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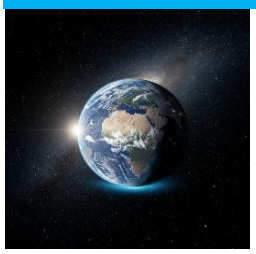

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Sleep and the Menstrual Cycle from Puberty to Menopause: A Review of Literature with Extra Focus on Athletes

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Abstract

Introduction

Sleep is essential for recovery and is influenced by circadian rhythms and hormonal changes across a woman's lifespan. However, evidence on how the menstrual cycle affects sleep remains inconsistent. As sleep is critical for athletic performance, understanding these relationships is important for optimizing recovery in female athletes.

Aim

This review examines clinical evidence on how ovarian hormone fluctuations and related symptoms influence sleep across different life stages, with a focus on athletes.

Material and Methods

A literature search was conducted in PubMed using keywords such as "menstrual cycle," "estradiol," "luteal," "perimenopause," "sleep," "sleep disturbances," and "athletes."

Results

In adolescents, menstrual pain is a greater cause of poor sleep than cycle phase. During reproductive years, sleep disturbances are more common in the luteal phase, although lifestyle and health factors also contribute. Athletes similarly report poorer sleep and fatigue in this phase, with training load and physical symptoms playing a major role. In menopause, reduced deep sleep and weakened circadian rhythms lead to more frequent sleep disruptions.

Conclusions

Sleep varies across life stages, with the luteal phase being most associated with disturbances. For adolescents and athletes, managing pain and physical stress may be more effective than tracking cycle phases. Improving women's sleep requires individualized approaches focused on overall health and symptom management.

Key words: menstrual cycle, sleep, recovery, estrogen, progesterone, luteal, follicular, perimenopause, athletes

Content

1. Introduction

a. Background

The relationship between the menstrual cycle and sleep has been studies for many years. Sleep is not just downtime, it is a fundamental physiological recovery process driven by a tight interplay between homeostatic and circadian signaling. This regulation is heavily influenced by ovarian hormone modulation. We see estrogen and progesterone receptors distributed throughout the key CNS regions that govern sleep, specifically the basal forebrain, hypothalamus, dorsal raphe nucleus, and the locus coeruleus (Alzueta i Baker 2023). Beyond just "sleepiness," these gonadal hormones also modulate the suprachiasmatic nucleus, which effectively exerts control over broader

circadian rhythms (Gava et al. 2019). Because of this, the hormonal shifts seen throughout a woman's reproductive lifespan, from menarche through menopause, directly impact sleep architecture. In a sports medicine context, where sleep extension is already a proven tool for boosting athletic performance, understanding these hormonal nuances becomes vital for tailoring recovery protocols (Cunha et al. 2023).

b. Menstrual cycle overview

The menstrual cycle begins with the menstrual phase, where a sharp withdrawal of both estrogen and progesterone triggers endometrial shedding. This leads directly into the follicular phase. The hypothalamus secretes GnRH, which in turn stimulates FSH production to promote ovarian follicle growth (Monis i Tetrokalashvili 2025). As these follicles develop, they drive a rise in estrogen that effectively thickens the uterine lining (Monis i Tetrokalashvili 2025). We then see mid-cycle ovulation, which is triggered by a distinct LH surge alongside peak estrogen levels. The cycle wraps up with the luteal phase. This is dominated by progesterone from the corpus luteum, which prepares the body for potential implantation. If pregnancy does not occur, these hormone levels naturally drop off, resetting the entire biological loop (Rugvedh, Gundreddy, i Wandile b.d.).

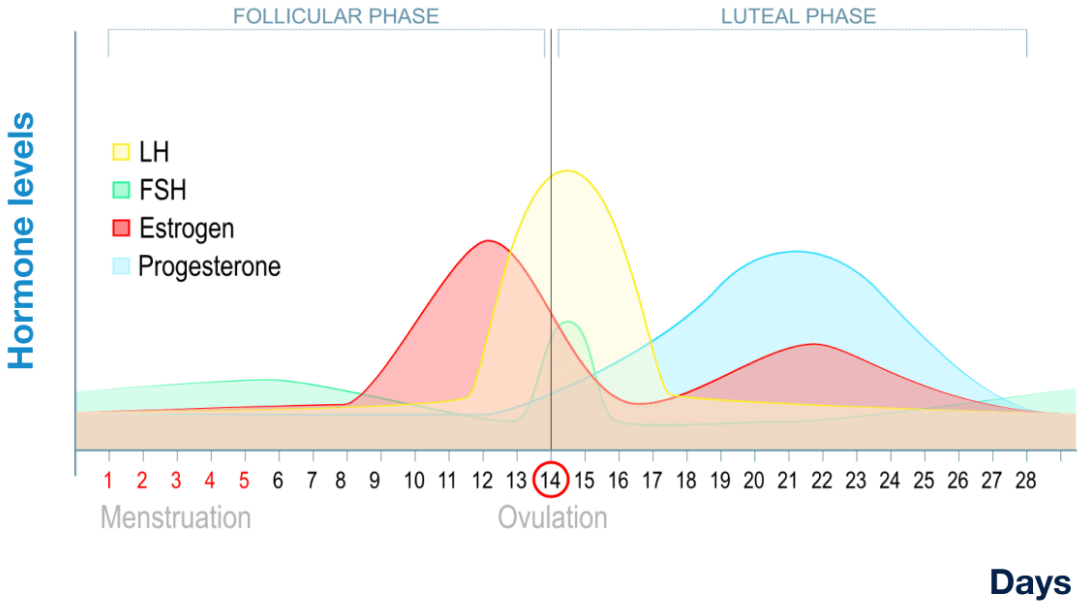

Figure 1. (Normal Menstrual Cycle | UCSF Center for Reproductive Health)

c. Hormones and sleep

Gonadal hormones play contrasting roles in regulating sleep and mood. Estrogen acts as a stabilizer that reduces sleep latency meaning the time it takes to fall asleep. It promotes REM sleep and actively promotes lower body temperature. (Baker, Siboza, i Fuller 2020) This effect is most prominent during the follicular phase when estrogen is the dominant steroid. Progesterone and its metabolite, allopregnanolone, modulate the GABAergic pathways by suppressing synaptic transmission.(Gava et al. 2019) This process is thought to have an anxiolytic effect

comparable to the pharmacological effect of benzodiazepines. However, this is a double-edged sword, because while its sedative quality aids in sleep onset, it primarily promotes lighter NREM sleep, which can limit the time spent in deeper, restorative stages(Gava et al. 2019; Morssinkhof et al. 2020). When progesterone levels drop, such as during the premenstrual period or throughout the transition into menopause, the loss of its sedative effect often leads to decline in sleep quality (Tandon et al. 2022). Furthermore, the thermogenic effect of progesterone raises core body temperature, frequently leading to fragmented sleep and disrupted deep sleep architecture. (Baker, Siboza, i Fuller b.d.). This biological interface explains why sleep patterns so closely mirror the hormonal shifts of the menstrual cycle and why hormonal changes during perimenopause frequently result in sleep disorders.

d. **Menopausal Transition**

The transition toward menopause is marked by a progressive decline in ovarian activity (Santoro 2005). This withdrawal of estrogen disrupts the standard regulation of gonadotropins, which in turn triggers the pituitary gland to release erratic, unpredictable levels of FSH and LH (Tandon et al. 2022). Interestingly, research suggests that these fluctuations—rather than just the absolute baseline levels—are the primary drivers of sleep disruption in these patients. Specifically, rising FSH levels correlate with difficulties in staying asleep, while the decrease in estrogen is linked to both increased sleep latency and a general inability to maintain sleep (Gava et al. 2019; Santoro 2005). These hormonal imbalances are the primary drivers of the symptoms associated with menopause, such as hot flashes, vaginal dryness and sleeping problems.(Patel, Patil, i Kaur 2025).

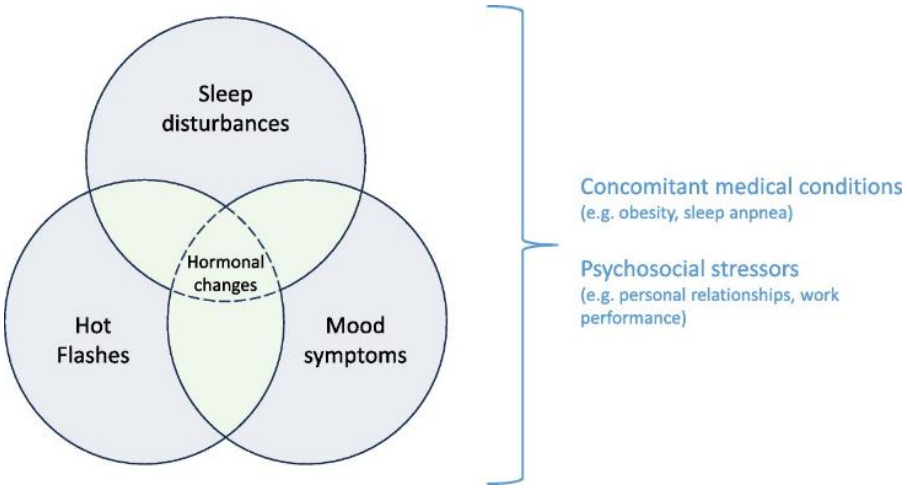

Figure 2. (Maki, Panay, i Simon 2024)

Clinically, we can categorize these sleep issues into three primary groups: difficulty falling asleep (latency), sleep fragmentation, and early morning awakening (Gava et al. 2019). Previous reviews indicate that waking up multiple times is the most common problem among perimenopausal patients. (Baker et al. 2018) If we want to develop better treatments for aging women, we have to start by understanding these specific hormone-driven patterns.

e. Research materials and methods

To ensure the review focused on high-quality, clinical data filters were applied to restrict the results to clinical trials (including randomized controlled trials, controlled clinical trials and clinical studies). Furthermore, the search was limited to articles available as free full text and published in English, between the years 2015 and early 2026. Titles and abstracts were screened manually to identify studies meeting the inclusion criteria. The primary objective was to analyze the physiological relationship between hormonal phases and sleep in diverse groups, including athletes, adolescents, adult and perimenopausal women. Following this screening process, a total of 19 articles were retained for the final detailed analysis.

2. Results

a. Adolescence and Early Adulthood

In the adolescent population, the onset of menarche marks a critical physiological transition, bringing with it various physical changes and symptoms, often including significant disruptions to sleep. In a study of over three thousand adolescent girls around the age of thirteen, Kiss et al. (2024) found that starting menstruation comes with a clear shift in sleep habits. Girls who reached menarche went to bed later and slept less overall compared to those who did not (Kiss et al. 2024). The relationship between the menstrual cycle and sleep is not yet fully understood, with studies showing varying results. Some research points to phase dependent changes in sleep architecture, while other findings suggest that sleep is disrupted mainly by physical symptoms like pain or cramps. This complexity is even greater for adolescents, as their hormonal regulation is still maturing. During these years, cycles are often irregular, and painful cramps occur much more frequently than in adults. (Attia, Alharbi, i Aljohani b.d.) This makes it difficult to determine whether sleep disruptions are caused by the hormonal phase itself or simply by the discomfort of the symptoms.

Returning to the previously mentioned study by Kiss et al. (2024), further investigation within the post-menarcheal group revealed a relation between sleep habits and symptom severity. Shorter sleep duration was associated with more intense menstrual pain. Later wake-up times were also linked to greater discomfort. These findings suggest a potential bidirectional relationship, meaning that poor sleep patterns do not only occur with menstruation but may actually exacerbate the pain.(Kiss et al. 2024)

Supporting the argument that symptoms are main cause of sleep disturbance, another group of researchers provided strong epidemiological evidence in a large-scale study of over five thousand girls aged twelve to eighteen years old (Liu et al. 2017). Their analysis revealed that the transition into puberty brings specific risk factors for insomnia, most notably menstrual pain. In fact, dysmenorrhea was the strongest predictor of sleep disturbance, nearly doubling the risk for those affected. Beyond pain, the study found that physiological irregularities also played a

significant role. Girls with irregular cycles or prolonged menstrual flow lasting at least 7 days were more likely to suffer from insomnia. The timing of developing was significant as well. Girls who experienced early menarche, at the age of eleven or younger, noted more sleep issues. This suggests that early puberty may have a short-term negative impact on sleep.(Liu et al. 2017)

Similarly, another study by Akman et al. (2024) showed that for teens, painful cramps and PMS were the main reasons for poor sleep quality. It is important to note that heavy bleeding itself had no effect on sleep, which showed that the discomfort mattered more than the flow volume.(Kocabey, Oden Akman, i Kasim 2024)

Shifting the focus from symptoms to biological phases, Hrozanova et al. (2021) investigated whether the menstrual cycle itself alters sleep architecture in a group of junior endurance athletes. The researchers found that on days of menstrual bleeding, athletes actually spent more time in bed and had more deep sleep compared to other days (Hrozanova et al. 2021). While measures like total sleep time remained stable throughout the cycle, the sleep structure changed. Specifically, the follicular phase was linked to a higher percentage of deep sleep, even though sleep efficiency was slightly lower (Hrozanova et al. 2021). This increase in objective sleep depth could mean that for young athletes, the body may naturally prioritize physical recovery to handle the stress of menstruation, even if they do not feel like they slept well. However, the researchers stated that these shifts were minor, concluding that while the cycle does alter sleep stages, these changes are likely of little clinical relevance for performance (Hrozanova et al. 2021).

Overall, the evidence found during research indicates that adolescent sleep disruption is driven mainly by menstrual symptoms, specifically pain, rather than the biological cycle phase or bleeding volume. However, in athletic girls, this relationship is nuanced by an increase in deep sleep, highlighting a disconnect between subjective fatigue and the body's objective need for recovery.

b. **Reproductive years**

In adult women, according to previous studies, sleep is not the same every night (Zheng et al. 2015). Instead, it changes in a cycle along with their hormones. To understand these changes objectively, a study by Spector et al. (2016) used polysomnography to monitor brain waves and breathing during sleep among two groups of healthy women. This research found that women are nearly four times more likely to have serious sleep disruptions in the luteal phase rather than follicular phase (Spector et al. 2016). Specifically, the study showed that the number of times a woman’s breathing is interrupted can more than double during this time, jumping from about 6 times an hour to over 14 times an hour (Spector et al. 2016). The actual structure of sleep is disrupted during the luteal phase, causing a major drop in sleep quality. While only 12% of women had sleep issues in the first half of their cycle, this number jumped to 46% in the two weeks before their period (Spector et al. 2016).

In another study conducted by Tada et al. (2017), researchers measured heart rate as it’s variability reflects sympathetic nervous hyperactivity (Toschi-Dias et al. 2013). During the study they found that in the luteal phase heart rate variability was higher compared to the follicular phase. This physical stress makes it harder to stay asleep

and leads to a higher number of nightly awakenings, which was observed in the study. It suggests a decrease in sleep quality in the luteal phase. Interestingly, this same study found that the transition from the follicular phase to the luteal phase also makes participants crave more food and engage in more emotional eating (Tada et al. 2017).

As shown in a study by Van Reen and Kiesner (2016), there are two specific trouble times for sleep during the cycle, the perimenstrual days and the time around ovulation. During those periods participants reported the most difficulty sleeping (Van Reen i Kiesner 2016). This study also pointed out that sleep trouble usually does not happen alone as it is closely linked to physical symptoms like bloating and discomfort.

In another study by Meers et al. (2024), results showed that during sleep, time spent awake in the perimenstrual period was greater than during the mid-follicular and mid-luteal phase. Sleep efficiency was lower compared to the luteal phase (Meers et al. 2024). Furthermore, in addition to researchers studying sleep across the menstrual cycle, they also studied the interaction of emotions. They showed that not only women sleep poorly during the perimenstrual phase, but they also feel significantly more anger and have fewer positive emotions (Meers et al. 2024). This could mean that the changes in sex hormones contribute to emotional vulnerability in various ways and reducing perimenstrual sleep disruptions could be a target for females with mood disorders.

While most studies found during the search focused on how the cycle affects sleep, a study by Michels et al. (2020) focused on the opposite direction. They studied how sleep habits impact hormonal changes. They found that while the total amount of sleep a woman gets is linked to the estrogen and progesterone levels, having different sleep habits, like staying up late or working night shifts, did not have a large impact (Michels et al. 2020). However, as noted in the study, these subtle shifts can still influence a female metabolism in a long run.

When we compare the studies conducted on the adolescent girls and studies with adult females, we can see a shift from the focus on symptoms to the cycle phases. Thus, we want to include a study by Kische et al. (2016). According to them, lifestyle and general health have more impact on sleep than hormones do on their own (Kische et al. 2016). They discovered that things like age, comorbidities or waist size, were much stronger predictors of sleep quality, as most of the links between hormones and sleep disappeared once the researchers accounted for the other factors (Kische et al. 2016). They concluded that while hormones may be related to sleep changes, they are just one piece of a much larger puzzle involving a woman's overall health.

Overall, the reviewed literature indicates that among adult women, the luteal phase represents a period of increased physiological stress with more sleep disturbances, higher heart rates, breathing instability and emotional vulnerability. However, hormones are not the only reason for these changes, as factors like general health and lifestyle also play a role. For those in high-stress environments, such as athletes, understanding these changes may be essential for managing recovery and performance.

c. The Athletes

For a female athlete, a good night’s sleep is essential for staying competitive and avoiding injury (Halson 2014). To date, studies on female athletes have produced inconsistent findings, making it difficult for coaches and sports scientists to provide clear advice. This lack of clarity often leaves athletes to manage sleep disruptions on their

own without evidence-based tools. In this chapter, we will review the existing studies on athletes and highlight the limitations in how this research is conducted.

While many studies rely on subjective data, study conducted by Koikawa et al. (2020) provided objective results by using EEG to track the sleep of healthy college athletes with regular menstrual cycles. Their research compared the initial nights of cycle during menstruation to the mid-follicular phase, revealing that the onset of a period brings challenges to rest (Koikawa et al. 2020). Total sleep time was significantly reduced, the time it took to fall asleep was prolonged, and overall sleep efficiency dropped during menses (Koikawa et al. 2020). The quality of deep sleep was not depending on cycle phase alone, it fluctuated based on whether the athlete experienced physical menstrual symptoms or even concerns, such as the worry of leakage from sanitary products (Koikawa et al. 2020).

Moving from objective EEG data to the experience of athletes, another study by Carmichael et al. (2021) looked at professional Australian Football League athletes to understand how the menstrual cycle influences perceived recovery. While the study was limited by a small sample size and relied on subjective questionnaires, it provided a crucial look at how women perceive their own recovery. While aspects like physical performance and muscle soreness remained stable across the cycle, the athletes' sense of wellbeing did not (Carmichael et al. 2021). The results showed a shift during the luteal phase leading up to menstruation. Athletes reported worse sleep quality and higher levels of perceived fatigue (Carmichael et al. 2021). Research on actual performance outcomes like jump height remained inconsistent. Researchers suggested that the increased fatigue felt in the luteal phase is likely tied to the drop in sleep quality reported by the athletes (Carmichael et al. 2021). This could mean that even though an athlete's physical performance has not dropped, their increased fatigue and poor sleep during the late luteal phase are early warning signs that the recovery is being compromised.

Expanding on these findings, a 2024 study by Antero et al. investigated elite female rowers. The researchers found that for athletes with natural cycles, sleep quality, mood, and energy levels peaked around the middle of the cycle, near ovulation, where athletes reported the highest frequency of top wellness scores (Antero et al. 2023). The premenstrual phase stood out as a period of vulnerability, with a drop in high-quality sleep scores (Antero et al. 2023). These findings match what we see in the general public, where sleep issues are linked to the way hormones shift during the cycle (Driver et al. 2008). This suggests that elite athletes experience the same cycle-related changes in their health and mood as most other women.

A recent 2025 study by Kullik et al. involving female basketball athletes adds to this discussion by suggesting that the specific phase of the menstrual cycle may be less important than the symptoms. After monitoring the players, the researchers found that the cycle phases themselves had inconsistent effects on sleep and recovery (Kullik et al. 2025). Instead, the real cause of poor sleep and high stress was symptoms. Athletes who reported more frequent and severe symptoms, no matter the cycle phase they were in, consistently had poorer sleep quality and worse recovery (Kullik et al. 2025). The study noted that the most changes happened during menstruation, when athletes spent more time in bed and experienced deeper sleep (Kullik et al. 2025). Researchers interpreted that as a body's higher need for recovery. While some minor shifts happened, such as falling asleep slightly faster in the luteal phase compared to the early follicular phase, the overall effect of the cycle phases was small (Kullik et al. 2025).

The authors concluded that the menstrual cycle should be viewed as just one of many potential stressors, rather than the main cause of sleep issues.

Current research is still limited by small study groups and rely mostly on personal diaries rather than objective medical tools. This makes it hard to say if the results apply to every athlete, especially since everyone's symptoms are so different. To really help, future research needs to look at larger groups so we can create better, more personal plans for every female athlete.

d. The Transition

Sleep issues are incredibly common during the transition to menopause, affecting anywhere from 40% to nearly 70% of women (Nappi et al. 2021). A 2015 study by de Zambotti et al. used EEG to track the sleep of 20 women in the early stages of menopause. They tested the women both in the follicular and luteal phase. The researchers found that when progesterone levels were higher, the women woke up more often throughout the night, they also experienced less deep sleep (de Zambotti et al. 2015). This shows that for women in midlife, the luteal phase of the cycle makes sleep much more interrupted and less deep (de Zambotti et al. 2015). Importantly, this happened even to women who did not have a history of sleep disorders, meaning these hormonal shifts can affect almost anyone going through the transition.

Another study from 2015 by Zheng et al**.** looked at perimenopausal women using wrist actigraphy, which is a small device worn on the wrist, similar to a fitness tracker, that measures movement to see how much time someone is actually sleeping. The researchers found that sleep efficiency slowly went down as the month went on (Zheng et al. 2015). However, this decline became much worse during the premenstrual phase (Zheng et al. 2015). This shows that for women nearing menopause, the days right before their period are a particularly difficult time for getting good rest just like for a general population examined earlier (Driver et al. 2008).

Focusing on a more recent study from 2022 by Pérez-Medina-Carballo et al., it looked at women who already were postmenopausal. By measuring core body temperature, melatonin and brain activity in EEG, the researchers compared postmenopausal women to premenopausal women to see how their biological clocks had changed. The results showed that postmenopausal women had a harder time staying in a deep sleep, they spent more time in light sleep and woke up more often during the night (Pérez-Medina-Carballo et al. 2022). The study also found that their melatonin levels did not rise and fall as clearly as in younger participants (Pérez-Medina-Carballo et al. 2022). The older women found it easier to fall asleep during the day but felt more alert during the middle of the night (Pérez-Medina-Carballo et al. 2022). Essentially, the researchers concluded that the body’s internal clock becomes weaker after menopause and instead of having a clear time for sleep and a clear time for being awake, the lines become blurred, leading to shorter total sleep times and lower energy during the day.

Lastly, we would like to include a study by Geiger et al. from 2016 that looked at whether hormone therapy could directly help with these sleep issues in perimenopausal females. Researchers studied almost two hundred women who were either going through the transition or were in early postmenopausal stage. For a full year, one group used a skin patch with estradiol, while the other group used a placebo patch. The results showed that women using

the hormone treatment fell asleep significantly faster than those who did not. This improvement happened even when other issues like hot flashes or mood swings associated with menopause stayed. This suggests that replacing hormones can directly improve sleep quality for some women in perimenopausal transition.

3. Discussion

Looking at all these studies together, it seems clear that the menstrual cycle and sleep are linked, but it is not always in the same way for every woman. One of the biggest things we noticed in the research is that for younger girls and athletes, the physical symptoms, like cramps and pain, seem to matter way more than the actual hormonal phases. It can seem like an ongoing cycle where the pain stops a person from sleeping, and then because a person did not sleep well, the pain feels even worse the next day.

When we look at adult women in their reproductive years, the luteal phase seems to be the hardest time for sleep. The studies showed some pretty surprising physical changes during this time, like breathing getting interrupted more often and heart rates going up. This makes it harder for the body to stay in a deep sleep, which is probably why so many women report feeling tired or moody right before their period starts. However, it is also important to remember what one of the studies found, that things like your weight, age, and general health might actually have a bigger impact on your sleep than hormones do on their own. It is not just about the cycle phase, it is about the whole lifestyle.

For athletes, the search results regarding cycle phase's impact are a bit confusing. Some studies say the athletes sleep worse in the luteal phase, while others found that they actually get more deep sleep when they are in their perimenstrual time. This might be the body's way of trying to recover from the stress of training and bleeding at the same time, but because most of these studies used small groups of people or just personal subjective data, we cannot be sure if these findings apply.

Finally, the transition to menopause shows a shift in how the internal clock works. As women get older and their hormones drop, the clear line between being awake and being asleep starts to blur. They spend more time in light sleep and wake up more during the night. The fact that hormone therapy helped some women fall asleep faster suggests that hormones really do play a direct role in how the brain handles sleep, even if females do not present other symptoms like hot flashes.

4. Conclusions

This review shows that a woman's sleep changes a lot throughout her life depending on her age, hormonal phase, activity and general health. In the beginning, during the teenage years, pain and cramps are the main reason for bad sleep. In the middle years, the hormonal shifts in the luteal phase cause more disruptions and lower sleep quality overall. Then, as women approach menopause, the body's natural rhythm starts to weaken, leading to more wakefulness at night and less deep sleep.

For athletes and their coaches, these findings can be used to make training and recovery more effective and instead of just following a strict schedule, athletes should track their cycles alongside their sleep so they can predict when they might feel more tired. Since the research shows that beside cycle phase, pain has a big impact on sleep as well, athletes should focus on managing cramps which might actually help recovery as much as trying to get more quality sleep.

One thing that stands out from looking at all these studies is that not a lot of brand new information has been discovered in the last 10 years. Most of the recent research just confirms what we already knew, that the perimenstrual days in the luteal phase are the hardest for sleep and that physical symptoms like pain are the biggest disruptors. While we have more studies now, they often just repeat the same findings. Even though we have a lot of data, there are still some gaps. A lot of the research on athletes is inconsistent and many studies rely on subjective information rather than using medical tools. If we want to help women sleep better, we need to look at more than just their hormones, we have to consider their symptoms, their stress levels, and their general health. Future research should focus on larger groups of women so we can give better advice for every stage of life.

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Declaration of generative AI and AI-assisted technologies in the writing process.

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