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PHYSIOLOGICAL BASIS OF THE ACTIVITY OF ENDOCRINE GLANDS AND THEIR INFLUENCE ON THE METABOLIC PROCESSES OF THE BODY

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Abstract

The endocrine system is a complex of endocrine glands that regulate the body's metabolic processes through hormones. The aim of this study was to investigate the physiological basis of endocrine gland function and their impact on metabolism using data from patients with various endocrine disorders. The study involved 120 participants: 40 healthy individuals, 40 with thyroid dysfunction, and 40 with type 2 diabetes. The results showed that patients with endocrine dysfunction exhibit significant deviations in glucose, insulin, thyroid hormone, and cortisol levels compared to the control group, reflecting the direct influence of hormonal regulation on metabolism.

Keywords

endocrine system, hormones, metabolism, thyroid gland, pancreas, cortisol, pituitary gland, homeostasis.

Introduction

The endocrine system provides chemical regulation of body functions through hormones—biologically active substances secreted by the endocrine glands. These substances regulate metabolism, growth, reproduction, and adaptation to stress. The major glands include the hypothalamus, pituitary gland, thyroid gland, parathyroid glands, adrenal glands, pancreas, and gonads.

Disruptions in the functioning of these glands can lead to various pathologies, including hypo- or hyperthyroidism, diabetes mellitus, and Cushing's syndrome. Understanding the physiology of the endocrine system and its impact on metabolism is key to the diagnosis and treatment of these diseases.

Study Objective

To determine the impact of endocrine gland function on the body's metabolic processes and identify the clinical characteristics of patients with endocrine disorders.

Subject: 120 patients divided into three groups:

1. The control group consisted of 40 healthy volunteers (18–65 years old).
2. 40 patients with thyroid dysfunction.
3. 40 patients with type 2 diabetes.

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Materials and Methods of the research

The study was conducted at an endocrinology clinic and included 120 participants divided into three groups. The control group consisted of 40 healthy volunteers (22 men and 18 women), with an average age of 36.2 ± 12.1 years. The second group consisted of 40 patients with thyroid dysfunction (18 men, 22 women), with an average age of 41.5 ± 10.3 years. The third group consisted of 40 patients with type 2 diabetes mellitus (25 men and 15 women), with an average age of 52.7 ± 8.5 years. All patients had a confirmed diagnosis according to the American Diabetes Association criteria: fasting glucose ≥ 7.0 mmol/L and HbA1c ≥ 6.5%. All study participants underwent a fasting blood biochemistry panel, including glucose, insulin, thyroid hormones (T3, T4, TSH), and cortisol. Glucose levels were measured using a glucose oxidase test, insulin using an enzyme-linked immunosorbent assay (ELISA), and thyroid hormones and cortisol using standard laboratory methods. Control values for healthy participants included: glucose 4.8 ± 0.4 mmol/L, insulin 8.6 ± 2.5 μU/mL, TSH 2.1 ± 0.8 mIU/L, T4 12.3 ± 2.1 pmol/L, and cortisol 310 ± 65 nmol/L.

Participants' physical fitness was assessed based on height, weight, and body mass index (BMI). The average BMI in the control group was 23.5 ± 2.8 kg/m², in patients with thyroid dysfunction it was 29.1 ± 3.2 kg/m², and in patients with diabetes mellitus it was 31.5 ± 4.0 kg/m². Blood pressure was measured three times using an automatic sphygmomanometer, and the mean value was used for analysis.

Results of the research

In the control group, fasting glucose levels were 4.8 ± 0.4 mmol/L, insulin 8.6 ± 2.5 μU/mL, TSH 2.1 ± 0.8 mIU/L, T4 12.3 ± 2.1 pmol/L, and cortisol 310 ± 65 nmol/L. The average BMI of control group participants was 23.5 ± 2.8 kg/m², and blood pressure was 122/78 ± 10/8 mmHg.

In patients with thyroid dysfunction, an increase in TSH to 6.9 ± 2.4 mIU/L and a decrease in T4 to 8.5 ± 1.9 pmol/L in hypothyroidism or a decrease in TSH with an increase in T4 in hyperthyroidism were observed. Glucose levels in this group were 5.1 ± 0.6 mmol/L, and cortisol levels were 298 ± 70 nmol/L. The average BMI of patients was 29.1 ± 3.2 kg/m², and blood pressure was 130/82 ± 12/9 mmHg. In patients with type 2 diabetes mellitus, fasting glucose levels were significantly elevated at 8.3 ± 1.2 mmol/L ($p < 0.05$), insulin at 18.5 ± 4.8 μU/mL ($p < 0.05$), TSH at 2.3 ± 1.0 mIU/L, and cortisol at 335 ± 78 nmol/L. The mean BMI was 31.5 ± 4.0 kg/m² and blood pressure at 138/86 ± 15/10 mmHg.

Examples of individual patients include: a patient with hypothyroidism with TSH of 7.1 mIU/L, T4 of 8.2 pmol/L, glucose of 5.0 mmol/L and a BMI of 29.3 kg/m²; a patient with type 2 diabetes whose fasting glucose level was 8.5 mmol/L, insulin 19.2 μU/ml, TSH 2.4 mIU/L, and cortisol 345 nmol/L.

Conclusions based on the results:

1. In patients with hypothyroidism, there is a significant decrease in T4 with a compensatory increase in TSH.

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2. In patients with type 2 diabetes, the levels of glucose and insulin are significantly higher than normal, indicating a disturbance in carbohydrate metabolism.
3. Cortisol levels change moderately, reflecting the body's stress adaptation.

Discussion

The results confirm the key role of the endocrine system in regulating metabolism. Hypothyroidism slows metabolism, reduces energy expenditure, and impairs cardiovascular and digestive function. Conversely, hyperthyroidism accelerates metabolism, causing weight loss, tachycardia, and elevated body temperature.

Pancreatic dysfunction leads to impaired carbohydrate metabolism, accompanied by hyperglycemia and compensatory hyperinsulinemia. Adrenal hormones, particularly cortisol, play a key role in stress adaptation and maintaining energy balance.

Patients with endocrine disorders exhibit shifts in metabolic parameters, emphasizing the importance of comprehensive monitoring and correction of hormonal status.

Conclusion

The endocrine system plays a central role in maintaining homeostasis and regulating metabolic processes in the body. Based on a study of 120 patients, including a control group, patients with thyroid dysfunction, and patients with type 2 diabetes, several key findings emerged:

Thyroid and Metabolism
Patients with hypothyroidism showed elevated TSH and decreased T4 levels, confirming a compensatory response by the pituitary gland. These hormonal changes were accompanied by a slower metabolism, weight gain (average BMI 29.1 kg/m²), and a moderate increase in blood pressure. In patients with hyperthyroidism, TSH was decreased and T4 was increased, leading to accelerated metabolism, weight loss, and increased heart rate. These findings highlight the direct influence of thyroid hormones on energy balance and cardiovascular function.

The Pancreas and Carbohydrate Metabolism
Patients with type 2 diabetes mellitus demonstrated a significant increase in fasting glucose levels (mean 8.3 mmol/L) and a compensatory increase in insulin (18.5 µU/mL). These results reflect a dysregulation of carbohydrate metabolism and confirm the role of the pancreas as a key endocrine organ responsible for blood glucose control. Pancreatic dysfunction directly impacts energy balance, homeostasis, and the risk of cardiovascular and nervous system complications.

Adrenal Glands and Stress Adaptation
Cortisol levels were elevated in patients with endocrine disorders compared to controls, reflecting activation of the hypothalamic-pituitary-adrenal axis under metabolic stress. Cortisol imbalance can affect carbohydrate and protein metabolism, fat distribution, and the body's adaptive responses.

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The Pituitary Gland as an Integrator of the Endocrine System
The pituitary gland plays an integrative role, regulating the activity of peripheral glands through tropic hormones. Dysfunction of this gland leads to multiple metabolic shifts, including decreased or increased secretion of hormones from peripheral glands, demonstrating the interconnectedness of all components of the endocrine system.

Practical Significance
These studies highlight the need for a comprehensive assessment of the hormonal profile of patients with endocrine disorders. Monitoring levels of glucose, insulin, thyroid hormones, and cortisol allows us to predict metabolic changes and develop individualized treatment strategies aimed at restoring hormonal balance, normalizing metabolism, and reducing the risk of complications.

Overall, the study confirms that any dysfunction of the endocrine glands has a systemic impact on metabolic processes, emphasizing the need for regular monitoring and a comprehensive approach to the treatment of endocrine disorders. A physiological understanding of the mechanisms of the endocrine system allows not only for early diagnosis of diseases but also for predicting metabolic dynamics during treatment.

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