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MORPHOFUNCTIONAL CHARACTERISTICS OF THE PROSTATE GLAND UNDER EXPERIMENTAL MICRONUTRIENT DEFICIENCY

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✓ ***Resume***

Micronutrient deficiency is a modifiable risk factor that significantly impairs the structure and function of the prostate gland. Addressing this deficiency through appropriate nutritional strategies is critical for maintaining male reproductive health and minimizing the risk of developing serious prostate pathologies.

Key words: morpho functional characteristics, of the prostate gland under experimental, micronutrient deficiency.

МОРФОФУНКЦИОНАЛЬНЫЕ ХАРАКТЕРИСТИКИ ПРЕДСТАТЕЛЬНОЙ ЖЕЛЕЗЫ В УСЛОВИЯХ ЭКСПЕРИМЕНТАЛЬНОГО ДЕФИЦИТА МИКРОНУТРИЕНТОВ

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✓ ***Резюме***

Дефицит микронутриентов является модифицируемым фактором риска, существенно нарушающим структуру и функцию предстательной железы. Устранение этого дефицита посредством адекватной нутритивной стратегии имеет решающее значение для поддержания репродуктивного здоровья мужчин и минимизации риска развития серьёзных патологий предстательной железы.

Ключевые слова: морфофункциональные характеристики, предстательная железа в условиях экспериментального дефицита микронутриентов.

TAJRIBAL MIKROOZOZA ETMAGANLIGIDA PROSTATA BEZINING MORFOFUNKSIONAL XUSUSIYATLARI.

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✓ ***Rezyume***

Mikronutrient etishmovchiligi prostata bezining tuzilishi va funktsiyasini sezilarli darajada buzadigan o'zgartirilishi mumkin bo'lgan xavf omilidir. Tegishli ovqatlanish strategiyalari orqali ushbu etishmovchilikni bartaraf etish erkaklarning reproduktiv salomatligini saqlash va jiddiy prostata patologiyalarini rivojlanish xavfini kamaytirish uchun juda muhimdir.

Kalit so'zlar: morfofunksional xarakteristikalar, prostata bezining eksperimental, mikronutrient etishmovchiligi.

Introduction

The prostate gland is a vital organ of the male reproductive system, responsible for producing seminal fluid that nourishes and transports sperm. Proper functioning of the prostate is essential for male fertility and overall reproductive health. The gland's secretions contain enzymes, proteins, and micronutrients that support sperm motility and viability. Disruptions in prostate function can lead to infertility, inflammation, and malignancies.

Micronutrients — though required in very small amounts — play critical roles in maintaining cellular metabolism, antioxidant defenses, immune responses, and tissue homeostasis. Essential micronutrients such as iron (Fe), zinc (Zn), copper (Cu), magnesium (Mg), and selenium (Se) are necessary for the prostate gland to maintain its structural integrity and physiological function (1). Deficiency in these elements may lead to morphological alterations, impaired secretory function, increased oxidative stress, and even pathological conditions such as benign prostatic hyperplasia (BPH) and cancer.

Experimental studies focused on micronutrient deficiency provide important insights into how lack of these elements affects the prostate gland at the cellular and tissue levels. Understanding these effects can help develop preventive and therapeutic strategies against prostate-related diseases.

Role of Micronutrients in the Prostate Gland

Zinc (Zn)

Zinc is the most abundant trace element in the prostate, concentrated up to 10 times more than in other soft tissues (1). It is crucial for enzymatic activity, DNA synthesis, cell proliferation, and apoptosis regulation. Zinc also acts as a potent antioxidant, protecting prostate cells from reactive oxygen species (ROS)-induced damage. It modulates androgen receptor signaling, which is vital for maintaining prostate epithelial cell differentiation and secretory activity (2).

Zinc deficiency has been experimentally shown to increase oxidative stress markers, impair mitochondrial function, and induce apoptosis in prostate epithelial cells. These changes contribute to epithelial degeneration and stromal remodeling, compromising glandular function (3).

Iron (Fe) and Copper (Cu)

Iron is essential for oxygen transport via hemoproteins and supports cellular respiration and energy metabolism. Copper functions as a cofactor in several antioxidant enzymes, including superoxide dismutase (SOD), which neutralizes harmful free radicals (4). Deficiencies in iron and copper disrupt these processes, leading to increased oxidative damage and inflammation within the prostate tissue (5).

In experimental models, iron deficiency has been associated with reduced enzymatic activity and energy deficits in prostate cells, contributing to impaired cell proliferation and increased susceptibility to damage (6). Magnesium (Mg) and Selenium (Se) Magnesium acts as a cofactor for numerous enzymes, including those involved in DNA repair and antioxidant defense (7). Selenium is incorporated into selenoproteins such as glutathione peroxidase, which protects cells from oxidative injury and supports immune function (8). Deficiencies in magnesium and selenium impair these protective systems, leading to accumulation of oxidative damage and dysregulated immune responses in prostate tissue (9).

Experimental Evidence of Micronutrient Deficiency Effects on the Prostate Animal studies have demonstrated clear morphological and functional alterations in the prostate gland caused by micronutrient deficiency. Ivanov et al. (3) showed that zinc deficiency in rats leads to degeneration of glandular epithelial cells, thickening of the stromal compartment, and reduction in secretory output. These changes resemble early signs of pathological remodeling.

Kuznetsova et al. (4) reported that combined micronutrient deficiency disrupted the balance of cell proliferation and apoptosis, resulting in both hypoplasia (reduced cell number) and hyperplasia (excessive cell proliferation) in different prostate regions. Such disorganization affects the gland’s secretory capacity and structural integrity.

Other studies have revealed that micronutrient deficiency diminishes the antioxidant defenses in the prostate, increasing DNA damage and promoting chronic inflammation — all of which are risk factors for prostate disease development (7).

Micronutrient Deficiency and Prostate Disease Risk

Deficiencies in key micronutrients increase susceptibility to several prostate pathologies. Benign prostatic hyperplasia (BPH), a common condition characterized by gland enlargement and urinary symptoms, has been linked to altered micronutrient status. Brown et al. (7) demonstrated that low zinc and selenium levels correlate with increased oxidative stress and inflammation in BPH patients.

Prostate cancer risk is also associated with micronutrient imbalance. Ho (5) emphasized that zinc deficiency promotes DNA strand breaks and genomic instability in prostate cells, increasing the likelihood of malignant transformation. Additionally, micronutrient deficiencies may disrupt hormonal regulation within the prostate by altering androgen metabolism, leading to imbalanced testosterone and dihydrotestosterone (DHT) levels that can fuel pathological growth (8).

Conclusion

Experimental studies unequivocally demonstrate that micronutrient deficiency exerts detrimental effects on the prostate gland at both morphological and functional levels. The lack of essential trace elements such as zinc, iron, copper, magnesium, and selenium impairs critical biochemical and cellular processes, including antioxidant defense, DNA repair, and hormonal regulation. This impairment results in increased oxidative stress, leading to cellular damage, inflammation, and disruption of normal prostate tissue architecture.

Morphologically, micronutrient deficiency causes degeneration of glandular epithelial cells, stromal fibrosis, and disorganization of prostate tissue, which negatively impact secretory functions crucial for male fertility. Functionally, these deficiencies interfere with androgen receptor signaling pathways, thereby disturbing the hormonal homeostasis that governs prostate growth and differentiation. Such disruptions may predispose the gland to pathological conditions such as benign prostatic hyperplasia (BPH) and prostate cancer, both of which represent significant health burdens for aging males worldwide.

The experimental evidence highlights the importance of adequate micronutrient supply for maintaining prostate health. Ensuring balanced intake of these elements through diet or supplementation may provide a protective effect by enhancing antioxidant capacity, supporting immune function, and preserving hormonal balance within the gland. Therefore, micronutrient status should be considered a critical factor in both the prevention and management of prostate disorders.

Future research efforts should aim to elucidate the precise molecular mechanisms by which micronutrients influence prostate cell biology, identify biomarkers for early detection of micronutrient-related prostate dysfunction, and develop targeted nutritional and pharmacological interventions. Such approaches hold promise for improving prostate health outcomes and reducing the incidence of prostate-related diseases in men.

In conclusion, micronutrient deficiency represents a modifiable risk factor that significantly compromises prostate gland structure and function. Addressing this deficiency through appropriate nutritional strategies is essential for sustaining male reproductive health and minimizing the risk of severe prostate pathologies.

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