (5%); 18-year-old males – 33 individuals (11%); 18-year-old females – 26 individuals (9%); adult men – 45 individuals (12%); adult women – 63 individuals (17%).

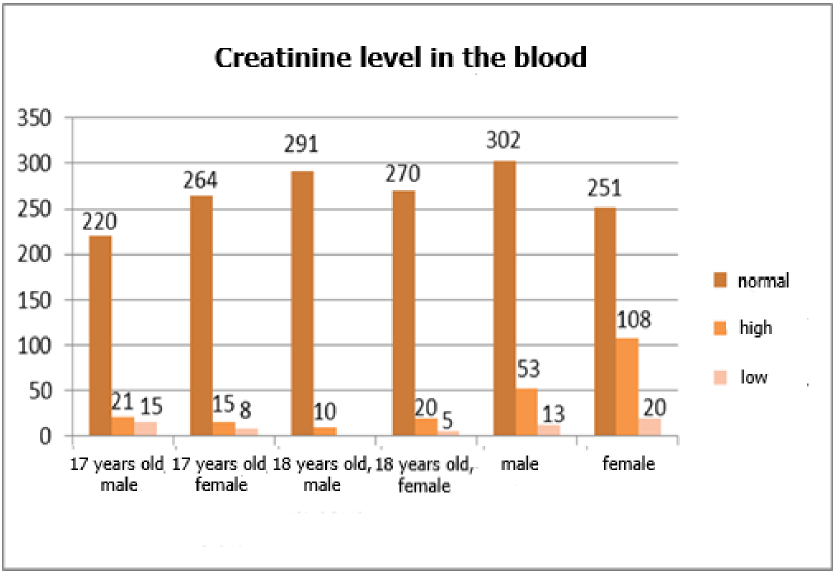


Figure 19. Creatinine levels in adolescents and adults

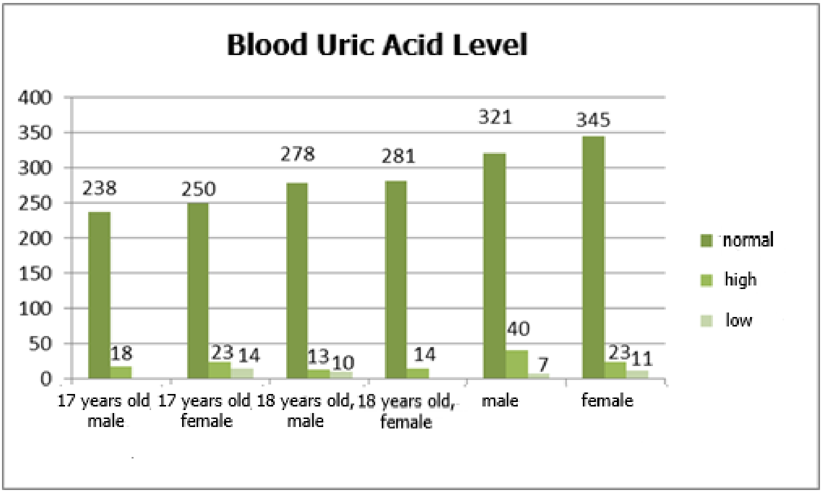


Figure 20. Uric acid levels in adolescents and adults

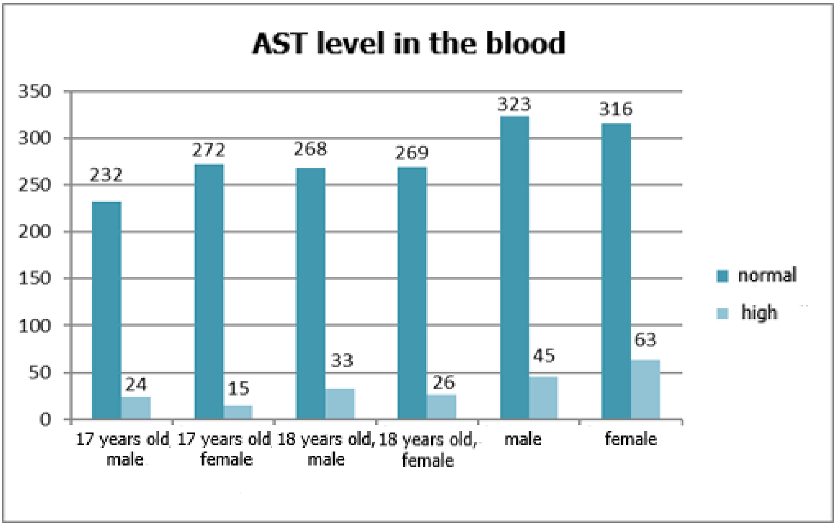


Figure 21. AST levels in adolescents and adults

Figure 22 displays ALT levels.

ALT levels are normal in 1,754 individuals (93%). Elevated ALT levels were found in: 17-year-old males – 15 individuals (6%); 17-year-old females – 10 individuals (3%); 18-year-old males – 16 individuals (5%); 18-year-old females – 10 individuals (3%); adult men – 28 individuals (8%); adult women – 53 individuals (14%).

Thus, the comparative analysis of biochemical blood indicators across different age groups revealed age- and sex-related variations, which reflect physiological characteristics unique to each developmental period.

5. Conclusions

The analysis of scientific sources indicates that comparative assessment of blood biochemical parameters for diagnosing diseases across different age groups is not widely utilised. However, laboratory findings enable us to analyse human blood biochemical indicators and evaluate the health status of various age categories based on specific parameters.

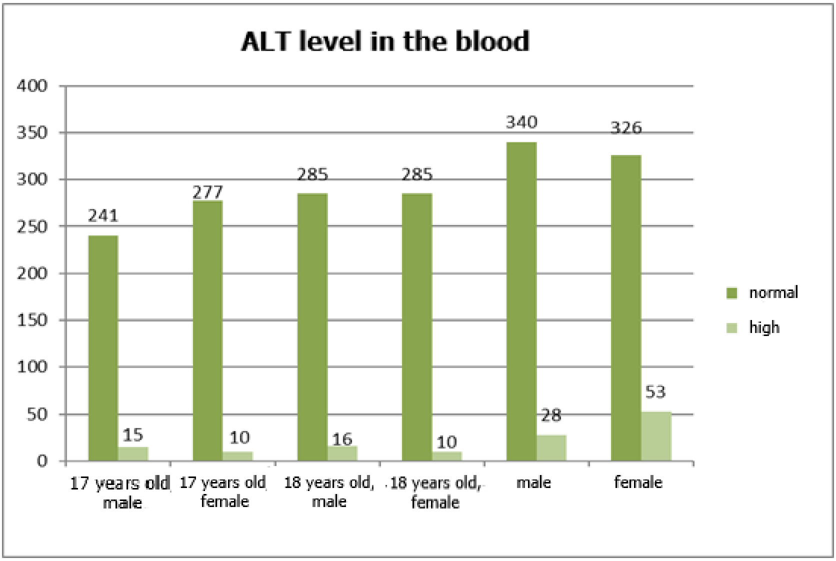


Figure 22. ALT levels in adolescents and adults

According to the results of laboratory diagnostics, we conducted monitoring of blood biochemical parameters. In particular, 1,886 biochemical blood test results were analysed among adolescents and adults within the following age groups: 17–18 years – 1,139 individuals, and adults – 747 individuals. Among them: 17-year-old males – 256; 17-year-old females – 287; 18-year-old males – 301; 18-year-old females – 295; adult males – 368; adult females – 379.

Several biochemical blood parameters were assessed in adolescents (boys and girls) and adults (men and women), namely: glucose, creatinine, uric acid, and transferases (AST, ALT).

Among the analysed parameters, deviations from the normal range were found in adults: high (161 individuals, 22%) and low (33 individuals, 4%) creatinine levels; high uric acid levels (63 individuals, 8%); elevated glucose levels (321 individuals, 43%); and increased AST (108 individuals, 14%) and ALT (81 individuals, 11%). Among adolescents (boys and girls), the most common deviations were elevated creatinine (66 individuals, 5.5%), uric acid (68 individuals, 6%), and glucose (156 individuals, 14%) levels in both girls and boys. Low uric acid levels were found in 17-year-old girls (14 individuals, 5%) and 18-year-old boys (10 individuals, 3%). Low glucose levels were observed in 17-year-old girls (14 individuals, 5%).

A comparative analysis of blood biochemical parameters in adolescents and adults revealed the following:

Elevated glucose levels in adolescents may be associated with physiological changes, particularly the period of active growth and development; in adults, elevated glucose levels may indicate a risk of diabetes mellitus or other carbohydrate metabolism disorders.

Creatinine levels in adolescents typically normalise to adult reference values upon completion of the growth period; in adults, high creatinine levels may indicate impaired kidney function, which explains the higher percentage of elevated values among adults.

Elevated uric acid levels in adolescents may be related to metabolic characteristics and rapid growth; in adults, increased uric acid levels may be associated with the risk of gout or other conditions.

Elevated AST and ALT levels among adolescents constitute a small percentage, which may be explained by sex-specific characteristics, physical activity, and other factors; in adults, higher levels of these enzymes may indicate liver dysfunction or issues with other organs, and such deviations are more common in adults.

Based on the evaluation of blood biochemical indicators across the selected age groups, the following conclusions can be drawn:

– Elevated glucose levels are the most frequent abnormality observed in both adolescents and adults. This may indicate impaired glucose regulation and signal a risk of diabetes or other carbohydrate metabolism disorders.

– High and low creatinine levels are most commonly found in adults. Elevated creatinine may indicate impaired kidney function, while low levels may be associated with physiological features or other factors.

– Elevated uric acid levels are observed in both adolescents and adults. This may be associated with metabolic disorders, gout, or other diseases.

– Elevated AST levels are frequently observed in adults and adolescents, while elevated ALT levels are more common in adults. This may indicate potential impairments in liver function or abnormalities in other organs.

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