The Impact of Diet and Lifestyle on the Course of Autoimmune Diseases

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Abstract

Introduction and Purpose: Autoimmune diseases represent a diverse group of disorders caused by immune dysregulation, resulting in attacks on the body's own tissues. These conditions are increasingly common and significantly impact patients' quality of life. Environmental factors, including diet and lifestyle, are key contributors to this increase. This review explores the impact of diet and lifestyle on the progression and management of autoimmune diseases.

Materials and Methods: This review is based on articles obtained from scientific databases like PubMed, selected for their importance to the subject.

Results: Anti-inflammatory diets, such as the Mediterranean diet, omega-3 fatty acids, vitamin D, and selenium, reduce disease activity and modulate immune responses. Dysbiosis in the gut and oral microbiomes is a significant factor in disease progression, while probiotics and prebiotics may have a promising impact.Lifestyle factors complement dietary strategies by reducing systemic inflammation and improving physical and mental health. Gender-specific differences further highlight the need for personalized management approaches.

Conclusion: Diet and lifestyle modifications significantly influence autoimmune disease outcomes by reducing inflammation, supporting immune regulation, and addressing comorbidities. Future research should focus on precision nutrition and microbiome-based therapies to further enhance treatment outcomes and patient well-being.

Keywords: autoimmune diseases, diet, lifestyle, inflammation, microbiome, nutrition, dysbiosis, vitamin D, Mediterranean diet

Introduction

Autoimmune diseases represent a heterogeneous group of disorders arising from immune system dysregulation, leading to abnormal activation of B and T cells against the body's own tissues. These conditions can affect virtually any organ system and occur across all age groups, with a significantly higher prevalence in women [1]. The clinical presentations of autoimmune diseases vary widely, ranging from acute, life-threatening organ failure to minor laboratory changes. Depending on the disease symptoms may be limited to specific organs or present as systemic illnesses involving multiple organ systems [1].

The prevalence of autoimmune diseases has been steadily rising in industrialized nations, now affecting up to 9% of the population. Over 100 conditions have been identified, ranging from organ-specific diseases to systemic ones, such as rheumatoid arthritis or lupus. Autoimmune diseases significantly reduce quality of life and increase mortality, with treatments often relying on broad immunosuppression, which heightens the risk of infections and cancer. Their complex pathogenesis involves genetic predispositions and environmental triggers, including infections, diet, pollution, smoking, and lifestyle changes. The rising incidence is likely linked to modern dietary shifts, increased exposure to xenobiotics, air pollution, and psychosocial stress [2][3].

Diet plays a pivotal role in influencing the course of autoimmune diseases by directly affecting immune system function and inflammation. Certain dietary components have been identified as triggers that exacerbate autoimmune conditions. For instance, high salt intake promotes the differentiation of pro-inflammatory Th17 cells, worsening diseases like multiple sclerosis and rheumatoid arthritis. Red meat contains Neu5Gc, a sugar molecule absent in humans, which integrates into human tissues and elicits chronic inflammatory responses [4]. In celiac disease, gluten peptides can cross a compromised intestinal barrier, interact with specific HLA molecules such as HLA-DQ2, and activate autoreactive T cells, leading to tissue damage. Additionally, the phenomenon of molecular mimicry, where dietary proteins resemble human antigens, further explains how certain foods can unintentionally provoke immune attacks on the body's own tissues [4]. Diet and lifestyle play a crucial role in managing autoimmune diseases by modulating inflammation and supporting overall health. Chronic inflammation, often worsened by poor dietary choices, is central to autoimmune conditions. Tailored dietary interventions can significantly reduce symptoms and improve quality of life [5].In rheumatoid arthritis, omega-3-rich diets like the Mediterranean diet reduce pain and swelling, with fatty fish, walnuts, and phenolic compounds in olive oil and berries offering additional anti-inflammatory benefits. Avoiding processed and high-sodium foods helps minimize flare-ups [5][6]. For systemic lupus erythematosus (SLE), antioxidant-rich foods such as citrus fruits, green tea, and tomatoes reduce oxidative stress and inflammation. Low-calorie diets alleviate

fatigue, while balancing omega-3 and omega-6 intake supports cardiovascular and renal health [5][6]. In multiple sclerosis (MS), anti-inflammatory diets improve cognitive function and reduce relapses. Foods high in flavonoids and vitamin D are particularly beneficial, while avoiding processed foods and sugars is critical [6]. For inflammatory bowel disease (IBD), gut health is supported by fiber-rich foods, fermented vegetables and probiotics. Omega-3s from fish and flaxseed reduce intestinal inflammation, while processed meats, alcohol, and fried foods should be avoided [5][6]. In type 1 diabetes (T1D), dietary polyphenols in pomegranate, cocoa, and legumes protect insulin-producing cells, while whole grains and low-glycemic foods help regulate blood sugar and manage complications [5]. Lifestyle changes, including regular exercise, stress management, and adequate sleep, complement dietary strategies. Exercise reduces inflammation in rheumatoid arthritis, while mindfulness and yoga lower systemic inflammation in multiple sclerosis and SLE. Collectively, these interventions address specific needs and enhance outcomes across autoimmune conditions. A multifaceted interaction between environmental factors and genetic predispositions can be observed (Figure 1.) [5][6].
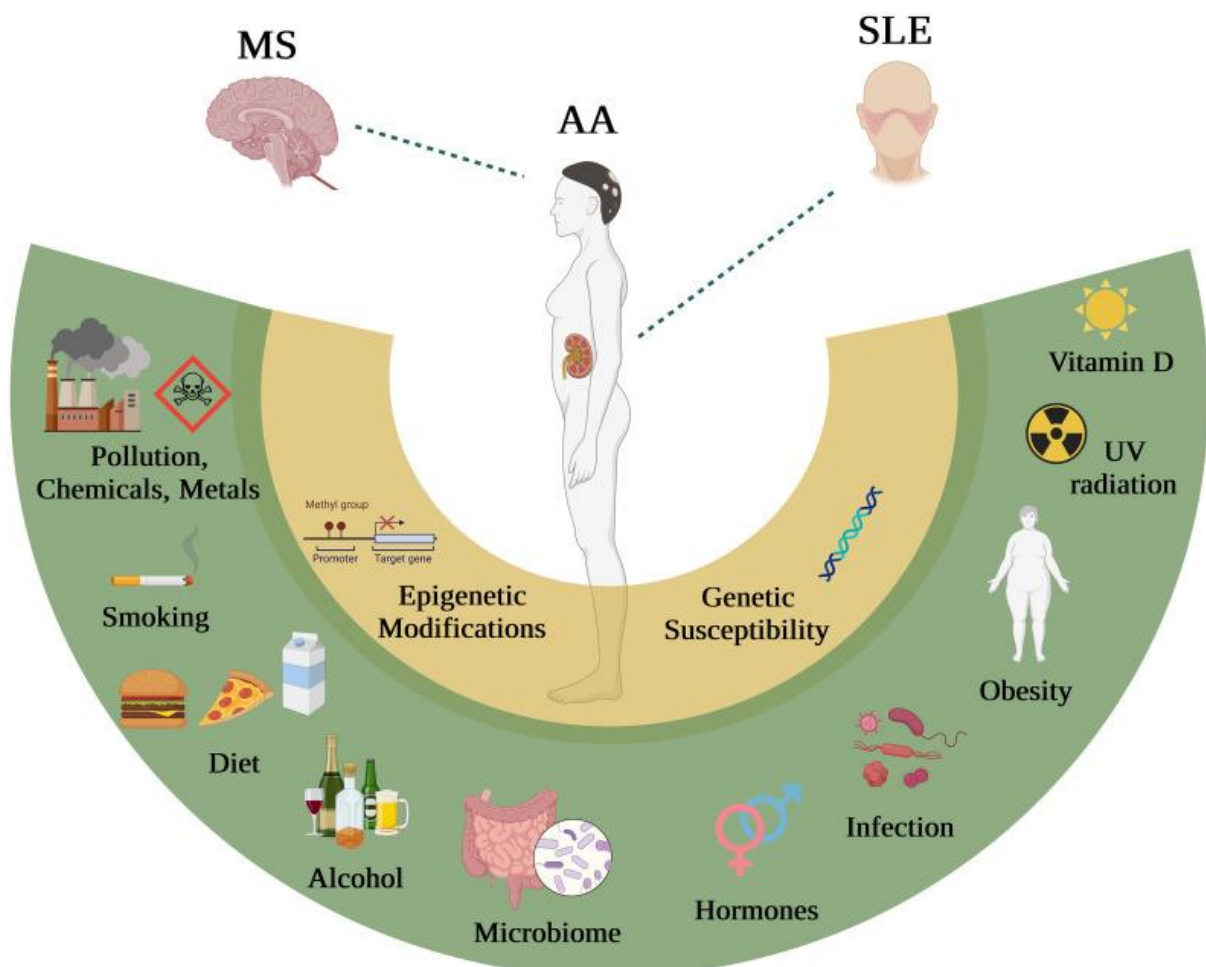

Figure 1. The impact of environmental factors and their interactions with genes in patients with multiple sclerosis (MS), alopecia areata (AA) and systemic lupus erythematosus (SLE). Adapted from Touil H, Mounts K, De Jager PL, *Differential impact of environmental factors on systemic and localized autoimmunity*, *Front Immunol*, 2023;14:1147447, doi:10.3389/fimmu.2023.1147447 [6].

Stress

Chronic stress plays a critical role in triggering and worsening autoimmune diseases, as it disrupts immune function and amplifies inflammation. Disorders like PTSD are strongly linked to a higher risk of autoimmune conditions, including rheumatoid arthritis, lupus, and autoimmune thyroid diseases. This connection is driven by the dysregulation of the hypothalamic-pituitary-adrenal (HPA) axis and the overproduction of pro-inflammatory cytokines, which fuel disease activity [7][8]. Recent research has uncovered shared genetic pathways, such as those involving G-protein coupled receptor signaling, that further explain the overlap between stress-related disorders and autoimmune diseases [7]. These findings highlight the need for holistic management strategies that target both stress reduction and lifestyle changes to effectively control autoimmune disease progression and improve patient outcomes [8].

Rheumatoid arthritis

Rheumatoid arthritis is a chronic autoimmune disease marked by systemic inflammation and joint damage. Evidence highlights that diet and nutrition significantly influence the progression of rheumatoid arthritis and its clinical manifestations. Adherence to anti-inflammatory diets, particularly the Mediterranean diet, has been shown to reduce disease activity and improve symptoms. The Mediterranean diet rich in fruits, vegetables, olive oil, fish, and whole grains, provides antioxidants, polyphenols, and omega-3 fatty acids that counteract inflammation and oxidative stress [9][10].

Probiotics and prebiotics also play a crucial role in rheumatoid arthritis management by modulating gut microbiota, which is often disrupted in rheumatoid arthritis patients. Improved gut health contributes to reduced systemic inflammation and enhanced immune regulation [11]. On the other hand, Western diets high in red meat, saturated fats, and processed sugars increase inflammation and have been linked to higher disease activity and difficulty achieving remission [9][12]. Emerging studies suggest that certain dietary components, like vitamin D, zinc, and polyunsaturated fatty acids, have direct effects on immune pathways and disease markers such as DAS28 scores, showing measurable reductions in rheumatoid arthritis activity [10][13]. Lifestyle modifications, including personalized nutrition plans and physical activity, further complement dietary interventions, improving overall patient outcomes and reducing cardiovascular risks associated with rheumatoid arthritis [10]

This growing body of evidence underscores the importance of integrating dietary and lifestyle strategies into rheumatoid arthritis treatment protocols to manage symptoms and enhance the quality of life for patients.

Systemic lupus erythematosus

Systemic lupus erythematosus (SLE) is a complex autoimmune disease that affects multiple organs, including the skin, joints, kidneys, and central nervous system, often leading to significant morbidity. Its pathogenesis is influenced by genetic, environmental, and lifestyle factors, with chronic inflammation and immune dysregulation [14][15].

While pharmacological treatments remain the cornerstone of management, emerging evidence underscores the critical role of diet and lifestyle in modulating disease activity and improving quality of life in SLE patients. Dietary interventions have shown promise in reducing inflammation and mitigating disease progression. For instance, a low-calorie diet has demonstrated the ability to decrease inflammatory markers, improve immune regulation, and delay disease onset in animal models and human studies [14][15].

Omega-3 polyunsaturated fatty acids (PUFAs), commonly found in fish oil, have been particularly effective in lowering pro-inflammatory cytokines, enhancing endothelial function,

and reducing oxidative stress. These benefits also extend to the cardiovascular risks often associated with SLE [14][15]. The Mediterranean diet, characterized by high consumption of fruits, vegetables, olive oil, and fish, has been linked to better disease activity scores and overall outcomes, showcasing its potential as a holistic dietary strategy for SLE management [15]. Furthermore, micronutrients such as vitamin D play an essential role in regulating immune responses, with supplementation shown to decrease disease flares and improve bone health, particularly in patients undergoing corticosteroid therapy [14][15].

In addition to diet, lifestyle modifications such as regular exercise and stress management are critical for reducing systemic inflammation and improving physical and mental well-being. Together, these approaches emphasize the value of integrating personalized nutrition and lifestyle strategies into SLE care, offering a promising pathway to enhance patient outcomes and quality of life [14][15].

Psoriasis

Psoriasis is a chronic autoimmune disease characterized by abnormal keratinocyte proliferation and inflammation, driven by immune dysregulation. The pathogenesis involves activation of Th1, Th17, and Th22 cells, leading to the release of pro-inflammatory cytokines such as IL-17, IL-23, and TNF-α, which sustain the inflammatory cycle in skin lesions [16][17]. Beyond its dermatological manifestations, psoriasis is recognized as a systemic disease linked to comorbidities like cardiovascular disease, metabolic syndrome, and obesity [17][18].

Diet and lifestyle factors play a pivotal role in modulating the severity and progression of psoriasis. Obesity, a common comorbidity, exacerbates psoriasis through increased secretion of adipokines like leptin and resistin, which promote systemic inflammation [19][20]. This bidirectional relationship underscores the importance of weight management in disease control. Dietary interventions, such as adopting a low-calorie or Mediterranean diet, have shown significant benefits in managing psoriasis. The Mediterranean diet, rich in omega-3 fatty acids, polyphenols, and antioxidants, reduces inflammatory markers like TNF-α and IL-6, while improving clinical outcomes and quality of life [17][18]. Additionally, vitamin D supplementation is associated with better immune modulation, leading to fewer flares and improved skin health [16].

Gut microbiota dysbiosis is another critical factor in psoriasis pathogenesis, as it amplifies systemic inflammation. Restoring microbiota balance through diets high in fiber, prebiotics, and probiotics has been shown to alleviate symptoms and reduce disease activity [16][20].

Physical activity complements dietary strategies by lowering systemic inflammation, reducing comorbid risks, and improving overall health. Regular moderate-intensity exercise is particularly beneficial for patients with psoriasis, helping to break the cycle of inflammation and metabolic dysfunction [17][18].

These findings highlight the need for a multidisciplinary approach to psoriasis management, integrating dietary and lifestyle modifications to complement pharmacological treatments and improve patient outcomes.

Multiple sclerosis

Multiple sclerosis is a chronic autoimmune disease that affects the central nervous system (CNS), leading to inflammation, demyelination, and neurodegeneration [21][22].The disease is primarily mediated by autoreactive T cells, particularly Th1 and Th17 cells, which produce pro-inflammatory cytokines such as IL-17 and TNF-α. These cytokines damage the myelin sheath and contribute to axonal loss and neurodegeneration [21][23]. Genetic predisposition and environmental factors, including infections (such as Epstein-Barr virus), smoking, and vitamin D deficiency, play a critical role in multiple sclerosis onset [21].Interestingly, latitude also influences multiple sclerosis prevalence, with higher rates observed in regions farther from the

equator, possibly due to lower sunlight exposure and consequent vitamin D deficiency [21]. Emerging evidence highlights the potential of dietary and lifestyle modifications in influencing multiple sclerosis progression and symptom severity. The Mediterranean diet, rich in fruits, vegetables, omega-3 fatty acids, and polyphenols, has been linked to reduced inflammation and improved outcomes in multiple sclerosis patients [21][22]. Antioxidants in the diet, such as curcumin and flavonoids, help counteract oxidative stress, which is a key driver of neurodegeneration in multiple sclerosis [22][23]. Similarly, the ketogenic diet has shown promise in reducing fatigue and promoting neuroprotection by providing an alternative energy source for neurons [22][24].

Vitamin D is important due to its role in modulating immune responses and reducing inflammation. Studies show that higher serum vitamin D levels correlate with lower relapse rates and reduced disease activity [21][23]. Omega-3 polyunsaturated fatty acids (PUFAs), found in fish and nuts, enhance remyelination and support neuronal health, making them valuable in managing multiple sclerosis [22].

Lifestyle factors such as physical activity and stress management play complementary roles. Regular exercise has been shown to improve functional mobility and reduce systemic inflammation [21][24]. Stress management, including mindfulness and meditation, supports overall well-being and may alleviate disease-related fatigue and anxiety [24].

The gut microbiota is important because dysbiosis, or an imbalance in gut bacteria, has been linked to multiple sclerosis progression, and dietary interventions such as probiotics and prebiotics are being explored for their potential to restore gut health and modulate immune responses [21][22]. Telomere length, a marker of biological aging, is often shorter in multiple sclerosis patients, correlating with disease severity and progression. Oxidative stress and chronic inflammation are believed to accelerate telomere attrition [21]. Vitamin A supplementation has been associated with improved cognitive function and reduced fatigue in multiple sclerosis patients, suggesting a broader role for micronutrients in disease management [22].

Together, these interventions underscore the potential of personalized diet and lifestyle modifications as integral components of multiple sclerosis management.

Autoimmune Thyroid Diseases
Hashimoto's thyroiditis is the most prevalent autoimmune thyroid disorder, marked by lymphocytic infiltration, chronic inflammation of the thyroid gland, and the production of thyroid autoantibodies, such as thyroperoxidase antibodies (TPOAb) and thyroglobulin antibodies (TgAb). This immune-mediated damage leads to fibrosis, progressive hypothyroidism, and a substantial impact on patient quality of life [25][26]. Genetic predisposition, environmental factors, and lifestyle choices significantly influence disease onset and progression [26][27].

The Role of Selenium and Vitamin D
Selenium, an essential trace element for thyroid function, plays a pivotal role in the synthesis of thyroid hormones and in reducing oxidative stress within thyrocytes. Multiple randomized controlled trials indicate that selenium supplementation lowers TPOAb levels, improves thyroid hormone profiles, and reduces oxidative stress markers [25]. Selenium's antioxidant properties contribute to attenuating immune activity and preserving thyroid tissue [25][26].

Vitamin D insufficiency is frequently observed in patients with autoimmune thyroid diseases, including Hashimoto's thyroiditis. Supplementation has been shown to modulate immune responses, reduce antibody production, and improve thyroid function [27]. These findings highlight the need to address micronutrient deficiencies as part of a comprehensive Hashimoto's thyroiditis management strategy.

Gluten-Free Diet and Gut Health

Emerging evidence links Hashimoto's thyroiditis with gluten-related conditions such as celiac disease and non-celiac gluten sensitivity, suggesting shared pathogenic mechanisms, including dysbiosis and intestinal permeability [27]. Adopting a gluten-free diet (GFD) has demonstrated potential benefits in lowering TSH, TPOAb, and TgAb levels, likely due to reduced gut inflammation and improved absorption of critical nutrients like selenium and vitamin D .Although GFD is not universally recommended for all Hashimoto's thyroiditis patients, it may be a beneficial adjunct for individuals with gluten sensitivity or related conditions. [27].

Anti-Inflammatory Diets and Lifestyle Interventions

Diets low in inflammatory components and rich in omega-3 fatty acids, antioxidants, and polyphenols have been associated with reduced thyroid antibody levels and improved metabolic health [26][28]. The Mediterranean diet, in particular, provides anti-inflammatory and antioxidant benefits, which can help mitigate the chronic inflammation seen in Hashimoto's thyroiditis [26]. Lifestyle changes, such as regular physical activity and stress management, further enhance Hashimoto's thyroiditis outcomes. Exercise reduces systemic inflammation and improves metabolic markers, while mindfulness and other stress-reduction techniques lower cortisol levels, which can otherwise exacerbate immune dysregulation [28].

A tailored approach that combines anti-inflammatory diets, micronutrient supplementation (selenium and vitamin D), and lifestyle interventions offers a promising strategy for managing autoimmune thyroid diseases. Addressing individual patient needs and comorbid conditions, such as gluten sensitivity or metabolic syndrome, can optimize outcomes and improve quality of life for those living with Hashimoto's thyroiditis.

Alopecia Areata

Alopecia areata is a chronic autoimmune condition characterized by non-scarring hair loss resulting from an immune attack on hair follicles. The pathogenesis involves the overactivation of Th1, Th2, and Th17 immune responses. Key cytokines such as IFN-γ, IL-13, and IL-17 contribute to the inflammatory milieu that drives hair follicle destruction. Environmental factors, diet, and lifestyle choices have been increasingly recognized as modifiable contributors to disease progression and management [29].

Psychological Stress and Its Effects

Psychological stress is a well-established trigger for alopecia areata and can exacerbate disease activity. Stress stimulates the hypothalamic-pituitary-adrenal (HPA) axis, leading to increased production of cortisol and pro-inflammatory cytokines such as IL-6 and TNF-α. These changes disrupt immune regulation, promoting an autoimmune attack on hair follicles. Stress reduction techniques, including mindfulness, yoga, and cognitive behavioral therapy, have been shown to lower systemic inflammation and potentially reduce alopecia areata flares [29].

Dietary Factors

The role of diet in alopecia areata is significant, with certain nutrients and dietary patterns directly influencing immune function. Anti-inflammatory diets, such as the Mediterranean diet, which are rich in omega-3 fatty acids, antioxidants, and polyphenols, may reduce the pro-inflammatory Th17 response and support hair regrowth [29]. Foods high in omega-3s, including fatty fish, walnuts, and flaxseeds, provide essential precursors for anti-inflammatory prostaglandins. Conversely, diets rich in omega-6 fatty acids, processed foods, and refined sugars promote inflammation and may worsen symptoms [29]. Gluten has also been implicated

in alopecia areata, particularly in individuals with coexisting gluten sensitivity or celiac disease. A gluten-free diet has shown potential in reducing autoimmune activity and improving outcomes in these patients [29]. Additionally, deficiencies in key micronutrients, such as zinc, iron, biotin, and vitamin D, have been associated with worse alopecia areata severity. Supplementation with these nutrients, particularly vitamin D, has been shown to modulate immune responses and support hair follicle regeneration [29].

Lifestyle Modifications

Lifestyle factors such as smoking, alcohol consumption, sleep quality, and weight management significantly impact alopecia areata progression. Smoking has been shown to exacerbate Th1 and Th17 immune responses, while alcohol intake can increase IL-17 production, further promoting inflammation [29]. In contrast, maintaining a healthy weight and improving sleep quality enhance overall immune function and reduce disease severity. By addressing modifiable factors such as stress, diet, and lifestyle habits, patients may experience reduced disease activity, improved hair regrowth, and enhanced quality of life [29].

Type 1 diabetes

Type 1 diabetes is a chronic autoimmune condition characterized by the destruction of insulin-producing beta cells in the pancreas, leading to insulin dependency. Genetic predisposition, particularly human leukocyte antigen (HLA) haplotypes such as DR3-DQ2 and DR4-DQ8, significantly influences disease susceptibility, though environmental and dietary factors also play a crucial role in the di sease's onset and progression [30]. Dietary patterns can modulate immune responses and influence the progression of type 1 diabetes. Early exposure to cow's milk proteins has been suggested as a potential trigger of autoimmune responses in genetically predisposed individuals, although evidence remains inconsistent [30]. Conversely, the Mediterranean diet, rich in omega-3 fatty acids, antioxidants, and low in pro-inflammatory foods, has shown potential benefits in modulating inflammation and supporting glycemic control in individuals with type 1 diabetes [30]. Vitamin D supplementation has demonstrated immune-modulating effects by enhancing regulatory T cell (Treg) activity and reducing pro-inflammatory cytokines. Calcitriol, the active form of vitamin D, also improves glycemic control and delays beta-cell destruction when administered during the early stages of the disease [30]. Additionally, omega-3 fatty acids, found in fish oil, exert anti-inflammatory effects and may complement traditional type 1 diabetes treatments [30].

Lifestyle modifications, such as stress management and regular physical activity, play a vital role in managing type 1 diabetes. Stress reduction techniques help lower systemic inflammation and improve insulin sensitivity, while exercise enhances glucose metabolism and reduces the risk of diabetes-related complications. Moreover, maintaining a healthy gut microbiome through probiotics and dietary fibers is an emerging area of interest, as gut health is intricately linked to immune regulation in type 1 diabetes [30].

These findings underscore the importance of integrating dietary strategies and lifestyle interventions alongside pharmacological treatments to improve outcomes and quality of life for individuals living with type 1 diabetes [30].

The Role of Dysbiosis in Autoimmune Diseases

Microbial dysbiosis, an imbalance in the gut microbiota, is increasingly recognized as a critical factor in the development and progression of autoimmune diseases. The gut hosts trillions of microorganisms that interact with the immune system to maintain homeostasis. Dysbiosis disrupts this balance, leading to immune dysfunction and systemic inflammation [31]. In autoimmune conditions such as type 1 diabetes, multiple sclerosis, and rheumatoid arthritis, dysbiosis contributes to increased gut permeability, allowing microbial metabolites like

lipopolysaccharides (LPS) to enter the bloodstream. This triggers a pro-inflammatory immune response characterized by elevated levels of cytokines such as IL-17 and TNF-α [31]. Additionally, dysbiosis influences the differentiation of T cells, shifting the balance from regulatory T cells (Tregs) to pro-inflammatory Th17 cells, further driving disease pathology [31]. Short-chain fatty acids (SCFAs), microbial metabolites derived from dietary fiber fermentation, play a dual role in gut health. While healthy microbiota produce SCFAs like butyrate to support mucosal barrier integrity and anti-inflammatory Treg differentiation, dysbiosis reduces SCFA levels, exacerbating gut inflammation and autoimmune activity [30]. Probiotics and prebiotics show promise in modifying dysbiotic states and reducing systemic inflammation. These findings underscore the importance of gut health in autoimmune disease management and highlight the potential of microbiome-based therapies in improving patient outcomes [31].

Oral Microbiome
The oral microbiome, comprising over 700 microbial species, plays a pivotal role in maintaining immune homeostasis. Dysbiosis of the oral microbiota, driven by factors such as poor oral hygiene, dietary habits, and infections, has been implicated in the development and progression of autoimmune diseases [32]. Under conditions of dysbiosis, commensal microorganisms can shift to pathogenic roles, triggering systemic inflammation and immune dysregulation [32]. The oral microbiota contributes to autoimmune pathology through microbial translocation, molecular mimicry, and autoantigen overproduction. For instance, Porphyromonas gingivalis produces enzymes that citrullinate proteins, leading to the formation of anti-citrullinated protein antibodies (ACPAs), which are closely associated with the development of rheumatoid arthritis [32]. Similarly, oral pathogens like Aggregatibacter actinomycetemcomitans and Fusobacterium nucleatum disrupt mucosal barriers, promoting systemic inflammation and exacerbating diseases such as systemic lupus erythematosus and inflammatory bowel disease [32]. Interestingly, the oral-gut microbiota axis has emerged as a critical pathway linking oral dysbiosis to systemic diseases. Oral bacteria translocating to the gut can alter its microbiota composition, enhancing gut permeability and amplifying immune responses. This ectopic colonization contributes to the exacerbation of conditions like multiple sclerosis and type 1 diabetes [32]. Therapeutic approaches targeting the oral microbiome, such as probiotics, prebiotics, and improved oral hygiene, show promise in restoring microbial balance and mitigating autoimmune disease severity. Understanding the complex interactions between the oral microbiota and the immune system offers novel insights into potential treatments for autoimmune diseases [32].

The Impact of Gender on Autoimmune Diseases
Gender significantly influences the prevalence, progression, and severity of autoimmune diseases, with women exhibiting a higher susceptibility due to a complex interplay of genetic, hormonal, and immune factors [33].
Females mount stronger innate and adaptive immune responses, which provide advantages in combating infections but predispose them to heightened autoimmunity. This dual effect is largely modulated by estrogen, which promotes lymphocyte activation, proliferation, and pro-inflammatory cytokine production, contributing to autoantibody generation and inflammation [33]. The X chromosome also plays a pivotal role, harboring numerous immune-related genes. Women, with two X chromosomes, experience incomplete X chromosome inactivation, leading to overexpression of these genes and increased immune dysregulation. This mechanism is associated with conditions such as systemic lupus erythematosus and rheumatoid arthritis, where females show a marked predominance [33].

In contrast, testosterone in males exerts immunosuppressive effects by expanding regulatory T cells (Tregs) and reducing pro-inflammatory Th17 cells, providing relative protection against autoimmunity [33].

Interestingly, hormonal fluctuations during pregnancy and menopause significantly alter disease activity. Pregnancy often improves symptoms in conditions like rheumatoid arthritis due to a shift toward anti-inflammatory Th2 responses, whereas postpartum periods can trigger disease flares. These gender-specific dynamics highlight the necessity for tailored therapeutic approaches considering hormonal and genetic differences to optimize autoimmune disease management [33].

Conclusion

Autoimmune diseases are complex conditions driven by a combination of genetic, environmental, and lifestyle factors. Their rising prevalence, particularly in industrialized societies, reflects changes in diet, increased exposure to environmental toxins, and heightened stress levels. These factors, combined with genetic predispositions, disrupt immune regulation and promote chronic inflammation, which are central to the development and progression of autoimmune diseases. Addressing these modifiable influences offers a practical and promising approach to improving outcomes and enhancing the quality of life for patients.

Diet plays a pivotal role in managing autoimmune diseases by directly influencing immune activity and reducing inflammation. Diets rich in processed foods, refined sugars, and omega-6 fatty acids can worsen disease symptoms, while anti-inflammatory diets, like the Mediterranean diet, have shown significant benefits. These diets, which emphasize omega-3 fatty acids, antioxidants, and polyphenols, have been particularly effective in conditions such as rheumatoid arthritis, systemic lupus erythematosus, and multiple sclerosis. Essential nutrients like vitamin D and selenium also help regulate the immune system, reduce the production of autoantibodies, and support overall health, especially in autoimmune thyroid diseases and type 1 diabetes.

The gut and oral microbiomes also play critical roles in autoimmune disease management. Dysbiosis contributes to increased gut permeability, systemic inflammation, and immune dysfunction. Emerging therapies like probiotics, prebiotics, and dietary fibers aim to restore microbial balance and have shown promise in conditions such as inflammatory bowel disease and rheumatoid arthritis. Additionally, targeting oral microbiota, particularly pathogens like Porphyromonas gingivalis, may offer new avenues for managing diseases linked to systemic inflammation.

Lifestyle factors, such as stress management, regular physical activity, and adequate sleep, are equally important. Chronic stress disrupts immune regulation through the hypothalamic-pituitary-adrenal axis, increasing inflammation in conditions like psoriasis and alopecia areata. Physical activity not only lowers systemic inflammation but also improves physical and cognitive function in diseases like multiple sclerosis.

Gender differences further underscore the need for tailored approaches to managing autoimmune diseases. Women experience a higher prevalence of autoimmune diseases, largely due to hormonal factors, with estrogen enhancing immune activation, whereas testosterone in men tends to have protective, anti-inflammatory properties. Hormonal changes during pregnancy and menopause can further influence disease activity, highlighting the importance of gender-specific treatment strategies.

This review demonstrates the significant impact that diet and lifestyle modifications can have on autoimmune disease management. Personalized interventions that address individual needs, genetic predispositions, and disease-specific factors are critical for optimizing outcomes. Future research should focus on exploring how diet, lifestyle, and immune regulation interact, with particular attention to emerging areas like microbiome-based therapies and adequate nutrition.

By addressing these adjustable factors, healthcare professionals can offer more comprehensive and effective care, enhancing both clinical outcomes and the overall quality of life for individuals living with autoimmune conditions.

Disclosures

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