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LIFESTYLE AND SOCIOECONOMIC DETERMINANTS OF AUTOIMMUNE ACTIVITY IN NEWLY DIAGNOSED HASHIMOTO'S THYROIDITIS

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Abstract. Lifestyle and socioeconomic determinants of autoimmune activity in newly diagnosed Hashimoto's thyroiditis. Levterova B.A., Tomov D.G. *Hashimoto's thyroiditis (HT) is a prevalent autoimmune disorder in which clinical expression is defined not only by immunological mechanisms but also by lifestyle and socioeconomic determinants. These factors may be particularly influential in newly diagnosed, untreated patients, where autoimmune activity reflects the natural course of the disease. Understanding how behavioral and social variables relate to subjective health and autoantibody levels may support early, non-pharmacological interventions.Aim: to assess the relationship between health behaviors, socioeconomic indicators, subjective health, and autoantibody levels in newly diagnosed, untreated HT patients.A case-control study was conducted among 105 newly diagnosed HT patients and 25 healthy controls. Sociodemographic characteristics, lifestyle behaviors, and dietary patterns were assessed using the validated KomPAN questionnaire. Thyroid function (thyroid-stimulating hormone,free thyroxine (TSH, fT4)) and serum anti-TPO(thyroid peroxidase) and anti-TG (thyroglobulin) concentrations were measured. Correlation analyses were performed to assess relationships between questionnaire-derived numerical scores of lifestyle and socioeconomic variables and autoimmune markers.HT patients exhibited significantly higher TSH and autoantibody levels and lower fT4 compared with controls. Diet quality, physical activity, and financial status showed significant correlations with anti-TPO antibody concentrations. Socioeconomic indicators demonstrated significant inverse associations with anti-TG antibody levels: financial status (r= -0.232), education (r= -0.182), and employment (r= -0.260) were inversely correlated with anti-TG levels (all p<0.01). Patients more frequently rated their health as "worse than peers," reflecting the psychosocial burden of early disease stages.Lifestyle behaviors were closely linked to subjective health, while socioeconomic vulnerability was associated with higher anti-TG antibody levels in untreated HT patients. These findings suggest that financial insecurity, lower level of education, and unstable employment may be related to increased autoimmune reactivity, potentially through mechanisms involving chronic stress and limited access to healthcare. Early lifestyle optimization and multidisciplinary support may improve well-being even before hormone therapy is initiated. Larger prospective studies are needed to confirm these associations and clarify the pathways through which behavioral and social determinants influence autoimmune activity.*

Реферат. Вплив способу життя та соціально-економічних детермінантів на автоімунну активність у пацієнтів з уперше діагностованим тиреоїдитом Хашимото. Левтерова Б.А., Томов Д.Г. *Тиреоїдит Хашимото (ТХ) є поширеним автоімунним захворюванням, клінічний перебіг якого визначається не лише імунологічними механізмами, але й факторами способу життя та соціально-економічними детермінантами. Ці фактори можуть мати особливе значення для пацієнтів з новим діагнозом, які ще не отримували лікування, оскільки автоімунна активність у них відображає природний перебіг захворювання. Розуміння взаємозв'язків між поведінковими та соціальними чинниками, суб'єктивним здоров'ям і рівнями автоантитіл може сприяти ранньому впровадженню немедикаментозних втручань. Мета – оцінити взаємозв'язок між поведінковими факторами здоров'я, соціально-економічними показниками, суб'єктивним здоров'ям та рівнями автоантитіл у пацієнтів з новодіагностованим нелікованим тиреоїдитом Хашимото (ТХ). Проведено дослідження типу*

«випадок-контроль» за участю 105 пацієнтів з новодіагностованим ТХ та 25 здорових осіб контрольної групи. Соціодемографічні характеристики, поведінкові звички та харчові патерни оцінювали за допомогою валідованого опитувальника KomPAN. Визначали функцію щитоподібної залози (тиреотропний гормон, вільний тироксин (ТТГ, fT4)) та концентрації сироваткових anti-TPO (антитіла до тиреоїдної пероксидази) й anti-TG (антитіла до тиреоглобуліну) антитіл. Для оцінювання взаємозв'язків між отриманими за допомогою опитувальника числовими показниками способу життя та соціально-економічними змінними й маркерами автоімунної активності було проведено кореляційний аналіз. Пацієнти з ТХ мали достовірно вищі рівні ТТГ та автоантитіл і нижчі значення fT4 порівняно з контрольною групою. Якість харчування, фізична активність та фінансовий стан продемонстрували значущі кореляції з концентраціями anti-TPO антитіл. Соціально-економічні показники продемонстрували значущі зворотні асоціації з рівнями anti-TG антитіл: фінансовий стан (r= -0,232), рівень освіти (r= -0,182) та зайнятість (r= -0,260) були зворотно пов'язані з рівнями anti-TG (усі p<0,01). Пацієнти частіше оцінювали свій стан здоров'я як «гірший, ніж у ровесників», що відображає психосоціальне навантаження на ранніх етапах захворювання. Поведінкові фактори здоров'я були тісно пов'язані із суб'єктивним здоров'ям, тоді як соціально-економічна вразливість була пов'язана з вищими рівнями anti-TG антитіл у нелікованих пацієнтів з ТХ. Отримані результати свідчать, що фінансова нестабільність, нижчий рівень освіти та нестійка зайнятість можуть бути пов'язані з підвищеною автоімунною реактивністю, потенційно через механізми, пов'язані з хронічним стресом та обмеженим доступом до медичної допомоги. Раннє покращення способу життя та мультидисциплінарна підтримка можуть сприяти покращенню самопочуття ще до початку гормональної терапії. Необхідні масштабні проспективні дослідження для підтвердження цих асоціацій та уточнення шляхів, через які поведінкові й соціальні детермінанти впливають на автоімунну активність.

Hashimoto's thyroiditis (HT) is a chronic autoimmune disorder of the thyroid gland and represents the most common form of autoimmune thyroid disease. It predominantly affects women of reproductive age and is characterized by lymphocytic infiltration and progressive destruction of the thyroid parenchyma [1]. A key diagnostic feature is the presence of autoantibodies against thyroid peroxidase (anti-TPO) and thyroglobulin (anti-TG), which correlate with the severity of the autoimmune process [1, 2]. Although the pathogenesis of HT remains incompletely understood, it is well established that the disease results from a complex interplay between genetic predisposition, environmental influences, and epigenetic mechanisms [3, 4]. Numerous studies support the concept of a multifactorial etiology, in which the combination of inherited factors and environmental exposures determines the clinical manifestation and severity of the disease [4].

Podolska et al. report that "lifestyle factors, including diet, physical activity, and stress levels, may influence both symptoms and autoimmune activity" [5]. Nutritional status is of particular importance, as deficiencies in micronutrients such as selenium and vitamin D, as well as excessive iodine intake, may contribute to modulation of autoimmune responses [6]. Additionally, Ruggeri et al. demonstrated that dietary habits influence oxidative stress markers in patients with Hashimoto's thyroiditis, while the impact on antibody levels may vary between individuals [2].

Physical activity has also been shown to play a significant role in immune regulation. Gleeson et al. found that moderate exercise enhances immune function and reduces inflammatory markers [7]. In the context of HT, regular physical activity may alleviate fatigue and improve quality of life, contributing to better overall well-being [5].

Socioeconomic factors – such as education, income, and employment – exert substantial influence on access to healthcare, dietary quality, and the ability to manage stress. Braveman et al. emphasize that "the social determinants of health are critical for chronic diseases, including autoimmune conditions" [8]. Lower socioeconomic status is often associated with limited access to preventive care and treatment, higher levels of psychosocial stress, and poorer dietary patterns, all of which may intensify autoimmune activity [9]. Education is a key determinant, as higher health literacy facilitates understanding of the disease and adherence to therapeutic recommendations [10].

Although socioeconomic status does not appear to substantially influence the incidence of Hashimoto's thyroiditis, increasing evidence suggests that it may affect disease severity, access to care, and clinical outcomes. Large population studies do not show significant differences in incidence across socioeconomic groups [11]. However, global prevalence is higher in low- and middle-income regions, likely due to reduced access to healthcare and preventive services. Women are affected approximately four times more often than men, regardless of socioeconomic background [4, 11]. Income and employment influence disease outcomes through two main pathways: lower income is associated with reduced access to nutrient-rich foods (such as those containing selenium and vitamin D) and to regular medical check-ups [12]. Furthermore, chronic stress arising from socioeconomic insecurity may alter

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immune responses through changes in hormonal regulation and cytokine profiles [13, 14].

The aim of the present study is to examine the relationship between health behaviors, socioeconomic characteristics, and autoantibody levels in newly diagnosed patients with Hashimoto's thyroiditis.

Our hypothesis is that lifestyle factors and socioeconomic conditions are associated with subjective health and autoimmune activity in patients with newly diagnosed Hashimoto's thyroiditis.

MATERIALS AND METHODS OF RESEARCH

A case-control observational study was conducted using a structured questionnaire to assess dietary habits through a direct anonymous survey. The study included 130 participants: 105 newly diagnosed patients with Hashimoto's thyroiditis and 25 healthy controls. All patients were untreated at the time of enrolment, thereby eliminating the potential influence of hormone therapy on immune activity. This approach is consistent with the recommendations of Vargas-Uricoechea et al. (2023), who emphasize that antibody assessment in untreated individuals provides a more accurate reflection of autoimmune activity [15]. Inclusion criteria: age 18-65 years; newly diagnosed Hashimoto's thyroiditis confirmed by serological and/or ultrasonographic criteria; and no prior initiation of thyroid hormone therapy. Exclusion criteria included: presence of other autoimmune diseases; previous treatment with levothyroxine or immunosuppressive agents; pregnancy or lactation; and severe chronic comorbidities (e.g., cardiovascular, renal, hepatic disorders).

An original Bulgarian-language self-administered questionnaire consisting of 58 items was developed specifically for this study. Selected items and scoring components from the validated KomPAN questionnaire (Dietary Habits, Nutrition, and Beliefs Questionnaire, version 2.2) were incorporated to assess key lifestyle domains, including dietary habits and physical activity [16, 17]. The complete KomPAN questionnaire was not administered; only those sections relevant to the predefined objectives and hypothesis of the present study were selected. Additional questions were developed by the authors to assess socioeconomic characteristics, health-related behaviors, and subjective health status. The final instrument therefore represented a combination of validated KomPAN-derived items and study-specific questions. An internal validation process, including expert assessment of content and face validity, was performed to ensure conceptual clarity and relevance of the questionnaire for the study population.

The study was conducted in accordance with the principles of the Declaration of Helsinki. Written informed consent was obtained from all participants prior to enrolment. The research protocol was approved by the Research Ethics Committee of the Medical University of Plovdiv (No. 4/04.05.2023).

Hashimoto's thyroiditis was diagnosed based on a combination of serological and ultrasonographic criteria. Patients were included when autoimmune thyroiditis was confirmed by the presence of elevated thyroid autoantibodies (anti-TPO and/or anti-TG) and/or characteristic ultrasonographic features, including thyroid heterogeneity, hypoechogenicity, and micronodularity. Patients with seronegative Hashimoto's thyroiditis, defined as the absence of elevated anti-TPO and anti-TG antibodies but the presence of characteristic ultrasonographic findings consistent with autoimmune thyroiditis, were also included. Ultrasound evaluation was performed by an experienced endocrinologist according to standard diagnostic criteria for autoimmune thyroiditis. Serum concentrations of anti-TPO and anti-TG antibodies were measured in all participants using a chemiluminescent immunoassay on a Mindray analyzer (Mindray Bio-Medical Electronics Co., Ltd., Shenzhen, China). Additional laboratory parameters were analyzed using enzyme-linked immunosorbent assay (ELISA) [18]. Autoantibody concentrations were evaluated as markers of autoimmune activity and were not used as the sole criterion for diagnosis.

Coding of questionnaire variables: responses derived from the KomPAN-based items and study-specific questions were not analyzed as individual nominal or categorical variables. Instead, composite scores were calculated from multiple questionnaire items to represent predefined constructs, including diet quality, physical activity, financial status, education, and employment status. These composite scores were treated as numerical indices reflecting the relative level of each construct rather than as isolated categories. Higher scores represented higher levels of the assessed domains (e.g., better diet quality, greater physical activity, or more favorable socioeconomic status). The scoring procedure followed the structure of the questionnaire domains, with ordered numerical values assigned to the respective categories (diet quality: 1-4; physical activity: 1-3; financial status: 1-3). Prior to correlation analysis, the relationships between the derived indices and antibody concentrations were examined for linearity. The transformed questionnaire scores demonstrated approximately linear relationships with antibody concentrations, which allowed the application of Pearson's correlation coefficient for exploratory assessment of linear associations between the derived indices and autoimmune markers.

The selection of questionnaire-derived variables was predefined according to the study hypothesis and focused on lifestyle and socioeconomic domains considered potentially relevant to autoimmune activity and subjective health outcomes.

Statistical analysis was performed using IBM SPSS Statistics for Windows, Version 23.0 (licensed institutional version). The distribution of continuous variables, including age, BMI, thyroid-stimulating hormone (TSH), free thyroxine (fT4), anti-TPO, and anti-TG antibody concentrations, was assessed using the Shapiro-Wilk test. As these variables demonstrated non-normal distribution, continuous data were presented as median values with minimum–maximum ranges. Comparisons between the two independent groups (patients with Hashimoto's thyroiditis and healthy controls) were performed using the Mann-Whitney U-test. Categorical variables were summarized as frequencies and percentages. Differences between groups were assessed using Pearson's chi-square test when the assumptions for its application were met. Fisher's exact test was used when the expected cell counts were less than 5.

Associations between questionnaire-derived numerical indices (diet quality, physical activity, financial status, education, and employment status) and antibody concentrations (anti-TPO and anti-TG) were evaluated using Pearson's correlation coefficient. These questionnaire-derived indices were obtained through predefined scoring procedures and were analyzed as numerical measures reflecting the respective lifestyle and socioeconomic domains. The use of Pearson's correlation was based on the assessment of linear relationships between the derived indices and antibody concentrations. Separate correlation analyses were performed for anti-TPO and anti-TG antibody levels. A p-value <0.05 was considered statistically significant [19].

RESULTS AND DISCUSSION

The socio-demographic, lifestyle, dietary and socioeconomic characteristics of the study participants are presented in Table 1. Among patients with Hashimoto's thyroiditis, 78.1% were women, which is consistent with epidemiological data indicating that the disease affects women 5-10 times more frequently than men [11]. The median age was 38 years in the patient group and 31 years in the control group. BMI was higher in the HT group (median 27.4 kg/m²) compared with controls (median 23.9 kg/m²), although this difference did not reach statistical significance (p=0.079). Serum anti-TPO and anti-TG concentrations were significantly higher in patients compared with controls (both $p<0.001$), with a wider distribution of values among patients. Differences in physical activity, dietary habits, education, and financial situation did not reach statistical significance, whereas self-reported health differed markedly between groups (p=0.001).

Education level did not differ significantly between patients and controls (p=0.549). A total of 63.8% of participants had higher education, which is above the national average. This aligns with the findings of Vuletić et al., who reported that individuals with autoimmune diseases are more likely to seek medical care and participate in research when they have a higher educational level [20].

Financial situation also showed no statistically significant differences (p=0.272), although patients were more concentrated in the "average" category. This is consistent with the observations of Braveman et al., who emphasized the association between chronic diseases and social vulnerability [8].

Regarding diet, 66.9% rated their dietary habits as "good," although patients more frequently reported "poor" diet quality. Ruggeri et al. found that patients with Hashimoto's thyroiditis often exhibit deficiencies in selenium, vitamin D, and antioxidants, particularly when dietary patterns are unbalanced [2].

In terms of physical activity, 55.4% reported moderate leisure-time activity, with patients being less frequently represented in the "high activity" category, although the difference was not statistically significant. Gleeson et al. demonstrated that moderate activity improves immune function, whereas excessive activity may enhance inflammatory processes [7].

Average sleep duration ranged between 6-8 hours, with no significant differences between groups. Screen time averaged 3-5 hours per day, with patients being slightly less digitally active. Chronic stress has been associated with immune dysregulation, which may represent a relevant pathway linking psychosocial factors and autoimmune activity [21].

Recent evidence indicates that environmental and behavioral factors may influence the development and progression of autoimmune thyroiditis. Correlation analysis revealed statistically significant associations between lifestyle factors and anti-TPO antibody levels in patients with Hashimoto's thyroiditis (Table 2). Dietary quality ($r=0.287$, $p<0.01$), physical activity ($r=0.296$, $p<0.01$), and financial status ($r=–0.224$, $p<0.01$) were significantly associated with anti-TPO antibody concentrations. These findings suggest that lifestyle and socioeconomic factors may be related to autoimmune activity [22].

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Table 1

Socio-demographic, lifestyle, dietary and socioeconomic characteristics of study participants (n=130)

Variable	Patients (n=105)	Controls (n=25)	p-value
Sex			**0.008****
– Female	**82 (78.1%)**	**13 (52.0%)**	
– Male	**23 (21.9%)**	**12 (48.0%)**	
Age (years, median [Min–Max])	**38 [19–65]**	**31 [18–55]**	**0.028***
BMI (kg/m², median [Min–Max])	**27.4 [18.2–45.1]**	**23.9 [17.5–33.2]**	**0.079***
anti-TPO (IU/mL, median [Min–Max])	**0.30 [0.10–92.50]**	**0.20 [0.10–0.50]**	**<0.001***
anti-TG (IU/mL, median [Min–Max])	**0.20 [0.10–35.40]**	**0.10 [0.10–0.40]**	**<0.001***
Physical activity			**0.081****
– Low	**31 (29.5%)**	**4 (16.0%)**	
– Moderate	**59 (56.2%)**	**13 (52.0%)**	
– High	**15 (14.3%)**	**8 (32.0%)**	
Work activity level			**0.326*****
– Low	**40 (38.1%)**	**13 (52.0%)**	
– Moderate	**53 (50.5%)**	**11 (44.0%)**	
– High	**12 (11.4%)**	**1 (4.0%)**	
Eating habits			**0.290*****
– Poor	**31 (29.5%)**	**4 (16.0%)**	
– Good	**69 (65.7%)**	**18 (72.0%)**	
– Very good	**5 (4.8%)**	**3 (12.0%)**	
Education			**0.549*****
– Primary/Secondary	**38 (36.2%)**	**9 (36.0%)**	
– College/Bachelor	**26 (24.8%)**	**6 (24.0%)**	
– Master's degree	**41 (39.0%)**	**10 (40.0%)**	
Financial situation			**0.272*****
– Below average	**8 (6.2%)**	**0**	
– Average	**80 (76.2%)**	**19 (76.0%)**	
– Above average	**17 (16.2%)**	**6 (24.0%)**	
Self-reported health			**0.001*****
Worse than peers	**20 (19.0%)**	**0 (0%)**	
Same as peers	**59 (56.2%)**	**10 (40.0%)**	
Healthier than peers	**26 (24.8%)**	**15 (60.0%)**	

Notes: p-value <0.05; * – Mann-Whitney U-test; ** – Pearson's chi-square test; *** – Fisher's exact test (used when expected cell counts were <5).

The inverse association between financial status and anti-TPO antibody levels suggests that socioeconomic conditions may be associated with variations in autoimmune activity. Previous studies support this pattern: Ruggeri et al. reported that antioxidant-rich diets may improve oxidative balance, although their impact on antibody levels varies individually [2], while Gleeson et al. demonstrated that moderate physical activity exerts anti-inflammatory effects and enhances immune function [7]. Taken together, these findings indicate that lifestyle behaviors (diet and physical activity) and financial status are significantly associated with autoimmune activity in patients with Hashimoto's thyroiditis.

Table 2

Correlations between lifestyle factors and anti-TPO antibody levels in patients with Hashimoto's thyroiditis (n=105)

Variable	Pearson R	p-value
Diet	**0.287**	**<0.01**
Physical activity	**0.296**	**<0.01**
Financial status	**-0.224**	**<0.01**

As shown in Table 3, the correlation analysis identified significant inverse relationships between socioeconomic indicators and autoantibody concentrations in patients with Hashimoto's thyroiditis.

Table 3

Correlations between anti-TG antibody levels and socioeconomic determinants in patients with Hashimoto's thyroiditis (n=105)

Variable	Pearson R	p-value
Financial status	**-0.232**	**<0.01**
Education	**-0.182**	**<0.01**
Employment status	**-0.260**	**<0.01**

Financial status ($r = -0.232$, $p<0.01$), education ($r = -0.182$, $p<0.01$), and employment status ($r = -0.260$, $p<0.01$) were inversely associated with anti-TG antibody levels, indicating that lower socioeconomic indicators were associated with higher anti-TG antibody levels. These findings highlight the relevance of socioeconomic determinants as modulators of immune dysregulation in Hashimoto's thyroiditis. Similar observations were reported by Braveman et al., who identified social determinants as key contributors to chronic disease burden [8]. The negative association between educational level and antibody titres may reflect differences in health literacy and engagement in preventive behaviors, consistent with the findings of Vuletić et al., who noted higher healthcare participation among individuals with higher education [20].

Our findings are consistent with those of Chen et al., who demonstrated that socioeconomic disparities significantly influence healthcare access and clinical outcomes in patients with thyroid disorders [12]. Similarly, the systematic review by Hu et al. reported a higher prevalence of Hashimoto's thyroiditis in resource-limited regions, suggesting that socioeconomic inequalities may contribute to disease burden [11].

Subjective health assessment also differed markedly between patients and controls. A total of 53.1% of participants rated their health as "the same as their peers," while 19% of patients perceived their health as "worse than others," compared with none of the controls. Conversely, controls more frequently described themselves as "healthier than their peers" (60% vs. 24.8% among patients). These observations align with the findings of Podolska et al., who reported that subjective health in patients with Hashimoto's thyroiditis is often lower than objective clinical indicators, particularly in early disease stages [5]. Danailova et al. similarly noted that healthier lifestyle behaviors are associated with better subjective health [6]. Additional studies have shown that dietary improvements combined with increased physical activity may enhance perceived health status in individuals with autoimmune thyroid disorders [23, 24, 25].

CONCLUSION

1. Lifestyle behaviors were associated with subjective health and showed significant correlations with anti-thyroid peroxidase antibody levels in patients with newly diagnosed Hashimoto's thyroiditis.
2. Socioeconomic factors – especially financial status, education, and employment, showed significant associations with anti-thyroglobulin antibody concentrations, suggesting that social disadvantage may may be associated with increased autoimmune reactivity, potentially reflecting mechanisms related to chronic stress and healthcare accessibility.
3. The results emphasize the importance of assessing dietary habits and socioeconomic context in newly diagnosed patients with Hashimoto's thyroiditis.

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4. A multidisciplinary approach involving medical, nutritional, and psychosocial expertise is essential for optimal disease management.

5. Early adoption of healthy dietary patterns and moderate physical activity may improve subjective well-being and support the overall management of autoimmune thyroiditis before hormone therapy is initiated.

Limitations. This study has several limitations. First, the cross-sectional case–control design allows identification of associations but does not permit causal inference. Reverse causality cannot be excluded; it remains unclear whether lower socioeconomic status contributes to higher autoantibody levels or whether the clinical manifestations of Hashimoto's thyroiditis reduce work capacity and subsequently worsen financial status. Second, the statistically significant difference in sex distribution between patients and controls may represent an important confounding factor influencing both lifestyle behaviors and immunological parameters. Third, several variables, including diet, physical activity, and subjective health, were self-reported, which may introduce recall and reporting bias. The relatively small sample size also limits more detailed stratification and adjustment for potential confounders. Future research should include larger and more diverse cohorts and apply multivariable regression models adjusting for age, sex, BMI, TSH, and fT4, as well as prospective designs that enable monitoring of autoantibody dynamics and the long-term impact of socioeconomic factors.

Contributors:

Levterova B.A. – conceptualization, methodology, validation, investigation, formal analysis, resources, data curation, writing – original draft, writing – review & editing;

Tomov D.G. – conceptualization, methodology, investigation, resources, writing – review & editing, visualization, supervision, funding acquisition, project administration.

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