The effects of sunlight exposure on menstrual cycle variability in women with cardiovascular: a systematic review

Los efectos de la exposición a la luz solar sobre la variabilidad del ciclo menstrual en mujeres con enfermedades cardiovasculares: una revisión sistemática

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Abstract

Introduction: Dysfunctions in menstrual physiology significantly impact the quality of life, including mood changes, body image, infertility, and pregnancy complications. Light exposure may affect menstrual cycles and symptoms by influencing melatonin secretion. This systematic review aims to investigate the impact of sunlight exposure on menstrual cycle variability, particularly in women with cardiovascular conditions.

Methods: Databases including Science Direct, PubMed, Google Scholar, SID, and MagIran were reviewed to identify studies examining the effect of sunlight on menstrual cycle changes. An initial search yielded 42 articles, with 9 duplicates removed. After applying inclusion and exclusion criteria, 17 articles were selected for detailed screening and analysis. Two researchers with experience in conducting systematic reviews evaluated the articles based on title, abstract, introduction, methodology, results, discussion, and references, identifying strengths and weaknesses. Ultimately, 7 articles met the criteria and were included in the review.

Results: Out of the 42 initially identified articles, 7 studies met the inclusion criteria and were included in the review. Evidence indicates a relationship between light exposure, melatonin secretion, irregular menstrual cycles, menstrual cycle symptoms, and ovarian dysfunction. Research on the light-dark cycle's role in menstrual physiology has implications for managing menstrual disorders.

Conclusion: Increased ovarian activity, including larger ovarian follicle size, higher ovulation frequency, and shorter menstrual cycles, is observed in summer compared to winter among women living in temperate latitudes. These findings have significant implications for women with cardiovascular conditions, suggesting that sunlight exposure may play a role in managing menstrual cycle variability and associated symptoms.

Keywords: sunlight, menstrual cycle, cardiovascular conditions, infertility, ovarian follicle.

Resumen

Introducción y antecedentes. Las disfunciones en la fisiología menstrual afectan significativamente la calidad de vida, incluidos los cambios de humor, la imagen corporal, la infertilidad y las complicaciones del embarazo. La exposición a la luz puede afectar los ciclos menstruales y los síntomas al influir en la secreción de melatonina. Esta revisión sistemática tiene como objetivo investigar el impacto de la exposición a la luz solar en la variabilidad del ciclo menstrual, en particular en mujeres con afecciones cardiovasculares.

Métodos. Se revisaron bases de datos como Science Direct, PubMed, Google Scholar, SID y MagIran para identificar estudios que examinaran el efecto de la luz solar en los cambios del ciclo menstrual. Una búsqueda inicial arrojó 42 artículos, de los cuales se eliminaron 9 duplicados. Después de aplicar los criterios de inclusión y exclusión, se seleccionaron 17 artículos para una revisión y análisis detallados. Dos investigadores con experiencia en la realización de revisiones sistemáticas evaluaron los artículos en función del título, el resumen, la introducción, la metodología, los resultados, la discusión y las referencias, identificando las fortalezas y debilidades. Finalmente, 7 artículos cumplieron con los criterios y se incluyeron en la revisión.

Resultados. De los 42 artículos identificados inicialmente, 7 estudios cumplieron con los criterios de inclusión y fueron incluidos en la revisión. La evidencia indica una relación entre la exposición a la luz, la secreción de melatonina, los ciclos menstruales irregulares, los síntomas del ciclo menstrual y la disfunción ovárica. La investigación sobre el papel del ciclo de luz-oscuridad en la fisiología menstrual tiene implicaciones para el manejo de los trastornos menstruales.

Conclusión. En comparación con el invierno, en las mujeres que viven en latitudes templadas, en verano se observa una mayor actividad ovárica, que incluye un mayor tamaño de los folículos ováricos, una mayor frecuencia de ovulación y ciclos menstruales más cortos. Estos hallazgos tienen implicaciones importantes para las mujeres con afecciones cardiovasculares, ya que sugieren que la exposición a la luz solar puede desempeñar un papel en el manejo de la variabilidad del ciclo menstrual y los síntomas asociados.

Palabras clave: luz solar, ciclo menstrual, afecciones cardiovasculares, infertilidad, folículo ovárico.

Introduction

One of the common reasons for women to visit the physician is menstrual disorders. Disturbances in menstrual physiology significantly affect the quality of life of women, mood, body image, fertility, and pregnancy. In addition, it has been well documented that psychological changes ranging from mild cravings to debilitating mood swings are associated with menstrual phases, particularly the luteal phase. Several lifestyle factors such as weight, stress, smoking, and alcohol consumption can significantly affect pregnancy and menstrual cycle [1, 2]. Increased stress considerably affects a person's solute and mineral status [3]. Numerous studies have marginally evaluated the role of several factors in reproductive health and the menstrual cycle of women. They have mostly been in the areas of pathology of special reproduction methods with an emphasis on vitamins and multivitamin supplements [4-7].

A few seasonal studies examined whether annual fluctuations in female reproductive performance are caused by light or other environmental factors. Kumar & Sharma [8] analyzed endometrial histological samples taken from 1036 infertile women in India. They found that anovulatory endometrium was associated with higher temperature. Rojansky et al. [9] indicated a direct association between monthly in vitro fertilization rates and monthly sunshine hours. Studies on the annual rhythm of human birth have revealed a lower rate of conception during the dark seasons, and seasonal changes in birth were related to changes in the region's sunshine [10]. Studies have indicated that artificial light can affect the menstrual cycle [11]. Exposure to light before the supposed day of ovulation shortens the menstrual cycle in women with long menstrual cycles or in women with winter depression. This may be due to stimulation of pituitary reproductive hormone secretion [12], increased ovarian follicle growth, and ovulation [13], shortening the follicular phase. The second (luteal, post-ovulatory) phase of the menstrual cycle is more stable than the first (follicular, pre-ovulatory) phase [14].

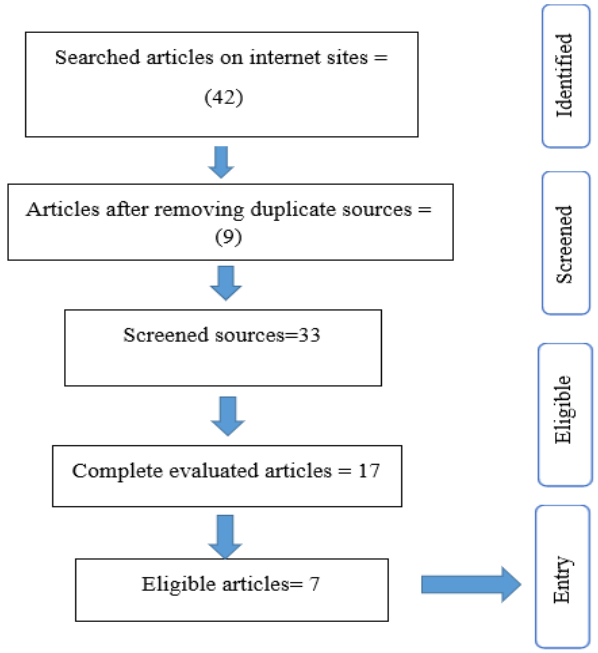
Given these findings, this study systematically investigates the effect of sunlight exposure on changes in the menstrual cycle, particularly in women with cardiovascular conditions. By understanding the potential impacts of light exposure on menstrual physiology, this study seeks to contribute to the broader field of reproductive health and provide insights into managing menstrual disorders in women with cardiovascular conditions.

Materials and methods

The present study was a systematic review. Data were collected through searching for articles on the Internet. To obtain the required data, Persian and English texts were searched in the Science Direct, PubMed, Google Scholar, SID, and MagIran databases from 1990 to 2024. Articles were searched using keywords such as sunlight, menstrual cycle, cardiovascular conditions, support program, family's psychosocial needs, care burden, family caregivers, and ischemic heart disease. Inclusion criteria included articles published in reputable scientific journals, publication of the article in Persian or English, and access to the full text of the articles. There was no restriction based on the design of the conducted studies.

Exclusion criteria included lack of access to the full text of the article, letters to the editor, articles published in non-reputable journals, and articles presented as posters at conferences. In the initial search, 42 articles were obtained, with 9 duplicates removed. After applying the inclusion and exclusion criteria, the number of articles was reduced to 17. Among these, the articles related to the study subject were screened and analyzed. To increase the robustness of the research methodology, examine the quality of the collected articles, and prevent possible biases, three researchers with a history of conducting systematic review articles reviewed the title, abstract, introduction, methodology, results, and discussion sections of the articles. They also discussed their references and identified their strengths and weaknesses. Finally, 7 articles were included in the study Figure 1.

Figure 1. Flowchart of article selection



Our search approach, review methods, and reporting strategy conformed to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. Articles identified in our initial database search were screened for redundancy, and duplicate articles were removed. Then, all remaining articles were screened for eligibility using the study title and abstract review by our study team. If articles were ineligible based on the information provided in the abstract, they were excluded from the sample. Full-text articles were used for the remaining studies to determine eligibility. If it was found that a full-text study should be included in the review sample, the research team's several members screened the full-text article. In such conditions, all decisions regarding inclusion/exclusion were made by the team members to ensure consistency. A table to report key study details, including study design, methods, sample, variables/measurements, results, identified psychosocial needs, and whether the study tested an intervention was developed for the studies that met our inclusion criteria.

Results

Forty-two articles were screened, leading to the selection of 7 studies that met the inclusion criteria and were included in our review **Figure 1**. The studies by Lin, Cripke, Perry, and Berga (1990) on 7 women and Rex, Cripke, Cole, and Klaber (1997) on 10 women used a light intensity of 250 lux. The intervention consistently led to shorter and more regular cycles in study participants ($p<0.001$). In the study by Rex, even low light levels (<1 lux) had a marginal effect ($p<0.09$). These results indicate that light may play a role in the physiological parameters of the menstrual cycle. However, it is unclear exactly at which part of the cycle the light exposure treatment was most effective due to limitations in the study methodology.

Researchers sought to expose women to light at the time of ovulation. Although the luteal phase length is constant in a given woman, it varies from 9 to 17 days among women. This means that one woman may have a luteal phase of 9 to 10 days per cycle, while another woman may have a luteal phase of 16 to 17 days per cycle. Since the researchers did not use other physiological measures such as basal body temperature, observation of cervical mucus, or serum markers, the light treatment may have been administered several days before ovulation, occurring in the follicular phase instead of the desired ovulation phase.

Danilenko & Samoilova reported on the impact of minimizing light exposure during sleep in 48 infertile women using natural family planning to achieve pregnancy. Abnormalities of the follicular phase (96%), ovulation (58%), and luteal phase (63%) (i.e., prolonged and

shortened phases, abnormal cervical mucus patterns) were identified through female charts in three cycles. The researchers created a light score by identifying common light sources likely to be present in the bedroom. Participants were taught how to maximize light scores. A significant reduction in abnormal menstrual parameters was observed over six cycles in patients who reported compliance with the guidelines (n = 33). The pregnancy rate was also reported to be 78%. The abnormal parameters returned as the light sources were reintroduced. Although this study had design shortcomings (e.g., lack of a control group and inaccuracy in measuring ambient light), several important concepts require further study.

First, this study questions if there are more vulnerable women, especially those with cardiovascular conditions, who are sensitive to ambient light exposure. The fact that the reduction of abnormalities occurred over several periods, and not just in one cycle, should also be considered in the design of future studies.

Richards et al. [15] recently examined the effect of bright light (4300 lux) and dim light (<100 lux) on reproductive hormone levels and ovulation. Twenty-two healthy women whose menstrual cycles ranged from 28 to 37 days were exposed to bright or dim light for 45 minutes every morning during one cycle. They were exposed to the alternative in a second experimental cycle. Prolactin, LH, and FSH increased significantly with bright light but not with dim light. Additionally, the number of ovulation cycles (confirmed by ultrasound scan) increased after exposure to bright light Table 1.

Table 1. Characteristics of the studies including the results and the date of the study

Row	issue	Authors	Study type	Number of samples	The effect of sunlight on changes in the menstrual cycle
1	Night light alters menstrual cycles	Lin et al., [16]	Clinical trial		Seven women slept with 100 W white light and 9 women slept with dark red placebo light on days 13 to 17 of their menstrual cycle. The menstrual cycle of women in the white light group decreased the length of the menstrual period from a mean of 45.7 days to 33.1 days and reduced variability, but the placebo had no effect.
2	Seasonal changes in pituitary function: amplification of midfollicular luteinizing hormone secretion during the dark season	Martikainen et al., [17]	Quasi-experimental	10	In this study, eight women had ovulatory cycles with a luteal length of more than 11 days and determined the circadian melatonin pattern in each menstrual phase. Despite gonadal steroid changes characteristic of ovulatory cycles, consistent changes in plasma melatonin patterns were not found based on the menstrual phase. Diurnal levels were 43 pmol/l or less in all women, and all except for 2 women showed significant nocturnal increases. However, changes in the circadian pattern of melatonin secretion immediately preceding the LH surge cannot be ruled out, the lack of consistent changes in the menstrual cycle phase and the absence of significant circadian changes in the 2 women suggest that the melatonin secretion profile is not altered by fluctuations.
3	Nocturnal light effects on menstrual cycle length.	Rex et al., [18]	Cross-sectional experimental design	18	Ten women slept with a sleep mask of less than 1 lux on days 13 to 17 of their menstrual cycle and switched to a sleep mask with 235 lux light in the next cycle. Eight women slept under a 235 lux incandescent lamp on days 13 to 17 of their menstrual cycle.
4	Stimulatory effect of morning bright light on reproductive hormones and ovulation: results of a controlled crossover trial	Danilenko & Samoilova [1]	Quasi-experimental	48	Pre-intervention parameters measured include pre-follicular stimulation, follicular, ovulation, and luteal phase length; And the cycle length was three cycles long. An abnormality in FP was detected in 96% of participants. Abnormalities in LP were detected in 63%. The reduction of ambient light resulted in a significant reduction of abnormal parameters during six cycles.
5	Shortening of the menstrual cycle following light therapy in seasonal affective disorder.	Danilenko [19]	Quasi-experimental	38	After light therapy in 38 women in the winter season, a mean of 1.2 days earlier onset of menstruation was observed. In two of them, it can be classified as a minor side effect. There was no correlation between this shortening and improvement in depression in affected women. The study by Lin recommended studying the direct effect of light on the hypothalamus-pituitary-gonadal axis.
6	Light exposure, melatonin secretion, and menstrual cycle parameters: an integrative review	Lee Barron [20]	Mixed review	166	There is evidence of a relationship between light exposure and melatonin secretion and irregular menstrual cycles, menstrual cycle symptoms, and ovarian dysfunction. In women with psychiatric pathologies such as bipolar disorder or endocrine disorders such as polycystic ovary syndrome, there is a higher vulnerability to the effects of exposure to light than to darkness. Studies on the complex role of light-dark in menstrual physiology have implications for the treatment of menstrual disorders.
7	Menstrual cycles are influenced by sunshine	Danilenko et al. [21]	Cohort	129	In winter, there was a trend toward increased FSH secretion, significantly larger ovarian follicle size, higher ovulation frequency (97% vs. 71%), and shorter menstrual cycles (by 0.9 days). LH and prolactin levels did not change. In all seasons, increased sunshine 2-3 days before the presumed ovulation day caused a shorter cycle length. Temperature/perceived temperature, atmospheric pressure, and moon phase/light were not significant predictors.

Discussion

This systematic review investigated the effect of sunlight on the occurrence of changes in the menstrual cycle, given its importance in improving women's health, particularly those with cardiovascular conditions. Sunlight significantly affects the menstrual cycle and overall health. Studies have indicated that more exposure to sunlight increases ovarian activity and the release of hormones such as follicle-stimulating hormone (FSH) during hot seasons, especially summer, leading to shorter menstrual periods. In contrast, ovarian activity decreases in cold seasons, potentially leading to a longer menstrual cycle. Temperature also plays a vital role in menstrual cycle changes. Warm weather generally increases hormone secretion and reduces menstrual pain, while cold weather may increase contractions and menstrual pain. Changes in temperature and sunlight also affect the body's metabolism. In cold seasons, reduced sunlight can lower vitamin D levels and slow metabolism, which can affect hormonal balance and the menstrual cycle [22,23].

Our study revealed higher ovarian activity (larger ovarian follicle size, increased ovulation frequency, and shorter menstrual cycles) in summer compared to winter in women living in continental climates with temperate latitudes. This could be due to the effect of natural light, as daily differences in sunshine hours affect the menstrual cycle length regardless of the season. The cycle tends to be shorter if there is more sunshine 2 to 3 days before ovulation. We did not find significant seasonal differences in LH and prolactin levels, which may be due to the high pulsatility of LH secretion. One Finnish study indicated that mid-follicular LH levels were lower during the light season [24]. Prolactin levels may also be affected by circadian rhythms, with higher levels observed in healthy women from November to January in Japan [25].

Our results revealed a tendency for increased hormone secretion in summer, consistent with Finnish studies that observed higher FSH levels during the mid-follicular phase in May to June. Since FSH secretion determines follicle growth in the mid-follicular phase, its increase in summer corresponds to larger ovarian follicles. To our knowledge, only Ronkainen et al. from Finland reported folliculometric research throughout the year, though they found no significant seasonal differences [26]. In winter, 29% of menstrual cycles were non-anovulatory, compared to only 3% in summer, indicating a significant seasonal effect.

Previous studies by Finnish groups did not report seasonal differences in ovulation rates [27]. However, in a Siberian study, women were generally healthy based on selection criteria and hormonal indices of LH, FSH, and prolactin. Ovulation outcomes may be biased by using medical centers to select subjects, especially in winter months. Additionally, the winter anovulation rate of 29% is much lower than the 73% observed in women with menstrual cycles longer than 28 to 38 days, who typically have frequent ovulatory cycles [28].

Increased FSH secretion, follicle maturation, and ovulation occurrence in summer shorten the follicular phase and the menstrual cycle. The seasonal difference in the menstrual cycle was 0.9 days, with the longest cycles from November to January and the shortest from June to August. Lambert et al. reported a smaller difference of 0.2 days between December and July cycles in a Minnesota population, possibly due to more extreme weather and heterogeneity by including women of all cycle lengths [29].

Knowing that artificial light before ovulation shortens menstrual cycles, natural light may work similarly. Results indicated that exposure to light 2 to 3 days before ovulation is the most effective time for treating anovulation with bright light, as shown in previous studies [30]. Studies on bright light for opsomenorrhea and seasonal affective disorder indicate that natural light works through the eyes, not through the skin. Light impulses are directed to the hypothalamus through the retinohypothalamic tract, stimulating endocrine neurons to release gonadotropin-releasing hormone (GnRH) into the pituitary. This process is mediated by serotonin, which is strongly affected by light. The release of gonadotropins to the pituitary gland may also be influenced by hormones[31-36].

Conclusions

The study has shown that ovarian activity, including larger ovarian follicle size, increased ovulation frequency, and shorter menstrual cycles, is higher in summer compared to winter among women living in continental climates with temperate latitudes. These findings have significant implications for managing menstrual cycle variability and related symptoms in women with cardiovascular conditions.

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