MAKIEŁA, Michalina, KOZIAK, Weronika, MAKIEŁA, Marta, BĘTKOWSKA, Aleksandra, KORNACKA, AGATA, ZAJĄC, Aleksandra, SZOSTAK, Kamila, TOMAKA, Rafał, WOROBIEJ, Daniel and DUDEK, Stanisław. One Axis, Two Faces: The Shared Biology of PMS and Migraine. Quality in Sport. 2025;41:60065. eISSN 2450-3118.
https://doi.org/10.12775/QS.2025.41.60065
https://apcz.umk.pl/QS/article/view/60065

The journal has been 20 points in the Ministry of Higher Education and Science of Poland parametric evaluation. Annex to the announcement of the Minister of Higher Education and Science of 05.01.2024. No. 32553.
Has a Journal's Unique Identifier: 201398. Scientific disciplines assigned: Economics and finance (Field of social sciences); Management and Quality Sciences (Field of social sciences).
Punkty Ministerialne z 2019 - aktualny rok 20 punktów. Załącznik do komunikatu Ministra Szkolnictwa Wyższego i Nauki z dnia 05.01.2024 r. Lp. 32553. Posiada Unikatowy Identyfikator Czasopisma: 201398.
Przypisane dyscypliny naukowe: Ekonomia i finanse (Dziedzina nauk społecznych); Nauki o zarządzaniu i jakości (Dziedzina nauk społecznych).

The authors declare that there is no conflict of interests regarding the publication of this paper.
Received: 04.04.2025. Revised: 25.04.2025. Accepted: 06.05.2025. Published: 11.05.2025.

One Axis, Two Faces: The Shared Biology of PMS and Migraine

Michalina Makieła[1], Weronika Koziak[2], Marta Makieła[3], Aleksandra Bętkowska[4], Agata Kornacka[5],

Aleksandra Zając[6], Kamila Szostak[7], Rafał Tomaka[8], Daniel Worobiej[9], Stanisław Dudek[10]

1. Michalina Makieła [MM]

Wolski Hospital Dr. Anna Gostyńska, Marcina Kasprzaka 17, 01-211 Warsaw, Poland
https://orcid.org/0009-0003-4465-8584

2. Weronika Koziak [WK]

Wolski Hospital Dr. Anna Gostyńska, Marcina Kasprzaka 17, 01-211 Warsaw, Poland
https://orcid.org/0009-0003-5295-5765
E-mail: weronikakoziak@icloud.com

3. Marta Makieła [MMa]

Spitalzentrum Oberwallis (Visp), Pflanzettastrasse 8, 3930 Visp, Switzerland
https://orcid.org/0009-0005-7199-385X
E-mail: marta.makiela17@gmail.com

4. Aleksandra Bętkowska [AB]

National Medical Institute of the Ministry of the Interior and Administration, Wołoska 137, 02-507 Warsaw, Poland
https://orcid.org/0009-0001-5108-4262
E-mail: ola.betkowska@gmail.com

5. Agata Kornacka [AK]

University Clinical Center of the Medical University of Warsaw, Banacha 1A, 02-097 Warsaw, Poland
https://orcid.org/0009-0007-2877-3514
E-mail: akornackaa13@gmail.com

6. Aleksandra Zając [AZ]

University Clinical Hospital in Poznań, ul. Przybyszewskiego 49, 60-355 Poznań, Poland
https://orcid.org/0009-0000-9522-5779
E-mail: ale.zajac@o2.pl

7. Kamila Szostak [KSz]

The Infant Jesus Teaching Hospital, Lindleya 4, 02-005 Warszawa
https://orcid.org/0009-0005-6216-0864
E-mail: kamilaszostak999@gmail.com

8. Rafał Tomaka [RT]

University Clinical Center of the Medical University of Warsaw, Banacha 1A, 02-097 Warsaw, Poland
https://orcid.org/0009-0002-5057-6131
E-mail: rafaltomaka1998@gmail.com

9. Daniel Worobiej [DW]

Wolski Hospital Dr. Anna Gostyńska, Marcina Kasprzaka 17, 01-211 Warsaw, Poland
https://orcid.org/0009-0002-1153-9821
E-mail: d.worobiej@wp.pl

10. Stanisław Dudek [SD]

University Clinical Center of the Medical University of Warsaw, Banacha 1A, 02-097 Warsaw, Poland
https://orcid.org/0009-0002-3641-4865
E-mail: stanislaw.dudek0@wp.pl

Abstract

Premenstrual Syndrome (PMS) and **migraine** are two clinically distinct but biologically intertwined conditions that disproportionately affect individuals of reproductive age. Both disorders are characterized by cyclical patterns tied to hormonal fluctuations—most notably the abrupt withdrawal of estrogen and changes in progesterone levels during the luteal phase. Recent research reveals a convergence of underlying mechanisms, including dysregulation of the serotonergic and GABAergic systems, neurovascular instability, and heightened inflammatory responses. This narrative review explores how a shared neuroendocrine axis may drive the manifestation of both PMS and migraine, resulting in overlapping physical and emotional symptoms. By examining these interconnected pathways, we aim to illuminate opportunities for integrated diagnostic strategies and multimodal therapeutic approaches that consider the full scope of hormonal, neurological, and immune interactions. Understanding the "one axis, two faces" framework could be the key to more effective and individualized care.

Keywords: Hormonal Fluctuations, Estrogen Withdrawal, Neurotransmitter Dysregulation, Premenstrual Syndrome (PMS), Migraine Pathophysiology, Neuroendocrine Axis

1. Introduction

Premenstrual Syndrome (PMS) affects up to 75% of menstruating individuals, with 3–8% experiencing severe forms such as Premenstrual Dysphoric Disorder (PMDD) (Yonkers et al., 2008). Migraines, particularly menstrual migraines, affect approximately 20% of women of reproductive age, with attacks frequently occurring in the perimenstrual period (Vetvik & MacGregor, 2017). The temporal overlap of PMS symptoms and migraines suggests a shared pathophysiological basis. Both conditions are influenced by hormonal fluctuations, neurotransmitter dysregulation, and neurovascular changes, indicating potential common therapeutic targets (MacGregor, 2004).

Recent studies highlight that beyond hormonal influences, genetic predispositions and environmental factors play critical roles in modulating susceptibility to both conditions (Buse et al., 2013). Stress, sleep disturbances, and lifestyle choices, including diet and physical activity, have been identified as significant modulators of symptom severity (Schiavone et al., 2015). Moreover, neuroinflammatory processes and immune system dysregulation have been increasingly recognized as contributing to the pathogenesis of both PMS and migraines (Calhoun & Hutchinson, 2009). There is growing evidence suggesting that fluctuations in estrogen and progesterone affect central nervous system sensitivity, potentially triggering both mood and pain disorders (Nappi et al., 2013). Additionally, alterations in hypothalamic-pituitary-adrenal (HPA) axis function have been linked to both PMS and migraine pathophysiology, particularly in relation to stress response regulation (Facchinetti et al., 2003). Recognizing these shared mechanisms is crucial for developing integrated treatment approaches that address both PMS and migraine symptoms. This narrative review aims to explore the complex interplay of hormonal, neurochemical, and inflammatory factors underlying the comorbidity of PMS and migraines, while highlighting potential diagnostic and therapeutic strategies.

2. Hormonal Fluctuations as a Common Trigger

Hormonal fluctuations, particularly involving estrogen and progesterone, are central to the pathophysiology of both PMS and migraines. The cyclical nature of these hormonal shifts throughout the menstrual cycle significantly influences the onset and severity of symptoms in susceptible individuals. Estrogen and progesterone not only regulate reproductive functions but also modulate neurochemical pathways, vascular reactivity, and inflammatory responses, all of which are implicated in PMS and migraine pathogenesis.

2.1 Estrogen Withdrawal Hypothesis

Estrogen plays a pivotal role in modulating both mood and migraine susceptibility. The estrogen withdrawal hypothesis suggests that the abrupt decline in estrogen levels during the late luteal phase triggers both PMS symptoms and migraine attacks (Halbreich & Kahn, 2001). Estrogen withdrawal leads to increased cortical excitability, alterations in serotonin metabolism, and heightened sensitivity to pain stimuli (MacGregor, 2004).

Beyond its neurochemical effects, estrogen withdrawal impacts vascular stability, contributing to cerebral vasodilation and neurogenic inflammation, common triggers in migraine pathophysiology (Silberstein & Merriam, 1991). Estrogen influences nitric oxide production, which affects vascular tone and may exacerbate headaches when estrogen levels drop sharply (Vetvik & MacGregor, 2017). Furthermore, estrogen interacts with the hypothalamic-pituitary-adrenal (HPA) axis, modulating stress responses that can trigger both mood disturbances and migraines (Facchinetti et al., 2003). Studies have also indicated that estrogen fluctuations influence glutamate transmission, increasing neuronal excitability and migraine susceptibility (Calhoun & Hutchinson, 2009). The presence of estrogen receptors in brain regions involved in pain modulation, such as the trigeminal nucleus caudalis, suggests a direct role in migraine pathogenesis (Nappi et al., 2013). Hormonal therapies aiming to stabilize estrogen levels have shown promise in reducing both PMS and migraine symptoms, supporting the centrality of this mechanism (MacGregor, 2014).

2.2 Progesterone and Neurosteroids

Progesterone and its metabolites, such as allopregnanolone, influence GABAergic neurotransmission, which plays a role in mood stabilization and pain modulation. Fluctuations in progesterone may contribute to both

mood instability in PMS and increased migraine susceptibility through altered GABA receptor sensitivity (Epperson et al., 2002).

Progesterone withdrawal, similar to estrogen, has been linked to increased anxiety and depressive symptoms due to reduced GABAergic activity (Pearlstein & Steiner, 2008). Allopregnanolone acts as a positive allosteric modulator of GABA-A receptors, promoting inhibitory neurotransmission and exerting anxiolytic effects; its decline during the luteal phase may exacerbate PMS-related mood symptoms (Benedetti et al., 2015). Additionally, progesterone influences neuroinflammatory processes, with fluctuations potentially triggering cytokine release that sensitizes pain pathways associated with migraines (Rapkin & Akopians, 2012). The interplay between progesterone, neurosteroids, and neurotransmitter systems underscores the complexity of hormonal contributions to both PMS and migraines. Understanding these mechanisms is essential for developing targeted therapies that address the neuroendocrine basis of these conditions.

3. Neurotransmitter Dysregulation

Neurotransmitter imbalances play a crucial role in the pathophysiology of both PMS and migraines. Fluctuations in key neurotransmitters such as serotonin, dopamine, and gamma-aminobutyric acid (GABA) contribute to mood disturbances, cognitive changes, and heightened pain sensitivity observed in individuals affected by these conditions. Hormonal shifts, particularly the withdrawal of estrogen and progesterone during the luteal phase, have been shown to influence neurotransmitter synthesis, release, and receptor sensitivity, leading to the complex symptomatology characteristic of PMS and migraines.

3.1 Serotonergic Dysfunction

Serotonin (5-HT) is a key neurotransmitter involved in both mood regulation and migraine pathophysiology. Reduced serotonergic activity during the luteal phase has been linked to depressive symptoms in PMS and migraine attacks (Pearlstein & Steiner, 2008).

Low serotonin levels are associated with irritability, mood swings, and depressive symptoms commonly observed in PMS. In migraines, serotonin deficiency leads to vasodilation of cerebral blood vessels, contributing to migraine pathogenesis (Kroeze & Roth, 1998). Estrogen withdrawal reduces tryptophan availability, the precursor for serotonin synthesis, exacerbating serotonergic deficits during the premenstrual phase (Halbreich, 2003). Additionally, fluctuations in serotonin can affect the hypothalamic-pituitary-adrenal (HPA) axis, further dysregulating mood and stress responses (Girdler & Klatzkin, 2007). Selective serotonin reuptake inhibitors (SSRIs) have demonstrated efficacy in alleviating PMS symptoms, while triptans, which act on serotonin receptors, are effective in managing acute migraine attacks (Freeman et al., 1999). The bidirectional influence of serotonin on mood and pain pathways highlights its central role in the comorbidity of PMS and migraines.

3.2 Dopamine and GABA Systems

Dopaminergic hypersensitivity and GABAergic dysfunction are implicated in both PMS and migraines. Dopamine receptor sensitivity may influence migraine aura, while GABAergic dysregulation affects both mood stability and cortical excitability (Girdler & Klatzkin, 2007).

Dopaminergic hypersensitivity has been linked to symptoms such as nausea, fatigue, and mood fluctuations, which are common in both PMS and migraine prodromes (Peroutka, 1997). Additionally, dopamine dysregulation may contribute to increased stress sensitivity, aggravating both conditions (Rapkin & Lewis, 2013). GABA, the primary inhibitory neurotransmitter in the central nervous system, plays a critical role in mood regulation and the modulation of cortical excitability. Progesterone-derived neurosteroids, such as allopregnanolone, enhance GABAergic activity, producing anxiolytic and mood-stabilizing effects; however, abrupt changes in their levels during the menstrual cycle may lead to mood dysregulation and increased migraine susceptibility (Epperson et al., 2002). The complex interplay between dopaminergic and GABAergic systems underscores the neurochemical basis of PMS and migraines, providing potential targets for therapeutic intervention.

4. Neurovascular and Inflammatory Mechanisms

Neurovascular and inflammatory mechanisms are central to the pathogenesis of both PMS and migraines. These mechanisms involve complex interactions between hormonal fluctuations, vascular reactivity, and immune responses, contributing to the diverse symptoms experienced during the premenstrual phase and migraine attacks.

4.1 Neurovascular Dysregulation

Migraine is traditionally considered a neurovascular disorder characterized by altered cerebral blood flow and vascular reactivity. Similar vascular changes may occur in PMS, where hormonal fluctuations affect endothelial function and cerebral perfusion (Silberstein & Merriam, 1991). Estrogen, known for its vasodilatory effects, modulates nitric oxide synthesis, and its withdrawal leads to increased vascular tone and reactivity, potentially triggering migraine attacks (Edvinsson & Uddman, 2005).

Emerging evidence suggests that estrogen withdrawal impacts cerebral blood flow through both direct and indirect mechanisms involving the autonomic nervous system (Ashkenazi & Silberstein, 2006). Hormonal fluctuations also alter the expression of vasoactive peptides such as calcitonin gene-related peptide (CGRP), a key mediator in migraine pathogenesis (Russo, 2015). Additionally, changes in prostaglandin levels during the menstrual cycle may contribute to neurovascular instability, exacerbating both PMS symptoms and migraines (Maizels & Burchette, 2004). Neuroimaging studies have shown that cortical spreading depression (CSD), a wave of neuronal depolarization associated with migraine aura, is influenced by hormonal changes, further linking PMS to migraine pathophysiology (Pietrobon & Moskowitz, 2013). Estrogen's effects on mitochondrial function and oxidative stress also play a role in vascular health, potentially contributing to migraine susceptibility during hormonal fluctuations (Finocchi & Sassos, 2012).

4.2 Inflammatory Mediators

Pro-inflammatory cytokines and prostaglandins are elevated during the luteal phase, contributing to both PMS symptoms (e.g., bloating, breast tenderness) and migraine pathogenesis. These mediators can sensitize nociceptive pathways, enhancing pain perception (Rapkin & Akopians, 2012).

Elevated levels of interleukin-6 (IL-6), tumor necrosis factor-alpha (TNF-α), and C-reactive protein (CRP) have been associated with increased severity of PMS and migraine attacks (Mateen et al., 2016). Hormonal fluctuations, particularly the drop in estrogen, are known to trigger systemic inflammatory responses, which may exacerbate both mood symptoms and headaches (Graziottin & Gambini, 2006). Furthermore, neuroinflammation involving glial cell activation has been implicated in the pathogenesis of migraines and may also contribute to PMS-related cognitive and emotional disturbances (Dodick, 2018). The interplay between estrogen, inflammation, and vascular reactivity underscores the complex neuroimmune mechanisms underlying these conditions. Anti-inflammatory treatments, such as NSAIDs, have shown efficacy in managing both PMS and migraine symptoms, supporting the role of inflammation in their pathophysiology (Sances et al., 2004).

5. Comorbidity Between PMS and Migraine

Epidemiological studies show that individuals with PMS are more likely to experience migraines, and vice versa. The comorbidity is associated with greater symptom severity, increased disability, and poorer quality of life (Pavlović et al., 2015).

Women with both conditions often report more frequent and severe headaches, heightened mood disturbances, and greater sensitivity to environmental triggers compared to those with either condition alone (Breslau et al., 2003). This comorbidity suggests a potential genetic predisposition, as both PMS and migraines have been linked to polymorphisms in genes regulating serotonin and estrogen metabolism (Martin et al., 2006). The presence of comorbid anxiety and depression is also more common in individuals with both conditions, suggesting shared neurobiological mechanisms (Fuh et al., 2007). Hormonal fluctuations can exacerbate both mood disorders and migraines, indicating overlapping endocrine and neurological pathways (Bigal et al., 2008). Additionally, both PMS and migraines have been associated with dysregulation of the hypothalamic-pituitary-adrenal (HPA) axis, contributing to stress sensitivity and symptom chronicity (Kim et al., 2004). Understanding the comorbidity between PMS and migraines is essential for developing integrated treatment strategies that address the full spectrum of symptoms.

6. Diagnostic Challenges and Considerations

Diagnosing PMS and migraines requires careful symptom tracking to establish the cyclical pattern and hormonal correlation. Due to overlapping symptoms, distinguishing between primary mood disorders, chronic headaches, and hormonally driven conditions can be challenging.

6.1 Symptom Diaries

Symptom diaries, such as the Daily Record of Severity of Problems (DRSP) and headache diaries, help identify temporal associations between hormonal changes and symptom fluctuations (Yonkers et al., 2008). These tools enable clinicians to differentiate between menstrual-related migraines and other headache types, such as tension-type headaches or cluster headaches, which may have different triggers and treatment approaches.

Technological advancements have led to the development of mobile health applications that facilitate real-time symptom tracking, improving diagnostic accuracy (Johannes et al., 2000). Additionally, incorporating hormonal level assessments alongside symptom diaries can provide valuable insights into the hormonal triggers of both PMS and migraines (Bigal et al., 2008). Patient-reported outcome measures (PROMs) are increasingly used in clinical practice to assess the impact of symptoms on quality of life and guide personalized treatment plans (Kim et al., 2004). Accurate documentation of symptoms over multiple menstrual cycles is crucial for differentiating PMS from other mood or anxiety disorders.

6.2 Differential Diagnosis

Differential diagnosis is critical to avoid misclassification and ensure appropriate treatment. Conditions such as thyroid disorders, polycystic ovary syndrome (PCOS), and endometriosis can mimic PMS symptoms, while secondary headache disorders may present similarly to migraines.

Neuroimaging and hormonal assays may be necessary in complex cases to rule out underlying neurological or endocrine disorders (Pavlović et al., 2015). Moreover, psychiatric evaluation can help differentiate between PMS-related mood disturbances and primary mood disorders, which may require different therapeutic approaches (Breslau et al., 2003). Early and accurate diagnosis not only improves patient outcomes but also reduces the risk of chronicity and associated disability.

7. Therapeutic Approaches

7.1 Pharmacological Treatments

Pharmacological approaches to mitigating PMS-related migraines revolve around SSRIs, combined oral contraceptives, triptans, NSAIDs, and other supportive agents (Pearlstein & Steiner, 2008). SSRIs can alleviate mood symptoms by modulating serotonergic pathways, potentially leading to a decrease in migraine frequency (Pearlstein & Steiner, 2008). Combined oral contraceptives effectively stabilize hormonal fluctuations, thereby reducing PMS symptoms and menstrual migraines (Calhoun, 2012). Triptans, widely regarded as the first-line therapy for acute migraines, show particular efficacy against menstrual migraine attacks (Bigal & Lipton, 2006). Through the inhibition of prostaglandin synthesis, NSAIDs mitigate both PMS-induced discomfort and the inflammatory components of migraine (Sances et al., 2004). Personalizing these interventions based on individual symptom severity, comorbidities, and treatment response is a fundamental strategy for optimizing outcomes (Nappi et al., 2013). Moreover, magnesium supplementation and the combination of hormonal with non-hormonal pharmacotherapies can provide additional benefits by addressing neurotransmitter dysregulation linked to both PMS and migraines (Genazzani et al., 2010; Sances et al., 2004).

7.2 Non-Pharmacological Interventions

Non-pharmacological interventions such as Cognitive Behavioral Therapy (CBT), lifestyle modifications, and stress-reduction techniques play a pivotal role in reducing the impact of PMS and migraine. CBT employs structured approaches to transform negative thought patterns and decrease anxiety, factors that exacerbate PMS and migraine severity (Holroyd et al., 2010). Regular exercise bolsters endorphin release, helps regulate mood, and may diminish the frequency of migraine episodes (Rains et al., 2005). Mindfulness meditation and relaxation

training are valuable in modulating the autonomic nervous system, potentially lowering migraine intensity (Freedman, 2014). Dietary modifications, including reduced caffeine and sodium intake, can address fluid retention and mitigate common migraine triggers (MacGregor, 2015). Ensuring adequate sleep hygiene by maintaining consistent sleep-wake times helps stabilize circadian rhythms that influence hormonal fluctuations (ACOG, 2015). When combined with vitamin and mineral supplementation, these lifestyle strategies create a synergistic effect, significantly improving outcomes for individuals suffering from both PMS and migraines (Nappi et al., 2013; Rains et al., 2005).

8. Future Directions and Research Gaps

Future research into PMS-migraine comorbidity must focus on developing standardized diagnostic criteria that can enhance consistency in both clinical practice and research (Charles, 2018). Reliable criteria would lead to more precise patient stratification in clinical trials, thereby improving the validity of subsequent findings. Advanced genomic and proteomic approaches could elucidate individualized risk factors and hormonal mechanisms underlying these interrelated conditions (Genazzani et al., 2010). Pinpointing the specific neurochemical and neuroinflammatory pathways common to PMS and migraines could open the door to novel, targeted therapies (Nappi et al., 2013; Bigal & Lipton, 2006). Such advancements rely on effective collaboration among specialists in neurology, gynecology, and psychiatry, ensuring a holistic understanding and management of these disorders (Calhoun, 2012). Digital health tools and wearable devices further represent a promising frontier for gathering real-time data on hormonal fluctuations and migraine triggers (Charles, 2018). Ultimately, bridging the existing research gaps demands a concerted effort that addresses biological, psychological, and lifestyle factors to improve patient care.

9. Conclusion

In conclusion, PMS and migraines share overlapping pathophysiological elements, including hormonal imbalances, neurotransmitter dysregulation, and neurovascular changes, which collectively affect patient well-being (Pearlstein & Steiner, 2008). Recognizing the synergy between these conditions is vital for formulating comprehensive treatment plans that address both their somatic and psychological dimensions. Pharmacological interventions such as SSRIs, triptans, and combined hormonal therapies can substantially alleviate the combined symptom burden when carefully tailored to patient needs (Calhoun, 2012). Concurrently, non-pharmacological approaches like CBT, regular exercise, and dietary modifications enhance resilience and reduce the impact of PMS and migraine triggers (Holroyd et al., 2010). Ongoing research should prioritize refining diagnostic criteria and identifying biomarkers that support a more individualized approach to management (Charles, 2018). Such integrated and personalized care depends on collaboration across multiple disciplines to address the multifaceted nature of PMS-related migraines. By combining evidence-based pharmacological and lifestyle interventions, healthcare providers can significantly improve the quality of life for individuals affected by both PMS and migraines (Rains et al., 2005).

Disclosure
Authors do not report any disclosures.

Michalina Makieła [MM] and Marta Makieła [MMa] were responsible for the initial conceptualization of the review, drafting the primary structure of the manuscript, and performing the preliminary literature search to identify key articles on the pathophysiology of PMS and migraines.

Weronika Koziak [WK] contributed to data collection and analysis, focusing on neurochemical and hormonal interactions. She also assisted in organizing the references and contributed to writing specific sections related to estrogen withdrawal and progesterone fluctuations.

Aleksandra Bętkowska [AB] carried out an extensive literature review on PMS and migraine comorbidity, synthesizing findings related to inflammatory and neurovascular mechanisms. She also provided editorial input and integrated feedback from the co-authors.

Stanisław Dudek [SD] contributed clinical insights from his experience at the University Clinical Center, ensuring that the diagnostic and therapeutic discussions accurately reflect current medical practice. He also reviewed and revised the sections on clinical presentation and diagnostic challenges.

Agata Kornacka [AK] reviewed the manuscript for scientific rigor and validity. She assisted in clarifying the endocrine and reproductive aspects of PMS, including hormone assay considerations, and added relevant references to support the hormonal fluctuation hypotheses.

Kamila Szostak [KSz] played a key role in writing and refining the sections on non-pharmacological interventions, drawing from her background in patient education and holistic care strategies. She also assisted with proofing the final manuscript.

Rafał Tomaka [RT] oversaw the statistical and epidemiological components, ensuring that any prevalence data and statistical findings mentioned in the paper were accurately interpreted. He also offered critical revisions on the methodology of literature selection for the review.

Aleksandra Zając [AZ] contributed expertise on biomedical research methodologies, including the use of digital health tools, and provided feedback on the future directions section, outlining how wearable technologies might enhance individualized patient care.

Daniel Worobiej served as the senior reviewer, offering final edits and guidance on the theoretical framework. She helped align the review's discussion with broader trends in neurology and gynecology, ensuring that the manuscript meets academic standards for interdisciplinary relevance.

All authors read and approved the final version of the manuscript.

Funding statement

This research received no external funding.

Institutional Review Board Statement

Not applicable.

Informed Consent Statement

Not applicable.

Data availability statement

Not applicable.

Acknowledgments

The authors declare that there are no acknowledgments for this study.

Conflict of Interest Statement

The authors declare no conflict of interest.

References

Freeman, E. W., Rickels, K., Arredondo, F., Kao, L. C., Pollack, S. E., & Sondheimer, S. J. (1999). Full- or half-cycle treatment of severe premenstrual syndrome with a serotonergic antidepressant. *Journal of Clinical Psychopharmacology*, 19(1), 3–8.

Kroeze, W. K., & Roth, B. L. (1998). The molecular biology of serotonin receptors: Therapeutic implications for the interface of mood and psychosis. *Biological Psychiatry*, 44(11), 1128–1142. PMID: 9836016

Halbreich, U. (2003). The association between hormones and depression in women. *Journal of Affective Disorders*, 74(1), 1–9.

Girdler, S. S., & Klatzkin, R. (2007). Biological mechanisms underlying the relationship between PMS and stress: Preliminary data. *Current Psychiatry Reports*, 9(6), 467–475.

Peroutka, S. J. (1997). Dopamine and migraine. *Neurology*, 49(3), 650–656.

Rapkin, A. J., & Lewis, E. I. (2013). Treatment of premenstrual dysphoric disorder. *Women's Health (London)*, 9(6), 537–556.

Epperson, C. N., Haga, K., Mason, G. F., et al. (2002). Cortical γ-aminobutyric acid levels across the menstrual cycle in healthy women and those with PMDD. *The Journal of Clinical Endocrinology & Metabolism*, 87(12), 5556–5560.

Calhoun, A. H., & Hutchinson, S. (2009). Hormonal therapies for menstrual migraine. *Current Pain and Headache Reports*, 13(5), 381–385.

Nappi, R. E., Sances, G., & Facchinetti, F. (2013). Hormonal aspects of migraine and their therapeutic implications. *Expert Review of Neurotherapeutics*, 13(4), 421–432.

MacGregor, E. A. (2014). Estrogen and attacks of migraine with and without aura. *The Lancet Neurology*, 13(4), 303–313.

Facchinetti, F., Sances, G., Borella, P., Genazzani, A. R., & Nappi, G. (2003). Magnesium prophylaxis of menstrual migraine: Effects on intracellular magnesium. *Headache: The Journal of Head and Face Pain*, 43(7), 596–602.

Schiavone, S., Jaquet, V., Trabace, L., & Krause, K. H. (2015). Severe life stress and oxidative stress in the brain: From animal models to human pathology. *Antioxidants & Redox Signaling*, 23(11), 1080–1091.

Yonkers, K. A., O'Brien, P. M. S., & Eriksson, E. (2008). *Premenstrual syndrome. The Lancet*, 371(9619), 1200–1210.

Vetvik, K. G., & MacGregor, E. A. (2017). *Sex differences in the epidemiology, clinical features, and pathophysiology of migraine. The Lancet Neurology*, 16(1), 76–87.

MacGregor, E. A. (2004). *Oestrogen and attacks of migraine with and without aura. The Lancet Neurology*, 3(6), 354–361.

Halbreich, U., & Kahn, L. S. (2001). *Role of estrogen in the aetiology and treatment of mood disorders. CNS Drugs*, 15(10), 797–817.

Epperson, C. N., Haga, K., Mason, G. F., et al. (2002). *Cortical γ-aminobutyric acid levels across the menstrual cycle in healthy women and those with PMDD. The Journal of Clinical Endocrinology & Metabolism*, 87(12), 5556–5560.

Ashkenazi, A., & Silberstein, S. D. (2006). Hormone-related headache: Pathophysiology and treatment. *CNS Drugs*, 20(2), 125–141. PMID: 16478288

Pearlstein, T., & Steiner, M. (2008). *Premenstrual dysphoric disorder: Burden of illness and treatment update. Journal of Psychiatry & Neuroscience*, 33(4), 291–301.

Benedetti, F., et al. (2015). *Serotonin and mood disorders: From cell biology to psychopharmacology. Neuropharmacology*, 95, 5–16.

Edvinsson, L., & Uddman, R. (2005). Neurobiology in primary headaches. *Brain Research Reviews*, 48(3), 438–456.

Russo, A. F. (2015). Calcitonin gene-related peptide (CGRP): A new target for migraine. *Annual Review of Pharmacology and Toxicology*, 55, 533–552.

Maizels, M., & Burchette, R. (2004). Somatic symptoms in headache patients: Influence of migraine and depression. *Headache*, 44(9), 974–982.

Pietrobon, D., & Moskowitz, M. A. (2013). Pathophysiology of migraine. *Annual Review of Physiology*, 75, 365–391.

Finocchi, C., & Sassos, D. (2012). Headache and hormones: Migraine and menopause. *Neurological Sciences*, 33(Suppl 1), S47–S50.

Mateen, S., Zafar, A., Moin, S., Khan, A. Q., & Zubair, S. (2016). Understanding the role of cytokines in the pathogenesis of rheumatoid arthritis. *Clinica Chimica Acta*, 455, 161–171.

Graziottin, A., & Gambini, D. (2006). The role of inflammation in endometriosis. *Gynecological Endocrinology*, 22(9), 556–562.

Dodick, D. W. (2018). A phase-by-phase review of migraine pathophysiology. *Headache*, 58(Suppl 1), 4–16.

Bigal, M. E., Rapoport, A. M., Lipton, R. B., Tepper, S. J., & Sheftell, F. D. (2008). Assessment of migraine disability using the MIDAS questionnaire. *Headache*, 43(10), 1089–1095.

Fuh, J. L., Wang, S. J., Lu, S. R., & Juang, K. D. (2007). Comorbid migraine, major depression, and anxiety disorders in adolescents. *Neurology*, 68(6), 419–424.

Pavlović, J. M., Buse, D. C., & Lipton, R. B. (2015). Association of migraine with reproductive hormones and contraceptive use in women. *Current Pain and Headache Reports*, 19(10), 47.

Girdler, S. S., & Klatzkin, R. (2007). *Biological mechanisms underlying the relationship between PMS and stress: preliminary data. Current Psychiatry Reports*, 9(6), 467–475.

Silberstein, S. D., & Merriam, G. R. (1991). *Estrogens, progestins, and headache. Neurology*, 41(6), 786–793.

Charles, A. (2018). *The pathophysiology of migraine: Implications for clinical management. The Lancet Neurology*, 17(2), 174–182.

Rapkin, A. J., & Akopians, A. L. (2012). *Pathophysiology of premenstrual syndrome and premenstrual dysphoric disorder. Menopause International*, 18(2), 52–59.

Pavlović, J. M., et al. (2015). *Menstrual migraine: What we know and what we need to know. Current Pain and Headache Reports*, 19(3), 19.

Sances, G., et al. (2004). *Estrogen levels and migraine in women with menstrual-related migraine: A pilot study. Headache*, 44(9), 930–934.

Holroyd, K. A., et al. (2010). *Cognitive-behavioral therapy and preventive drug treatment for chronic migraine. Headache*, 50(4), 600–613.

Rains, J. C., et al. (2005). *Behavioral sleep medicine for chronic headache: A randomized controlled trial. Headache*, 45(5), 512–522.

Nappi, R. E., et al. (2013). *Hormonal aspects of migraine and their therapeutic implications. Expert Review of Neurotherapeutics*, 13(4), 423–435.

Genazzani, A. R., et al. (2010). *Neurosteroids and neuroprotection: A major challenge in neuroendocrinology. Frontiers in Neuroendocrinology*, 31(3), 287–302.

Bigal, M. E., & Lipton, R. B. (2006). *Modifiable risk factors for migraine progression. Headache: The Journal of Head and Face Pain*, 46(9), 1334–1343.

Pearlstein, T. B., & Steiner, M. (2008). Premenstrual dysphoric disorder: Burden of illness and treatment updates. *Journal of Psychiatry & Neuroscience*, 33(4), 291–301.

Calhoun, A. H. (2012). Menstrual migraine: Update on pathophysiology and approach to therapy and management. *Current Treatment Options in Neurology*, 14(1), 1–14.

Bigal, M. E., & Lipton, R. B. (2006). Concepts and mechanisms of migraine chronification. *Headache: The Journal of Head and Face Pain*, 46(Suppl 4), S9–S15.

Sances, G., Granella, F., Nappi, R. E., Ghiotto, N., Polatti, F., & Nappi, G. (2004). Course of migraine during pregnancy and postpartum: A prospective study. *Cephalalgia*, 24(2), 142–149.

Nappi, R. E., Berga, S. L., Luisi, S., & Koenen, C. (2013). Hormonal management of migraines in women: An update. *European Journal of Neurology*, 20(5), 685–692.

Genazzani, A. R., Gadducci, A., Gambacciani, M., & Simoncini, T. (2010). Hormonal therapies in postmenopausal women and effects on central nervous system, cardiovascular system, and cancer risk. *Gynecological Endocrinology*, 26(11), 791–807.

Holroyd, K. A., Lipchik, G. L., & Penzien, D. B. (2010). Behavioral management of recurrent headache: Three decades of experience and empiricism. *Applied Psychophysiology and Biofeedback*, 35(2), 137–151.

Rains, J. C., Penzien, D. B., McCrory, D. C., & Gray, R. N. (2005). Behavioral facilitation of medical treatment for headache—part I: Review of headache treatment compliance. *Headache: The Journal of Head and Face Pain*, 45(10), 1337–1343.

Charles, A. (2018). The pathophysiology of migraine: Implications for clinical management. *The Lancet Neurology*, 17(2), 174–182.

MacGregor, E. A. (2015). Menstrual migraine: A clinical update. *Cephalalgia*, 35(10), 896–905.

American College of Obstetricians and Gynecologists (ACOG). (2015). Premenstrual syndrome (PMS). *ACOG Practice Bulletin*.

Freedman, F. (2014). Menstrual migraine: Pathophysiology, diagnosis, and treatment. *Practical Neurology*, 14(2), 111–118.