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## **The impact of regular yoga practice on the course of endocrinological and diabetological disorders - a literature review**

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**Abstract**

**Introduction and purpose:** Yoga originates from ancient Indian culture. Its practice includes asanas (yoga poses) and relaxation (shavasana). An important element of yoga is breath control. It can also be practiced by individuals who are not adapted for physical activity. Numerous studies have proven the positive impact of yoga on various disorders. The aim of this study is to outline the role of yoga in the treatment of diseases with underlying endocrinological disorders: polycystic ovary syndrome, hypothyroidism, and type 2 diabetes.

**Brief description of the state of knowledge:** The growing interest in yoga practice has led to many studies evaluating the impact of regular yoga training on normalizing abnormal hormone levels, metabolic parameters, anthropometric measurements, as well as reducing clinical symptoms of a particular disease. The importance of yoga practice in improving the respiratory and circulatory system functions, regulating menstrual cycles, and ultimately - improving mental health, has also been the subject of research among endocrine patients. Their results suggest a positive impact of regular yoga training on many aspects of endocrine diseases and its advantage over conventional forms of physical activity.

**Summary:** Regular practice of yoga is beneficial as an additional element of therapy for endocrine diseases. It has an impact not only on the regulation of hormonal disorders or anthropometric parameters, but also on improving the mental state, which is often disturbed in endocrine patients. It is worth considering this form of physical activity instead of standard exercises, taking into account its additional benefits.

**Key words:** yoga; PCOS; hypothyroidism; type 2 diabetes; endocrine diseases

## Introduction

Yoga originates from ancient Indian culture [1]. Patanjali formulated eight parts of it: Yama (self-behavior control), Niyama (observance of principles), Asana (adopting specific postures), Pranayama (breath regulation), Pratyahara (restraining senses), Dharana (calming the mind), Dhyana (meditation), and Samadhi (universal awareness contemplation) [1].

Yoga reduces the activity of the sympathetic nervous system and the hypothalamic-pituitary-adrenal axis, and enhances the parasympathetic nervous system, contributing to stress reduction [2]. By affecting the reduction of cortisol levels, it has a positive impact on glycemic control [2]. By reducing stress and improving self-awareness, it helps to maintain a healthy lifestyle [2]. Many studies have been conducted, showing the positive impact of yoga on heart diseases, hypertension, diabetes, endocrine diseases, musculoskeletal diseases, depression, and even reduction of menstrual pain [3-8].

It is worth noting that people with obesity, limited joint mobility, and those not adapted to physical activity can also participate in yoga [9]. It is therefore an accessible form of exercise not only for healthy individuals, but primarily for those with various health conditions. The aim of this study is to outline the role of yoga in the treatment of diseases with underlying endocrinological disorders: polycystic ovary syndrome, hypothyroidism, and type 2 diabetes.

### PCOS - polycystic ovary syndrome

In women of reproductive age, polycystic ovary syndrome (PCOS) is considered the most common endocrine disorder, affecting 12-18% of them [10]. The Rotterdam criteria are used for its diagnosis:

Table 1. The Rotterdam Criteria [10]

The Rotterdam Criteria
Oligo- or anovulation
Hyperandrogenism features: clinical or biochemical
Polycystic ovaries image in ultrasound

At least two of the characteristics listed in the table must be met [10]. It should be noted that PCOS is a diagnosis of exclusion [10, 11]. Women affected by this condition experience a variety of disorders:

Table 2. Disorders related to PCOS [10-12]

<b>Disorders related to PCOS</b>
Reproductive: decreased fertility, infertility, disorders occurring during pregnancy
Metabolic: increased risk of IGT*, type 2 diabetes, cardiovascular diseases, NAFLD/NASH**, metabolic syndrome, obesity
Psychological: depressive and anxiety disorders, eating disorders, sexual disorders, sleep disorders

\*IGT - impaired glucose tolerance

\*\*NAFLD - nonalcoholic fatty liver disease; NASH - nonalcoholic steatohepatitis

The underlying cause of this syndrome is insulin resistance, which is associated with obesity (approximately 40-80% of women with PCOS are overweight or obese), and increased body weight leads to exacerbation of PCOS symptoms [10, 12]. A sedentary lifestyle, a diet based on processed foods, and environmental pollution can also contribute to the progression of the syndrome [10, 13]. Because of this, treatment recommendations take into account lifestyle modification leading to weight loss, which includes physical activity and diet [10-12]. Additionally, extremely important, and often overlooked in daily clinical practice, is the improvement of mental health [12]. Deeks AA et al. [14] demonstrated that anxiety, depression, and negative body image occur significantly more often among women with PCOS comparing to healthy individuals. Furthermore, the study conducted by Lamb JD et al. [15] indicates that physically active women with PCOS experience depression less frequently compared to those leading a sedentary lifestyle.

Untreated PCOS can lead to heart disease, hypertension, type 2 diabetes, infertility, as well as endometrial hyperplasia and cancer [11, 13]. Pharmacological treatment involves the use of [11]:

- Hormonal contraception in the treatment of menstrual disorders and symptoms of hyperandrogenism (such as hirsutism and acne),
- Metformin in the treatment of IGF and type 2 diabetes - in women for whom lifestyle modification was ineffective,

- Clomiphene in the treatment of infertility.

However, the effect of this treatment is transient, and moreover, it carries the risk of adverse effects [13]. Therefore, according to some authors, lifestyle modification should be the first-line treatment [16]. A special type of physical activity is yoga, because it affects not only the body but also the mind, bringing additional benefits for women with this syndrome [12].

Patel V et al. [17] in a randomized controlled clinical trial demonstrated the impact of regular yoga training (3 times a week for 3 months) on reducing levels of free testosterone and DHEA. They also showed that testosterone levels remained lower even after cessation of the exercises. Furthermore, they observed a reduction in the intensity of anxiety and depression in women undergoing the intervention. The table below presents, in a simplified manner, statistically significant differences in parameter results between groups ( $P < 0.05$ ):

	Control group (n = 9) - prior to intervention	Control group - after 3 months	P	Experimental group (n = 13) - prior to intervention	Experimental group - after 3 months	P
Free testosterone concentration (pg/mL)	7.39	7.36	> 0.05	5.96	4.24	0.0413
DHEA concentration (ng/dL)	382.7	368.3	> 0.05	359.7	316.6	0.0574
BAI	12.0	10.9	> 0.05	14.4	11.3	0.0365
BDI-II	18.0	12.0	> 0.05	16.0	7.25	< 0.0001

*BAI - Beck Anxiety Inventory*

*BDI - Beck Depression Inventory*

The reference values: free testosterone concentration 0.2-0.5 pg/mL; DHEA concentration 102-1185 ng/dL

However, neither of the groups demonstrated improvement in terms of levels of DHEA-S, androstenedione, fasting glucose, insulin, HOMA-IR, BMI, WHR (waist-hip ratio), or the severity of hirsutism.

Nevertheless, statistically significant improvement in anthropometric parameters among PCOS patients regularly practicing yoga was observed by Ratnakumari M et al. [18]. The aim of their study was to assess the impact of regular 3-month yoga training on anthropometric parameters, ovarian morphology, and menstrual cycle frequency in women with PCOS. They also documented statistically significant improvement in ovarian morphology. They suggested that regulating menstrual cycles requires longer intervention.

Furthermore, Shrivastava R et al. [19] describe the case of a 25-year-old woman with PCOS who underwent lifestyle modification, including regular yoga practice, a healthy diet, and sleep hygiene, resulting in a significant weight and BMI reduction, menstrual cycle regulation within 3 months, and normal ovarian morphology on ultrasound within 6 months.

Moreover, Mohseni M et al. [20] conducted a randomized controlled clinical trial assessing the impact of regular daily yoga training practiced for 6 weeks on anthropometric parameters, clinical symptoms, and blood pressure in patients with PCOS. Compared to the control group, the intervention group showed statistically significant reductions in hip and waist circumference, as well as a reduction in hirsutism. However, in this study, no statistically significant impact on BMI or blood pressure was observed. Likely, the influence of yoga on blood pressure values depends on the intensity and duration of its practice [20]. Activation of baroreceptors during performing asanas may modulate the activity of the sympathetic nervous system, lowering blood pressure and heart rate [20]. For instance, Lakkireddy D et al. [21], assessing the effectiveness of regular yoga practice among patients with atrial fibrillation, demonstrated a statistically significant decrease in systolic and diastolic blood pressure after a 3-month intervention.

In a prospective, controlled study conducted on infertile women with PCOS, Patil A. et al. [22] proved that a 90-minute daily yoga training over 3 months exerted a significant positive impact on body weight, postprandial insulin levels, cholesterol levels, LDL, HDL, as well as ultrasonographic parameters in PCOS. Additionally, women undergoing the intervention compared to the control group achieved greater improvement in quality of life regarding fertility disorders. Within a year, 13 women from the intervention group and 7 from the control group became pregnant, suggesting that adding yoga to conventional infertility treatment methods could increase the chances of conceiving a child.

Nidhi R et al. [23] conducted a randomized controlled clinical trial comparing the impact of yoga and conventional physical exercises on the course of PCOS. Yoga or standard exercises were practiced daily for one hour over 12 weeks. Statistically significant differences - in favor of yoga - were observed in terms of reducing LH and testosterone levels, hirsutism severity, and menstrual cycle regulation. In a separate study [24] comparing the effects of yoga and regular physical activity on anxiety severity in adolescents with PCOS, they also demonstrated the superiority of yoga.

Yoga plays a role not only in the therapy of PCOS but also in its prevention. Selvaraj et al. [25] demonstrated this in their study. It involved adolescents at moderate and high risk of this syndrome. Girls in the intervention group practiced yoga for the first 2 months and brisk walking for the next 2 months. The study results are presented in a simplified manner in the table below, developed based on the text:

<b>The number of patients</b>	<b>Control group - moderate risk</b>	<b>Intervention group - moderate risk</b>	<b>Control group - high risk</b>	<b>Intervention group - high risk</b>
<b>At the beginning of the study</b>	85	87	17	15
<b>At the end of the study</b>	90	49	12	0

The research results presented above demonstrate the positive impact of yoga on the course of PCOS. It can facilitate the normalization of LH and androgen levels, regulation of menstrual cycles, and increase the chance of conceiving a child for women with fertility disorders. It plays a role in improving the clinical picture of the disease. Its regular practice may contribute to reducing the severity of hirsutism and improving ovarian morphology. It also increases the chances of achieving psychological well-being.

### **Hypothyroidism**

Hypothyroidism is the most common endocrine disorder, occurring more frequently in women than in men [3, 26]. In the European population, depending on the diagnostic criteria used, it affects 0.2-5.3% of the population [27]. It is an independent risk factor for cardiovascular diseases, metabolic syndrome, infertility, and depression [3]. Thyroid hormone



deficiency results in a decrease in metabolic activity in the body [26]. The clinical presentation varies from asymptomatic to coma [27]. Symptoms include weight gain, cold intolerance, fatigue, menstrual irregularities, dry skin, and hair loss [27].

Depression is common in this medical condition [28]. It is associated with the severity of the disease symptoms and its exacerbation (its presence correlates with higher levels of anti-TPO antibodies) [28]. Therefore, it can be inferred that yoga, as a practice contributing to mental well-being, may play a role in alleviating the symptoms of hypothyroidism.

The treatment of hypothyroidism involves hormone replacement therapy with thyroxine [3, 26]. Lifestyle modification is also important, including physical activity, a healthy diet, and sleep hygiene [3, 29].

Rani S et al. (28) conducted a clinical study assessing the impact of regular three-month yoga exercises (60 minutes 5 times a week) on the severity of depression, stress, anxiety, fatigue as well as lipid profile, BMI, and TSH levels in women with hypothyroidism coexisting with mild or moderate depression. The training included asanas, pranayama, and relaxation techniques. The table below presents parameters that showed statistically significant improvement after the study ( $P < 0.05$ ):

Parameter	Percentage decrease	Percentage increase
sTSH	-37.2	
Intensity of fatigue	-64.9	
Intensity of stress	-55.2	
Severity of anxiety	-58.3	
Severity of depression	-58.0	
BMI	-6.0	
HDL		14.9

*TSH - Thyroid-Stimulating Hormone; BMI - Body Mass Index; HDL - High-Density Lipoprotein*

On the other hand, Nilakanthan S et al. [30] investigated the impact of six months of regular yoga training (1 hour daily, 4 times a week) on lipid profile, thyroxine dosage, and TSH levels in women with hypothyroidism. They observed a statistically significant reduction in

total cholesterol, LDL, and triglyceride levels, as well as the thyroxine dosage required to achieve euthyrosis. Unlike the study by Rani S et al. [28], in this case, the decrease in TSH concentration was not statistically significant:

Parameter	Percentage decrease	Percentage increase	P
Total cholesterol	-7.90		< 0.001
Triglycerides	-7.23		< 0.001
HDL		5.10	< 0.05
LDL	-9.24		< 0.05
TSH	-14.00		> 0.05 (0.45)
Thyroxine dose	-15.30		< 0.05

*HDL - High-Density Lipoprotein; LDL - Low-Density Lipoprotein; TSH - Thyroid-Stimulating Hormone*

Singh P et al. [26] demonstrated in their trial the impact of regular yoga training (once a day for a month) on improving the quality of life of patients with hypothyroidism. The authors of a similar study are Akhter J et al. [31]. In this instance, patients in the experimental group practiced yoga regularly for a longer period of time (6 months). Investigators observed a statistically significant improvement in the physical aspect of quality of life (17.79%) as well as in the psychological dimension (18.38%) among individuals practicing yoga compared to the control group.

In response to manipulation of breathing movements, which is the essence of pranayama, there is an increase in parasympathetic nervous system activity, resulting in a subsequent decrease in heart rate and arterial pressure, as well as tissue oxygen consumption (32). Chintala KK et al. [33] demonstrated the beneficial impact of pranayama (practiced daily for a month) on cardiovascular autonomic function in patients with hypothyroidism. The results of this study show that the practice of pranayama modulates the activity of the autonomic nervous system, leading to a predominance of parasympathetic activity.

Sharma and Mahabala P [34] assessed the change in thyroid hormone levels and TSH in women with hypothyroidism who practiced yoga regularly for 3 months. They demonstrated a statistically significant improvement in thyroid hormone levels. Additionally, women practicing yoga reported a reduction in gastrointestinal symptoms as well as a sense of psychological well-being.

Muscle weakness in hypothyroidism also affects respiratory muscles [35]. Therefore, it's not surprising that pranayama, which involves breathing exercises, has become a subject of research in this field. Swami G et al. [35] investigated the impact of regular, six-month pranayama practice (45 minutes daily) on respiratory function among women with hypothyroidism. All spirometric parameters measured in the study showed improvement compared to baseline values.

Moreover, respiratory infections are more common among individuals with hypothyroidism [35]. By positively influencing the immune system, yoga may serve as a protective factor in this case [35].

The studies presented above show that regular yoga practice can improve the effectiveness of thyroid hormone replacement therapy and may even allow for a reduction in levothyroxine dosage. It can facilitate achieving euthyroidism and normalization of lipid levels, thereby reducing cardiovascular risk in patients. In this disease entity, an important part of yoga appears to be pranayama, which significantly influences the respiratory system's function and improves psychological well-being.

## **Type 2 diabetes**

Diabetes is a chronic disease characterized by inadequate insulin production by the pancreas or the inability of tissues to use it [36, 37], leading to hyperglycemia. Insulin is an anabolic hormone that plays an important role in the metabolism of carbohydrates, fats, and proteins [37].

The severity of clinical symptoms depends on the duration and type of diabetes [37]. In type 1 diabetes, characterized by the destruction of pancreatic beta cells by autoantibodies [38], symptoms such as polydipsia, polyuria, increased appetite, weight loss, and visual disturbances occur more frequently [37]. Patients with type 2 diabetes, especially in its early stage, may be completely asymptomatic [37]. The underlying factors of this type of diabetes are inadequate insulin secretion relative to glycemic levels and insulin resistance [37, 38].

Diabetes is an important risk factor for heart attack and stroke [36]. It also leads to damage to the blood vessels of the retina, kidneys, and nerves [36]. Its prevalence is rapidly increasing, primarily affecting developed countries [36]. In 2021, its global prevalence was estimated at 537 million [38]. It is projected that by 2045, this number will reach 783 million [38].

The treatment of type 2 diabetes primarily involves the use of antihyperglycemic medications, which are not free from adverse effects [36]. Pharmacotherapy often proves insufficient in achieving glycemic control [2]. Therefore, incorporating lifestyle modifications, including a healthy diet, regular physical activity, and stress management, alongside pharmacological treatment, is crucial in managing this condition [2]. In our article, we aim to explore the role of yoga in complementing the therapy for type 2 diabetes.

Chimkode SM et al. [9] conducted a study aimed at assessing the impact of regular 6-month yoga training on blood glucose levels in patients with type 2 diabetes. They demonstrated a statistically significant reduction in fasting and postprandial blood glucose levels compared to values at the beginning of the study and after 3 months of regular training. A similar study was conducted by Kumar K [39], who also proved the positive role of yoga in relation to these parameters.

Moreover, Amita S et al. [40] in their study compared glycemia levels in patients with type 2 diabetes between two groups: the experimental group, whose members, in addition to hypoglycemic treatment, practiced yoga, and the control group, in which patients used only diabetes pharmacotherapy. Yoga was practiced for 30 minutes daily for 90 days. They also observed a statistically significant decrease in fasting and postprandial glucose levels after 3 months of yoga practice in the study group. Similarly to other investigators, they also observed a statistically significant decrease in fasting and postprandial glucose levels after a 3-month yoga practice.

The aim of the randomized controlled clinical trial by Hirosaki M et al. [41] was to investigate whether laughter yoga affects glycemic control improvement among patients with type 2 diabetes. Patients in both groups received standard treatment. Patients in the experimental group additionally practiced yoga for 12 weeks. The study included parameters such as: HbA1c, body mass, waist circumference, psychological factors, and duration of sleep. The researchers demonstrated a statistically significant improvement in HbA1c concentration and positive affect scores. It is worth noting that reducing HbA1c by 1% reduces the risk of diabetic retinopathy, nephropathy, and neuropathy by 40% [2].

The randomized controlled clinical trial conducted by Danasegaran M et al. [42] showed that a 12-week regular yoga practice (including asanas and pranayama) statistically significantly influences the reduction of cardiometabolic risks [total power of heart rate variability, rate pressure product (the marker of myocardial stress), lipid risk factors, MDA level (malondialdehyde), and hsCRP (high-sensitive C-reactive protein)] in patients with type 2 diabetes.

Malhotra V et al. [43] conducted a clinical trial to assess the impact of regular yoga training on nerve conduction velocity in patients with type 2 diabetes and subclinical diabetic neuropathy. The experimental group underwent a 40-day intervention consisting of daily yoga training (asanas, 30-40 minutes per day). The control group received mild physical activity (walking) instead of yoga. After the study, an increase in conduction velocity was observed in the yoga group in both the right and left median nerves. In the control group, there was a slow progression of deterioration in conduction velocity, which is typical of diabetes.

In a randomized controlled clinical trial, Bock BC et al. [44] compared yoga training and standard physical exercises in terms of viability, acceptability, HbA1c concentration, level of emotional stress, self-care, and quality of life. Yoga in the experimental group and standard exercises in the control group were practiced twice a week for 12 weeks. Satisfaction with the classes was high in both groups. Among the patients practicing yoga, the HbA1c level at the end of the study was lower compared to the control group. Yoga also showed advantages over standard exercises in improving self-care, quality of life, emotional well-being, and mindfulness.

Raghuram N et al. (45) carried out a randomized controlled clinical trial among individuals at high risk for diabetes. It aimed to assess the effectiveness of yoga in reducing the risk of progression from pre-diabetes to diabetes (primary outcome) and achieving normoglycemia (secondary outcome). Individuals in the experimental group practiced yoga regularly for 3 months. Authors showed that yoga more effectively compared to standard care inhibits the progression of pre-diabetes, and furthermore accelerates the achievement of normoglycemia.

The studies above prove the positive impact of regular yoga practice on the course of type 2 diabetes, also in comparison with standard physical activity. It can slow down the progression of prediabetes and accelerate the achievement of normoglycemia. It leads to a reduction in cardiovascular risk and lowers the risk of diabetic retinopathy, nephropathy, and neuropathy. People with diabetic neuropathy practicing yoga may benefit from an increase in

nerve conduction velocity. The improvement in mental state and quality of life of patients is also important.

### **Conclusions**

The research results presented above demonstrate the positive impact of regular yoga practice on the course of PCOS, hypothyroidism, and type 2 diabetes. Yoga can facilitate the normalization of abnormal hormone levels, lipids, and glycemia. It contributes to improving anthropometric parameters. It reduces cardiovascular risk and improves respiratory system function. In patients with PCOS, it leads to reducing the severity of hirsutism and improving ovarian morphology, as well as regulating menstrual cycles, increasing the chance of conceiving a child. Among those with hypothyroidism, it improves the effectiveness of substitution therapy, allowing for a reduction in the dose of thyroxine. In individuals with type 2 diabetes, it lowers the risk of micro- and macroangiopathic complications. Improving mental health and quality of life in individuals regularly practicing yoga is relevant as well. However, more extensive research conducted on a larger group of patients is needed to introduce yoga training into daily clinical practice. In my opinion, in an individualized approach to treatment, yoga should be considered primarily as a possibility to complement standard therapy in individuals who may derive additional benefits from its practice, such as improving mental health in those with depressive and/or anxiety disorders or increasing self-awareness and thereby compliance in non-compliant patients.

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Authors do not report any disclosures

### **Author's contribution**

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The authors declare no conflict of interest.

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