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ONTOGENETIC FORMATION OF THE IMMUNE SYSTEM IN CHILDREN AND PHYSIOLOGICAL AND HYGIENIC FACTORS OF ITS STRENGTHENING

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Abstract
This study analyzes the ontogenetic formation of the immune system in children and the physiological, nutritional, and hygienic factors influencing its strengthening. The article examines age-dependent differentiation of innate and acquired immunity, morphofunctional maturation of lymphoid tissues, and development of immune responses based on scientific evidence. Research findings demonstrate the direct impact of rational nutrition, intestinal microbiota homeostasis, psychoemotional stability, and ecological conditions on immunogenic characteristics development. The article provides a theoretical foundation for developing preventive strategies in pediatric practice.

Keywords: ontogenesis, immune system, innate immunity, acquired immunity, lymphoid organs, microbiota, nutritional immunomodulation, hygienic factors, pediatrics, immune response, morphofunctional maturation, psychoneuroimmunology, ecological immunology, prevention, immunogenic characteristics.

Introduction

The formation of the immune system in children's organisms represents one of the most critical components of ontogenetic processes, determining the organism's capacity for adaptive responses to infections, antigenic influences, and ecological stressors. Contemporary research in pediatrics and clinical immunology demonstrates that complete differentiation of immunogenic structures occurs during the early years of life, and this process results from complex interactions between genetically programmed mechanisms and environmental factors. The current increase in immunodeficiency conditions among children, widespread prevalence of allergic diseases, and rising incidence of autoimmune pathologies underscore the urgent necessity of developing immune strengthening strategies. The objective of this research consists of analyzing the mechanisms of ontogenetic formation of the immune system in children and identifying, based on scientific evidence, the physiological, nutritional, and hygienic factors that influence its strengthening. The research tasks encompass determining the immunogenic function of intestinal microbiota, the immunomodulatory properties of nutritional components, and the significance of psychoneuroimmunological connections.

Literature Review

The research contributions of Russian and Uzbek immunology schools have established fundamental knowledge regarding immune system development in children. Nasirov M.N. and Karimova D.A. examined the ecological and ethnic characteristics of immunogenic indicators in Central Asian

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children, demonstrating significant influences of climatic and socioeconomic factors on immune homeostasis. Yaroslavtseva N.G. and Korovina N.A. analyzed immunomodulation strategies in pediatric practice, confirming through clinical research the impact of nutritional factors on immune development. Shodmonov G.M., in his comprehensive monograph, conducted an extensive study of the immunological profile of Uzbek children, emphasizing the necessity of developing preventive programs that account for regional epidemiological characteristics. This body of sources elucidates the morphofunctional foundations of immunity while indicating the need for deeper analysis of the molecular mechanisms of microbiota-immune interaction and psychoneuroimmunological connections in the pediatric context.

Methodology

The ontogenetic development of the immune system begins in the embryonic period and continues through complex sequential differentiation processes. Innate immunity mechanisms demonstrate functional activity from the first days of life, including neutrophils and macrophages that perform phagocytosis, natural killer cells, and the complement system, all of which hold significant importance. The thymocrit index and lymphoid organ mass change with age, with the thymus gland exhibiting maximal activity until age four before entering the involution process. The formation of adaptive immunity begins through initial encounters with antigens, characterized by lymphocyte clonal expansion and the development of immunological memory cells. In children, immunoglobulin synthesis activates after the influence of maternal antibodies received from the mother's organism diminishes. IgM synthesis occurs in the first month, IgG increases significantly after approximately six months, while IgA, as the primary component of mucosal immunity, develops more slowly but consistently.

Rational nutrition creates the essential environment for optimal immune system functioning. Breast milk serves as a biologically vital source of immunological protection during the first six months of life, containing secretory immunoglobulins, lactoferrin, lysozyme, and immunomodulatory cytokines that not only provide passive protection but also activate the child's immune system. Among micronutrients, zinc, iron, selenium, and vitamin D hold particular importance because they directly affect lymphocyte differentiation, cytokine synthesis, and phagocytosis efficiency. The intestinal microbiota functions as a central regulator of immunogenic functions, with its bifidobacteria and lactobacilli supporting mucosal immunity, preventing pathogen colonization, and modulating systemic immune response. Dysbiotic conditions increase the risk of developing allergic diseases and autoimmune pathologies, making the application of probiotics and prebiotics one of the important directions of immunoprophylaxis. Psychoemotional stress and social factors significantly affect immune status through neuroimmunological interactions, with chronic stress increasing cortisol levels and consequently weakening lymphocyte proliferation and disrupting proinflammatory cytokine synthesis. Environmental quality, particularly air pollution, the entry of toxic substances into the organism, and ultraviolet radiation intensity comprise external factors that determine the functional state of children's immunity, requiring a system of hygienic measures to reduce their impact.

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Results

The research results demonstrate that the complete functional maturation of the immune system in children depends on the concordance between genetically programmed ontogenetic processes and environmental factors, with this process undergoing its most critical stages during the first five years of life. Nutritional immunomodulation, particularly the breastfeeding period, plays a decisive role in the formation of mucosal and systemic immunity and establishes the foundations for long-term immunological memory. The composition and functional activity of intestinal microbiota holds central importance in ensuring immune homeostasis, with dysbiotic disruptions potentially leading to immunodeficiency and hyperreactive states. Psychoneuroimmunological connections prove the direct impact of stress factors on immunogenic indicators in children and demonstrate the necessity of optimizing sociopsychological conditions. From the perspective of ecological immunology, improving environmental quality, adhering to hygienic norms, and reducing the impact of chemical stressors constitute integral components of immunoprophylactic strategies.

Discussion

Comparing the obtained results with the perspectives of international and national immunology schools reveals that the ontogenetic development of children's immunity obeys universal biological laws, yet regional, ethnic, and socioeconomic characteristics significantly influence its specific parameters. While some researchers recommend widespread use of immunostimulating agents, from the standpoint of contemporary evidence-based medicine, supporting natural immunomodulation mechanisms through prioritizing nutritional, hygienic, and psychoprophylactic measures proves more appropriate. Numerous unanswered questions remain in the field of molecular mechanisms of microbiota-immune interaction, requiring integrated approaches combining genomics, metabolomics, and immunology. In evaluating immunoprophylaxis effectiveness, consideration must extend beyond short-term results to include long-term immunological memory formation and the preservation of immunogenic health throughout subsequent life. For prospective research, important directions include the role of epigenetic mechanisms in shaping immunogenic characteristics, the microbiota-neuroimmunity axis, and the development of personalized immunoprophylactic strategies.

The ontogenetic formation of the immune system in children represents a complex, multistage, and multifactorial process whose success depends on the harmonization of the organism's internal genetic programs with nutritional, microbiological, psychoneuroimmunological, and ecological external factors. Rational nutrition, intestinal microbiota homeostasis, psychoemotional stability, and favorable hygienic conditions constitute the fundamental pillars of immunoprophylaxis. Through the integrated application of these factors in pediatric practice, it becomes possible to strengthen children's immunogenic health, prevent infectious and non-infectious diseases, and ensure long-term immunological protection.

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