International Journal of Innovative Technologies in Social Science

e-ISSN: 2544-9435

Scholarly Publisher
RS Global Sp. z O.O.
ISNI: 0000 0004 8495 2390

Dolna 17, Warsaw,
Poland 00-773
+48 226 0 227 03
editorial_office@rsglobal.pl

ARTICLE TITLE	LIFESTYLE AND AUTOIMMUNITY: HOW MODERN HABITS SHAPE IMMUNE DYSREGULATION
DOI	https://doi.org/10.31435/ijitss.4(48).2025.4475
RECEIVED	15 October 2025
ACCEPTED	21 December 2025
PUBLISHED	29 December 2025
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LIFESTYLE AND AUTOIMMUNITY: HOW MODERN HABITS SHAPE IMMUNE DYSREGULATION

Aleksandra Tomaszewska *(Corresponding Author, Email: aleksandratomaszewska4@gmail.com)*
University Clinical Hospital of Bialystok, Białystok, Poland
ORCID ID: 0009-0000-4684-0492

Kinga Karczewska
7th Naval Hospital, Gdańsk, Poland
ORCID ID: 0009-0002-4773-3044

Michalina Chodór
7th Naval Hospital, Gdańsk, Poland
ORCID ID: 0009-0000-2541-3686

Maciej Kokoszka
7th Naval Hospital, Gdańsk, Poland
ORCID ID: 0009-0009-7682-9767

Natalia Dymel
5th Military Clinical Hospital with Outpatient Clinic SPZOZ in Kraków, Kraków, Poland
ORCID ID: 0009-0009-3928-5393

Ryszard Feret
Jagiellonian University - Medical College, Kraków, Poland
ORCID ID: 0009-0000-1022-1411

Sonia Mojzyk
7th Naval Hospital, Gdańsk, Poland
ORCID ID: 0009-0008-6397-7739

Aleksandra Mierniczek
Independent Public Healthcare Institution of the Ministry of Interior and Administration in Gdańsk, Gdańsk, Poland
ORCID ID: 0009-0003-5596-2135

Aleksandra Ćwirko-Godycka
Szpitale Tczewskie Joint Stock Company (S.A.), Tczew, Poland
ORCID ID: 0009-0000-3171-6085

Nikola Murawska
University Clinical Centre, Gdańsk, Poland
ORCID ID: 0009-0006-5632-9739

ABSTRACT

According to current estimates, between 80 and 150 autoimmune diseases have been identified. In the United States alone, over 50 million individuals live with an autoimmune condition. These disorders substantially impact healthcare expenditures and, most importantly, the quality of life, mental health, and physical functioning of affected patients. Epidemiological data indicate a steady increase in both the incidence and recognition of autoimmune diseases. Modern lifestyle factors exert a profound influence on immune system function and may contribute to their development. This review discusses key everyday habits—such as stress, physical activity, the use of substances (alcohol consumption, smoking), contemporary dietary patterns, the growing epidemic of obesity, sleep, as well as infections with pathogens such as SARS-CoV-2—that modulate immune responses and promote their dysregulation. This article is a comprehensive review based on studies retrieved from scientific databases such as PubMed and Google Scholar, with sources selected for their relevance and significance to the topic. The analysis indicates that chronic stress, sleep deprivation, substance use, and highly processed diets exacerbate inflammatory processes, immunosenescence, and inflammaging, thereby increasing susceptibility to autoimmunity. Conversely, health-promoting non-pharmacological interventions—including lifestyle modification, stress-regulation techniques, and regular physical activity—may alleviate immunological disturbances and improve patients' functioning and quality of life. In light of current evidence, an integrated approach that combines medical treatment with lifestyle interventions represents a key component of both the prevention and management of autoimmune disorders.

KEYWORDS

Autoimmune Diseases, Autoimmunity, Modern Lifestyle, Immune Dysregulation

CITATION

Aleksandra Tomaszewska, Kinga Karczewska, Michalina Chodór, Maciej Kokoszka, Natalia Dymel, Ryszard Feret, Sonia Mojzyk, Aleksandra Mierniczek, Aleksandra Ćwirko-Godycka, Nikola Murawska. (2025) Lifestyle and Autoimmunity: How Modern Habits Shape Immune Dysregulation. *International Journal of Innovative Technologies in Social Science*. 4(48). doi: 10.31435/ijitss.4(48).2025.4475

1. Introduction

The first definition of an autoimmune disease was likely proposed in 1904 by Paul Ehrlich, who coined the term "horror autotoxicus." For decades, Ehrlich's statement was misinterpreted as implying that autoantibodies could not exist. It was not until the 1940s and especially the 1950s that clear evidence emerged demonstrating the presence of specific antibodies directed against particular tissues of the human body. (Parnes, 2006)

According to the contemporary definition autoimmune diseases represent a heterogeneous group of chronic disorders that develop secondary to the loss of tolerance to self-antigens. (Sharif et al., 2018)

According to available data, between 80 and 150 autoimmune diseases have been identified. In this family of disorders, the immune system mistakenly attacks healthy, functional parts of the body, consequently destroying them. In the United States, approximately 8% of the population is affected. (n.d.) The incidence of autoimmune diseases is higher in industrialized countries, ranging between 5% and 10% of the population. In recent decades, global statistics have been steadily increasing, and autoimmunity can no longer be considered a phenomenon limited to "Western" nations (Shapira et al., 2010). Earlier studies estimated the overall prevalence of autoimmune diseases at 3.2%, based on a literature review from 1965–1995.(Cooper et al., 2009) In developing countries, the prevalence tends to be lower, which has been linked to various hypotheses involving factors such as nitric oxide and TNF. (n.d.-c)

Epidemiological data from Brazil are limited due to the lack of specific health policies addressing this group of disorders. However, available information aligns with global trends in autoimmunity: the female-to-male ratio was higher among women (69%), and the most affected age group consisted of individuals over 60 years old (30.5%) (Tolentino Júnior et al., 2019) Contemporary theories of autoimmunity suggest that the development of autoimmune diseases requires the interplay between genetic predisposition and environmental factors. Environmental triggers activate immune pathways that ultimately lead to tissue destruction. Despite

the genetic background, the concordance rate in monozygotic twins is only 12–67%, emphasizing the major role of non-genetic influences. (Wang et al., 2015) _ Globally, autoimmunity is on the rise, influenced by socioeconomic factors, environmental exposures, stress, and diet. Climate change and pollution also contribute to the increasing risk. (Zheng et al., 2024)

The primary objective of this study is to analyze how modern lifestyle factors—including stress, physical activity, sleep deficiency, smoking, alcohol consumption, infections, obesity and diet—contribute to immune dysregulation and the development or progression of autoimmune diseases. The study aims to synthesize current evidence linking everyday habits to immune system imbalance and to identify modifiable risk factors that could support prevention and better disease management.

2. Results

2.1. Stress and Mental health

According to new data released by the World Health Organization (WHO), more than 1 billion people are living with mental health disorders, with conditions such as anxiety and depression (Over a billion people living with mental health conditions – services require urgent scale-up, n.d.). Modern populations are also affected by work overload. The concept of "death from overwork," or karoshi, has even been described (Xiao et al., 2025). Numerous studies in both animals and humans have demonstrated the impact of various stressors on the functioning of the immune system (Stojanovich & Marisavljevich, 2008). Many retrospective studies have shown that up to 80% of patients reported experiencing unusual emotional stress prior to disease onset. The disease itself also causes significant stress in patients, becoming both a cause and a consequence of illness, thereby creating a vicious cycle. In Sweden, a retrospective population- and sibling-based cohort study was conducted between 1981 and 2013. The cohort included 106,464 patients exposed to stress-related disorders, 1,064,640 matched unexposed individuals, and 126,652 siblings of the exposed patients. Within this cohort, exposure to a stress-related disorder was significantly associated with an increased risk of subsequent autoimmune disease compared to both matched unexposed individuals and siblings (Song et al., 2018). In a study analyzing treatment adherence patterns and mental health status in young individuals with autoimmune liver disease, a strong correlation was observed between these factors and both disease perception and overall health outcomes in this age group. Results from an electronic survey of sixty-eight patients revealed a low remission rate (51.5%), despite a high self-reported adherence rate (73%). Interestingly, patients who were not in remission experienced higher levels of depression and anxiety and required more intensive immunosuppressive therapy. The authors emphasized the correlation between poor adherence and mental health status, highlighting the need for routine assessment of barriers that affect treatment adherence (Hames et al., 2021). Cortisol, commonly referred to as the stress hormone, is synthesized in the zona fasciculata of the adrenal cortex. The hypothalamic-pituitary-adrenal (HPA) axis is the hormonal connection responsible for regulating its secretion (Hypothalamic-pituitary-adrenal (HPA) axis, 2024). A study by Montero-López et al. (2024) investigated HPA axis activity in women with autoimmune diseases compared to healthy controls. Cortisol concentrations were measured both in saliva throughout the day and in hair samples, reflecting cumulative levels over the preceding three months. The study included 65 women, divided into two groups: healthy controls (n = 30; mean age 44.70 ±11.65 years) and women with autoimmune diseases (n = 35; mean age 48.26 ±9.04 years). The autoimmune group included patients with systemic lupus erythematosus (SLE), Sjögren's syndrome (SS), and systemic sclerosis (SSc).The study also evaluated perceived stress and psychopathological symptoms. Women with autoimmune diseases scored higher on the somatization subscale and lower on the anxiety subscale of the SCL-90-R compared with controls. Analysis of the HPA axis showed that the area under the curve (AUC) for daily cortisol levels was higher in the autoimmune group, as was hair cortisol concentration. These findings indicate greater short- and long-term HPA axis activity in women with autoimmune diseases compared to healthy individuals (Montero-López et al., 2024).

2.2. Physical activity

Physical activity refers to any skeletal muscle movement that results in energy expenditure. In a study by Kassem Sharif et al. (2018), it was demonstrated that patients with autoimmune diseases—such as systemic lupus erythematosus (SLE), rheumatoid arthritis (RA), multiple sclerosis (MS), and inflammatory bowel diseases (IBD)—tend to be less physically active compared with the general population. Physically active RA patients exhibit a milder disease course, an improved cardiovascular disease (CVD) profile, and enhanced joint mobility. Physical activity exerts immunomodulatory effects, leading to an increase in regulatory T cells (Tregs), reduced immunoglobulin secretion, and a shift in the Th1/Th2 balance toward decreased Th1-cell

production. It also promotes the release of IL-6 from skeletal muscle, which acts as a myokine and triggers an anti-inflammatory response through the induction of IL-10 and inhibition of IL-1β (Sharif et al., 2018). Autoimmunity is associated with age-related alterations of the immune system (immunosenescence) as well as chronic low-grade inflammation (inflammaging). Maintaining an active lifestyle is one of the strategies that may reduce the risk of autoimmune diseases by mitigating inflammaging (Weyh et al., 2020). Beibei Luo et al. (2024), in a 20-year systematic review, evaluated the anti-inflammatory effects of physical exercise in individuals with autoimmune diseases such as MS, RA, and SLE. The analysis included 87 studies comprising a total of 2,779 participants.The main conclusion was that regular, repeated exercise programs—particularly those combining multiple exercise modalities (e.g., aerobic and resistance training)—exert a modest anti-inflammatory effect, reducing markers such as C-reactive protein (CRP), interleukin-6 (IL-6), and tumor necrosis factor-α (TNF-α). Regular physical activity is also associated with increased release of the anti-inflammatory cytokine IL-10. Combined exercise modes, incorporating both aerobic training (AT) and resistance training (RT), conferred the greatest anti-inflammatory benefits. For most patients, moderate-intensity exercise protocols are recommended, although improvements in inflammatory biomarkers are expected to be modest at best. In contrast, single exercise sessions are ineffective and may transiently increase inflammation. This rise in inflammatory biomarkers following acute moderate- or high-intensity exercise is likely attributable to exercise-induced muscle microtrauma. The impact of various exercise types on inflammatory markers also depends on the specific autoimmune disease in question (Luo et al., 2024). Recognizing the beneficial effects of physical activity on symptom alleviation and the reduction of systemic manifestations in RA, efforts are being made to develop an implementation model that facilitates long-term engagement in physical activity among patients with rheumatoid arthritis (Metsios & Kitas, 2018). Stephanie Nagy et al. (2025) highlight the potential role of yoga as an adjunct therapy for inflammation-related disorders. The authors reviewed 11 studies in which yoga interventions, ranging from six weeks to six months and involving various styles, were evaluated. Eight studies focused on patients with multiple sclerosis, two on rheumatoid arthritis, and one on irritable bowel syndrome. Assessed outcomes included stress levels, anxiety, sleep, self-efficacy, depression, and emotional fatigue. All conditions showed significant improvement. Yoga appears to be an effective non-pharmacological modality supporting both physical and psychological health in individuals with autoimmune diseases (Nagy et al., 2025).

2.3. Smoking

The association between smoking and autoimmunity has been the subject of research for many years (Shoenfeld & Tincani, 2005). It was found that cigarette smoking and nicotine exposure affects the immune system in diverse ways, having both pro-inflammatory as well as immuno-suppressive effects. Some of them include activation of dendritic cell-mediated adaptive immunity, proliferation of peripheral T-lymphocytes, abnormal CD4(þ)/CD8(þ) ratio, increased levels of acute phase proteins and pro-inflammatory cytokines, especially TNF-a, TNF-a receptors and IL-6, suppression of neutrophil-mediated inflammatory actions and inhibition of IL-1b, IL-2, IL-10, TNF-a, and IFN-g release (Arnson et al., 2010). Although there is conflicting evidence regarding the role of cigarette smoking in the development and severity of autoimmune diseases, there is strong evidence linking it to the presence of rheumatoid arthritis (RA), systemic lupus erythematous (SLE), Graves' disease, and primary biliary cirrhosis (PBC). Cigarette smoking is the only well established risk factor in RA - a common rheumatologic condition (Nyhäll-Wåhlin et al., 2006). The first association between RA and smoking was found in the 1980s when an increase in hospital admissions due to RA in smokers was unexpectedly documented (Vessey et al., 1987). Another link between smoking and RA was established in a study using animal models that showed that cigarette smoke condensate augmented the induction and clinical development of arthritis in collagen-induced arthritis in both young and older mice(Chujo et al., 2010). There is also a significant association between smoking and the presence of ACPA - autoantibodies that majority of RA patients generate. A study showed that ACPA were increased in patients with RA with exposure to tobacco. By contrast, no elevation in RF was noted in patients with a history of smoking (Lee et al., 2009). In another study in patients with ACPA-positive RA with a current or former tobacco exposure IgA and IgM ACPA were more frequent than in non-smokers (Verpoort et al., 2007). The overall risk of developing RA is approximately two times higher for male smokers and approximately 1.3 times greater for female smokers than for non-smokers as indicated by data from a meta-analysis (Sugiyama et al., 2010). Another autoimmune disease in which cigarette smoking is a well-established risk factor is Multiple sclerosis (MS) - the most common chronic inflammatory demyelinating disease of the central nervous system (CNS). It is characterized by localized areas of inflammation, demyelination, axonal loss, and gliosis

in the brain and spinal cord, resulting in a variety of neurological symptoms disseminated in time and space. The association between smoking and an increased risk of MS was suggested in 2001 by Hernàn et al (Hernán et al., 2001). In a study based on two cohorts of women, Nurses' Health Study (NHS, 121,700 women) and Nurses' Health Study II (NHSII, 116,671 women). Smoking exposure was assessed by biennial questionnaires. As a result 315 MS cases were documented with the relative incidence rate among current smokers, compared with that for women who never smoked, being 1.6 and 1.2 among past smokers. The relative rate increased significantly with cumulative exposure to smoking from 1.1 for 1-9 pack-years to 1.5 for 10-24 pack-years and 1.7 for 25 or more pack-years. Those observations were later supported in a case-control study from 2014 based in South East Queensland, Australia showing increased risk of MS for current and ex-smokers with an overall adjusted OR of 1.9 confirming a very clear association between smoking and risk of developing MS (O'Gorman et al., 2014). In a study from 1993 association between smoking and Graves 'disease was confirmed (Prummel & Wiersinga, 1993). The study comprised 200 subjects from a hospital-based population, and 200 from a population-based group served as control subjects. Smoking status was determined from a questionnaire at the time of onset of the disease. In observations smoking greatly increased the risk for the development of more severe ophthalmopathy, therefore a conclusion was made that smoking appears to be one of the multiple factors inducing Graves' disease in genetically predisposed individuals.

2.4. Infections

There are three mechanisms proposed as explanations on how pathogen infection can lead to autoimmunity: molecular mimicry, bystander activation and epitope spreading. Molecular mimicry represents a shared immunologic epitope with a microbe and the host (Fujinami et al., 2006). It means that immune cells are initially activated in response to the pathogen during infection, but later they can cross-react with self-epitopes, inducing an autoimmune response. Bystander activation is characterized by the activation of auto-reactive B and T cells due to a combination of an inflammatory milieu, co-signaling ligands, and interactions with neighboring cells, influencing the development of autoimmunity (Pacheco et al., 2019). Lastly, according to the model of epitope spreading, a chronic infection can cause the release of self-antigens that are then captured in an inflammatory environment by Phagocytic cells, initiating a self-immune response (Gómez-Rial et al., 2020). There are a number of pathogens proved through different studies to be associated with inducing an autoimmune disease, including rotavirus, Epstein-Barr virus, coxsackievirus B, cytomegalovirus, hepatitis C virus and bacteria, such as H. pylori(Pordeus et al., 2008). A longitudinal study from 2006 provided the first indication that rotavirus infections may increase the risk of celiac disease autoimmunity in childhood in genetically predisposed individuals, with the risk increasing proportionally to the number of rotavirus infections(Stene et al., 2006). Moreover, in a study published in 2019 participant children who received rotavirus vaccination had significantly lower prevalence of celiac disease 11-14 years after the vaccination than children who received placebo(Hemming-Harlo et al., 2019). Other autoimmune diseases that have been linked to rotavirus infections include type 1 diabetes, autoimmune uveitis and murine biliary atresia. (Gómez-Rial et al., 2020) [35]. Another pathogen identified as a potentially important factor in the pathogenesis of some of the autoimmune disorders is the Epstein-Barr virus (EBV). One of them is multiple sclerosis (MS). In a cohorts 'retrospective study from 2005 blood samples were collected from more than 3 million people with the average time between blood collection and MS onset being 4 years (Levin et al., 2005). The strongest predictors of MS were serum levels of IgG antibodies to EBNA complex or EBNA-1. Among individuals who developed MS, serum antibody titers to EBNA complex were similar to those of controls before the age of 20 years, but 2- to 3-fold higher at age 25 years and older. The risk of MS increased with these antibody titres with the relative risk in persons with high EBNA complex titres being 9.4 compared to persons with low titres. In longitudinal analyses, a fourfold increase in anti-EBNA complex or anti-EBNA-1 titers during the follow-up was associated with a threefold increase in MS risk. These results suggest an age-dependent relationship between EBV infection and development of MS. Evidence suggests that EBV also plays a role in triggering disease activity in MS. The correlation between elevated Epstein-Barr virus nuclear antigen 1 (EBNA-1)immunoglobulin G (IgG) and gadolinium-enhancing lesions in MRI was discovered in a study, suggesting an association between EBV infection and MS disease activity (Farrell et al., 2009). EBV infection has been linked to other autoimmune disorders including Sjögren's Syndrome, where a significantly higher prevalence of IgG-anti-EA antibody positivity was found in patients with SjS than in healthy controls as well as an association of SjS with IgM-anti-VCA antibody(Xuan et al., 2020). There are several viruses reported to play a role in the initiation of type 1 diabetes mellitus (T1DM) and type 2 diabetes mellitus (T2DM) in predisposed individuals including coxsackie B virus, cytomegalovirus, rotavirus, mumps and, most recently, SARS-CoV-

2 (Jeremiah et al., 2024). Multicenter regional data from North West London (NWL) of new-onset T1DM and diabetic ketoacidosis (DKA) in children up to the age of 16 years during the peak of the COVID-19 pandemic shows an 80% increase in new cases of T1DM compared to a typical year (Unsworth et al., 2020). Another similar observation was made in a cohort study where new T1DM diagnoses were more likely to occur among pediatric patients with prior COVID-19 than among those with other respiratory infections (n.d.-e).

2.5. Alcohol consumption

Alcohol is one of the most misused substances and has been identified as a factor in more than 200 diseases. Based on the quantity of consumption, alcohol affects autoimmune diseases (ADs) both negatively and positively, since it may also modulate the immune system's regulatory mechanisms to avoid attacking the body's tissues (Terracina et al., 2025). Low to moderate drinking supports the production of anti-inflammatory cytokines (IL-4, IL-10, TGF-β) while reducing proinflammatory cytokines (TNF-α, IL-8 and IL-6), modulates the intestinal microbiota, reducing inflammation and can modulate the activity of immune cells such as T cells and macrophages, promoting a regulatory phenotype that is less likely to initiate autoimmune responses. On the other hand, heavy alcohol intake may increase inflammation, oxidative stress, and the risk of bacterial and viral infection (through increased T-cell activation for cell death, increased B-cell production of IgM and IgA and higher TNF-α, IL-1β and IL-6) (Terracina et al., 2025). Most studies focus on the protective role of alcohol in the development and management of AD. Its positive properties were discovered in diseases such as autoimmune hypothyroidism, rheumatoid arthritis, autoimmune diabetes, systemic lupus erythematosus and multiple sclerosis. On the other hand, there is a direct correlation between consumption of high alcohol doses and the onset of some inflammatory diseases, such as irritable bowel syndrome (IBS) and perennial allergies (Caslin et al., 2021). Results from a population-based case–control study conducted in Denmark show that moderate alcohol consumption can be protective against the development of autoimmune hypothyroidism. After analyzing the association between alcohol intake and development of hypothyroidism it was found that not drinking at all seemed to be associated with a higher risk (OR 1.98) and moderate drinking (11–20 units/week) with a lower risk (OR 0.41) for development of overt autoimmune hypothyroidism irrespective of gender and type of alcohol consumed. High consumption (≥21 units/week) showed no significant difference (0.90) (Carlé et al., 2012). A similar study was conducted by the same author about ethanol's effect in Graves's disease where it was reported that moderate ethanol drinking is associated with a dose-dependent reduction in the risk of developing Graves's disease, irrespective of age or gender (Carlé et al., 2013). In relation to rheumatoid arthritis various studies confirmed that low-to-moderate alcohol consumption in women prevents the onset of RA in a time-, dose-, and sex-dependent manner (Lu et al., 2014), (Jin et al., 2014). Compared with non-drinking, low and moderate alcohol consumption was dose-dependently associated with a reduced risk of anticitrullinated protein antibody (ACPA)-positive and ACPA-negative RA (Hedström et al., 2019). On the other hand, a prospective study on a Chinese cohort found that increasing alcohol consumption was associated with an elevated risk of RA among women, but not in men (VanEvery et al., 2021). Another interesting cross-sectional study found that alcohol is associated with lower concentrations of C-reactive protein with the lowest levels in patients consuming 1–7 drinks/week however alcohol consumption was not associated with the severity of MRI-detected inflammation in hand and foot joints, suggesting that the pathophysiological mechanism underlying the effect of alcohol consists of a systemic effect that might not involve the joints (Mangnus et al., 2018). However a prospective study found that compared to non-drinkers, excessive alcohol consumption was significantly associated with increased risk of knee osteoarthritis (Liu et al., 2022). Moderate alcohol consumption, primarily the consumption of wine, has been associated with reduced risk of both Type2 diabetes and autoimmune diabetes in men, but not in women. At the same time high alcohol consumption does not seem to carry an increased risk of diabetes (Rasouli et al., 2013). In contrast to the protective effects of alcohol, alcohol consumption has been theorized to play a role in the development of allergic rhinitis (AR). In a population-based cohort study the adjusted odds ratio for perennial AR among women drinking more than 14 drinks per week compared with women drinking <1 drink per week was 1.78, suggesting that alcohol consumption increases the risk of developing perennial AR (Bendtsen et al., 2008). However, findings from a recent study show no correlation between alcohol consumption and the prevalence of AR in women, instead they show that correlation in the male population (He et al., 2025).

2.6. Obesity

In recent years there has been an increase in the prevalence of adult obesity. According to WHO, worldwide adult obesity has more than doubled since 1990, and adolescent obesity has quadrupled (Obesity and overweight, n.d.). In 2022, 1 in 8 people in the world were living with obesity and with current trends it is estimated that the total number of adults living with obesity will increase by more than 115% between 2010 and 2030, from 524 million to 1.13 billion (World obesity atlas 2025, n.d.). In short, obesity is the expansion of white adipose tissue (WAT). WAT is recognized as an endocrine organ, since it produces a wide variety of mediators called "adipokines" or "adipocytokines" that can be involved in causing inflammation, such as interleukin (IL)-6 and Tumor Necrosis Factor alpha (TNFα) (Cao, 2014), (Versini et al., 2014). Several studies over the years provided a link between the risk of developing rheumatoid arthritis (RA) and obesity. (Symmons et al., 1997), (Pedersen et al., 2006), (Lahiri et al., 2012), (de Hair et al., 2013). A study from 2012 focused on explaining the rise in the incidence of RA and its possible association with the "obesity epidemic". In 1985–2007, the incidence of RA rose by an increment of 9.2 per 100,000 among women and the study showed that obesity accounted for 4.8 per 100,000 (52%) of this increase (Crowson et al., 2013). Another large prospective study using two cohorts of women, Nurses' Health Study (NHS, 109,896 women) and Nurses' Health Study II (NHSII, 108,727 women), observed a trend toward increased risk of seropositive and seronegative RA among overweight and obese women (HR 1.37) (Lu, Hiraki, et al., 2014). The association appeared to be stronger for younger women (diagnosed at age 55 years or younger) with HR=1.45 for overweight and HR=1.65 for obese women. The number of years in obesity was also an important factor with the risk of RA at age 55 years or younger being 37% higher for women with a history of ten cumulative years of being obese. Moreover, obesity seems to be associated with higher disease activity, fewer patients in sustained remission, higher HAQ score, more pain, and worse general health in patients with RA (Ajeganova et al., 2013). Despite not having found a definite correlation between adult obesity and the risk of developing systemic lupus erythematous (SLE), in a prospective study among black women, obesity at age 18 was associated with increased SLE risk in adulthood: HR 2.38 for ≥30 vs. normal BMI (Cozier et al., 2019). Obesity seems to be also associated with a higher risk of renal impairment (lupus nephritis) and a decreased quality of life (QoL) and functional capacity (Rizk et al., 2012). Another autoimmune disease that is a subject of several studies concerning an association with obesity is multiple sclerosis (MS). A study using two cohorts of over 200,000 US women reported a greater than twofold increased risk of MS among subjects with obesity at age 18 (Munger et al., 2009). These results were later supported by other studies with the risk being more pronounced in women than in men (Munger et al., 2013), (Langer-Gould et al., 2013). Among subjects at ages 7-13 years, girls who were ≥95th percentile for BMI had a 1.61–1.95-fold increased risk of MS as compared to girls <85th percentile. Another study identified a higher risk of pediatric MS and clinically isolated syndrome (including optic neuritis and transverse myelitis) in extremely obese adolescent girls (BMI ≥ 35 kg/m2) with an OR = 2.57 (Munger et al., 2013), (Langer-Gould et al., 2013). A large prospective cohort study of American female nurses found a positive association between BMI measured at multiple time points and the risk of incident psoriasis (Setty et al., 2007). Compared with a BMI of 21.0-22.9, the multivariate relative risks of psoriasis were 1.48 for a BMI of 30.0-34.9 and 2.69 for a BMI of 35.0 or greater. Similar results come from another study where the relative risk of incident psoriasis for a BMI of 35.0 or greater was 2.03, compared to women with updated BMI of <25 (Kumar et al., 2013). The same results come from studies evaluating the association between obesity and the risk of incident psoriatic arthritis (PsA), that show a positive link between the two (Li et al., 2012), (Love et al., 2012). Furthermore, weight loss seems to be beneficial for the management of psoriasis and PsA. A review examined the effects of weight loss on psoriasis and found, through several prospective, controlled studies, that it has an additional positive effect on psoriasis or PsA when used in conjunction with other prescription medications. Moreover, caloric restriction in obese subjects lowers the level of circulating inflammatory cytokines (Debbaneh et al., 2014). Obesity has been found to be a risk factor or a worsening factor for several other autoimmune diseases, including inflammatory bowel disease, type-1 diabetes and hashimoto thyroiditis. (Versini et al., 2014) [61]

2.7. Diet and microbiome

Hashimoto's thyroiditis (HT), the most common autoimmune disease, may be associated with non-thyroidal autoimmune conditions, including celiac disease (CD) or other gluten-related conditions (GRC). In recent years, interest in the gluten-free diet (GFD) has increased due to its purported extra-intestinal anti-inflammatory effects. A meta-analysis investigating the effect of GFD on HT highlighted a potential beneficial impact of gluten deprivation on thyroid function and thyroidal inflammation, particularly in patients with both

HT and GRC, although current evidence remains insufficient to recommend routine GFD use in all individuals diagnosed with HT (Piticchio et al., 2023). In multiple sclerosis (MS), a chronic autoimmune disease of the central nervous system, nutritional factors and diet have been shown to influence disease mechanisms, progression, and activity. Diet affects several pathological processes associated with MS, including oxidative stress, immune function, and the gut–brain axis. Antioxidant dietary factors—such as vitamin D, omega-3 fatty acids, curcumin, polyphenols, and vitamin A—may mitigate oxidative stress and potentially prevent chronic demyelination and neuronal or axonal injury. Conversely, high-carbohydrate and high-fat diets can induce inflammatory cascades leading to the production of pro-inflammatory mediators, such as interleukins and TNF. Pro-inflammatory dietary components linked to MS include saturated and trans fats (SFAs), red meat, sugar-sweetened beverages, refined cereals, high salt intake, and cow's milk proteins (Stoiloudis et al., 2022). Studies on rheumatoid arthritis (RA) likewise emphasize the significant role of diet in disease susceptibility and progression. Obesity, increased BMI, and waist circumference are identified risk factors for RA. Adipose tissue—particularly white adipose tissue—acts as an "endocrine organ," releasing pro-inflammatory mediators such as leptin (promoting Th1 and Th17 responses) and adiponectin, both of which contribute to autoimmunity and synovial inflammation. The Western diet, characterized by high consumption of red meat, saturated and trans fats, a low omega-3:omega-6 ratio, and high intake of refined carbohydrates, is associated with increased RA risk through promotion of inflammation, insulin resistance, and obesity. In contrast, the Mediterranean diet (MD), rich in fish, vegetables, fruits, whole grains, and olive oil, offers antioxidant and anti-inflammatory benefits. These foods provide compounds with antioxidant properties, such as tocopherols, lycopene, and flavonoids. Flavonoids inhibit the production of inflammatory mediators (iNOS and COX-2). Green tea contains epigallocatechin-3-gallate (EGCG), a compound with proven anti-inflammatory and protective effects in animal models of RA; it suppresses synoviocyte apoptosis and the production of pro-inflammatory cytokines. Healthy dietary habits are therefore considered a promising adjunctive therapy to standard pharmacologic treatment of RA (Gioia et al., 2020). A hallmark of autoimmune conditions is impaired gut barrier function. This includes defective mucus barrier function, reduced epithelial integrity, and decreased TLR (Toll-like receptor) tolerance. Such impairment leads to abnormal recognition of external antigens by antigen-presenting cells, such as dendritic cells and macrophages, resulting in immune dysregulation. Autoimmune diseases such as MS, type 1 diabetes mellitus (T1DM), and RA may share a common mechanism involving compromised gut barrier function, commonly referred to as "leaky gut." These disorders are also characterized by a dysbiotic gut microbiome. Diet, the gut microbiome, and autoimmune diseases are closely interconnected, indicating that dietary interventions may serve as a precise means of modulating the microbiome to support improved health (Wolter et al., 2021). Contemporary climate change contributes to the loss of biodiversity, which in turn affects the human microbiome and consequently human health. Gut dysbiosis may lead, among other outcomes, to the development of Crohn's disease or ulcerative colitis. Climate warming, increased greenhouse gas concentrations, and alterations in the composition and antigenicity of foods burden the immune system's ability to maintain antigen-specific tolerance, thereby contributing to the rising prevalence and severity of food allergies (Ray & Ming, 2020). Dysbiosis, defined as disruption of the normal balance of the gut microbiota, has been observed across multiple autoimmune diseases. Early research and clinical trials suggest a therapeutic potential of fecal microbiota transplantation (FMT) in restoring eubiosis and alleviating symptoms in certain conditions, although results are often inconsistent and the procedure remains controversial in extra-intestinal disorders. Restoring eubiosis aims to modulate immune function. FMT may serve both as a research tool to explore causal mechanisms (e.g., inducing autoimmune-like states in recipients using microbiota from affected donors) and as a potential therapy (via transplantation from healthy donors to reestablish microbial balance) (Belvoncikova et al., 2022).

2.8. Sleep Deprivation

Sleep deficiency, resulting from reduced sleep duration, inappropriate sleep timing, or poor sleep quality, is highly prevalent in modern societies. Up to one-third of the population in developed countries is affected. Factors contributing to sleep deficiency include occupational demands, social obligations, mental and physical disorders, ethnicity, age, marital status, sex, and hospitalization (Gohari et al., 2022). A growing body of evidence indicates that insufficient sleep and insomnia constitute risk factors for the development of autoimmune diseases (Hsiao et al., 2015).Sleep deprivation is an increasingly prevalent issue in modern societies. Epidemiological and experimental studies demonstrate that inadequate sleep leads to immune dysregulation and chronic low-grade inflammation, thereby elevating the risk of numerous disorders. In cohort studies, individuals with sleep disturbances (unrelated to sleep apnea) exhibited a 1.47-fold increased risk

(adjusted hazard ratio: 1.47) of developing autoimmune diseases. Furthermore, among relatives of patients with systemic lupus erythematosus (SLE)—a population at elevated risk of disease development—self-reported short sleep duration (less than 7 hours per night) was associated with a twofold increase in the risk (adjusted odds ratio: 2.0) of progression to overt SLE, independent of other early clinical features (Garbarino et al., 2021). A retrospective analysis of a Korean cohort also demonstrated that individuals with sleep disorders had an elevated risk of developing autoimmune diseases. The risk estimates were as follows: alopecia areata (OR 1.913 [95% CI 1.717–2.171]), Graves 'disease (OR 1.717 [95% CI 1.562–1.886]), Hashimoto's thyroiditis (OR 1.641 [95% CI 1.413–1.905]), vitiligo (OR 1.539 [95% CI 1.236–1.917]), and rheumatoid arthritis (OR 1.886 [95% CI 1.780–1.998]) (Seo et al., 2018). Sleep deprivation has also been shown to accelerate the production of antinuclear antibodies (ANA) and the subsequent onset of systemic lupus erythematosus (SLE) in murine models. ANA are additionally associated with other autoimmune diseases, including Sjögren's syndrome, systemic sclerosis, polymyositis, and autoimmune hepatitis. In a study utilizing F1 NZB/NZW mice—which spontaneously develop a disease resembling human SLE—researchers exposed animals to repeated periods of sleep deprivation using the modified multiple platform method. The findings demonstrated that although sleep deprivation accelerated disease onset, as evidenced by increased ANA production, it did not significantly influence subsequent disease progression or severity, as assessed by albuminuria and survival. The study concluded that sleep deprivation may serve as a triggering risk factor for SLE development, but does not substantially affect its later course (Palma et al., 2006).

3. Materials and methods

The review was conducted based on an analysis of materials retrieved from the PubMed and Google Scholar databases. Authors also analyzed National Institute of Allergy and Infectious Diseases (NIAID), The Lancet, Cleveland Clinic, World Obesity and WHO websites. Keywords included: 'autoimmune diseases', 'autoimmunity', 'modern lifestyle', 'stress', 'physical activity', 'diet', 'smoking', 'alcohol consumption', 'infections', 'obesity', 'diet', 'sleep deprivation'. A total of 89 articles published between 1987.and 2025 were included and assessed for their relevance to the topic of How Modern Habits Shape Immune Dysregulation.

4. Discussion

This study focuses on the significant increase in incidence of autoimmune illnesses across industrialized societies and highlights the impact of contemporary lifestyle factors, such as psychosocial stress, decreased physical activity, dietary changes, sleep deficiency, obesity, smoking, alcohol consumption and pathogen encounters, on modulating immune tolerance, even though genetic predisposition is still a key determinant in the development of autoimmunity. These results offer more proof that autoimmune diseases are conditions that can be shaped through changes in modern habits.

One of the most significant lifestyle-related causes of autoimmunity is consistently found to be chronic psychological stress. Individuals diagnosed with stress-related disorders have a much higher chance of developing autoimmune diseases than both the general population and their own siblings, according to evidence from epidemiological research. These observations are corroborated by mechanistic findings: Prolonged activation of the hypothalamic-pituitary-adrenal (HPA) axis causes persistent low-grade inflammation, modifies cortisol dynamics, and compromises regulatory T-cell activity. Sustained activation of the HPA axis is further confirmed by studies that measure cortisol levels in hair and saliva in individuals with autoimmune diseases. It shows that stress may trigger the onset of the illness and the illness itself becomes a source of psychological burden. These findings emphasize how crucial it is to include psychosocial support, stress-reduction techniques, and mental health screening in standard autoimmune care.

People with autoimmune illnesses are less likely to engage in physical inactivity, which works to their detriment, because evidence from interventional research shows that regular, moderate-intensity exercise modifies immunity by boosting IL-10-mediated anti-inflammatory pathways, decreasing pro-inflammatory cytokines (TNF-α, IL-6, and IL-1β), and raising regulatory T cells. Exercise regimens that include both resistance and aerobic training seem to be the most beneficial. Crucially, one-time high-intensity workouts may temporarily worsen inflammation, highlighting the necessity of organized, continuous activity as opposed to intermittent effort. Additionally, a mind-body process, like yoga, may be especially helpful for autoimmune disorders, as multiple studies show. It is helpful in enhancing physical function, stress levels, sleep, and psychosocial outcomes.

Among all lifestyle exposures, smoking demonstrates one of the most consistent and well-documented associations with autoimmune disease risk, particularly for rheumatoid arthritis and multiple sclerosis.

Smoking promotes both innate and adaptive immune activation, increases pro-inflammatory cytokine production, alters T-cell ratios, and induces oxidative stress. A positive correlation between ACPA levels in ACPA-positive RA patients and tobacco exposure suggests its mechanistic role in autoantibody formation, whereas in MS, cumulative tobacco exposure correlates with higher incidence and more severe disease. Quitting smoking is still one of the most important modifiable preventative interventions because of its obvious dose-dependent effects and wide immunological impact.

Pathogens are believed to cause autoimmune responses in several mechanistic models, such as molecular mimicry, bystander activation and epitope spreading. Sjögren's syndrome, multiple sclerosis, type 1 diabetes, and celiac disease are all closely linked to viruses including rotavirus and Epstein-Barr virus, according to longitudinal and serological research. The COVID-19 pandemic provided new evidence linking SARS-CoV-2 infection to increased incidence of pediatric T1DM. At the same time, vaccinations against pathogens, like rotavirus, were found to be protective against the development of celiac disease. These results highlight the importance of preventing chronic or recurrent infections, expanding vaccination programs, and mitigating inflammatory responses during infections to influence long-term autoimmune risk.

Alcohol exhibits a special dualistic effect. Light to moderate consumption seems to have anti-inflammatory benefits, influencing cytokine production and benefitting conditions such as autoimmune hypothyroidism, rheumatoid arthritis, and Graves ’disease. On the other hand, excessive alcohol use exacerbates inflammatory and allergy diseases by increasing inflammation, oxidative stress, and susceptibility to infections. Gender-specific variations, such as higher RA risk among heavier-drinking women but not men, suggest that alcohol's immunologic effects may be also influenced by genetic and hormonal factors. These results show a complex dose-dependent connection, highlighting the need for caution with alcohol consumption for people with autoimmune diseases. It is also important to remember the detrimental effects alcohol has on our overall health.

Evidence suggests a connection between the global rise in obesity and the rising incidence of autoimmune disorders. As an endocrine organ, white adipose tissue releases inflammatory mediators including TNF-α and IL-6, which can initiate and worsen inflammatory response in autoimmune conditions, such as RA, MS, psoriasis, psoriatic arthritis, and lupus nephritis. Obesity in childhood and adolescence is associated with a significantly increased risk of MS and autoimmune diseases in adulthood, suggesting that early-life obesity is especially significant. In this study we show how weight-loss interventions provide significant improvements in disease severity and inflammatory biomarkers, underscoring the potential of weight management as a meaningful therapeutic adjunct.

One of the most direct ways that lifestyle influences immune function is through dietary habits. Diets rich in processed foods, refined carbohydrates, saturated fats, and excess salt encourage dysbiosis, an imbalance in gut microbial composition, and cause systemic inflammation. The resulting breakdown of the gut barrier, commonly referred to as "leaky gut," promotes antigen translocation and causes aberrant immune activation linked to T1DM, MS, and RA. Conversely, anti-inflammatory diets such as the Mediterranean diet, foods high in omega-3 fatty acids, antioxidants, polyphenols, and certain nutrients like vitamin D and EGCG reduce inflammation and support regulatory immune networks. Experimental evidence supporting fecal microbiota transplantation further suggests a causal role for dysbiosis in autoimmune pathogenesis, although therapeutic application remains investigational.

Lack of sleep is becoming a more significant but still underestimated risk factor. Epidemiological studies consistently demonstrate that short sleep duration, insomnia, and circadian disruption elevate the risk of autoimmune disease onset of conditions such as RA, Graves ’disease, vitiligo, alopecia areata, and SLE. Studies on mice show that chronic sleep deprivation speeds up the development of autoantibodies and causes an earlier disease onset. An association between short sleep and increased autoimmune risk among relatives of SLE patients further suggests that sleep may act as a catalyst in genetically susceptible individuals. In conclusion, prioritizing sleep hygiene and circadian health should be an integral component of autoimmune prevention and care.

Future research should focus on longitudinal assessments of combined lifestyle exposures, mechanistic studies clarifying causal pathways, and clinical trials evaluating multifaceted lifestyle interventions. The rising global trend of autoimmunity may be slowed or reversed by public health initiatives that address stress, obesity, pollution, microbiome health, and sleep hygiene. Ultimately, recognizing autoimmunity as a lifestyle-linked and environmentally influenced spectrum of diseases is essential for shifting clinical practice toward early prevention and personalized, integrative care.

5. Conclusions

A review of the literature indicates that key elements of modern lifestyle—such as chronic stress, physical inactivity, poor dietary patterns, smoking, alcohol consumption, sleep deprivation, and obesity—may significantly affect immune system function and increase the risk of developing autoimmune diseases. At the same time, regular physical activity, stress reduction, and maintaining a healthy body weight may help attenuate inflammation and support prevention efforts. The aim of this article was to present current evidence on the relationship between contemporary lifestyle factors and autoimmunity, and to highlight the importance of modifying daily habits as a potential component of preventive strategies. A limitation of the available data is the considerable heterogeneity of studies, methodological variability, and the scarcity of large, well-designed interventional trials. Further research is required to better define the direction and magnitude of these associations.

Author's contribution: Aleksandra Tomaszewska
Conceptualization: Kinga Karczewska, Natalia Dymel
Methodology: Aleksandra Tomaszewska, Maciej Kokoszka, Kinga Karczewska
Software: Michalina Chodór, Sonia Mojzyk, Aleksandra Mierniczek, Aleksandra Ćwirko-Godycka
Check: Nikola Murawska,, Ryszard Feret
Formal analysis: Natalia Dymel, Aleksandra Ćwirko-Godycka
Investigation: Aleksandra Tomaszewska, Kinga Karczewska
Resources: Nikola Murawska, Natalia Dymel, Aleksandra Mierniczek
Data curation: Sonia Mojzyk, Ryszard Feret, Natalia Dymel
Writing-Rough Preparation: Michalina Chodór, Maciej Kokoszka, Aleksandra Mierniczek, Nikola Murawska
Writing-Reviews and Editing: Aleksandra Tomaszewska, Kinga Karczewska, Sonia Mojzyk
Visualization: Michalina Chodór, Aleksandra Ćwirko-Godycka, Ryszard Feret
Supervision: Maciej Kokoszka, Sonia Mojzyk
Project administration: Aleksandra Tomaszewska, Kinga Karczewska
Funding statement: The study did not receive special funding.
Institutional reviewboard statement: Not applicable.
Informed consent statement: Not applicable.
Data availability statement: Not applicable.
No conflicts of interest to declare.

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