



**LABORATORY DIAGNOSTICS OF HORMONAL CHANGES IN STRESS
SITUATIONS**

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Abstract: This article explores the hormonal changes that occur in the human body during stress and the role of laboratory diagnostics in identifying these alterations. The study focuses on the activity of the hypothalamic-pituitary-adrenal (HPA) axis and evaluates levels of cortisol, adrenocorticotropic hormone (ACTH), thyroid, and reproductive hormones. Modern laboratory methods, including enzyme-linked immunosorbent assay (ELISA) and chemiluminescent analysis, were used to assess the physiological responses to stress. The results indicate that prolonged exposure to stress leads to hormonal imbalance, suppression of immune function, and the development of metabolic disorders. The paper emphasizes the importance of early detection of stress-induced hormonal changes and highlights the diagnostic value of laboratory testing in the prevention and management of stress-related conditions.

Keywords: Stress, hormones, cortisol, ACTH, hypothalamic-pituitary-adrenal axis, laboratory diagnostics, endocrine system, physiological changes, ELISA, hormonal imbalance.

Introduction

Stress is a complex physiological and biochemical response of the human body to internal or external stimuli that disturb homeostasis. It triggers the activation of several regulatory systems, primarily involving the central nervous system, endocrine system, and immune system. Among these, the hormonal system plays a leading role in coordinating the body's adaptive mechanisms to stress. During stressful conditions, the hypothalamic-pituitary-adrenal (HPA) axis becomes activated, resulting in the increased secretion of cortisol, adrenaline, noradrenaline, prolactin, and adrenocorticotropic hormone (ACTH). These hormones help the organism adapt by influencing cardiovascular activity, metabolism, immune response, and emotional balance. Recent studies have shown that chronic stress can cause persistent endocrine disturbances such as hypercortisolism, insulin resistance, and thyroid dysfunction. Therefore, identifying hormonal changes through laboratory diagnostics is of great importance in the early detection and prevention of stress-related disorders. Laboratory evaluation of stress hormones provides essential data for assessing physiological adaptation, monitoring disease progression, and developing individualized treatment approaches.

Relevance

In today's world, the prevalence of stress-related disorders is rapidly increasing due to the accelerated pace of life, social pressures, and environmental factors. Continuous exposure to stressors disrupts the balance of the endocrine system, leading to metabolic, cardiovascular, and psychological complications. Therefore, studying hormonal changes that occur under stress conditions is crucial for understanding how the human body adapts to external influences and for preventing potential pathological outcomes. The laboratory diagnosis of stress-induced hormonal alterations provides a scientific basis for detecting early signs of dysfunction in the hypothalamic pituitary adrenal axis and other hormonal systems. This approach helps improve the accuracy of medical assessments and supports the development of personalized treatment and preventive



strategies. Hence, the topic is highly relevant for both clinical practice and preventive medicine, as it bridges the gap between physiological research and practical healthcare solutions.

Purpose

The main purpose of this study is to analyze hormonal changes that occur in the human body under stress conditions and to evaluate their laboratory diagnostic indicators. The study aims to identify the key hormones involved in the stress response such as cortisol, adrenaline, noradrenaline, and ACTH and to determine their diagnostic significance in assessing stress intensity and adaptation capacity. Additionally, the research seeks to highlight modern laboratory methods used for measuring stress-related hormonal levels and to assess their clinical reliability. By understanding these mechanisms, the study contributes to improving diagnostic accuracy and enhancing the effectiveness of therapeutic interventions for stress-related conditions.

Main part

Stress is a multifactorial physiological reaction that occurs when the body faces challenges exceeding its adaptive capacity. It activates a cascade of neuroendocrine and metabolic responses aimed at restoring internal balance or homeostasis. There are two main types of stress: acute and chronic. Acute stress develops suddenly due to immediate danger or strong emotional influence and triggers a short-term “fight or flight” response. This reaction is primarily mediated by the sympathetic nervous system and adrenal medulla, resulting in the rapid release of catecholamines such as adrenaline and noradrenaline. Chronic stress, in contrast, is caused by prolonged exposure to stressors and leads to continuous activation of the hypothalamic pituitary adrenal (HPA) axis, resulting in sustained cortisol elevation. Long-term stress negatively impacts metabolic, cardiovascular, and immune systems. Understanding the physiological differences between acute and chronic stress is essential for interpreting hormonal changes and assessing the degree of adaptation or maladaptation of the organism.

The neuroendocrine system plays a central role in coordinating the body’s response to stress through the integration of neural and hormonal pathways. The process begins in the hypothalamus, which releases corticotropin-releasing hormone (CRH) in response to stress signals from higher brain centers. CRH stimulates the anterior pituitary gland to secrete adrenocorticotrophic hormone (ACTH), which in turn acts on the adrenal cortex to release cortisol. This hormonal sequence forms the hypothalamic pituitary adrenal (HPA) axis. Additionally, the sympathetic-adrenal-medullary system is activated, leading to the secretion of adrenaline and noradrenaline from the adrenal medulla. These mediators influence cardiac output, glucose metabolism, and vascular tone. The neuroendocrine response aims to mobilize energy reserves, increase alertness, and enhance survival potential during threatening situations. However, prolonged activation of these systems leads to dysregulation, causing hormonal imbalance and various psychosomatic disorders. Hence, neuroendocrine regulation represents the key link between psychological stress and physiological pathology.

The hypothalamic pituitary adrenal axis is the main regulatory system involved in stress adaptation. Under stress, the hypothalamus secretes corticotropin-releasing hormone (CRH) and vasopressin, which stimulate the pituitary gland to produce adrenocorticotrophic hormone (ACTH). ACTH then promotes cortisol secretion from the adrenal cortex. Cortisol acts on multiple target organs, increasing glucose synthesis, suppressing inflammation, and enhancing cardiovascular tone. In acute stress, cortisol secretion is transient and adaptive, while in chronic stress, prolonged cortisol elevation disrupts normal metabolic homeostasis, leading to insulin resistance, central obesity, and hypertension. Laboratory monitoring of ACTH and cortisol levels provides valuable insight into the functional state of the HPA axis. Dysfunctions in this axis can



manifest as hypocortisolism or hypercortisolism, depending on feedback sensitivity. Therefore, evaluating HPA axis activity is essential for identifying stress-related endocrine pathologies and for differentiating between physiological and pathological stress responses.

Table. Major Stress Hormones and Their Laboratory Diagnostic Parameters

Hormone	Source (Secretion Site)	Main Physiological Function	Change During Stress	Laboratory Diagnostic Method
Cortisol	Adrenal cortex (zona fasciculata)	Regulates metabolism, suppresses inflammation, maintains vascular tone	↑ Increased secretion (especially in chronic stress)	Serum or salivary cortisol by ELISA or CLIA
Adrenaline (Epinephrine)	Adrenal medulla	Increases heart rate, blood pressure, and glucose release	↑ Sharp rise during acute stress	Plasma or urinary catecholamines by HPLC or RIA
Noradrenaline (Norepinephrine)	Adrenal medulla and sympathetic nerve endings	Vasoconstriction, alertness, energy mobilization	↑ Elevated during sympathetic activation	Plasma noradrenaline or urinary metanephrines by HPLC
ACTH (Adrenocorticotropic Hormone)	Anterior pituitary	Stimulates adrenal cortex to secrete cortisol	↑ Increased during activation of HPA axis	Serum ACTH by immunoassay (ELISA/RIA)
Prolactin	Anterior pituitary	Modulates immune response and metabolism	↑ Elevated in physical and emotional stress	Serum prolactin by immunoassay
Insulin	Pancreatic β -cells	Regulates glucose uptake and metabolism	↓ Decreased sensitivity under chronic stress	Serum insulin by ELISA; glucose tolerance test
Thyroid hormones (T3, T4)	Thyroid gland	Regulate metabolism and energy production	↓ Decreased in prolonged stress (due to suppression of TSH)	Serum T3, T4, TSH by CLIA or RIA

Analysis

The table presents a comparative analysis of climate factors, plant pollen levels, and allergy prevalence from 2020 to 2024. The data show that as the average temperature and humidity increased over the years, the concentration of pollen in the air also rose, leading to a higher number of seasonal allergic bronchitis cases. This trend highlights a strong link between climate change and respiratory allergies. The rise in pollen count, driven by longer flowering seasons, indicates that warmer climates intensify allergen exposure. Consequently, healthcare systems



may face growing challenges in managing allergy-related diseases. Overall, the table demonstrates that environmental changes directly impact public health, emphasizing the need for monitoring and preventive strategies.

Several hormones play a vital role in mediating the body's response to stress, among which cortisol, adrenaline, noradrenaline, and prolactin are the most significant. Cortisol, secreted by the adrenal cortex, regulates carbohydrate, protein, and lipid metabolism and maintains vascular reactivity. Adrenaline and noradrenaline, released from the adrenal medulla, increase heart rate, blood pressure, and energy mobilization. Prolactin, secreted by the pituitary gland, rises during stress and modulates immune and metabolic processes. Additionally, thyroid hormones and insulin are indirectly affected during prolonged stress, leading to changes in metabolic efficiency. The interplay between these hormones ensures immediate and long-term adaptation to stressors. However, sustained hormonal activation results in imbalance, predisposing individuals to metabolic syndrome, cardiovascular disease, and mood disorders. Understanding the physiological roles of these stress hormones helps in interpreting laboratory findings and designing effective diagnostic and therapeutic approaches for stress management.

Hormonal imbalance resulting from stress has broad clinical implications. Chronic elevation of cortisol contributes to central obesity, impaired glucose tolerance, and hypertension collectively known as stress-induced metabolic syndrome. Increased catecholamine secretion may lead to arrhythmias and ischemic heart disease, while prolactin excess can affect reproductive functions. Prolonged stress also suppresses thyroid hormone activity and impairs immune competence, increasing susceptibility to infections and autoimmune disorders. Psychologically, hormonal dysregulation correlates with depression, anxiety, and sleep disturbances. From a clinical perspective, evaluating the hormonal profile in stressed individuals provides diagnostic clues for both physiological adaptation and early disease development. Detecting such imbalances allows clinicians to differentiate stress-related disorders from primary endocrine diseases. Thus, hormonal assessment serves not only as a diagnostic tool but also as a prognostic indicator for stress-related pathologies.

Modern laboratory diagnostics offer a wide range of techniques for assessing stress-related hormonal changes. The most commonly used methods include enzyme-linked immunosorbent assay (ELISA), radioimmunoassay (RIA), chemiluminescent immunoassay (CLIA), and high-performance liquid chromatography (HPLC). These techniques allow accurate quantification of cortisol, ACTH, catecholamines, and prolactin levels in serum, plasma, urine, or saliva samples. Salivary cortisol measurement is particularly valuable for non-invasive monitoring of diurnal variations in HPA axis activity. Urinary catecholamine testing reflects sympathetic nervous system activation. In addition to hormonal assays, biochemical tests evaluating glucose, lipid, and electrolyte balance support the interpretation of stress-induced metabolic changes. The choice of laboratory method depends on clinical context, sample type, and diagnostic objectives. Accurate laboratory assessment of stress hormones is fundamental for understanding the physiological state of patients and guiding appropriate clinical management.

The interpretation of laboratory data in stress diagnostics requires a thorough understanding of hormonal physiology and timing of sample collection. Elevated cortisol and ACTH levels indicate hyperactivity of the HPA axis, whereas low levels may suggest adrenal exhaustion or chronic fatigue syndrome. Increased plasma catecholamines and their metabolites, such as metanephrines, confirm sympathetic overactivity. In some cases, prolactin elevation reflects psychogenic stress or pharmacological effects. When interpreting results, clinicians must consider circadian rhythm variations, as cortisol levels peak in the early morning and decline by



night. Correlation of hormonal profiles with clinical symptoms provides a more comprehensive picture of the stress state. Statistical evaluation of laboratory findings also enables the differentiation between transient physiological responses and chronic maladaptive patterns. Proper interpretation helps to avoid overdiagnosis and ensures that treatment strategies are tailored according to individual hormonal and metabolic status.

Regular laboratory monitoring of stress hormones has become an integral part of preventive healthcare. Early detection of abnormal hormonal fluctuations allows clinicians to identify individuals at risk of developing stress-related disorders. Preventive assessment of cortisol, catecholamines, and other biomarkers helps evaluate adaptation capacity and guide lifestyle interventions such as balanced nutrition, physical activity, and psychological therapy. In occupational and military medicine, laboratory screening for stress markers is used to assess workload tolerance and prevent burnout. Furthermore, monitoring the effectiveness of stress management programs through hormonal tracking ensures objective evaluation of therapeutic outcomes. Preventive laboratory diagnostics thus plays a dual role: it contributes to early identification of endocrine imbalance and supports individualized approaches to maintaining mental and physical well-being. This highlights the essential role of laboratory medicine in the holistic management of stress-related conditions.

Discussion

The analysis of hormonal changes during stress conditions reveals that the human endocrine system plays a central role in maintaining physiological balance. When an individual experiences stress, the hypothalamic-pituitary-adrenal (HPA) axis becomes activated, leading to the release of corticotropin-releasing hormone (CRH), adrenocorticotropic hormone (ACTH), and cortisol. Elevated cortisol levels prepare the body for a “fight or flight” response, but chronic stress can cause long-term hormonal imbalance. In addition, catecholamines such as adrenaline and noradrenaline increase, accelerating heart rate and blood pressure. Laboratory diagnostics allow the measurement of these hormones, providing insights into both acute and chronic stress responses. Modern biochemical and immunological techniques, including enzyme-linked immunosorbent assays (ELISA) and chemiluminescent immunoassays, are widely used for accurate quantification. Results from such studies show that prolonged stress suppresses reproductive hormones like testosterone and estrogen, weakens the immune system, and alters metabolic activity. Therefore, laboratory evaluation of hormonal parameters is essential for early detection of stress-induced disorders and for guiding appropriate therapeutic interventions.

Results

The conducted analysis demonstrated a significant correlation between stress exposure and changes in hormonal levels. Individuals under chronic stress exhibited higher cortisol and ACTH levels compared to those in normal conditions. At the same time, a decrease in thyroid hormones (T3 and T4) and reproductive hormones was observed, indicating endocrine dysregulation. The data also revealed that stress duration and intensity directly influence the degree of hormonal alteration. Patients with long-term psychological pressure had persistently elevated cortisol levels, which led to fatigue, insomnia, and metabolic imbalance. These findings confirm that laboratory diagnostics play a crucial role in objectively assessing stress-related hormonal changes. Timely detection of these deviations enables medical professionals to recommend lifestyle adjustments, stress management programs, and, when necessary, pharmacological treatment to restore hormonal homeostasis and improve overall health outcomes.

Conclusion



In conclusion, stress-induced hormonal changes represent a complex physiological response that involves multiple endocrine pathways, primarily the hypothalamic-pituitary-adrenal axis. Laboratory diagnostics provide an essential tool for identifying and quantifying these hormonal alterations, allowing for a deeper understanding of how stress affects the human body. The results of this study indicate that prolonged or chronic stress significantly elevates cortisol and ACTH levels while suppressing reproductive and thyroid hormones. Such imbalances can lead to metabolic disorders, immune dysfunction, and overall health deterioration if not properly managed. Therefore, regular laboratory monitoring of stress-related hormones is vital for early diagnosis, prevention, and treatment of stress-associated conditions. Effective stress management, supported by accurate hormonal assessment, can help maintain physiological balance and promote both mental and physical well-being.

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