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Sleep Quality and Reproductive Health in Physically Active Women - The Literature Review

Katarzyna Milewska-Plis, Igor Kłak, Jan Szerocki, Wiktoria Nowakowska, Katarzyna Bartnik, Katarzyna Chwaleba, Ksenia Mazur, Monika Karalus, Weronika Curyło, Alina Grudina

Katarzyna Milewska-Plis

Faculty of Medical Sciences in Katowice, Medical University of Silesia, Medyków 12, 40-055 Katowice, Poland

<https://orcid.org/0009-0008-9931-5294>

milewska.k26@gmail.com

Igor Kłak

Independent Public Health Care Center Of the Ministry of Internal Affairs and Administration in Cracow; Kronikarza Galla 25, 30-053 Kraków, Poland

<https://orcid.org/0009-0005-3654-6755>

igor.klak98@gmail.com

Jan Szerocki

Independent Public Health Care Center Of the Ministry of Internal Affairs and Administration in Cracow; Kronikarza Galla 25, 30-053 Kraków, Poland

<https://orcid.org/0009-0002-2107-9777>

jasias99@interia.pl

Wiktoria Nowakowska

ORTOMED PLUS Dental Practice os. Wichrowe Wzgórze 122/3, 61-699 Poznań, Poland

<https://orcid.org/0009-0004-7358-9669>

wiktorianow@gmail.com

Katarzyna Bartnik

5th Military Hospital with Polyclinic in Cracow: Cracow, Wrocławska 1-3 Street 30-901
Kraków, Małopolska, Poland

<https://orcid.org/0009-0005-9095-5875>

kasiabartnik08@gmail.com

Katarzyna Chwaleba

University Hospital in Cracow, Jakubowskiego 2, 30-688 Kraków, Poland

<https://orcid.org/0000-0002-7064-0834>

chwalebakatarzyna@gmail.com

Ksenia Mazur

Independent Public Clinical Hospital No.2 of the Pomeranian Medical University in Szczecin,
al. Powstańców Wielkopolskich 72, 70-111 Szczecin, Poland

<https://orcid.org/0009-0008-8552-2903>

ksenia1016@gmail.com

Monika Karalus

Independent Public Clinical Hospital named after Prof. W. Orłowski, Center of Postgraduate
Medical Education, Czerniakowska 231, 00-416 Warsaw, Poland

<https://orcid.org/0009-0005-9355-4698>

m.karalus@protonmail.com

Weronika Curyło

Faculty of Medical Sciences in Katowice, Medical University of Silesia, 40-055 Katowice, Poland

<https://orcid.org/0009-0007-0254-3569>

weronikaccurylo@gmail.com

Alina Grudina

University Hospital in Cracow, Jakubowskiego 2, 30-688 Kraków, Poland

<https://orcid.org/0009-0006-1280-7006>

grudinaalina@gmail.com

Corresponding author: Katarzyna Milewska-Plis, <https://orcid.org/0009-0008-9931-5294>

milewska.k26@gmail.com

Abstract

Sleep plays a crucial role in maintaining women's reproductive health, as it regulates the secretion of key hormones within the hypothalamic-pituitary-gonadal (HPG) axis and modulates inflammatory processes. This literature review explores the complex, bidirectional relationships between sleep, the menstrual cycle, and fertility in physically active women. Physiological mechanisms, including the roles of melatonin, cortisol, and sex steroids, are discussed in the context of sleep architecture. Moreover, the review highlights how moderate physical activity generally promotes better sleep quality, while excessive or poorly planned exercise can disrupt sleep patterns, elevate cortisol levels, and impair reproductive function. The prevalence of sleep disorders—such as insomnia, restless legs syndrome, and circadian rhythm misalignment—among female athletes is examined, with emphasis on their underdiagnosis and potential consequences for performance and health. Non-pharmacological strategies, including behavioral interventions, sleep hygiene education, and sleep tracking technologies, are proposed as first-line measures to improve sleep quality and reduce the risk of menstrual irregularities and infertility. Pharmacological treatments are also mentioned as a complementary approach in complex cases. Finally, the review identifies gaps in current research and underscores the importance of integrating sleep management into the care of physically active women to safeguard both reproductive and overall health.

Keywords: sleep, sleep disorders, menstrual cycle, physical activity, women's health

Introduction

Sleep is one of the basic biological functions of all living organisms. Adequate sleep contributes to maintaining homeostasis, influencing the proper functioning of various systems, including the immune, endocrine, and reproductive systems. Regular physical activity, depending on its intensity, affects many aspects of the body's functioning. Numerous scientific studies conducted over the years show that both lack of sleep and poor sleep quality have a negative impact on women's reproductive health, causing menstrual cycle disorders and contributing to infertility, which in turn leads to an overall reduction in quality of life. The aim of this article is to analyze the available scientific literature on the impact of physical activity on sleep and reproductive health in women. The study presents an analysis of scientific articles published between 2000 and 2025 on the above topic.

Materials and Methods

The authors searched the following databases to review the available medical literature on the impact of sleep quality on the reproductive system of physically active women: PubMed, Google Scholar, UpToDate, ScienceDirect, and Cochrane Library. The following keywords were used to search for articles: sleep, sleep quality, reproductive system, and physical activity.

The scientific articles found were published between 2000 and 2025. After analyzing the abstracts, 43 scientific articles were selected and read, on which this study is based.

Physiology of Sleep

Sleep is one of the basic biological processes of living organisms, which is regulated by both homeostatic and circadian mechanisms. Sleep is a state of natural and reversible reduction in the threshold of sensitivity to stimuli from the external environment and loss of consciousness. The need for sleep is cyclical, occurring at regular intervals. Disturbances or lack of sleep can contribute to the development of serious emotional and cognitive disorders. There are two main phases of sleep: non-rapid eye movement (NREM) and rapid eye movement (REM), each of which is responsible for distinct physiological functions. NREM sleep is associated with physical regeneration, immune regulation, and hormone secretion, and is therefore

primarily responsible for maintaining the body's homeostasis, while REM sleep plays a key role in cognitive processes and emotional regulation, contributing to proper social functioning (1).

In addition, sleep also plays an important role in neuroendocrine regulation by influencing the pulsatile release of hormones from the hypothalamus (liberins) and the pituitary gland (tropins). Growth hormone (GH), secreted by the hypothalamus, reaches its peak secretion during deep sleep, while the secretion of gonadotropin-releasing hormone (GnRH) from the pituitary gland is correlated with the duration and quality of sleep. Therefore, considering the above, disruption of the normal sleep rhythm can affect the functioning of the hypothalamic-pituitary-gonadal (HPG) axis, which undoubtedly disrupts reproductive functions (2).

Another equally important neuroendocrine substance that influences the regulation of the circadian rhythm is melatonin. It is a protein hormone synthesized mainly by the pineal gland at night. Melatonin has a complex effect on the human body, but it should be emphasized that this hormone regulates both indirectly and directly the function of the gonads in humans. The most important aspect of melatonin's effect on the reproductive system involves the regulation of the secretion of other hormones, such as prolactin, lutropin, follitropin, and others responsible for the proper reproductive function of the body. In addition, melatonin also has a direct regulatory effect on ovarian function by providing antioxidant protection in the ovarian follicles (3). Sleep is therefore closely linked to reproductive health, both at the molecular and systemic levels.

The Impact of Sleep Disorders on the Female Reproductive System

Sleep is responsible for the proper functioning of the female reproductive system, so sleep disorders contribute to fertility problems. The following sleep disorders are distinguished: insomnia, sleep apnea, circadian rhythm disorders, and insufficient sleep. Poor sleep quality is associated with menstrual cycle disorders, including scanty menstruation, lack of ovulation, and luteal phase disorders (4, 5).

Women suffering from chronic sleep deprivation often show elevated serum cortisol levels, accompanied by reduced melatonin levels. These hormonal changes disrupt the physiological pulsatile secretion of GnRH, followed by LH and FSH, leading to impaired ovarian follicle maturation and ovulation disorders (6). Oligoovulation manifests as menstrual disorders,

contributing to female infertility. In addition, altered sleep patterns are associated with increased systemic inflammation, characterized by increased production of numerous pro-inflammatory cytokines, i.e., IL-6 and TNF- α , which may negatively affect endometrial receptivity (4). Chronic inflammation is a recognized etiological factor involved in the pathophysiology of a number of diseases that reduce fertility, such as obesity, along with metabolic syndrome, or even polycystic ovary syndrome. Therefore, with sleep disturbances increasing over time, there is an increase in the concentration of pro-inflammatory cytokines and the development of chronic, generalized inflammation of the body, which impairs the functioning of the hypothalamic-pituitary-gonadal axis.

The results of the latest scientific studies confirm the adverse effect of sleep disorders on fertility. For example, studies have shown that women who sleep less than six hours a day are significantly less likely to become pregnant and have a higher risk of miscarriage (7).

The Effect of Physical Activity on the Female Reproductive System

The impact of physical activity on the functioning of the female reproductive system should be considered in two ways. It is well known that moderate physical activity helps maintain hormonal balance and reproductive function, while excessive extreme training—especially in combination with a calorie deficit—can have a detrimental effect on reproductive function. Available scientific studies, including a meta-analysis of over 700,000 people, have shown that as physical activity levels increase, the risk of infertility decreases in both women and men. The level of physical activity that has a positive effect on fertility is considered to be the equivalent of 150 minutes per week of moderate aerobic activity (e.g., cycling, running, swimming), or 75 minutes of vigorous aerobic activity per week, or a combination of the above, giving a total equivalent energy expenditure as defined by the WHO (8). On the other hand, it is worth noting that excessive physical activity shows a positive correlation with reduced parental chances. Excessive physical activity is understood as an amount exceeding the values considered moderate.

Female athletes, especially those who participate in endurance sports professionally, are at risk of a number of implications for the endocrine system. Studies have shown that women who have been involved in professional sports for many years are primarily at risk of developing functional hypothalamic amenorrhea (FHA), the pathophysiology of which involves suppression of the hypothalamic-pituitary-ovarian axis without accompanying

anatomical changes or other organic diseases. This disorder occurs primarily among women who practice sports where it is important to maintain a low body weight (with reduced body fat) and undergo intensive endurance training (gymnasts, long-distance runners, ballet dancers). According to the literature, the above-mentioned disorders may occur in up to 70 percent of athletes in these disciplines. FHA is characterized by inhibition of GnRH pulsation and low estrogen levels (9). This condition often results from the accumulation of stress caused by heavy training, insufficient calorie intake, and psychosocial pressure.

It should be emphasized that reproductive disorders caused by physical exertion are also caused by increased cortisol secretion, changes in leptin and ghrelin concentrations, and decreased levels of insulin-like growth factor 1 (IGF-1), which affect the HPG axis. Leptin sends a signal to the central nervous system about the availability of energy reserves in the body. Female athletes with extremely low body fat, where leptin is produced and stored, are at risk of chronic leptin deficiency, which results in inhibition of pulsatile GnRH secretion to the hypothalamus, followed by a decrease in FSH and LH, contributing to ovarian hormone secretion disorders. Chronic inflammation caused by intense training also disrupts the physiologically functioning hormone feedback loops (10).

Although the initial suppression of reproductive function may seem adaptive in female athletes (i.e., energy conservation), over time it can lead to long-term effects such as reduced bone density, impaired fertility, or increased risk of cardiovascular disease.

Menstrual Cycle and Sleep Quality

The female menstrual cycle is divided into three phases: the secretory phase, ovulation, and the luteal phase. Regular fluctuations in estrogen and progesterone levels during the different phases of the menstrual cycle affect the length and quality of sleep (11,12). In the first phase of the menstrual cycle, serum estrogen levels increase, thereby affecting the REM phase of sleep. In addition, estrogen shortens the latency of stage I and prolongs its total duration (13,14). However, in a study conducted by Ressel et al. showed a positive correlation between estradiol concentration and REM phase duration. In addition, a negative correlation was found between estradiol concentration and deep sleep duration (15). No relationship was found between estradiol concentration and REM phase duration or total sleep duration (16). Discrepancies in the literature, as well as the demonstration of a weak correlation between the

variables studied, indicate the need for further research on the relationship between estrogen concentration in women and sleep (17).

Progesterone, on the other hand, acts mainly on the NREM phase of sleep, shortening the latency of stage I. Its action is sometimes compared to that of sedatives (18). In the luteal phase, increased progesterone levels cause thermogenic effects, raising body temperature and reducing the slow-wave sleep (SWS) phase. This results in sleep fragmentation and greater subjective fatigue (19).

Many women report poorer sleep quality during the premenstrual phase, which is often accompanied by mood swings, headaches, and night sweats. These symptoms may be exacerbated in active women, in whom training stress additionally affects hormonal sensitivity (12).

On the other hand, poor sleep can affect the menstrual cycle. Studies suggest that short or irregular sleep can lead to longer or irregular cycles, lack of ovulation, or worsening menstrual symptoms (12). The bidirectional relationship between sleep and the menstrual cycle highlights the importance of monitoring both factors simultaneously.

Physical Activity and Sleep Quality

The relationship between physical activity and sleep is bidirectional and complex. While regular moderate-intensity exercise generally promotes better sleep by improving sleep onset, sleep duration, and sleep quality, excessive or poorly planned exercise can have the opposite effect (20,21). Several studies have shown that women who engage in moderate physical activity have deeper sleep, better sleep efficiency, and wake up less often during the night (22). This may be due to the thermoregulatory and anti-anxiety effects of exercise (23). However, intense training or late-night training can delay melatonin secretion and increase arousal before bedtime. Athletes often report difficulty falling asleep after intense evening workouts due to the activation of the sympathetic nervous system (24). In addition, overtraining or overload can increase cortisol levels, which further impairs sleep quality and recovery (25). Circadian rhythm misalignment, which is common in traveling athletes, especially during important sporting events, also contributes to sleep fragmentation and poorer subjective sleep quality (26). It has also been suggested that frequent, irregular time zone changes may have a negative effect on sleep duration and quality (27).

Clinical Aspects of Sleep Disorders in Physically Active Women

Sleep disorders in women who are professional athletes are often underestimated, resulting in a lack of diagnosis and treatment. They are also often normalized as a side effect of intense physical activity and accompanying fatigue. Examples of the most common symptoms of sleep disorders in the population of competitive athletes are listed in the table below:

Table 1. The occurrence of sleep disorders among professional athletes.

Incidence rate [%]	Sleep disorders among professional athletes
27-37	Insomnia (28);
77	Problems with maintaining sleep continuity;
13	Restless legs syndrome (in runners) (29);
No detailed data available	Obstructive sleep apnea (athletes practicing strength sports, at risk of obesity) (30);
No detailed data available *approx. 3 (in the general adult population (31)	Circadian Rhythm Sleep Disorders (32).

The above symptoms are ignored until they manifest themselves in a decrease in performance or a clear negative impact on sports results. The tools used to diagnose sleep disorders are polysomnography and actigraphy. Due in part to these tools, it is possible to identify the following disorders: insomnia, sleep apnea, and circadian rhythm disorders. A valuable direction for the development of somnology seems to be the introduction of screening tests, especially in women diagnosed with amenorrhea, fatigue, or unexplained performance decline (33).

Improving Sleep Quality in Female Athletes

Effective interventions to improve sleep in physically active women require a holistic approach that addresses both behavioral and physiological factors. Below are some examples of suggestions aimed at improving sleep quality in physically active women:

Table 2. Modifications of activity improve sleep quality in physically active women.

Category of modification	Suggested activity	Benefit of the activity
Behavioural	Educate the patient on sleep hygiene;	Gaining greater awareness of the role of physical activity in sleep physiology (34);
	Limiting the impact of light emitted by screens before bedtime;	Reducing blue light emission increases melatonin synthesis (35);
	Ensuring a regular sleep-wake cycle.	Regulation of hormonal feedback loops leading to the maintenance of homeostasis (36).
Physiological	Limiting intense physical activity to a minimum of 2-3 hours before bedtime in favor of low-intensity relaxing exercises;	Reduce the amount of cortisol secreted during intense physical activity in favor of relaxing exercises, such as yoga (37,38);
	Consume (in small amounts) carbohydrates and/or tryptophan before bedtime;	Substitution of neurotransmitter precursors (serotonin and melatonin), contributing to shorter sleep onset and improved sleep quality (39);
	Limiting daily caffeine intake (class D recommendation);	Reducing the risk of exacerbating sleep disorders (e.g. RLS) (40);
	Consider vitamin D and iron supplementation, even in patients with normal serum levels of these elements.	Effect on dopamine and serotonin neuromodulation; increase in ferritin concentration; prevention of the development of sleep disorders (e.g. RLS (41).
Psychological	Cognitive Behavioral Therapy for Insomnia.	Improvement of sleep quality, reduction of anxiety, implementation of healthy sleep hygiene habits (42).
Technological	Use of electronic devices that enable monitoring of sleep duration and quality.	Objectification of sleep parameters, possibility of comparing data over time (43).

Additionally, it is worth emphasizing that the measures proposed above focus on non-pharmacological management of sleep disorders in women who engage in regular, intense physical activity. It is also important to mention pharmacological methods of treating these disorders, which in many cases constitute the mainstay of therapy. Pharmacological treatment is beyond the scope of this article. However, it is worth mentioning that the consensus published by the British Association for Psychopharmacology presents numerous

recommendations (40). The recommendations were formulated on the basis of the reliability of scientific data and the strength of the recommendations, and therefore constitute a comprehensive guide to the treatment of sleep disorders for specialists involved in their treatment. In addition, the presence of comorbidities, such as hypothyroidism, hyperthyroidism, anemia, mental disorders, and the use of psychoactive and addictive substances, should be ruled out.

Conclusion

Both sleep and physical activity play an important role in maintaining women's reproductive health. Sleep disorders, especially sleep deprivation and poor sleep quality, can lead to dysfunction of the hypothalamic-pituitary-gonadal axis, resulting in menstrual disorders, anovulation, and infertility. Moderate physical activity, on the other hand, improves sleep quality and supports the proper functioning of the reproductive system. However, excessive exercise, especially when combined with a persistent calorie deficit, can lead to functional menstrual disorders, secondary amenorrhea, and fertility problems. The relationship between sleep and physical activity is complex and bidirectional—activity affects sleep, and sleep quality modifies the effects of training and hormonal regulation. Optimizing lifestyle, including adequate sleep and balanced physical activity, should be an important part of preventing reproductive disorders in women. Proper education on hygiene and good sleep habits is also very important. This is a very important element in the prevention of sleep disorders. However, it should be remembered that in the case of diagnosed sleep disorders, physically active women should be referred to specialists in diagnosis and treatment in order to implement the correct management and prevent long-term complications.

Disclosure

Author Contributions:

Conceptualization: Katarzyna Milewska-Plis

Methodology: Katarzyna Milewska-Plis

Supervision: Katarzyna Milewska-Plis

Investigation: Igor Kłak

Check: Igor Kłak

Resources: Jan Szerocki

Formal analysis: Wiktoria Nowakowska

Writing-rough preparation: Katarzyna Bartnik

Writing-review and editing: Katarzyna Chwaleba

Visualization: Ksenia Mazur

Software: Monika Karalus

Project administration: Weronika Curyło

Data curation: Alina Grudina

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