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ENDOCRINE RESPONSES IN EXERCISE

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Abstract:
Background/Objective: The aim of this review is to provide general information about some important hormones that are closely related to exercise and information about their use for clinical and performance enhancement will be given. **Methods:** In this study, the related literature was studied by using the screening model. Data were obtained from various articles and internet websites. **Conclusion:** The effects of exercise on hormone secretion are one of the most important issues of sports physiology and sports health research. The developments and progress that have taken place in many areas in the century we live in bring about many innovations about exercise. The physiological dimension of exercise is also an important parameter that should be evaluated by experts in the field. The determination of the relationship between the endocrine system and the physiological changes occurring during and after exercise, whether for sporting or health purposes, is important in terms of human health and beneficial exercise practices. As a result, it is important to understand the general information about the endocrine system, hormones and their clinical uses in terms of healthy and consciously exercise practices.

Keywords: exercise, hormones, endocrine responses

1. Hormones and Exercise

The human body is designed according to the functional balance of the organs and systems and works with a balanced cooperation. The endocrine system is a control and regulation system. During exercise, hormonal changes are initiated by the central nervous system and regulated according to metabolic and environmental needs. The importance of hormonal adaptations increases as exercise continues. Hormonal control is provided by negative feedback mechanisms. Exercise, and intensive training affect the hormonal release, creating a number of fit responses that will facilitate the organism to cope with exercise stress. This leads to a decrease in the resting levels of some hormones, while increasing the levels of exercise at the time of exercise.

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The main task of the hormonal system in exercise is to regulate metabolism and cardiovascular systems. The basic endocrine gland in exercise and training is hypothalamus, pituitary, thyroid, parathyroid, adrenal glands and gonads. But they also secrete hormones in the heart, kidney, liver, gastrointestinal organs (1).

It has been shown that many working endurance and strength training increase Growth Hormone (GH) concentration in healthy individuals. Indeed, one of the strong physiological factors that increase GH release is known to be exercise (2).

It is known that max VO2 and heart rate are increased, resting heart rate decreases, metabolic blood lipid level and blood lactate concentration decrease. Various stress conditions, such as exercise and intensive training, affect hormonal release, leading to increased and reduced resting levels of some hormones. Although the exact cause of these effects is not known, there is information about the harmony of endocrine functions (3).
Hormone: a compound produced by endocrine glands, secreted into the bloodstream and capable of acting only on target cells (4).

Hormones are stimulatory molecules that coordinate physiological and metabolic functions by stimulating receptors in target cells.

Various hormones produced as endogenous (intracellular) are used to improve sportive performance. The most commonly used hormone is synthetic derivatives of testosterone, for example, growth hormone. In another example; with the uptake of erythropoietin secreted by the kidneys for the development of aerobic endurance, more red blood cells are produced. There are also drugs used for catecholamines and adrenaline (or epinephrine), which have an effect on the metabolic and nervous system, usually to increase weight loss and to provide more stimulation in the performance essence.

2. Endocrine Glands

The endocrine system consists of tissues and organs called endocrine glands. These glands synthesize and release chemicals hormones.

Endocrine Glands	**Hormones**
Hypothalamus	TRH, CRH, GHRH, Dopamine, Somatostatin, Vasopressin
Thyroid and Parathyroid	T3, T4, Calcitonin, PTH
Adrenal	Androgens, Glucocorticoids, Adrenaline, Noradrenaline
Pancreas	Insulin, Glucagon, Somatostatin
Pineal	Melatonin
Pituitary	GH, TSH, ACTH, FSH, MSH, LH, Prolactin, Oxytocin, Vasopressin
Liver	IGF, THPO
Thymus	Thymopoietin
Stomach	Gastrin, Ghrelin, Histamine, Somatostatin, Neuropeptide Y
Kidney	Calcitriol, Renin, Erythropoietin
Testes	Androgens, Estradiol, Inhibin
Ovary, Placenta	Estrogens, Progesterone
Uterus	Prolactin, Relaxin

3. Thyroid Gland

The thyroid gland is found in two lobes in front of the trachea in the neck.
Follicular cells of the thyroid gland:

- Thyroxine (thyroxine) (T4),
- Triiodothyronine (triiodothyronine) (T3)

3.1 Effects of Thyroid Hormones

It accelerates cellular reactions in many cells of the body. Thus, basal metabolic rate increases, growth accelerates. Thyroid hormones are necessary for the development of nerve, muscle and skeleton in children. Cellular differentiation and protein synthesis are stimulated. Carbohydrate and fat metabolism is stimulated (calorogenic effect). The increase in thyroid gland activity is called hyperthyroidism and the decrease is called hypothyroidism.

3.2 Oxytocin

Oxytocin is a hormone that stimulates uterine muscle contraction during labor and milk secretion after birth.

3.3 Calcitonin

Calcitonin is a hormone that:

- reduces blood calcium levels
- stimulates bone formation,
- inhibits parathyroid hormone secretion,
- reduces bone destruction in bone cells,
- reduces calcium transfer from bone to blood,
- increases calcium transfer from blood to bone; as a result, blood calcium is reduced. (5)

3.4 Cortisol

The best-known metabolic effect of glycocorticoids is the ability to stimulate glyconeogenesis in the liver (carbohydrate formation from proteins and other substances). Cortisol also moderately reduces the glucose utilization rate of all cells in the body (3).

One of the main effects of cortisol on the body's metabolic systems is the reduction of protein stores in all body cells except the liver. Cortisol increases the concentration of free fatty acids in the plasma and thus increases its use for energy. The use of fatty acids for energy is an important factor in the long-term preservation of glucose and glycogen in the body (3).

Although the rate of cortisol release in exercise is considered as an indicator of physiological stress, it has been shown that the response in the studies shows individual differences. Variables such as gender, age, affect, training status are some of the factors affecting cortisol release (6).

The response of cortisol to physical activity varies according to the intensity and duration of the activity (7).

Athletes need to do extensive and different intensity training to optimize their performance. The severity and extent of exercise cause many hormonal changes in the body of the athletes. Cortisol is one of the most important hormones that respond to training very quickly. Plasma cortisol level has tripled in short-term high-intensity exercises and long-term submaximal intensity exercises (8).

Studies investigating the importance of exercise severity have indicated that the plasma cortisol concentration shows a significant increase after exercise performed over 60% of VO2 max and above (9).

The increase in plasma cortisol concentration, which is considered a physiological response after heavy exercise, returns to the basal level at rest. However, long-term training without allowing the body to recover may lead to elevations in basal cortisol levels and adverse effects of prolonged high cortisol concentration. While the immunosuppressive effect of cortisol increases the tendency for infections, the catabolic effects of skeletal muscle tissue may lead to the reduction of sportive performance as well as disability (10).

As is known, cortisol hormone is actually a necessary hormone for the body. Some elite athletes use cortisol pills to improve their performance. It can provide an advantage by blocking pain in endurance sports. In fact, there is no objection to increase cortisol during exercise. However, if the cortisol level remains high after exercise, then a problem may arise (11).

3.5 Adrenal Medulla-Catecholamines

Adrenal medulla-catecholamines epinephrine (adrenaline) and norepinephrine (noradrenaline) are secreted from the adrenal medulla. The main secretion of the medulla is epinephrine, a small amount of norepinephrine is secreted. These two hormones stimulate the sympathetic nervous system. Epinephrine and norepinephrine have similar effects to the sympathetic nervous system. Hormonal effect lasts longer. Medulla hormones are stress hormones.

In stress situations, ACTH secretion from the pituitary gland is stimulated. ACTH stimulates the adrenal cortex and medulla to resist stress in the muscles, digestive, circulatory and respiratory systems. Protein degradation is stimulated, the released amino acids are used as energy sources or for tissue repair in the event of injury. Amino acids are converted to glucose in the liver. Sympathetic system effects are increased. In prolonged stress situations, the immune system is suppressed, and serious diseases may occur.

3.6 Catecholamines: epinephrine and norepinephrine

It is not surprising that catecholamines released from the adrenal gland (SMC) medulla are closely related to sympathetic nervous system activity, thus increasing catecholamine concentrations in exercise. About 80% of the hormones secreted from the MRP are

epinephrine (E). E and NE. have significant effects on the cardiovascular system, respiratory system, gastrointestinal tract, liver, glands, muscle and adipose tissue.

3.6.1 Effect of exercise

Plasma E and NE increase linearly with the duration of exercise. These increases help to make adjustments in the cardiovascular system to exercise as well as adjustments in fuel stabilization. Increases in plasma catecholamine concentrations are closely related to exercise duration and severity and increase in secretion as duration and severity increase (12).

4. Androgens

Androgen is a group of hormones present in both sexes, most of which is secreted by the shell portion of the adrenal gland. Androgens activate intracellular receptors and regulate the synthesis and differentiation of different enzymes and proteins in the cell.

4.1 Effects of Androgens

In the fetus, the development of external genital organs in the male direction, testis, penis and prostate growth, sound thickening, hair and increase the libido is caused.

Warning for the synthesis and incorporation of proteins in the muscle system; affecting blood production; there are tasks of preventing calcium, and phosphorus excretion from bones.

Androgens are responsible for the continuity of spermatogenesis, additive reproductive glands functions and secondary sex character; it is the primary responsible hormone testosterone for fast height increase in adolescent men.

They have anabolic effect by increasing protein synthesis. The anabolic effects of fluoximetron, oxandrolone and nondralone are higher than androgenic effects.

They affect the kidneys and cause water and salt retention. They increase the risk of atherosclerosis by increasing LDL synthesis and decreasing HDL synthesis. Testosterone excretion and lactation is given to women from outside and hirsutism (male type hair), acne, clitoris growth leads to such findings. This hormone is the precursor for the production of estrogen in both sexes.

4.2 Clinical Usage of Androgens

a. Gynecological diseases

Danazol, a weak androgen and a weak progesterone, is used to treat endometriosis. They may be given to suppress postpartum breast growth. They are also used in the medical treatment of breast cancer in women before menopause.

b. Use for anabolic effect

Trauma can be given to reduce muscle loss due to surgery and long-term immobilization. They are used for doping purposes to increase muscle mass and muscle strength.

c. Osteoporosis in Man

Anabolic steroids such as androgens or oxandrolone may be useful in the treatment of osteoporosis.

4.3 Antiandrogenic Drugs

- **Ketoconazole:** Makes synthesis of adrenal and gonodal steroid hormones
- **Abirateron:** Abirateron is a prodrug, used to treat prostate cancer, suppresses the synthesis of testosterone and cortisol. Siproteron is a steroid-constructed androgen receptor blocker. It is used for the treatment of hirsutism in women and for contraception. lutamid / Nilutamide / bicalutamide
- **Enzalutamid**: Nonsteroidal androgen receptor blockers. It is used in the treatment of prostate cancer, causing gynecomas. They are also useful in women with androgen excess.

5. Estrogens

Estrogens are a group of steroid hormones that play an important role in the menstrual cycle and in the estrus cycle in females of other mammals. Estrogens are found in both males and females, but in females with reproductive years their levels are much higher. These hormones provide the development of secondary sex characteristics in women, such as breasts, and regulate endometrial thickening and other processes associated with the menstrual cycle. Follicle stimulating hormone (FSH) and luteinizing hormone (LH) regulate the production of estrogen in ovulating women. Estrogen is found in some oral contraceptives because estrogen in the bloodstream causes a decrease in the levels of FSH and LH. The three main estrogen found in women are estradiol, estriol and estrone. The major estrogen among menarche and menopause is estradiol. In the body they are synthesized from androgens as a result of enzyme reactions. Estradiol is synthesized from testosterone and estrone from androstenedione. Estrone is weaker than estradiol, and postmenopausal women have estradiol rather than estradiol.

5.1 Effect of Estrogen

Estrogen hormone provides women with high resistance to pain. Estrogen makes the hormone aggressive; the hair growth is released. It contributes to the development of vagina, uterus and secondary sex characters, female specific fat distribution, skin pigmentation, ductal growth of mammary glands, milk synthesis and lengthening. They provide protection against osteoroporosis by suppressing calcium resorption from bones. They prevent bone fractures in postmenopausal women.

5.2 Clinical Usage of Estrogen

They are used for primary hypogonadism, atrophic vaginitis, hormone replacement therapy and contraception. (13). The side effects of estrogen are:

- sickness;
- menstruation;

- breast cancer;
- migraine, headache, gallbladder diseases;
- hypertension.

5.3 Prolactin

Prolactin has two tasks in women:

- Stimulates the development of breast canals in the mammary glands during pregnancy with estrogen (female sex hormone).
- Stimulates the production of milk in the breast tissue after birth.

5.3.1 Prolactin and Exercise

Prolactin levels increase with high intensity exercise and return to normal within 45 minutes of recovery. Exercise-induced prolactin changes may inhibit ovarian function, leading to cycling disorders in athletes. Prolactin levels also increase in men after maximal exercise.

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