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The function of the vestibular organ in Hashimoto's thyroiditis

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Abstract

Introduction: The aim of the study was to identify the prognostic factors and the relationship between vertigo and the results of objective assessment of the vestibular organ and the levels of thyroid status in patients with Hashimoto's thyroiditis.

Material and methods: The study population consisted of 28 women with Hashimoto's thyroiditis and coexisting chronic vertigo. In all patients, audiological assessment of hearing (tonal audiometry and impedance audiometry), Dix-Hallpike manoeuvre, caloric test, and kinetic tests (rotary chair test and swing chair test) were evaluated. Thyroid hormone levels [thyroid-stimulating hormone (TSH), free thyroxine (FT4)] and thyroid antibodies [autoantibodies against thyroid peroxidase (anti-TPO) and thyroglobulin (anti-TG)] were determined. The relationships between age, weight, height, and BMI and the results of the objective assessment of the vestibular organ were calculated.

Results: In the study group the mean age was 48 years and the mean BMI was 26.425. Normal hearing was found in 15 patients (54%). BPPV (n = 19), followed by Meniere's disease (n = 7) and vestibular neuronitis (n = 2), were the causes of chronic vertigo in this group of patients. The analysis of the objective assessment of the vestibular organ showed decreased excitability of the labyrinth in 15 patients (54%). Twenty-four patients presented with normal TSH and FT4 levels (85%). All patients presented with elevated anti-TPO and anti-TG levels.

Conclusion: No correlation was found between age, weight, height, BMI, and the results of thyroid function tests or the assessment of the vestibular organ. We did not confirm the negative influence of thyroid levels or the increase in thyroid antibodies on the abnormal results of the rotary chair test or the caloric test. **(Endokrynol Pol 2022; 73 (6): 935–941)**

Key words: *Hashimoto's thyroiditis; vertigo*

Introduction

The aim of the vestibular organ is to prevent falls by maintaining the body's centre of gravity in balance both at rest and in motion [1, 2]. The vestibular organ is responsible for providing information from peripheral receptors (sensory cells in the labyrinth of the inner ear, eyeballs, and peripheral somatic receptors) to the central nervous system (CNS), where it is processed so that a person becomes conscious of their body position. Vertigo can be caused by central or peripheral vestibular dysfunction. Both vertigo and balance disorders are common symptoms reported by about 20–30% of adults worldwide [3], which are caused by dysfunction of the peripheral and/or central part of the vestibular organ. The main causes of peripheral labyrinthine vertigo are related to inner ear diseases such as benign paroxysmal positional vertigo (BPPV) or Meniere's disease [4–6]. The causes of non-labyrinthine vertigo include neurological disorders (e.g. brain tumours, epilepsy, or craniocerebral trauma) or cardiovascular diseases (e.g. hypertension, cardiac arrhythmias, cerebral atherosclerosis) [7, 8]. Immune-mediated autoimmune diseases such as rheumatoid arthritis, Sjögren's syndrome, or Cogan's syndrome are also involved [9, 10]. Since Hashimoto's thyroiditis is caused by autoimmune mechanisms, we decided to assess the relationship between thyroid metabolism and the occurrence of vertigo by analysing a group of patients with Hashimoto's thyroiditis affected by chronic vertigo based on the correlation between the levels of thyroid hormones and autoantibodies and the results of objective assessment of the vestibular organ.

The aim of the study was to identify the prognostic factors and the relationship between vertigo and the results of the objective assessment of the vestibular organ and the levels of thyroid hormones [thyroid-stimulating hormone (TSH), free thyroxine (FT4)] and autoantibodies against thyroid peroxidase (anti-TPO) and thyroglobulin (anti-TG) in patients with Hashi-

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moto's thyroiditis, depending on age, weight, height, and body mass index (BMI).

Material and methods

A total of 28 patients with Hashimoto's thyroiditis and coexisting chronic vertigo were assessed in the Department of Otorhinolaryngology and Oncological Laryngology, Medical University of Silesia, Zabrze, Poland between January 2020 and December 2021. The subjects were enrolled in the study and audiological assessment of hearing (tonal audiometry and impedance audiometry) was performed in the outpatient clinic. Thyroid hormone levels (TSH, FT4) and thyroid antibodies (anti-TPO and anti-TG) were determined in the hospital laboratory. In all patients, the Dix-Hallpike manoeuvre was performed to diagnose or exclude BPPV. The second stage of the study included the objective assessment of the vestibular organ using the caloric (reflex) test and the rotary chair test. The assessment was performed in all patients in the Silesian Centre of Hearing, Tinnitus, Vertigo, and Balance Disorders in Tarnowskie Góry, Poland. The results of the caloric test in correlation with the kinetic tests allowed for an objective assessment of the inner ear functions and the decrease or lack of excitability.

The inclusion criteria were as follows: both sexes, age 18–75 years, (permanent or paroxysmal) chronic vertigo of at least 3-month duration, Hashimoto's thyroiditis confirmed by thyroid ultrasonography and thyroid hormone levels and thyroid antibodies, normal tympanic membrane confirmed by otoscopy, normal hearing test results or sensorineural hearing loss in one or both ears, and normal impedance audiometry (normal middle ear pressure - type A tympanogram).

The exclusion criteria were as follows: age < 18 years, age > 75 years, acute vertigo ≤ 3 months from the day of the occurrence of vertigo, conductive and/or mixed hearing loss in one or both ears, perforation of the eardrum, chronic otitis media with drainage from the tympanic cavity confirmed by otoscopy, and abnormal impedance audiometry (i.e. other than type A tympanogram).

Audiological tests

In all patients, tonal threshold audiometry and impedance audiometry were performed in the Laboratory of Audiology of the Department of Otorhinolaryngology and Oncological Laryngology, Medical University of Silesia, Zabrze, Poland. The hearing threshold was assessed using an AD229e audiometer. Pure tone audiometry was performed in an acoustic booth using the ascending method for air conduction (frequency range 250–8000 Hz) and for bone conduction (frequency range 250–4000 Hz) separately for the right and the left ear.

The compliance and pressure in the external auditory canal and eardrum cavity were measured using an AT235 tympanometer. The pressure in the tympanic cavity ranging from –100 daPa to +100 daPa was considered normal, while the range of 0.3–1.3 mL was regarded as the normal compliance of the ear conduction system.

Dix-Hallpike manoeuvre

The Dix-Hallpike manoeuvre, which is based on moving the patient from the sitting to the supine position with the head turned 45° to one side, was performed for both sides. The manoeuvre was considered positive [i.e. confirming bening proxymal positional vertigo (BPPV)] if vertigo occurred with positional nystagmus at the time of the assessment.

Assessment of thyroid hormone levels and thyroid antibodies

Blood tests were performed in the laboratory of the Department of Otorhinolaryngology and Oncological Laryngology, Medical University of Silesia, Zabrze, Poland. Venous blood samples (3 mL) were collected into clot-activated tubes to assess TSH, FT4, anti-TPO, and anti-TG levels. The following values were considered normal: TSH — 0.27–4.20 ulU/mL, FT4 — 0.93–1.70 ng/dL, anti-TPO — 0.0–5.61 IU/mL, and anti-TG 0.0–4.11 IU/mL.

Caloric test

The Fitzgerald-Hallpike caloric test was performed using Framiral vl.7.10.0. Eye movement and the vestibulo-ocular reflex (VOR) of the horizontal semicircular canal was assessed using video goggles. The subjects were examined in the supine position with the head tilted at 30°. Air (24°C and 47°C) was used as a thermal stimulus. It was administered alternately to the right and the left ear for 60 seconds. Nystagmus was recorded for 90 seconds after air irrigation was completed. The absolute value of the peak slow phase velocity of nystagmus was measured for cold and warm air and was calculated for each side. A value of 25% or less of the sum of the peak slow phase velocities of nystagmus for both stimuli [24°C/47°C] was considered normal.

Kinetic testing

The protocol of assessment consisted of the rotary chair test and the swing chair test. The assessment was performed using a manual rotary chair according to the installed algorithm (Framiral v1.7.10.0). The vestibulo-ocular reflex (VOR) of the horizontal semicircular canal was assessed using video goggles.

Rotary chair test

The test was performed in the sitting position (eyes closed, head bent to the chest at 30°). Two complete clockwise rotations and two counterclockwise rotations were performed. The velocity of chair rotation was 100°/s. The duration of each test was approximately 15 seconds. The occurrence of nystagmus was monitored during the rotation and in the post-rotation period. The symmetry of the response was assessed during and after rotation. Directional preponderance ≤ 30% was considered normal.

Swing chair test

The test was performed in the sitting position (head bent to the chest at 30°). All patients were subjected to swings with increasing-decreasing amplitude and the frequency of 0.1 Hz at Vmax = 50°/s. The duration of each test was approximately 20 seconds. The gain was assessed. Three tests were performed in each patient:

— the visually vestibulo-ocular reflex (VVOR) test was performed in patients with their eyes open. Optokinetic nystagmus was obtained when the chair was swung to the side. VVOR gain ≥ 0.9 was considered normal;
— the vestibulo-ocular reflex (VOR) test was performed in patients with their eyes closed. Vestibular nystagmus was observed when the chair swung to the side. VOR gain ≥ 0.5 was considered normal;
— the cervico-ocular reflex (COR) test was performed in patients with their eyes closed and their head immobilized. Trunk movements were performed to the left and to the right side simultaneously with chair movements. COR gain ≤ 0.4 was considered normal.

The aim of this study was to identify the prognostic factors and the relationship between vertigo and the results of objective assessment of the vestibular organ and thyroid hormone levels (TSH, FT4) and thyroid antibodies (anti-TPO, anti-TG) in patients with Hashimoto's thyroiditis depending on age, weight, height, and body mass index (BMI).

The relationships between age, weight, height, and BMI and the results of the objective assessment of the vestibular organ (caloric test and rotary chair test) were calculated using the Spearman correlation coefficient. The chi-square test was used to examine whether the above parameters were normal for the variables depending on whether the subjects had comorbidities, were smokers, or had hearing problems. The level of statistical significance was adopted at $p = 0.05$. Statistical analysis was performed using Statistica 13.1.

The study was approved by the Bioethics Committee of the Medical University of Silesia and was financed from the statutory funds of the Medical University of Silesia in Katowice (KNW-1-054/N/9/K).

Results

Twenty-eight female patients aged 23–71 years (mean age 48 years) were included in the study between January 2020 and December 2021. The weight of the subjects ranged from 52 to 98 kg and their height ranged from 158 to 178 cm (Tab. 1). The mean BMI in the study group was 26.425.

Fifteen patients presented with comorbidities such as hypertension, type 2 diabetes, degenerative spine disease, or gastroesophageal reflux disease. The most common comorbidity was hypertension, which was found in 8 patients. Seven subjects were regular cigarette smokers.

After audiological assessment (tone and impedance audiometry), normal hearing was found in 15 patients. Other patients were diagnosed with sensorineural hearing loss in one or both ears. Normal tympanic membrane compliance and normal pressure in the tympanic cavity were reported in all patients (type A tympanogram). BPPV (n = 19), followed by Meniere's disease (n = 7) and vestibular neuronitis (n = 2), were the most common causes of chronic vertigo based on history, audiological assessment, and the objective evaluation of the vestibular organ.

Table 2 shows thyroid hormone levels (TSH, FT4) and thyroid antibodies (anti-TPO, anti-TG) in the group of patients, most of whom were euthyroid. Three patients presented with abnormal TSH levels, which were above the normal range, while one patient presented with TSH below the normal range (Fig. 1). As regards FT4, only 4 patients had elevated FT4 levels. All patients presented with elevated anti-TPO and anti-TG levels.

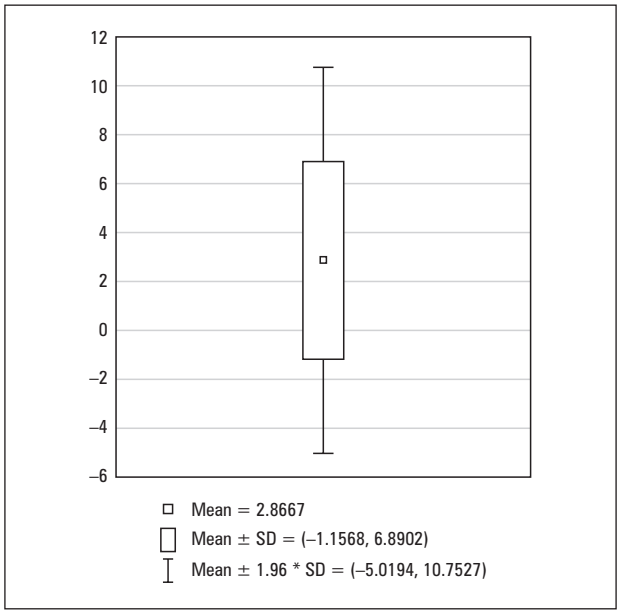

Figure 1. *Mean and standard deviation (SD) of thyroid-stimulation hormone in female patients (n = 28)*

After performing the caloric test and videonystagmography, directional labyrinthine preponderance was assessed (mean 13.143). Only 5 women presented with asymmetry of the labyrinthine responses to a caloric stimulus in the form of directional preponderance in the caloric test above the normal range.

After performing tests using a rotary chair, directional preponderance in the rotary chair test was assessed.

Table 1. *Age, weight, height, and the body mass index in the study group (n = 28)*

	Mean	Minimum	Maximum	Standard deviation
Age	48.571	23	71	13.296
Weight	74.393	52	98	9.739
Height	1.68	1.58	1.78	0.043
BMI	26.425	18.125	38.281	3.857

BMI — body mass index

Table 2. *Thyroid hormone levels (TSH, FT4) and thyroid antibody levels (anti-TPO, anti-TG) in the group of women (n = 28)*

	Mean	Minimum	Maximum	Standard deviation
TSH	2.004	0.121	6.33	1.332
FT4	1.368	0.98	1.81	0.234
anti-TPO	224.604	7.86	2000	369.422
anti-TG	621.229	6.46	10,000	1998.758

TSH — thyroid-stimulating hormone; FT4 — free thyroxine; anti-TPO — autoantibodies against thyroid peroxidase; anti-TG — autoantibodies against thyroglobulin

Table 3. *Directional preponderance in the rotary chair test and the gain values for the swing chair test of the female subjects (n = 28)*

	Mean	Minimum	Maximum	Standard deviation
Rotary chair test	12.481	0	50	13.066
Swing chair test — VVOR gain	0.825	0.5	1	0.108
Swing chair test — VOR gain	0.464	0.2	0.8	0.159
Swing chair test — COR gain	0.104	0	0.5	0.137

VVOR — visually vestibulo-ocular reflex; VOR — vestibulo-ocular reflex; COR — cervico-ocular reflex

Additionally, the value of gain in the swing chair test was evaluated during the assessment of VVOR, VOR, and COR (Tab. 3). Five patients presented with results above the normal range of directional preponderance in the rotary chair test. The VVOR gain below the normal range was observed in 16 patients. Fifteen patients presented with the VOR gain below the normal range. Only one patient presented with the COR gain above the normal range.

The analysis of the objective assessment of the vestibular organ showed normal labyrinthine function in 14 patients. However, 15 patients presented with decreased excitability of the labyrinth.

The next stage was based on the assessment of the relationship between age, weight, height, BMI and the results of thyroid function tests and the assessment of the vestibular organ (Tab. 4). All analyses were performed at the significance level of $\alpha = 0.05$. No statistically significant correlations were found between the above factors and the thyroid function tests or the assessment of the vestibular organ. However, the correlation coefficient (0.45) between the height of the patients and the VVOR gain values was statistically significant, which means that there was a moderate positive relationship between the height and the gain value, i.e. the greater the height, the higher its value.

Analysis of the correlation related to the above parameters was performed (Tab. 5) and showed that the VOR gain increased with the increase in the level of anti-TPO antibodies. There was no negative impact of an increase in anti-TPO antibodies on the result of the test because a high value of gain indicated a normal result. It was also shown that directional preponderance in the rotary chair test decreased with the increase in anti-TG antibodies. Poor directional preponderance or no directional preponderance gives a normal result in the rotary test. Therefore, a negative effect of thyroid hormone levels or increased levels of thyroid antibodies on abnormal results of the rotary chair test or the caloric test has not been proven. The statistical calculations did not show any negative effect of thyroid hormone levels or increased thyroid antibody levels on abnormal results of the rotary chair test or the caloric test. It was also shown that the VOR gain value increased with the increase in the VVOR gain.

Discussion

Autoimmune mechanisms are involved in Hashimoto's thyroiditis. Due to abnormal stimulation of the immune system, antibodies directed against the thyroid gland are formed [11–13]. Hashimoto's thyroiditis is

Table 4. *Spearman's rank correlation coefficients between age, weight, height, body mass index, and the parameters (significance level $\alpha = 0.05$)*

	Age	Weight	Height	BMI
TSH	–0.214	–0.229	0.057	–0.146
FT4	0.232	0.157	0.161	0.067
Anti-TPO	–0.136	–0.174	0.282	–0.303
Anti-TG	0.167	–0.118	0.241	–0.146
Caloric test	0.141	0.172	–0.071	0.311
Rotatory chair test	0.305	0.168	–0.081	0.122
Swing chair test — VVOR gain	–0.282	0.042	0.145	–0.004
Swing chair test — VOR gain	0.039	0.216	0.451	–0.075
Swing chair test — COR gain	0.239	0.349	0.201	0.254

TSH — thyroid-stimulating hormone; FT4 — free thyroxine; anti-TPO — autoantibodies against thyroid peroxidase; anti-TG — autoantibodies against thyroglobulin; VVOR — visually vestibulo-ocular reflex; VOR — vestibulo-ocular reflex; COR — cervico-ocular reflex

Table 5. *Spearman's rank correlation coefficients between the parameters (significance level $\alpha = 0.05$)*

	TSH	FT4	anti-TPO	anti-TG	Caloric test	Rotatory chair test	Swing chair test — VVOR gain	Swing chair test — VOR gain	Swing chair test — COR gain
TSH	1.000	–0.213	–0.080	–0.149	0.130	–0.115	0.011	–0.008	–0.106
FT4	–0.213	1.000	–0.007	0.064	–0.159	0.144	0.271	0.140	0.315
Anti-TPO	–0.080	–0.007	1.000	0.355	0.245	0.082	0.212	0.517	0.103
Anti-TG	–0.149	0.064	0.355	1.000	0.049	–0.393	0.339	0.361	0.405
Caloric test	0.130	–0.159	0.245	0.049	1.000	0.158	0.293	0.156	0.321
Rotatory chair test	–0.115	0.144	0.082	–0.393	0.158	1.000	–0.291	0.084	0.027
Swing chair test — VVOR gain	0.011	0.271	0.212	0.339	0.293	–0.291	1.000	0.499	0.273
Swing chair test — VOR gain	–0.008	0.140	0.517	0.361	0.156	0.084	0.499	1.000	0.302
Swing chair test — COR gain	–0.106	0.315	0.103	0.405	0.321	0.027	0.273	0.302	1.000

TSH — thyroid-stimulating hormone; FT4 — free thyroxine; anti-TPO — autoantibodies against thyroid peroxidase; anti-TG — autoantibodies against thyroglobulin; VVOR — visually vestibulo-ocular reflex; VOR — vestibulo-ocular reflex; COR — cervico-ocular reflex

characterized by the presence of autoreactive lymphocytes infiltrating the thyroid tissue and anti-TPO and anti-TG antibodies. Hypothyroidism develops due to reduced production of thyroid hormones. However, mild hyperthyroidism may initially occur as a result of the excessive hormone release from affected thyrocytes [14]. The autoimmune background of Hashimoto's thyroiditis was the reason for the attempts to find the relationship between this disease and the conditions of the peripheral part of the vestibular organ because the immunological background may be the cause of inner ear disorders. There are few studies assessing the degree of the relationship between the occurrence of vertigo and Hashimoto's thyroiditis. Therefore, the authors of this study decided to analyse such a group of patients. The immunological background was found in many inner ear disorders such as BPPV, Meniere's disease, or vestibular neuronitis [15–25]. Of note, our group of patients was homogeneous in terms of inner ear disorders, and therefore it included patients with such diseases. Patients with vertigo of central origin and severe vertigo (< 3 months) were excluded from the study. Chronic vertigo was confirmed in patients by the objective assessment of the vestibular organ and physical examination.

No correlation was found between age, weight, height, BMI, and the results of thyroid function tests or the assessment of the vestibular organ. The statistically significant correlation between the patients' height and the results of the VVOR test was most likely due to a technical error at the time of the assessment on a rotary chair. We did not confirm the negative influence of thyroid levels or the increase in thyroid antibodies on the abnormal results of the rotary chair test or the caloric test.

Some studies have confirmed the relationship between thyroid hormones and inner ear disorders. In a group of 47 patients with Hashimoto's thyroiditis, Chiarella et al. showed that patients with positive anti-TPO antibodies had a higher risk of developing balance disorders, which was confirmed by the objective assessment of the vestibular organ. However, they assessed patients who did not report vertigo at the time of the study and patients with vertigo with mixed origin (i.e. peripheral and central vertigo) [26]. Papi et al. found a statistically significant relationship between Hashimoto's thyroiditis and BPPV, which was most likely related to the presence of positive thyroid antibodies that could induce vasculitis in the inner ear [27]. According to Modungo et al., these antibodies may lead to impaired endolymph flow, which in turn may adversely stimulate vestibular sensory cells and initiate attacks typical of BPPV [28]. In addition, anti-TPO and anti-TG antibodies may penetrate the structures of the endolymphatic sac via blood vessels and, due to the reaction with its cells, generate an increase in endolymph pressure, thus inducing attacks of Meniere's vertigo [29–32].

Some studies reported that the decrease in the prevalence of vertigo attacks in patients after a three-month treatment with levothyroxine confirmed the relationship between Meniere's disease and Hashimoto's thyroiditis [33–36]. Kim et al. demonstrated that hypothyroidism was a risk factor for Meniere's disease in a group of women under 65 years of age [37]. However, the above studies did not prove the relationship between the thyroid function in Hashimoto's thyroiditis

and endolymphatic sac hydrops. To the best of our knowledge, there have been no studies confirming the relationship between Hashimoto's thyroiditis and vestibular neuronitis.

Sari et al. did not confirm a relationship between the occurrence of symptoms and their severity and the presence of anti-TPO antibodies or elevated TSH levels in patients with BPPV [38]. The same conclusions were presented by Papi et al. [39]. In a large cohort of patients with vertigo, Choi et al. found no relationship between BPPV and Hashimoto's thyroiditis. Additionally, they found no impact of levothyroxine on the prevalence of positional vertigo, although a statistically significant correlation was shown between BPPV and hypothyroid goitre [40]. Furthermore, Tricarico et al. found no correlation between both diseases. However, they reported that hypothyroidism, which is common in Hashimoto's thyroiditis, was a risk factor for recurrent attacks of BPPV [41]. After an extensive review of the literature related to the relationship between thyroid diseases and vertigo, Chiarella et al. reported the lack of control groups and imprecise thyroid assessment [42]. At the same time, they found that patients with BPPV or Meniere's disease were potential candidates to develop Hashimoto's thyroiditis, which confirms the immunological background of both diseases [42].

A limitation of the study that may have influenced the results was the small number of female patients, which was mainly related to the COVID-19 outbreak. The patients' fear of a hospital visit and the related risk of COVID-19 infection significantly limited the sample size.

Conclusions

The analysis of the prognostic factors and the association between vertigo and the results of the objective assessment of the vestibular organ and the levels of thyroid hormones (TSH, FT4) and thyroid autoantibodies (anti-TPO, anti-TG) in patients with Hashimoto's thyroiditis did not show a negative effect of thyroid hormone levels or increased thyroid antibody levels on abnormal results of the rotary chair test or the caloric test.

Conflict of interests

None declared.

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