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A comprehensive approach to the treatment of atopic dermatitis in children with food sensitisation

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Abstract. The relevance of the study was determined by the high prevalence of atopic dermatitis and food allergy in children, which substantially impaired their quality of life and necessitated the development of individualised therapeutic approaches. The aim of the study was to determine the effect of food allergy on the clinical course of atopic dermatitis in children and to evaluate the efficacy of individualised therapeutic strategies. The study was based on the analysis of clinical data obtained from children with atopic dermatitis, including skin allergy tests, immunoglobulin E levels, pro-inflammatory cytokine profiles, and the dynamics of symptoms under the influence of an elimination diet and comprehensive therapeutic strategies. The principal findings demonstrated that food allergens, such as proteins derived from milk, eggs, nuts, and wheat, significantly affected the course of atopic dermatitis, causing elevated levels of immunoglobulin E and pro-inflammatory cytokines. The application of an elimination diet reduced the severity of clinical manifestations by 45% according to the Scoring Atopic Dermatitis (SCORAD) scale, whilst restoration of the skin barrier contributed to a reduction in the frequency of exacerbations. Comprehensive therapeutic strategies resulted in an improvement in patients' quality of life, increasing the disease-related quality of life index by 40%. The conclusions of the study confirmed that individualised therapeutic strategies, including an elimination diet, skin barrier restoration, and pharmacological therapy, effectively reduced the clinical manifestations of atopic dermatitis and improved the quality of life of children with concurrent food allergy. The practical significance of the study lies in the development of evidence-based recommendations for diagnosis and treatment, which may be implemented in clinical practice to improve therapeutic outcomes

Keywords: genetic factors; phenotypes; skin barrier function; allergology; immunological mechanisms; dietary therapy

INTRODUCTION

The widespread prevalence of atopic dermatitis among children and its close association with food allergies, which substantially worsen the disease course and patients' quality of life, necessitated a deeper investigation into this issue. The concurrent presence of these two conditions in patients complicated diagnosis, the selection of therapeutic strategy, and the prevention of relapses. The principal features of the immune response

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in atopic dermatitis included the activation of type 2 T-helper cells (Th2) and elevated cytokine levels, such as interleukin-4 (IL-4), interleukin-5 (IL-5), and interleukin-13 (IL-13), which were also involved in the mechanisms of food allergy [1]. This indicated shared pathogenetic mechanisms requiring detailed investigation.

Research examining the relationship between atopic dermatitis and food allergies in children had both considerable achievements and certain gaps. The study by Y. Mehta & D.G. Fulmali [2] focused on the investigation of immunological markers, such as immunoglobulin E (IgE) levels and specific cytokines, which facilitated a better understanding of the mechanisms of the inflammatory response. However, attention was directed primarily towards laboratory parameters, whilst clinical correlations, particularly in children with combined sensitisation, remained insufficiently elucidated. The study by G. Korçari *et al.* [3] emphasised the importance of understanding seasonal risks of food allergies, specifically sensitisation to fish and crustaceans. Although the findings were analysed in detail for different seasons, insufficient attention was paid to the effect of these allergens on the clinical course of atopic dermatitis. Furthermore, the possibility of adapting therapeutic approaches to seasonal changes was not addressed.

A. Seker *et al.* [4] evaluated the association between maternal atopic conditions and the risk of autism spectrum disorder in offspring. Despite the study identifying contradictory findings regarding the role of atopic diseases, including eczema/atopic dermatitis, it did not encompass the question of the effect of maternal food allergen sensitisation on the course of dermatological conditions in children. The study by J. Asllani *et al.* [5] examined the safety of allergen immunotherapy in children with respiratory allergies, which allowed conclusions to be drawn concerning the systemic mechanisms of allergen action. However, the specific mechanisms of food allergen penetration through the impaired skin barrier, which play an important role in the pathogenesis of atopic dermatitis, were not considered. The work of E. Jorgaqi & E. Jorgaqi [6] identified a knowledge deficit among Albanian dermatologists in the field of psychodermatology. However, the authors did not examine how psychological triggers, such as stress, affected the relationship between food sensitisation and exacerbations of atopic dermatitis. The study by G. Tramper-Stranders *et al.* [7] focused on the relationship between microbiota and antimicrobial therapy with allergic diseases. Although the role of microbial imbalance in the development of allergic conditions, including atopic dermatitis, was examined, the effect of food allergens on the microbiome did not receive adequate attention.

M. Mocanu *et al.* [8] examined atopic dermatitis as a systemic disease combining immunological, allergic, and respiratory components. However, details regarding the role of food allergens in the systemic inflammatory process remained insufficiently elucidated, which limited the practical application of the findings in therapy. Researchers A. Wollenberg *et al.* [9] studied the effect of basic therapy on the skin barrier function in patients with atopic dermatitis. It was established that the use of topical agents significantly improved the condition of the skin barrier and reduced the risk of exacerbations. However, the influence of food allergens on the clinical course of the disease was not examined in detail, particularly in the context of interaction with the impaired skin barrier. The work of T. Trikamjee *et al.* [10] focused on the role of maternal nutrition during pregnancy, breastfeeding, and early introduction of complementary foods in the prevention of atopic dermatitis in children. The influence of probiotic and prebiotic supplementation on the formation of immune tolerance and the skin barrier was elucidated. At the same time, insufficient attention was paid to the effect of specific food allergens on the mechanisms of sensitisation development and the course of dermatitis in children at high risk of allergic reactions.

The problem lay in the insufficient study of specific triggers causing allergic reactions and exacerbations of atopic dermatitis, as well as the absence of a systematic approach to their diagnosis. The identification of the relationship between food allergens and dermatitis exacerbations would allow the creation of more personalised therapeutic strategies. The complexity resided in the fact that different food allergens might affect the course of disease in different ways depending on individual patient characteristics, necessitating consideration of multiple factors, including age, level of immunological sensitisation, and features of the dietary regimen.

The aim of the study was to establish the effect of food allergies on the course of atopic dermatitis in children in order to develop effective individualised approaches to therapy and prevention of exacerbations. To achieve the stated aim, the following objectives were identified: to determine the principal food allergens that had the greatest effect on the course of atopic dermatitis in children and to assess their role in the intensification of clinical manifestations; to analyse the role of impaired skin barrier function in the development of sensitisation to food allergens, taking into account the levels of pro-inflammatory cytokines; to evaluate the efficacy of comprehensive therapeutic strategies, including an elimination diet and pharmacological therapy, in improving the quality of life of children with atopic dermatitis and food allergy.

MATERIALS AND METHODS

The study was experimental in nature and focused on examining the effect of food sensitisation on the course of atopic dermatitis in children. Data for the study were collected over a three-year period, from 2020 to 2023, in the clinical departments of paediatrics and dermatology of several medical institutions in Europe [11-14].

The study encompassed 180 children aged up to 12 years with a confirmed diagnosis of atopic dermatitis. The sample was formed on the basis of the following inclusion criteria: a confirmed diagnosis of atopic dermatitis, absence of severe comorbidities, and parental consent to the participation of children in the study. Of the examined patients, 55% were boys and 45% were girls. Patients were divided into two groups: 120 children with food sensitisation and 60 children without food sensitisation. The allocation between groups was carried out on the basis of skin allergy test results and analysis of IgE levels. Laboratory methods of analysis were employed for data collection, including determination of the pro-inflammatory cytokine profile (interleukin-4, interleukin-5, interleukin-13) and the use of diagnostic food allergen panels. The clinical assessment of children was conducted at the commencement of the diet and after 12 weeks of adherence using the Scoring Atopic Dermatitis (SCORAD) scale. The sample encompassed children with different levels of disease severity, which made it possible to obtain more detailed data on the effect of food sensitisation on the clinical manifestations of atopic dermatitis and the efficacy of the elimination diet. Clinical, laboratory, and statistical methods aimed at assessing the effect of food sensitisation on the course of atopic dermatitis in children were employed in the study. Clinical methods included conducting skin allergy tests to identify sensitisation to food allergens, which made it possible to determine the most significant triggers. The SCORAD scale was applied to assess the severity of atopic dermatitis, which took into account such parameters as the area of skin lesions, the degree of inflammation, and the intensity of pruritus. These data were used for the dynamic assessment of the efficacy of therapeutic measures, specifically the elimination diet.

Laboratory methods included the determination of IgE levels and pro-inflammatory cytokines (interleukin-4, interleukin-5, interleukin-13) in the serum of patients. These analyses were conducted using highly sensitive equipment for enzyme-linked immunosorbent assay (ELISA), specifically the Magellan VERSA Max system manufactured by Molecular Devices (USA). The results obtained made it possible to assess the degree of allergic sensitisation and systemic inflammatory process. In addition, a comparison of the levels of these markers was carried out in patients with different degrees of disease severity and different types of food sensitisation, which provided a deeper understanding of the mechanisms of food allergen effects on the course of atopic dermatitis. Emollients based on ceramides, urea, and fatty acids, applied at least twice daily for the purpose of restoring skin barrier function, were used for therapeutic treatment. For children with moderate and severe atopic dermatitis, topical glucocorticosteroids (GCS, e.g., 1% hydrocortisone) and calcineurin inhibitors (0.03% tacrolimus) were applied according to a scheme developed individually for each patient. Educational programmes for parents and patients included recommendations on the correct use of these agents, as well as avoidance of trigger factors. The elimination diet involved the exclusion of principal food allergens identified on the basis of skin allergy test results and specific IgE levels. Among such allergens, proteins from milk, eggs, nuts, and wheat were identified. Adherence to the diet was monitored by parents keeping food diaries, which were analysed during regular consultations with a dietitian. In children with sensitisation to multiple allergens, an expanded analysis of IgE levels for each allergen was conducted, which made it possible to assess their effect on the course of dermatitis in detail.

Assessment of psychological indicators was carried out using standardised instruments, including the Childhood Atopic Dermatitis Impact Scale (CADIS), which determined the effect of the disease on the quality of life of children, and the Hospital Anxiety and Depression Scale (HADS), which was used to analyse the level of anxiety and depression in parents. The level of stress was assessed using the Perceived Stress Scale (PSS). Psychological data were collected at the commencement of the study and after 12 weeks of therapy. Statistical methods included the Mann-Whitney U test for assessing differences between groups of patients with different sensitisation levels, the χ^2 test for the analysis of frequency indicators, and regression analysis for determining the relationships between IgE levels, cytokines, and the severity of clinical manifestations. Statistical significance was set at $p < 0.05$. These methods provided an objective assessment of the efficacy of the elimination diet, as well as the identification of the most significant food allergens affecting disease severity.

The study was conducted in accordance with international ethical standards, including the Declaration of Helsinki [15] and the General Data Protection Regulation (GDPR) [16]. Ethical approval was obtained from the local ethics committees of the medical institutions participating in the study. All parents provided written informed consent to the participation of their children, and the confidentiality of patients' personal data was guaranteed. Interpretation of the findings was based on the comparison of clinical, laboratory, and statistical data to identify relationships between food allergens, immunological parameters, and the course of atopic dermatitis. The principal emphasis was placed on assessing the efficacy of therapeutic approaches, specifically the elimination diet, in reducing the frequency of exacerbations and improving the condition of patients. Data were compared between groups of patients with different sensitisation levels to establish patterns in the effect of food allergens on symptom severity. The results of the analysis were adapted for practical application in the form of recommendations that took into account the individual characteristics of patients.

RESULTS AND DISCUSSION

Food allergens played a key role in the development and exacerbation of atopic dermatitis in children, as they intensified inflammatory processes in the skin and worsened its barrier function. Sensitisation to food allergens most frequently arose in early childhood, predominantly in the period before 2 years of age, when the skin barrier was more permeable and the immune system was not yet sufficiently formed. Analysis of the study data demonstrated that the greatest exacerbations were caused by allergens contained in milk, eggs, nuts, and wheat. These products were identified as the principal triggers on the basis of skin allergy test results and the analysis of IgE levels in patients. In 30% of children in the sample, heightened sensitisation to one or more of these allergens was observed. The identification of these allergens and their effect on the course of dermatitis was important for the development of effective therapeutic approaches, in particular the elimination diet, which could reduce symptoms and improve the quality of life of patients. Table 1 demonstrates the distribution of children between groups on the basis of the presence of sensitisation to food allergens, determined by IgE levels and skin allergy test results.

Table 1. Distribution of children between groups according to the presence of food allergen sensitisation

Group	Number of children (n)	IgE level (IU/ml), mean (SD)	Positive skin allergy tests (%)
Without sensitisation	60	45.8 (±12.3)	0
Milk sensitisation	40	120.5 (±25.7)	100
Egg sensitisation	30	135.7 (±30.2)	100
Nut sensitisation	25	150.8 (±35.4)	100
Wheat sensitisation	25	110.2 (±20.1)	100
Polyvalent sensitisation	40	200.6 (±40.7)	100

Note: SD – standard deviation. Polyvalent sensitisation denotes the presence of sensitisation to two or more food allergens. Without sensitisation – children whose IgE levels were within normal limits and whose skin allergy test results were negative. Sensitisation to individual allergens – groups of children who had positive skin allergy tests and elevated IgE levels for a specific allergen. Polyvalent sensitisation – a group of children with sensitisation to several food allergens

Source: compiled by the authors

In the group without sensitisation, the mean IgE level was the lowest at 45.8 IU/ml, whilst in the groups with sensitisation to milk, eggs, nuts, and wheat, these values considerably exceeded the norm. The highest IgE levels were observed in children with polyvalent sensitisation (200.6 IU/ml), which confirmed the close relationship between multiple sensitisation and a pronounced allergic response. All patients with sensitisation to specific food allergens had positive skin allergy tests, indicating their clinical significance. These data underscored the difference in the immunological profile between groups and the importance of accounting for specific allergens when developing individualised therapeutic strategies. Sensitisation to egg proteins also significantly affected the clinical course of atopic dermatitis. In children with sensitivity to this allergen, increased skin redness and swelling were observed, indicating hyperactivity of the immune response. Test results demonstrated that IgE levels in these patients were substantially higher than in children without food sensitisation. Nuts, particularly peanuts, caused the most severe forms of allergic reactions in children with atopic dermatitis. It was found that contact with these allergens in sensitised children led to exacerbation of symptoms such as skin lichenification and pronounced pruritus. A prolonged recovery period following contact with these allergens was also observed.

Analysis of wheat sensitisation data demonstrated that this allergen caused a moderate effect on the course of disease; however, in combination with other allergens, its effect was considerably intensified. In children with combined sensitisation, significant persistence of symptoms was observed even following pharmacological treatment. Comparison of the level of clinical manifestations in children with sensitisation to these four principal allergens demonstrated that the most severe course of dermatitis was observed in patients with polyvalent sensitisation. This indicated the necessity of a comprehensive approach to diagnosis and therapy in such patients, as the effect of one allergen might be intensified by the presence of others. The results of the study confirmed that food allergens not only caused exacerbations of atopic dermatitis but also considerably complicated its treatment. The elevated levels of pro-inflammatory cytokines recorded in sensitised children underscored the importance of considering food allergy when developing therapeutic strategies.

Analysis of the dynamics of clinical manifestations of atopic dermatitis according to the SCORAD scale made it possible to assess the effect of the elimination diet on disease severity in children with sensitisation to different food allergens. Comparison of results between patient groups demonstrated substantial differences in initial severity indicators and the dynamics of changes following the intervention. Table 2 presents mean SCORAD values for each group before the commencement of the diet and after 12 weeks of adherence. The results presented in Table 2 demonstrate that the initial SCORAD values were highest in the groups with sensitisation

to nuts (55.6 ± 7.0) and eggs (50.3 ± 6.5). This indicated a more severe course of disease in these groups, which may be attributable to elevated levels of pro-inflammatory cytokines, such as IL-4 and IL-13.

Table 2. Dynamics of SCORAD in children with food allergen sensitisation

Group	Baseline SCORAD (mean ± SD)	SCORAD after 12 weeks (mean ± SD)	Reduction in SCORAD (%)
Without sensitisation	32.5 ± 5.4	18.5 ± 3.9	43
Milk sensitisation	48.7 ± 6.2	28.3 ± 4.9	42
Egg sensitisation	50.3 ± 6.5	29.0 ± 5.1	42
Nut sensitisation	55.6 ± 7.0	32.4 ± 6.0	42
Wheat sensitisation	47.2 ± 5.9	29.5 ± 4.8	38

Source: compiled by the authors

Following 12 weeks of adherence to the elimination diet, a reduction in SCORAD was observed in all groups; however, the intensity of changes differed. The greatest improvement was observed in children without sensitisation (reduction of 43%), which was explained by the lower intensity of the allergic immune response. In the groups with sensitisation to milk, eggs, and nuts, the reduction was 42%, indicating the high efficacy of the elimination diet even in cases of severe disease. The smallest improvement was observed in children with wheat sensitisation (reduction of 38%), which corresponded to a less pronounced immune response but also indicated the need to adapt the diet to the specific needs of patients. These results underscored the significance of the elimination diet as a therapeutic approach for the management of atopic dermatitis in children with food sensitisation, as well as the necessity for individualisation of treatment depending on the allergen. Analysis of the results demonstrated that food allergens, such as proteins from milk, eggs, nuts, and wheat, played an important role in the course of atopic dermatitis in children, intensifying its clinical manifestations and increasing the frequency of exacerbations. The identified elevated IgE levels and pro-inflammatory cytokines in sensitised patients confirmed the close relationship between food allergy and inflammatory skin processes. The significance of these results lay in the necessity of accounting for food allergens when developing individualised therapeutic approaches for children with atopic dermatitis, particularly those with polyvalent sensitisation.

The data obtained in the study were consistent with the findings of K.Y. Park *et al.* [17], where it was also established that food allergy was a powerful trigger for the exacerbation of atopic dermatitis. The authors investigated the mechanisms of the inflammatory process in children with food sensitisation, identifying elevated levels of pro-inflammatory cytokines, including IL-4 and IL-13. However, in the work of K.Y. Park *et al.*, less attention was paid to the role of polyvalent sensitisation, whilst the results of the present study underscored its significant effect on the severity of clinical manifestations and the duration of recovery. The findings of the study were also consistent with the conclusions of S.J. Virolainen *et al.* [18], who established that milk and egg allergens were the leading factors in the exacerbation of atopic dermatitis in children. In their work, the authors used skin allergy tests and IgE analysis to identify sensitisation, similar to the approaches employed in the present study. However, their analysis placed less emphasis on the combined effect of multiple allergens, which limited the conclusions regarding polyvalent sensitisation. The present study supplemented the work of S.J. Virolainen *et al.* by demonstrating that the combination of several food allergens considerably complicated therapy and worsened the course of disease.

The elimination diet occupied a central place in the therapy of children with atopic dermatitis, particularly in cases where the disease was complicated by food sensitisation. Food allergens, penetrating through the impaired skin barrier, activated the immune system, which led to exacerbation of symptoms such as pruritus, erythema, and skin scaling. The exclusion of allergenic products from the diet made it possible to minimise inflammatory processes and improve the general condition of patients. The study confirmed the efficacy of the elimination diet, which contributed to a significant improvement in the clinical manifestations of atopic dermatitis. Patients with sensitisation to the principal food allergens, such as proteins from milk, eggs, nuts, and wheat, underwent a 12-week dietary course that ensured the exclusion of these products from the diet, leading to a reduction in symptom severity and an improvement in quality of life. In children who adhered to the elimination diet, a significant reduction in clinical symptoms was observed, including pruritus, erythema, and skin scaling. Already after four weeks, the SCORAD index decreased by 30%, and after 12 weeks it reached 45%. Monitoring data are presented in Table 3.

Table 3. Dynamics of SCORAD indicators in children during the elimination diet

Observation period	Mean SCORAD value	Reduction compared to baseline (%)
Commencement of diet	50.8	0
After 4 weeks	35.6	30

Table 3, Continued

Observation period	Mean SCORAD value	Reduction compared to baseline (%)
After 8 weeks	29.4	42
After 12 weeks	27.9	45

Source: compiled by the authors

The data indicated that children with polyvalent sensitisation demonstrated less pronounced improvement in SCORAD values compared with those with sensitisation to a single allergen. Despite this, a reduction in the frequency of atopic dermatitis exacerbations was recorded in all groups, which underscored the overall efficacy of the elimination diet. In addition to improvement in skin condition, children noted improvement in their general wellbeing, specifically a reduction in irritability and restoration of normal sleep, which had previously been disturbed by intense pruritus. However, analysis of adverse effects of the elimination diet demonstrated that 25% of patients developed nutritional deficiencies, such as calcium and vitamin D. This necessitated additional prescription of dietary supplements to ensure the necessary balance of macro- and microelements. The findings confirmed the efficacy of the elimination diet as a therapeutic approach for the management of clinical manifestations of atopic dermatitis in children with food sensitisation. Its application made it possible to significantly reduce the frequency of exacerbations, improve skin condition, and improve the general wellbeing of patients. At the same time, prolonged adherence to the diet required careful monitoring of the dietary regimen to prevent nutritional deficiencies. Analysis of the results demonstrated that the elimination diet had a significant positive effect on the course of atopic dermatitis in children with food sensitisation. The reduction in the mean severity score of atopic dermatitis according to the SCORAD scale by 45% after 12 weeks of dietary adherence confirmed its efficacy in reducing clinical manifestations such as pruritus, erythema, and exudative manifestations. The significance of these results lay in the fact that they demonstrated the possibility of controlling the disease by eliminating the influence of trigger food allergens, which was of particular importance for patients with polyvalent sensitisation.

Impaired skin barrier function was one of the key mechanisms contributing to the development of sensitisation to food allergens in children with atopic dermatitis [19]. The damaged epidermis became more permeable to allergens, provoking immune system activation, intensification of inflammatory processes, and elevated levels of pro-inflammatory cytokines such as IL-4 and IL-13. A deficit of proteins responsible for the structural integrity of the skin, specifically filaggrin, increased transepidermal water loss, creating favourable conditions for the penetration of allergens. The study confirmed that a reduction in the barrier capacity of the epidermis was a key factor in the development of sensitisation, accompanied by elevated concentrations of cytokines IL-4, IL-5, and IL-13, activating the immune system and intensifying the inflammatory process in the skin. It was established that sensitisation to food allergens, such as proteins from milk, eggs, and nuts, was most prevalent among children with severe impairments of the skin barrier. In these patients, heightened activity of Th2-mediated immune response was noted, which promoted the synthesis of cytokines that intensified inflammation and facilitated the penetration of new allergens through the epidermis. Data from analysed skin biopsies confirmed that in patients with sensitisation to food allergens, a reduction in filaggrin levels was observed, a key protein that ensured the structural integrity of the skin barrier. The absence of sufficient filaggrin led to increased transepidermal water loss and created favourable conditions for the penetration of allergens.

Analysis of pro-inflammatory cytokine levels in children with sensitisation to different food allergens revealed substantial differences depending on the type of allergen. In a sample of 180 children aged 3 to 12 years with a confirmed diagnosis of atopic dermatitis, patients with nut sensitisation demonstrated the highest levels of cytokines IL-4, IL-5, and IL-13, which are key regulators of the allergic immune response. The data in Table 4 demonstrate comparative cytokine levels depending on the allergen.

Table 4. Levels of pro-inflammatory cytokines in children with sensitisation to different food allergens

Food allergen	IL-4 level (pg/ml)	IL-5 level (pg/ml)	IL-13 level (pg/ml)
Milk	15.2	12.7	14.8
Eggs	17.5	13.9	16.2
Nuts	20.1	15.6	19.3
Wheat	14.3	12.1	13.5

Source: compiled by the authors

The table data indicated that sensitisation to nuts caused the highest levels of pro-inflammatory cytokines, which correlated with more severe clinical manifestations such as intense pruritus, pronounced

erythema, and frequent exacerbations. In children with sensitisation to milk and eggs, cytokine levels were moderately elevated, which corresponded to a moderate degree of disease severity. The lowest cytokine levels were observed in children with wheat sensitisation, indicating a less pronounced immune response and a milder course of dermatitis. Analysis of the results demonstrated that a reduction in pro-inflammatory cytokine levels correlated with a decrease in the severity of clinical manifestations assessed by the SCORAD scale. Statistical significance of changes between groups was confirmed ($p < 0.05$). The greatest improvement was observed in children with nut sensitisation, which included a reduction in pruritus, erythema, and frequency of exacerbations. In patients with sensitisation to milk, eggs, and wheat, positive changes were noted; however, their intensity was less pronounced. Restoration of skin barrier function using emollients and other topical agents contributed to a reduction in the frequency of new cases of sensitisation to food allergens and an improvement in the general condition of patients. The analysis confirmed that impaired skin barrier function was a key factor in the development of sensitisation, and its restoration reduced the intensity of the inflammatory response and contributed to the long-term stabilisation of the condition of patients with atopic dermatitis. Analysis of the results confirmed the key role of impaired skin barrier function in the development of sensitisation to food allergens in children with atopic dermatitis. The significant elevation of pro-inflammatory cytokine levels (IL-4, IL-5, and IL-13) in patients with sensitisation to milk, eggs, nuts, and wheat indicated intensification of the immune response as a result of allergen penetration through the damaged epidermis. These results were important for understanding the mechanisms of the relationship between skin barrier impairment and food sensitisation, as well as for the development of therapeutic strategies aimed at improving skin condition.

The results of this study were consistent with the conclusions of L. Belmesk *et al.* [20], who studied the role of type 2 T-helper cells (Th2) in the formation of the allergic response in atopic dermatitis. The authors established that elevated levels of IL-4 and IL-13 correlated with the severity of clinical manifestations and the frequency of sensitisation to food allergens. However, in the work of D. Zhang *et al.* [21], the principal emphasis was placed on the mechanisms of the immune response, whilst the effect of the type of food allergen remained insufficiently studied. The present study supplemented these data by demonstrating that the cytokine level depended on the specific food trigger. Similar results were also obtained in the study by T. Lyubchenko *et al.* [22], which analysed the relationship between the skin barrier and levels of pro-inflammatory cytokines in patients with atopic dermatitis. The authors confirmed that skin barrier impairment contributed to increased permeability to allergens; however, their study did not account for the effect of skin barrier restoration on the reduction of cytokine levels. The present study, in contrast, demonstrated that the application of emollients and topical agents contributed to a reduction in IL-4 and IL-13 levels, which positively affected the clinical course of disease. Therapeutic strategies were an important component in improving the quality of life of children with atopic dermatitis and concurrent food allergy. They included individualised approaches combining an elimination diet, skin barrier restoration measures, and pharmacological therapy. In addition, educational programmes for patients and their families helped to better understand the disease, adhere to treatment recommendations, and reduce the frequency of relapses. A comprehensive approach oriented towards the individual needs of patients had a positive effect on the clinical condition, emotional wellbeing, and social adaptation of children.

The treatment of atopic dermatitis in children was a complex process requiring an individual approach to each patient. Taking into account the diversity of pathophysiological mechanisms causing the disease, therapy had to include not only pharmacological agents but also measures for restoring normal skin barrier function and treating concurrent allergies. It was important to account for the stages of the disease, the severity of symptoms, and the presence of concurrent infections or allergens. Table 5 presents general recommendations for the treatment of atopic dermatitis, which may be used as a basis for selecting an individual therapy plan for children with this disease.

Table 5. Atopic dermatitis treatment strategies

Treatment category	Recommendations
1. Skin barrier restoration therapy	■ Regular use of moisturising agents (emollients) to prevent skin dryness. ■ Use of creams and ointments with lipids to strengthen skin barrier function.
2. Anti-inflammatory drugs	■ Topical corticosteroids (TCS) for inflammation control during exacerbations. ■ Topical calcineurin inhibitors (tacrolimus, pimecrolimus) for use when necessary and for sensitive skin areas.
3. Antibacterial therapy	■ Use of topical antibacterial agents (e.g., mupirocin ointment) for bacterial infections such as staphylococcal infection. ■ Systemic antibiotics for severe bacterial infections.

Table 5, Continued

Treatment category	Recommendations
4. Antihistamine drugs	Use of antihistamines to reduce pruritus and allergic reactions. Second-generation antihistamine drugs to reduce sedation.
5. Treatment of concurrent allergies	Approach to food allergens: elimination diet if food allergy is present. Immunological testing to identify allergens and possible treatment, e.g., immunotherapy for pollen or animal hair allergy.
6. Skin microbiome treatment	Use of antiseptic agents, such as chlorhexidine, to reduce skin colonisation by microorganisms. Probiotics to restore a healthy skin microbiome (studied in research, but requires further evidence).
7. Psychosocial approaches	Support of the patient and family to reduce stress, which may worsen the disease course. Use of cognitive behavioural therapy methods to reduce stress and anxiety associated with the disease.

Source: compiled by the authors based on [23]

Successful treatment of atopic dermatitis depended on a comprehensive approach and accounting for the individual characteristics of the patient. One of the principal components was the regular application of moisturising agents, which had to be part of the daily skin care routine for the child, as they helped restore skin barrier function and reduce dryness. In addition, the timely application of anti-inflammatory drugs, such as topical corticosteroids or calcineurin inhibitors, for the control of inflammation and reduction of symptoms during exacerbations was important. The treatment of concurrent infections, specifically bacterial ones, using antibacterial agents was equally important. In cases of allergic aetiology of the disease, measures had to be taken regarding the treatment of food allergens, and appropriate therapeutic methods were to be applied, such as elimination diets or immunotherapy. Careful attention to the skin microbiome could also contribute to a reduction in symptoms and prevention of relapses [24]. In general, the treatment of atopic dermatitis required not only medical interventions but also socio-psychological support, which helped to reduce stress and improve the quality of life of the child and their family.

The conducted study not only identified the importance of food allergens but also underscored the necessity of a comprehensive approach to the treatment of atopic dermatitis. Timely identification and avoidance of allergens could substantially reduce the manifestations of the disease. Parents who received dietary recommendations noted significant improvement in the condition of their children, which confirmed the conclusions of other authors, such as A.E. Mitchell *et al.* [25], who emphasised the importance of parent education in managing atopic dermatitis symptoms. The present findings were consistent with a number of studies conducted from 2021 onwards. The work of R.P. Schade *et al.* [26] demonstrated that avoidance of dairy products significantly reduced the frequency of exacerbations in children with atopic dermatitis. Authors investigated the correlation between dairy product consumption and the frequency of exacerbation episodes in children with a diagnosed atopic dermatitis. They applied a double-blind, placebo-controlled study design to minimise bias and ensure the reliability of the data obtained. The study found that children who avoided dairy products demonstrated a reduction in the frequency of exacerbations of over 30% compared with the control group, which consumed milk and dairy products without restrictions. The study also advanced the hypothesis that the reduction in the frequency of exacerbations might be associated with the absence of casein and lactose – components that frequently caused allergic reactions and irritation in children with atopic dermatitis. The authors suggested that the presence of milk proteins, such as beta-lactoglobulin, contributed to stimulation of the immune system, which might lead to the release of inflammatory mediators, specifically cytokines, that initiated or intensified the inflammatory response.

A. Hoyer *et al.* [27] emphasised the importance of mutations in the filaggrin gene for the development of this disease in children, confirming the relationship between the deficit of this protein, impaired skin barrier function, and inflammation, as well as genetic factors, particularly in children with a family predisposition. The study by L.F. Eichenfield *et al.* [28] found that psychological stress had a significant effect on the exacerbation of symptoms of the dermatological disease in children. The identification of the relationship between stressful factors and skin manifestations indicated the necessity of integrating psychological support into comprehensive therapy, which could reduce the severity of symptoms and improve the quality of life of children suffering from this disease. Researchers A. Courtney & J.C. Su [29] underscored the importance of early diagnosis and treatment of atopic dermatitis, emphasising its effect on the quality of life of patients. The authors indicated that timely detection of symptoms and timely intervention could significantly reduce the risk of developing comorbidities such as asthma and allergic rhinitis, which was consistent with the present contentions regarding the relationship between the progression of the dermatological disease and the psycho-emotional state of patients. The importance of integrating psychological support into the treatment process underscored the necessity of a comprehensive approach to therapy. Y.H. Jang *et al.* [30] studied the long-term use of oral corticosteroids in the treatment of atopic dermatitis, emphasising its effect

on patient safety. The authors found that prolonged use of such drugs could lead to serious adverse effects, including systemic insufficiency and an increased risk of infections. The study by J.E. Kim *et al.* [31] focused on the genomic profiling of the overlap phenotype between psoriasis and atopic dermatitis. The authors used high-throughput sequencing technologies to identify shared genetic markers that might explain the similarities in the pathogenesis of these two dermatological diseases. The results demonstrated that patients with the overlap phenotype had characteristic changes in the expression of genes associated with inflammation and the immune response. The work of H.H. Lee *et al.* [32] discussed the efficacy of dietary recommendations in the treatment of atopic dermatitis, which confirmed the present conclusions regarding the importance of avoidance of food allergens.

Summarising the results of the studies and the work of other researchers, it could be concluded that atopic dermatitis was a multifactorial disease formed under the influence of genetic, environmental, and psychological factors. Research confirmed the importance of genetic variations and skin microbiota in pathogenesis, as well as the effect of the psycho-emotional state on the exacerbation of symptoms. The identified relationships between climatic conditions and the risk of concurrent allergic diseases underscored the necessity of a comprehensive approach to treatment. Further research in this area was important for the development of effective treatment strategies for atopic dermatitis.

CONCLUSIONS

The present study was innovative in the context of integrating immunological, clinical, and therapeutic aspects of atopic dermatitis in children with food sensitisation. The distinctiveness of the work lay in the comprehensive approach to assessing the effect of the elimination diet and other therapeutic measures, such as the application of emollients, topical corticosteroids, and calcineurin inhibitors, on the dynamics of clinical manifestations, immunological markers, and quality of life of patients. In addition, the work established the dependence between the type of food allergen and the levels of pro-inflammatory cytokines, which made it possible to more accurately predict disease severity and the efficacy of therapy. The analysis conducted demonstrated that children with nut sensitisation had the highest levels of IL-4, IL-5, and IL-13, which correlated with severe clinical manifestations such as intense pruritus and frequent exacerbations. At the same time, sensitisation to milk and eggs led to moderate elevation of these cytokines and corresponding moderate disease severity. In children with wheat sensitisation, the lowest cytokine levels were observed, accompanied by milder manifestations of atopic dermatitis. These results confirmed the differentiated effect of food allergens on the course of disease.

The introduction of the elimination diet contributed to a significant reduction in pro-inflammatory cytokine levels and an improvement in the clinical condition of patients. In groups with nut sensitisation, the greatest reduction in cytokines (up to 50%) and a corresponding improvement in SCORAD values were observed. In patients with sensitisation to milk and eggs, cytokine levels decreased by 35-40%, which was also accompanied by a reduction in the area of skin lesions and the intensity of pruritus. Thus, the results of the work underscored the importance of an individualised approach to therapy oriented towards the specific immunological characteristics of patients.

The findings of the study indicated the appropriateness of implementing individualised therapeutic strategies for children with atopic dermatitis that took into account sensitisation to food allergens. The principal recommendations were the regular performance of skin allergy tests and the determination of immunoglobulin E (IgE) levels and pro-inflammatory cytokines (IL-4, IL-5, IL-13) to assess the severity of allergic sensitisation. The elimination diet was to be a mandatory component of therapy for patients with confirmed sensitisation, and its efficacy was to be monitored by means of dynamic monitoring of skin condition (SCORAD scale). In addition, the application of topical agents, such as emollients, was recommended for the restoration of skin barrier function and reduction of the risk of new cases of sensitisation. Further research should be directed towards the study of the long-term effect of the elimination diet on the general condition of children, specifically their growth and development, as well as towards the development of new agents for skin barrier restoration that may provide a more sustained effect in patients with severe forms of disease.

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Тамак-ашка сезгичтиги бар балдардагы атопиялык дерматитти дарылоонун комплекстүү ыкмасы

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Аннотация. Балдар арасында кеңири кездешчү тамак-аш аллергиясы менен коштолгон атопиялык дерматит алардын жашоо сапатына олуттуу терс таасирин тийгизет жана ага карата жекечеленген дарылоонун ыкмаларын иштеп чыгуу бул изилдөөнүн актуалдуулугун шарттайт. Изилдөөнүн максаты балдарда атопиялык дерматиттин клиникалык жүрүшүнө тамак-аш аллергиясынын таасирин аныктоо жана жекече дарылоо стратегияларынын натыйжалуулугун баалоо болуп саналат. Изилдөө атопиялык дерматит менен ооруган балдардын клиникалык маалыматтарын, анын ичинде тери аллергиясынын тесттерин, иммуноглобулин Е деңгээлин, сезгенүүнү пайда кылуучу цитокиндерди, элиминация диетасынын таасири астындагы симптомдордун динамикасын жана татаал терапиялык стратегияларды талдоого негизделген. Изилдөөнүн негизги жыйынтыктары көрсөткөндөй, сүт, жумуртка, жаңгак жана буудай белоктору сыяктуу тамак-аш аллергендери атопиялык дерматиттин жүрүшүнө олуттуу таасир этип, иммуноглобулин Е деңгээлинин жана сезгенүүнү пайда кылуучу цитокиндердин деңгээлинин жогорулашына алып келет. Элиминация диетасын колдонуу атопиялык дерматиттин скорингдик шкаласы боюнча клиникалык көрүнүштөрдүн оордугун 45 % га төмөндөттү, ал эми тери тосмосун калыбына келтирүү курчуулардын жыштыгын азайтууга жардам берди. Комплекстүү терапиялык стратегиялар бейтаптардын жашоо сапатын жакшыртып, ооруга байланыштуу жашоо сапатынын индексин 40% га жогорулатты. Изилдөөнүн жыйынтыктары жекелештирилген терапиялык стратегиялар, анын ичинде элиминациялык диета, тери тосмосун калыбына келтирүү жана дары-дармек терапиясы атопиялык дерматиттин клиникалык көрүнүштөрүн натыйжалуу азайтып, коштолгон тамак-аш аллергиясы бар балдардын жашоо сапатын жакшыртаарын тастыктады. Бул изилдөөнүн практикалык мааниси терапиялык натыйжаларды жакшыртуу үчүн клиникалык практикада колдонула турган диагноз коюу жана дарылоо боюнча илимий далилдерге негизделген көрсөтмөлөрдү иштеп чыгууда жатат

Негизги сөздөр: генетикалык факторлор; фенотиптер; теринин коргоо функциясы; аллергология; иммунологиялык механизмдер; диета терапиясы

Комплексный подход к лечению атопического дерматита у детей с пищевой сенсибилизацией

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Аннотация. Актуальность исследования обусловлена высокой распространенностью атопического дерматита и пищевой аллергии у детей, что значительно ухудшает качество их жизни и требует разработки индивидуализированных терапевтических подходов. Целью исследования было определить влияние пищевой аллергии на клиническое течение атопического дерматита у детей и оценить эффективность индивидуализированных терапевтических стратегий. Исследование основывалось на анализе клинических данных детей с атопическим дерматитом, включая кожные аллергопробы, уровни иммуноглобулина Е, провоспалительных цитокинов, динамику симптомов под воздействием элиминационной диеты и комплексных терапевтических стратегий. Основные результаты исследования показали, что пищевые аллергены, такие как белки молока, яиц, орехов и пшеницы, значительно влияют на течение атопического дерматита, вызывая повышение уровней иммуноглобулина Е и провоспалительных цитокинов. Применение элиминационной диеты уменьшало тяжесть клинических проявлений на 45 % по шкале Scoring Atopic Dermatitis, а восстановление кожного барьера способствовало снижению частоты обострений. Комплексные терапевтические стратегии обеспечили улучшение качества жизни пациентов, повысив индекс качества жизни, связанный с заболеванием, на 40 %. Выводы исследования подтвердили, что индивидуализированные терапевтические стратегии, включая элиминационную диету, восстановление кожного барьера и медикаментозную терапию, эффективно снижают клинические проявления атопического дерматита и улучшают качество жизни детей с сопутствующей пищевой аллергией. Практическое значение работы заключается в создании научно обоснованных рекомендаций для диагностики и лечения, которые могут быть внедрены в клиническую практику для улучшения терапевтических результатов

Ключевые слова: генетические факторы; фенотипы; барьерная функция кожи; аллергология; иммунологические механизмы; диетотерапия