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Review

Premenstrual Syndrome and Exercise: A Narrative Review

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Abstract: Premenstrual Syndrome (PMS) is a complex physiological and psychological condition that affects a significant number of women during their reproductive years. Although the exact etiology of PMS remains unclear, its symptoms, including mood swings, bloating, irritability, and fatigue, can significantly impair the quality of life for affected individuals. The management of PMS traditionally involves pharmacological interventions; however, emerging evidence suggests that exercise may offer a valuable non-pharmacological approach to alleviate PMS symptoms. This narrative review aims to explore the proposed etiology, prevalence, and impact PMS has on women as well as examine the literature through which exercise can positively influence PMS symptoms. While the existing literature on exercise and PMS is limited and inconclusive, several studies have reported promising results. Regular exercise has been associated with a reduction in physical and psychological symptoms of PMS including pain, fatigue, mood disturbances, and water retention. Furthermore, exercise has demonstrated its potential to enhance overall well-being and mitigate the negative effects of PMS on daily functioning. Further research is warranted to elucidate the optimal exercise prescription, duration, and intensity required to maximize the benefits and improve the understanding of exercise mechanisms on PMS symptomatology.

Keywords: premenstrual syndrome; women's health; exercise; menstrual health

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1. Introduction

Premenstrual syndrome (PMS) is characterized by a collection of physical, emotional, psychological, and behavioral symptoms that appear in a cyclic and recurring pattern during the late luteal phase of the menstrual cycle and alleviate within two to four days of menstruation. These symptoms negatively influence personal and professional aspects of life including work performance, social activities, and inter/intrapersonal relationships. The extent to which PMS impacts the lives of women is underrecognized and is oftentimes dismissed as a natural part of being a woman.

This narrative review will provide a comprehensive understanding of PMS through exploring its etiology, manifestation, and impact as well as synthesize the current literature on the effectiveness of exercise as a treatment option. There is no singular treatment for PMS as there are over 150 documented symptoms [1,2], and wide variability in its prevalence, expression, and impact. Treatments have varied from pharmacological agents and psychological therapy to the use of herbs and supplements with only brief mention of lifestyle factors such as physical activity and structured exercise behaviors. This review will present findings on studies looking at exercise and its impact on PMS, how exercise can influence the presence and severity of PMS symptoms, and importantly, critique the quality of research studies in this area. With exercise being a cost-effective, socially engaging, and modifiable activity, its implementation in PMS care should be explored to further enhance women's health outcomes and their quality of life.

2. Defining PMS

The American College of Obstetricians and Gynecologists (ACOG) defines PMS as a condition where a woman experiences at least one affective symptom and one somatic symptom that causes dysfunction in social, academic, and/or work performance [3]. These symptoms must occur outside of the context of other conditions such as thyroid disorders and other mental health illnesses, and in the absence of any pharmacologic therapy, hormone ingestion, or drug use [3].

There is a more severe, psychological premenstrual condition called Premenstrual Dysphoric Disorder (PMDD) which the American Psychiatric Association (APA) defines as the presence of debilitating somatic and behavioral symptoms, which could include a major depressive episode, that significantly affects the quality of life or prevents a woman from functioning on an everyday basis [4]. Using the DSM-5, the presence of at least five of the listed symptoms must be present for a PMDD diagnosis [4]. Some of these symptoms include depressed mood, anxiety, affective lability, loss of interest, lethargy, a marked change in appetite, hypersomnia or insomnia, and other physical and emotional symptoms.

The International Society for Premenstrual Disorders (ISPD) published a consensus article with a thorough classification of PMS by distinguishing premenstrual disorders (PMD) into two categories [5]. The symptom characteristics of the core PMD category can be somatic and/or psychological, occurring in ovulatory menstrual cycles during the luteal phase, and are prospectively rated for at least two menstrual cycles. These symptoms could cause significant impairment of work, school, social activities, hobbies, and interpersonal relationships [5]. The other category is described as variant PMD which includes premenstrual exacerbation where symptoms of a separate and underlying psychological or somatic disorder are significantly worsened premenstrual; PMD due to non-ovulatory ovarian activity where symptoms arise from continued ovarian activity even though menstruation itself is suppressed; progestogen induced PMD where symptoms result from ovarian activity other than those resulting from ovulation; PMD with absent menstruation where symptoms result from exogenous progestogen administration [5]. Variant PMD has more complex characteristics that do not directly stem from a direct PMS diagnosis. For the context of this review, we will focus on the core category of PMD according to ISPD and PMS according to the ACOG, both will be referred to as PMS going forward.

It is important to understand the cultural context surrounding the discussion of menstrual health in women across the world. The cultural environment can influence how women perceive premenstrual symptoms, how the symptoms impact her ability to complete daily responsibilities, and the support she receives about management and care. Although exploring cultural influences on women's reproductive health and its relation to PMS diagnosis, symptom expression, management, and care are outside the scope of this review, these cultural influences must be acknowledged for the holistic understanding of this syndrome and how the community responds and supports women who have premenstrual distress.

2.1. Symptoms of PMS

There are a vast number of documented symptoms of PMS that cover physical, psycho-emotional, and behavioral domains. The most common physical symptoms include abdominal cramps, abdominal bloating, tenderness and pain in the breasts, pain (back, head, muscle, joints), swelling of hands and feet, weight fluctuations, constipation, diarrhea, and fatigue [1,2,6–8]. Psycho-emotional symptoms include depressed mood, tendency to cry, irritability, emotional lability, anxiety, difficulty concentrating, anger, and mood swings [2,6–8]. Behavioral symptoms can stem from the consequences of physical and psych-emotional symptoms and/or stem from being PMS symptoms themselves. They can include changes in libido and in sexual desire, social withdrawal including from partner, family and friends, sensitivity, increased appetite, decreased interest in activities, restlessness, social phobia, and increased interpersonal conflict [1,2,6,9].

The severity and timing of this collection of symptoms varies per woman. There are other external factors, such as stress and illness, which could also exacerbate symptoms. For example, a woman may experience bloating and cramps several days before menstruation while the symptoms of irritability and anxiety could manifest on the day of menstruation. Add in an external stressor such as an exam or a big work deadline and other symptoms could manifest, or the present symptoms could worsen. Proper diagnosis of PMS involves keeping a record of symptom presence and severity so women and their healthcare providers can identify patterns and confirm the cyclic nature of symptoms. Given that most women in the United States go through 400 to 500 menstrual cycles in their lifetime, a consistently symptomatic woman experiencing PMS may spend 4 to 10 years of her life in a compromised physical, emotional, and psychological state [10]. Proper identification of symptoms and monitoring well-being throughout the menstrual cycle is key for optimal female health as PMS has been associated with decreased health-related quality of life [11].

2.2. Prevalence of PMS

Estimates for the prevalence of diagnosed PMS are varied and encompass a wide range from 12% reported in a study that surveyed 2800 French women [12], to 98.2% reported in a survey of 300 university students in Iran [13], with an average of 47.8% as reported in a meta-analysis of studies conducted across 17 countries [14]. However, many studies note that a larger percentage of women experience at least some premenstrual symptoms that could affect their daily life but not to the extent of having a complete PMS diagnosis. In addition, it should be noted that other factors such as race, ethnicity, and cultural norms surrounding menstruation can impact prevalence findings as well as how PMS impacts women. According to data from the World Health Organization (WHO), dysmenorrhea affects 1.7–97% of women and the percentage of women that experience more than one premenstrual symptom ranges from 20–40% [15].

It is difficult to provide a more robust estimation of PMS prevalence for a variety of reasons. First, the definition of PMS has only begun to solidify even though there are still some nuances depending on which organizational body the definition is coming from. Second, access to medical care, methods used to identify and diagnose PMS, self-diagnosis, self-medication, underlying diseases, cultural influences, and failure to report premenstrual symptoms due to social stigma and/or complacent acceptance that PMS is just what a woman goes through are potential reasons for the wide range in prevalence values. Nonetheless, premenstrual symptoms burden millions of women whether they constitute confirmed PMS or not, therefore, finding ways to enhance the discussion of women's health and improve the quality of life of women through exercise could serve as a potent and welcomed way to alleviate PMS symptoms.

2.3. Impact of PMS

With up to 10 years of their lives spent in premenstrual distress, the impact PMS has on women does not solely affect their physical health, mental well-being, and psychological states. The effects permeate every aspect of a woman's life. Compared to women without PMS, those with PMS have been reported to have more absent days from work and more days in which they struggle to complete work and school tasks which translates to lowered productivity [2,16]. Some women with PMS even report a poorer perception of their overall quality of life [17], as well as their work-related quality of life and decreased job career satisfaction levels [18]. A study has also shown that women with PMS have a 27.5% lower work performance and 23.1% perceived impairment of their working relationships [19]. University students also report that PMS significantly influences their daily activities and their ability to complete coursework, which directly impacts their educational endeavors [13,20].

These occupational and educational impacts of PMS come with direct and indirect economic consequences. Borenstein et al. [21] reported that direct medical costs of those with PMS average out to \$210 $\pm$ \$328 per year in outpatient medical visits, \$16 $\pm$ \$146 in

laboratory services, and \$59 ± 310 in radiology services. The large standard deviations presented demonstrate large variability in the direct costs to women which could be related to occupation type, access to quality medical care, social economic status, and other community-based factors. Some women may have hundreds of dollars of direct medical costs that add to the burden of having PMS. Indirectly, women with PMS lose an average of 15% of work productivity and 3.6 ± 7.8 h missed from work [21]. According to their model, PMS alone would cost women's healthcare plans \$174,936 per year in the United States. This is in addition to any other underlying condition a woman experiences or general health care costs.

Outside education and professional spaces, the indirect costs of PMS can be detrimental to self-esteem, and bring about depressed moods that could increase the sense of dissatisfaction and inadequacy, particularly in young women [22]. Interpersonal relationships can also undergo strain during the occurrence of PMS symptoms [23], bringing forth conflicts, controversies, and discomfort among partners, friends, and family [24], further impacting the quality of life and well-being in women. This distress demonstrates that PMS is a biopsychosocial phenomenon which demonstrates a critical need to support and manage the care of women as they undergo this cyclic pattern of symptoms that could deteriorate life quality.

2.4. Risk Factors of PMS

The role of potential genetic factors that increase the risk of premenstrual disorders is an active field of research that has not brought definitive conclusions. A study conducted by Miller et al. supported the relevance of estrogen receptor alpha (ESR-1) polymorphic variants in the regulation of affective state-independent personality traits in women with PMDD [25]. Later work in the area supported the consideration of ESR-1 to be used as a marker of PMS [26]. These studies call for future research to further explore potential genetic risk factors of PMS and other premenstrual disorders.

Another potential risk factor for PMS is the age of menarche or the age at which a girl experiences her first menstrual period. Studies have demonstrated that women with premenstrual disorders were younger during menarche compared to those without PMS [27]. In fact, the authors report an inverse relationship between the age of menarche and the risk of PMS symptoms [27]. Therefore, the younger a woman was when she first got her menstrual period, the greater the risk of developing or at the very least, having PMS symptoms. In addition, the early growth of pubic hair led to a 28% increased risk of premenstrual symptoms and PMD [27]. Based on this observation, it seems plausible that early menarche exposes the woman's body to more ovulatory cycles and thus more hormone fluctuations that could lead them to be more susceptible to PMS and other PMD than those who experience menarche at an older age.

The impact of stress cannot be overlooked in the discussion of risk factors for premenstrual distress. In a broader sense, the existence of serious mood disorders, history of abuse, exposure to violence, and heightened stress levels due to occupation, education, and domestic demands could contribute to PMS [28]. Women with PMS experience an increased sensitivity to environmental stress and a heightened sensory perception that makes everyday activities more burdensome [29]. This information demonstrates that women with PMS are more susceptible to the negative consequences of stress and that stress itself can influence the severity of PMS symptoms. Such a situation poses the opportunity for exercise to serve as an invaluable tool not only to combat PMS directly but also through providing an avenue of stress relief that can improve the overall quality of life in women.

3. Proposed Etiology of PMS

3.1. Role of Ovarian Hormones

One of the proposed etiologies of PMS involves the cyclic hormonal fluctuations of estrogen and progesterone during the menstrual cycle, particularly during the late luteal phase as the body prepares for menstruation. It has been reported that the suppression of

ovulation with oral medication has beneficial effects on PMS symptoms [30], but this could merely be an association since there could have been other influential factors at play. Women with and without PMS have similar cyclic changes in ovarian steroid concentrations [12,31], and studies have found no significant correlation between progesterone levels and several affective and somatic symptoms of PMS [32,33]. The distinction between having or not having PMS could stem from how the body responds to the cyclic changes in ovarian hormones across the menstrual cycle. Investigators have proposed that women with PMS may have an abnormal response to the cyclic hormonal changes that contribute to PMS even when the serum concentration of estrogen and progesterone are within normal limits [34]. There is no conclusive evidence to warrant a high degree of certainty that abnormal responses to ovarian hormones trigger PMS, but it is a plausible factor to take into consideration as future research can provide more detail on the degree of abnormal responses and how those responses influence the presence of the numerous possible premenstrual symptoms.

3.2. Role of Neurotransmitters

Interestingly, another proposed cause of PMS is the interaction between ovarian steroid fluctuations and the functioning of central neurotransmitters, notably serotonin, gamma-aminobutyric acid (GABA), and beta-endorphins [23]. During the luteal phase, women with PMS have more serotonin abnormalities than women without PMS symptoms [35]. Serotonin is responsible for many psychologic, physiologic, emotional, and behavioral responses and women with PMD express similar symptoms to individuals who have a reduced level of serotonin, posing the thought that the two could be related [35]. In fact, studies show that women with PMS have lower levels of whole-blood serotonin, platelet serotonin, and serotonin metabolites during the luteal phase [36–38]. In addition, the use of serotonin reuptake inhibitors is cited as one of the most effective drugs for treating PMS [39].

The role GABA may play in the etiology of PMS is an area that has not been extensively investigated; however, present work suggests that progesterone may play a modulatory role in GABA's inhibitory system. This hypothesis is supported by observations of improvement in PMS symptoms using agents such as benzodiazepine and alprazolam that work to increase GABA activity [40]. In addition, metabolites of progesterone have been shown to function as positive allosteric modulators of GABA in the brain [41]. Women diagnosed with Premenstrual Dysphoric Disorder (PMDD) demonstrate changes in $GABA_A$ receptor sensitivity and overall GABA concentrations that could play a role in the negative mood states associated with the disorder [42]. Whether these sensitivities and concentration fluctuations contribute to PMS and overall premenstrual distress is still unclear.

The role endorphins play in PMS symptomology has not been definitively concluded but there is evidence that shows the release of endorphins is coupled with the release of estrogen and could theoretically decline with ovulation and remain at low levels during the late luteal phase when estrogen levels decline again prior to menstruation [43]. It has also been reported that beta endorphin levels of women with PMS during the luteal phase are lower than asymptomatic controls [44]. Although this may not mean there is a direct connection between lower endorphin levels and the presence of PMS symptoms, Peck [45] described several peripheral actions through which reduced levels of endorphins connect to PMS. Lambert [46] summarized these peripheral actions as the following: reduced endorphin levels may depress the E1 prostaglandin which may lead to the symptom of constipation in PMS; a reduction in endorphin release could increase prolactin levels which can lead to irritability, tension, and anxiety. Increased levels of prolactin have also been cited as another cause of breast tenderness and edema in women premenstrually [47]. Women with PMS could potentially have higher levels of prolactin compared to women without PMS or they may experience an increased sensitivity to prolactin level changes that contribute to these premenstrual symptoms.

Another peripheral action of endorphins relates it to its influence on adrenocorticotrophic hormone (ACTH) which helps regulate the renin-angiotensin aldosterone system [45]. This system is essential for the regulation of fluid in the body. These peripheral endorphin reactions could lead to increased water retention, resulting in the occurrence of premenstrual bloating, weight gain, and edema [8,48]. Deficiencies in vitamin B6 and magnesium could also factor into these symptoms [8,49]. The role endorphins have on the symptomology of PMS has not been substantially concluded; however, it is clear participating in physical exercise can serve as a potent way to help women mitigate PMS through the connection between exercise and endorphin release which has been linked to changes in mood states, altered pain perception, and the stress response on hormones such as ACTH, prolactin, catecholamines, and cortisol [45,50].

4. Role of Exercise in Managing PMS

4.1. Summarizing the Literature: Is Exercise Helpful in Managing PMS?

Many women report using exercise as a strategy to help them deal with PMS [51], and exercise is frequently suggested for symptom management [3,5,52]. However, studies have not demonstrated consistent symptom improvement leading to the notion that PMS management with exercise should be implemented on a case-by-case basis as there are numerous factors impacting and influencing each women's PMS presentation and many ways to manipulate exercise prescription variables to tailor programs to the individual's needs and preferences. Nonetheless, the benefits of exercise are too grand to ignore, and a discussion of current research findings can pave the way for future research directions to better understand and help women take charge of their health by managing premenstrual distress. Table 1 summarizes key components of exercise studies investigating PMS outcomes.

Table 1. Exercise Intervention Studies and PMS Outcomes.

Author	Sample	Definition of PMS	Exercise Modality	Exercise Prescription	Results
Prior et al., 1986 [53]	Ex: 8 sedentary, eumenorrheic women Control: 6 sedentary, eumenorrheic women with insulin-dependent diabetes mellitus	No formal definition or screening for PMS "Most spontaneously volunteered moliminal symptoms though none complained of severe premenstrual symptoms for which she sought medical help". 10-item intensity-graded menstrual symptom questionnaire provided at baseline and at 3 months	Ex: Running; walking was incorporated if fitness was low, then progressed to running Control: no exercise	2–4 sessions per week; 10–15 min across a 3-month period	Exercise group reported a decrease in global premenstrual symptoms ($p < 0.001$), breast awareness or tenderness ($p < 0.005$), fluid symptoms/perceived puffiness and bloating ($p < 0.025$) compared to control No significant different in depressive symptoms, anxiety, appetite, interest in sex, tendency to premenstrual headache or perceived external causes of stress
Prior et al., 1987 [54]	Control (C-NT): 3 sedentary, eumenorrheic women Sedentary (ST): 8 sedentary, eumenorrheic women Marathon (MT): 7 eumenorrheic women actively training for a marathon	No formal definition of PMS Menstrual Cycle Questionnaire and Daily Symptom Diary	ST and MT: Running C-NT: no exercise	No specific prescription was given to either ST or MT ST: gradually increased program of running with session 2–4 days/week MT: self-chosen marathon training program Quantified by estimated distance (km/cycle), average training distance (average length of run) and "training impulses" (TRIMPS), a measure of time and average heart rate with respect to basal and max heart rate	ST women reported a decrease in global premenstrual symptoms ($p < 0.001$), breast awareness or tenderness ($p < 0.005$), fluid symptoms or perceived puffiness and bloating ($p < 0.001$), and perceived external causes of stress ($p < 0.025$) MT women reported a decrease fluid-related symptoms ($p < 0.05$), luteal phase feelings of depression ($p < 0.02$) Both exercising groups (ST and MT) experienced decreases in physical and emotional symptoms over time with no changes in the C-NT group

Table 1. *Cont.*

Author	Sample	Definition of PMS	Exercise Modality	Exercise Prescription	Results
Ghanbari et al., 2008 [47]	Non-exercise control: 48 women with no prior history of regular exercise Exercise: 43 women who underwent exercise program for 3 months, 22 had a prior history of exercise	Using a Modified Menstrual Distress Questionnaire, investigators classified symptoms as mild, moderate, or severe along emotional, behavioral, electrolyte changes, autonomic, skin and neurovegetative domains	Aerobic based	"The exercise program consisted of a five-minute warm up, 45 min limb and trunk fast exercise and a ten-minute cool down. The exercise time duration was one hour and was carried out three times per week for three months".	The mean severity for total PMS symptoms was less in the exercise group compared to the non-exercise control after the 3-month intervention ($p = 0.07$) Significant differences in electrolytic ($p = 0.05$), neurovegetative ($p = 0.03$) and cognitive ($p = 0.02$ symptoms The exercise group who did not have a prior exercise history (n = 22) had significantly less skin ($p = 0.048$) and neurovegetative ($p = 0.002$) symptoms compared to the non-exercise control
El-Lithy et al., 2015 [6]	30 eumenorrheic, sedentary women diagnosed with PMS were allocated into an exercise group and control group both groups got vitamin B6 and calcium supplements	Modified Premenstrual Syndrome Questionnaire was given, scoring at least 50% greater in the premenstrual symptoms compared to post menstrual symptoms and rating moderate to severe impairment in one or more subscale	Treadmill walk/run	"The treadmill exercise programme was started with warm-up period, in which each participant walked at 80 m/min at 0.0% grade for 5 min. After the walk, the treadmill speed was increased to 147 m/min and the grade was increased gradually until it reached 25%, for 20 min. This was followed by a cool-down period, in which the treadmill speed and grade were decreased to 2.0 m.p.h. and 0.0% grade. The participants continued the treadmill exercise programme 3 days per week for 3 months".	Exercise group showed significant post-programme decreases in anxiety ($p = 0.001$), craving symptoms ($p = 0.002$), depression score ($p = 0.001$), hyperhydration symptoms ($p = 0.001$), menstrual cramps ($p = 0.001$), backache ($p = 0.002$) and total score ($p < 0.001$) Control group showed significant decreases in craving symptoms ($p = 0.02$) Highly significant decrease in all post-treatment subscale symptoms scores ($p < 0.001$) (except for craving score; $p < 0.05$) and total score ($p < 0.001$) of the exercise group when compared with the posttreatment scores of the control group.
Steege and Blumenthal 1993 [55]	23 premenopausal women were randomly assigned to either strength training (ST; n = 11) or aerobic exercise (AER; n = 12)	No formal definition of PMS 23-item Menstrual Symptom Questionnaire (MSQ)	Aerobic exercise for AER Circuit Training with Nautilus and Universal Gym Equipment for ST	AER: 60 min sessions consisting of 15 min warm up, 30 min aerobic exercise at HR equivalent of 70–85%VO_2max, 15 min cool-down, 3 times a week for 12 weeks ST: keep HR at <50% of VO_2max (no other information provided)	Both exercise groups reported a mean decrease over time in MSQ score ($p < 0.001$) Sum of responses to all 23 MSQ items did not significantly change in the ST group but significantly decline in the AER group ($p < 0.05$)
Vishnupriya and Rajarah-eswaram 2011 [56]	61 women were randomly assigned to Group A (n = 20), Group B (n = 20), and Group C (n = 21)	Menstrual Symptom Questionnaire (MSQ) was filled out menstrually, premenstrually and intermenstrually	Aerobic	Group A: 35–60% HR max Group B: 60–80% HR max Group C: 80–90% HR max The aerobic exercise included a warmup phase, upper body exercise, lower body exercise and cool down phase	All groups reported a decrease in menstrual symptoms however Groups B and C showed significantly decreased level of menstrual symptoms when compared to Group A, specifically pain, concentration, negative effect, and behavioral change
Mohebbi et al., 2017 [57]	Control: 35 women Intervention: 35 women	PMS diagnosis according to two standard questionnaires of temporary determination of PMS and record daily symptoms of PMS that indicated moderate severity and intensity of 30–60% Those with mild severity (0–29%) and very intense severity (60% and above) of PMS were excluded.	Aerobic sport exercises	8 weeks; 3 times per week; 30 min duration Each exercise cession included a 5 min warm up, 20 min of aerobic exercises "kinetic movements including rotating and stretching the arms, rotating the upper body, standing-in-place movements", followed by a 5 min cool down	The difference in pre and post scores in the two groups was significant only in mood fluctuation ($p = 0.02$).

Table 1. *Cont.*

Author	Sample	Definition of PMS	Exercise Modality	Exercise Prescription	Results
Samadi et al., 2013 [24]	Control: 20 women Exercise Intervention: 20 women	Syndrome identification based on PMS standard option complaint check list. Less than 30 points from the list were considered as mild PMS, more than 30 points were considered moderate to severe PMS	Aerobic	8 weeks; 3 times per week; 60 min duration "5 min warm-up and stretch was performed, then the rapid movements of the limbs and trunk in a combined manner were conducted for 50 min, and at the final 5 min, light stretching was conducted to go back to the original state. Once a week, and also to increase the intensity, hand weights were used". First week was at 60% HR max and progressed over the 8 weeks to 80% HR max	After 4 weeks, overall, 31% of PMS, 29% physical symptoms, and 33% psychological symptoms were reduced in aerobic group. After 8 weeks, the reduction rate became 60%, 65%, and 52%, respectively The control group did not have significantly different PMS scores after the 8-week intervention period.
Tsai 2016 [58]	64 Females employed in a large electronics manufacturer	Participants filled out a 24 item self-reported PMS questionnaire rating the severity of PMS symptoms as "not at all", "mild", "moderate", or "severe". The participants were then divided into "moderate to severe PMS" and "no/mild PMS"	Yoga	12 weeks; 2 times a week; 50 min sessions "Each 50 min session comprised a 5 min breathing exercise, a 35 min yoga pose practice, and 10 min supine meditation/relaxation. In this study, we adopted Kapalbhati Pranayama breathing exercises of yoga, and five basic yoga poses (cat-ow, child's pose, downward dog, plank, and cobra) were included in our yoga protocol".	After the 3 months, participants decreased their use of analgesics during menstruation ($p = 0.029$) and the prevalence of a moderate or severe effect of menstrual pain on work was lower ($p = 0.0011$) The yoga intervention was associated with the improvement of the scale of physical function ($p = 0.034$) and bodily pain ($p = 0.0087$)
Kamalifard et al., 2017 [7]	62 women were randomly divided into 2 groups: yoga (n = 31) and non-exercise control (n = 31)	Premenstrual Symptoms Screening Tool (PSST) was used to identify PMS in participants	Yoga	10 weeks; 3 sessions per week; 60 min duration	After the intervention, the yoga group had a significant decrease in all emotional, physical, and behavioral variables of the PSST The yoga group also reported that their PMS had a reduced impact on their life in comparison to the control group after intervention
Vaghela et al., 2019 [59]	72 women with PMS were randomized into the aerobic exercise group (Group A) or yoga (Group B)	Diagnosed by a gynecologist Pain assessed using Visual Analog Scale (VAS) and symptoms of PMS were assessed by PMS Scale (PMSS)	Aerobic exercise (n = 34) Yoga (n = 38)	4 weeks; 3 times a week; 40 min duration Group A: 5 min warm up and cooldown and 30 min treadmill based on 60–70% HR reserve Group B: 10 min of Kapalbharti Pranayam, 20 min of yoga movements (cat-cow pose, child's pose, plank pose, cobra pose), and 10 min meditation/relaxation in Savasana pose	Significant reduction both in pain intensity (VAS) and PMSS in both groups at the end of the treatment program ($p < 0.05$) Significant reduction in Premenstrual syndrome scale in Group B compared to Group A; however, no significant difference was found with regard to reduction in pain intensity (VAS) between two groups at the end of treatment program ($p < 0.05$)
Maged et al., 2018 [60]	70 women with PMS were randomly allocated to exercise group (n = 35; Group I) or non-exercise control (n = 35; Group II)	Diagnosis of PMS was conducted based on University of California at San Diego criteria defined as "The presence of one or more of affective and somatic presentation in the premenstrual 5 days in the last three cycles". Affective symptoms included depressive disorder, anger, irritability, anxiety, confusion, and social pulling out. Somatic symptoms included mastalgia, abdominal distension, headache, and limbs swelling. Diagnosis confirmed by gynecologist	Swimming	3 months; 3 times a week; 30 min sessions; exercise ceased on the first 3 days of menses then resumed afterwards 5 min warm up, 20 min swim starting with 5 min walking inside pool and then forth and back swimming without reaching fatigue level for 15 min, 5 min cool down	There was a highly significant difference ($p < 0.001$) between the swimming and control groups regarding anxiety (33.3% decrease), depression (79.29% decrease), tension (81.18% decrease), mood changes (33.33% decrease), feeling out of control (91.67% decrease), weak coordination (100% decrease), confusion (84.17% decrease), headache (77.78% decrease), tiredness (65.69% decrease), tenderness of the breast (87.87% decrease), and cramps (60.77% decrease)

Table 1. *Cont.*

Author	Sample	Definition of PMS	Exercise Modality	Exercise Prescription	Results
Çitil and Kaya 2021 [61]	50 women were allocated into the experimental group (n = 25) or control group (n = 25)	Premenstrual Syndrome Scale (PMSS) was administered with a score of 88 or more being classified as having PMS (lowest possible score is 44, highest is 220)	Pilates	3 months; 3 days a week; 60 min duration The following pilates mat exercises were employed 30 basic mat exercises out of 33 which are Spine Stretch, Hundred, Spine Twist Supine, Roll-Up, Neck Pull, Saw, Rolling Back, One Leg Stretch, Double Leg Stretch, Rollover, Bcycle, Control Balance, Shoulder Bridge, Teaser, Hip Circles Prep, Rocker With Open Legs, Bomerang, Seal, Crab, One Leg Circle, Leg Pull, Leg Pull Front, Side Bend, One Leg Kick, Double Kick, Side Kick Kneeling, Swimming, Rocking, Swan Dive, and Push Up.	After the intervention, the experimental group had a significant reduction in the sub-dimensions of depressive affect, anxiety, fatigue, irritability, depressive thoughts, pain, changes in appetite, changes in sleep, and swelling, as well as the PMSS mean score ($p < 0.001$).

4.1.1. Observational Studies

Observational studies reveal associations between engagement in physical activity and the presence, severity, and duration of premenstrual symptoms. Women who engaged in aerobic exercise at least 5 h a week were found to have lower mean scores on the Menstrual Distress Questionnaire (MDQ), lower measures of negative affect, and fewer physical symptoms compared to a sedentary group of women [62]. Lower mean scores on the MDQ in women who exercise was also replicated when comparing sedentary women to exercising women who did at least 3–6 h of moderate aerobic exercise regularly [10]. However, sportswomen defined as women who trained for competitive or public events were found to not experience the same amount of positive affect and reduced menstrual symptomology compared to a group of recreationally active women [63]. The women who were high recreational exercisers were found to have the greatest positive affect and the least negative affect which led the authors to propose that women who frequently exercise may be somewhat protected from deterioration of mood premenstrually and menstrually [63] but accumulating exercise in a manner that reflects competition preparation may decrease this protection.

It is not only adult women who exercise that seem to have reduced PMS symptoms. A study conducted on female high school students demonstrated a negative correlation ($r = -0.859$) between aerobic fitness and PMS symptom severity and between aerobic capacity and PMS severity ($r = -0.706$) [64]. Amongst women who participated in tango dancing and running, Witkos et al. [2] reported that tango dancers experienced a fewer number of days in which PMD symptoms negatively influenced them, had their symptoms resolved significantly faster and experienced a shorter duration of PMD symptoms compared to runners and a group of sedentary women. These findings from observational studies point to the beneficial association between being aerobically active with suffering less from PMS and other PMD. Unfortunately, no observational studies involved women who were resistance trained, therefore, it is still unknown whether women who primarily resistance train express comparable positive benefits on their premenstrual experiences as those primarily engage in aerobic exercise.

4.1.2. Experimental Studies

Aerobic Exercise

Aerobic exercise prescription is optimized when using the FITT principle as described by the American College of Sports Medicine (ACSM) [65]. The FITT principle is presented as the frequency of exercise, intensity using some metric related to heart rate (HR), oxygen

consumption (VO_2) and/or perceived exertion levels, time (duration) of the exercise session, and modality of activity. In addition to these principles, there are also quantifications of exercise volume through the multiplication of frequency, intensity and time components and the implementation of progression throughout the program as individuals adapt to the stimulus presented [65]. The benefits of aerobic exercise are expansive as researchers modify these core principles of exercise prescription in countless ways to investigate how exercise influences health outcomes, quality of life, and the overall human condition.

One of the first series of exercise intervention studies involving PMS came from the late 1980s where researchers first reported women who underwent a 12 [53] and 24 week [54] aerobic exercise intervention had decreased global premenstrual symptoms [53,54]. Specifically, after 12 weeks, the aerobic exercise group reported a significant reduction in breast tenderness, bloating, anxiety, depression, swings in appetite, headache, and perceived external causes of stress compared to the sedentary control group [53]. These results were replicated in a group of sedentary women who completed a six month, 2–4 session per week, aerobic exercise intervention program [54], in a general group of women who completed a three day a week aerobic exercise intervention for three months [47], and after three months of a treadmill based aerobic program where women also reported a decrease in backache and total PMS score [6].

In the only study that included resistance training as a modality of exercise, investigators reported that aerobic exercise training for 12 weeks significantly decreased PMS symptoms to a greater degree than resistance exercise training for 12 weeks [55]. However, the study did not include a control group nor were the aerobic and resistance training programs sufficiently equivalent. The aerobic training group worked at a HR equivalent of 70–85% VO_2 max while the resistance training group worked at a HR equivalent of 50% VO_2 max with no other description provided on the programmatic variables of resistance training such as exercise choice and order, number of exercise sets, load implemented, number of repetitions completed, and rest period length provided [66]. The clear intensity differences alone and the lack of sufficient exercise programming details would influence the quality, nature, and reproducibility of the findings from this study.

When it comes to various intensities of aerobic exercise, 6 weeks of both moderate (60–80% HR max) and high intensity (80–90% HR max) aerobic activity significantly decreased pain, concentration, negative affect, and behavioral change symptom domains of the Menstrual Symptom Questionnaire (MSQ) [56]. Women who were in the high intensity group experienced a greater reduction in the named symptoms compared to the moderate intensity group, but both exercise groups showed significant reduction in symptoms compared to the light intensity (35–60% HR max) group [56]. These results suggest that engaging in a structured aerobic exercise program of at least moderate intensity of 60% HR maximum could help reduce several domains of PMS symptoms in otherwise healthy adult women.

A group of studies conducted aerobic exercise interventions for eight weeks and all reported significant benefits to the exercise group in the expression of PMS symptoms [1,24,57]. One study reported that only mood-related symptoms improved after eight weeks of aerobic exercise conducted for 30 min, three times a week [57]. Another study conducted by the same authors demonstrated that when engaging in aerobic exercise for the same 30 min sessions, three times a week at an intensity of 120–150 beats per minute, many physical symptoms such as headache, nausea, constipation, diarrhea, bloating, swollen breasts, and appetite decreased compared to a non-exercising control group [1]. A progressive, 60 min aerobic exercise program conducted three times a week for eight weeks resulted in a 60% decrease in overall expression of PMS symptoms, a 65% decrease in physical symptoms of PMS, and a 52% decrease in psychological symptoms [24]. Together, these studies further support the wide range of positive effects aerobic exercise can have on PMS even when different programmatic variables, intervention durations, and types of aerobic activity comprise the exercise programs.

Yoga

Yoga is an effective form of physical activity that has many physical and psychological benefits. Yoga assists in moderating the hypothalamic–pituitary–adrenal (HPA) axis, helping to reduce stress in the body [7]. The benefits of yoga are not limited to overall stress release as its impact on occupational success has also been studied.

Researchers in Taiwan had 64 female employees of a manufacturing plant complete a 12-week yoga intervention that comprised of 50 min sessions, twice a week after the work shift [58]. After the intervention, the female employees reported a reduction in their use of analgesics during menstruation from 35.9% to 21.9% and reported that the prevalence of moderate or severe effects of menstrual pain on their work performance decreased from 53.1% to 29.7%. The yoga intervention was significantly correlated with reductions in abdominal swelling, breast tenderness, abdominal cramps, and cold sweats [58]. In addition, the menstrual pain mitigated was correlated with an improvement in physical function, bodily pain, general health perception, vitality, social function, and mental health [58].

Taken together, this 12-week yoga intervention seemed to significantly impact the lives of these female workers and brought them towards a positive health state that also benefited their job performance. Similar results were reported in a randomized control trial where women completed a 60 min yoga session, once a week, for 10 weeks and saw significant improvements in emotional, physical, and behavioral PMS symptoms compared to a non-yoga practicing control group [7].

The use of aerobic exercise has demonstrated positive effects on women with PMS, so researchers sought to investigate if yoga is equally effective in helping women with PMS compared to aerobic exercise [59]. The researchers took a group of 72 women with PMS diagnosed by a gynecologist and split them into an aerobic exercise group and a yoga group. The aerobic exercise group completed a four-week program exercising on a treadmill at 60–70% HR max for 30 min, three days a week. The yoga group did 40 min of yoga that consisted of 10 min of breathing exercises, 20 min of yoga movements, and finished with 10 min of meditation three days a week.

The results from the study show that both aerobic exercise and yoga significantly decreased pain intensity and reduced scores on a premenstrual symptom questionnaire; however, the women in the yoga group had lower premenstrual symptom scores compared to the aerobic group at the end of the intervention [59]. This shows that both aerobic exercise and yoga can help women with PMS, but yoga seems to be a more effective mode of activity for overall symptom reduction. The authors postulated that the focus on stress relief and the meditation of yoga could have contributed to the study findings.

Swimming

One study investigated how swimming can be a form of aerobic exercise that could help women with PMS [60]. Researchers randomized a group of 70 women who were diagnosed with PMS into a swimming group and a control group. The swimming group did 30 min of swimming, 3 times a week for 12 weeks. The program involved 5 min of breathing, circulatory and stretching exercises for both the warmup and the cooldown with the 20 min bulk of the workout being back and forth swimming at a pace that would not lead to fatigue.

At the end of the 12-week intervention, the women in the swimming group reported a greater reduction in anxiety, depression, tension, mood changes, feeling out of control, weak coordination, confusion, headache, tiredness, pain, tenderness of the breast, and cramps compared to the control group [60]. Interestingly, there were no differences in the groups regarding irritability, insomnia, crying, swelling, or food cravings. Further work using swimming as an exercise modality in PMS-related research is necessary to not only confirm these findings but also see how variations in the programming of swimming exercise, notably intensity and duration, impact women with PMS, and other PMD.

Pilates

Pilates is a form of exercise that, such as yoga, focuses on mindfulness and breath, but differs in that Pilates places greater emphasis on exercises that can strengthen the body and with a particular emphasis on core strength. It helps develop muscular strength and endurance in the body and core while also improving psychological health and motor functions [67]. With these benefits, researchers sought to investigate whether Pilates could help decrease PMS symptoms.

In a quasi-experimental design, researchers had 50 university students who had high scores on the Premenstrual Syndrome Scale (PMSS) complete a 12-week Pilates program that involved three 60 min sessions per week [61]. During these sessions, the students would practice 30 basic Pilates mat exercises while the control group was instructed to not change their current physical activity habits. The results showed that after the 12-week program, the women in the experimental group had significant decreases in their total PMSS score and also in the subdimension scores of depressive affect and thoughts, anxiety, irritability, pain, changes in appetite, as well as changes in sleep and swelling [61]. However, fatigue did not seem to benefit from the same decrease seen in the other subdimensions.

The authors noted that this study was the first of its kind looking into the use of Pilates as a mode of exercise to help women with PMS. With known positive effects on women's health in physical, psychological, and motor function domains, further work is needed across diverse groups of women in this area. Future works could also investigate how group mediated Pilates impact PMS compared to mat exercises conducted at home like the Pilates design used in this current study.

5. How Does Exercise Help Women with PMS?

Many women have turned to exercise as a cost-effective, non-pharmacological treatment for their PMS symptoms and doctors frequently cite exercise as a common recommendation to help alleviate premenstrual distress [3]. Although exercise does not reduce all premenstrual symptoms for every woman, it is an effective treatment for improving a wide array of physical, emotional, behavioral, and psychological symptoms as discussed in previous sections. This section will provide a brief overview of proposed mechanisms through which exercise can help women with PMS and other PMD.

During the late luteal phase of the menstrual cycle, hormone levels of estrogen and progesterone are at low levels to prepare for menstruation. These low levels seem to be a factor in the occurrence of PMS symptoms. Aerobic exercise transiently increases concentrations of estrogen and progesterone which may give positive benefits to mood and decrease stress levels without substantially altering the menstrual cycle [10,56]. These small increases may be enough to counteract the withdrawal of these hormones that hallmark this menstrual phase. The increases in these ovarian hormones influence decreases in the concentrations of rennin and aldosterone [10,47], which help regulate fluid balance and contribute to symptoms like bloating and edema. The reduction in these hormones and the continual muscular contractions that happen during aerobic exercise helps the reabsorption process of sodium and water, leading to improvements in physical symptoms of PMS [24], and helps to increase prostaglandins in the body that help prevent and reduce pain and discomfort in the pelvis and abdomen [68].

The release of endorphins that occur during exercise serves to alleviate pain, reduce stress, and uplift mood [43,45]. This release has been associated with reduction in pain, anxiety, and depression in those with PMS [56,62]. The role of endorphins go into the larger psychological benefits of exercise as exercise helps induce positive thought and feelings in individuals [62], reduces stress levels that could exacerbate menstrual symptoms [59], could serve as a distraction from intrusive, negative thoughts [62], and increase efficiency of the mind and sense of happiness [57]. In addition, engaging in exercise is a social activity that impacts confidence, promotes self-esteem and positive body image and increases feelings of community [69]. Altogether, exercise is a beneficial and strongly recommended activity for women of all stages of premenstrual discomfort to engage in.

6. Critiquing the Literature: What Are Some Methodological Limitations and How Does the Field Move Forward?

Exercise and its impact on PMS have been investigated for the last 40 years with the literature overly dominated by aerobic exercise interventions. Even so, there are present methodological issues with the current literature that need to be addressed so future studies can build upon the existing knowledge. Several studies within this narrative review did not present a clear description of the aerobic exercise used for the study intervention which greatly diminishes the reproducibility of these studies to confirm and expand findings. One of the studies had an aerobic-based exercise intervention based on the FITT principle of ACSM [65], which is notable; however, in the description, "the aerobic exercise includes (1) warm up phase, (2) upper body exercise, (3) lower body exercise, and (4) cool down phase" [56]. Although exercise intensity was based on percentages of HR max, this limited description does not allow readers to understand exactly what the participants were doing in the intervention.

Another study described their aerobic exercise as "limb and trunk fast exercise" [47] and others as "kinetic movements including rotating and stretching the arms, rotating the upper body, and standing-in-place movements" [1,57]. Principles of exercise prescription not only serve to optimize exercise but also to communicate how exercise was structured to assure that the proper prescription was used for the desired outcome as well as to best tailor interventions to the demographic of interest. Not providing a clear description of how exercise was programmed and conducted makes it nearly impossible to present high-quality research that could make a difference in real-world settings.

When and if a clear description of aerobic exercise used in PMS research interventions was provided, details of exercise progression throughout the intervention are oftentimes limited. Stoddard et al. [10] described their aerobic modalities as the treadmill, stair master and cycle and provided the ranges of the intensity of exercise, but with limited mention of progression it is difficult to decern the total volume of work completed in the 24-week exercise intervention. With this limitation, it is only speculation if PMS symptom improvement could have been enhanced if principles of exercise progression were applied. Other studies implemented progression by specifically stating that participants gradually increased exercise duration, distance and intensities of running [53,54], with one describing target HR values during week 1 to be 60% of HR max while by week eight, the participants were working at an intensity equal to 80% of their HR max [24].

Along with the principle of progression, one of the core FITT principles of exercise programming according to the ACSM involves the duration of exercise. It is important to mention that all studies within this narrative review reported positive benefits of exercise on PMS symptom presence and severity. However, some of the intervention studies involved an exercise duration of 20–30 min with 5–15 min devoted to warmups and cool downs [1,55,57,59,60]. This variability in duration of exercise does not allow cross study comparisons to be made as duration is a crucial factor in an aerobic exercise prescription. Some of these exercise interventions do not meet ACSM's criteria for moderate physical activity being at least 150 min per week [1,55,57,60] and others do not mention exercise duration [56]. Therefore, authors need to be detailed and explicit in describing how they created the exercise program and how they implemented exercise principles throughout the intervention. It is plausible that increasing duration, modifying intensity, and implementing progression into an aerobic exercise program could lead to further improvements in PMS and help women better manage their symptoms. The wide array of modalities that aerobic exercise can be conducted on also gives women control over their preferred way to engage in physical activity.

A clear future direction in this area of research would be the incorporation of resistance training as an exercise modality of interest to help lessen and potentially alleviate PMD symptoms. There have been a limited number of studies that involve high methodological quality in this regard. One study sought to compare aerobic and resistance exercise on premenstrual symptoms in middle-aged women. The aerobic exercise prescription involved

60 min sessions, 3 times a week that consisted of a 15 min warm up, 30 min of aerobic exercise at a HR intensity equal to 70–85% VO_2 max, and 15 min cooldown for 12 weeks. The resistance exercise prescription involved the use of Nautilus and Universal Gym equipment with participants working at a HR equivalent of 50% VO_2 max [55] for an unknown exercise duration, with no other information provided about other aspects of the resistance training program like the load used, rest period length, number of sets per exercise, and what specific resistance exercises were completed.

It is difficult to be certain that the two exercise groups received similar stimulus from this one measure of HR equivalent. Moreover, the authors did not mention how other resistance training principles like volume changes and the use of progressive overload were put into effect. These are the basic resistance training principles that need to be outlined in any exercise intervention study using resistance training. The details allow readers to quantify the workload imposed on the subjects, to identify potential adaptations to those stressors, to critique whether the resistance prescription was optimal enough to achieve study objectives, and to enhance the reproducibility of the methods and overall quality of the study design.

7. Conclusions

In general, this narrative review addressed the existing knowledge of PMS and exercise research that has proven that exercise can be an effective, non-pharmacological treatment option for PMS that has wide-ranging benefits outside of menstrual health. Within this discussion, it is important to understand the cultural context surrounding the discussion of menstrual health in women across the world. The cultural environment can influence how women perceive premenstrual symptoms, how the symptoms impact her ability to complete daily responsibilities, and the support she receives about management and care. Although exploring cultural influences on women's reproductive health and its relation to PMS diagnosis, symptom expression, management, and care were outside the scope of this review, these cultural influences must be acknowledged for the holistic understanding of this syndrome, and how the community responds and supports women who have premenstrual distress.

Future areas should investigate different combination of exercise modalities not limited to aerobic exercise, yoga, Pilates, and resistance exercise with detailed and well-designed exercise programs that adhere to exercise prescription principles for both short- and long-term inquiries within culturally appropriate influences and contexts. With numerous ways to participate, exercise allows any woman to take charge of her menstrual health and should be a central part of managing PMS and other PMD.

From a practical perspective, there are no specific guidelines and formal recommendations regarding exercise as a non-pharmacological treatment for PMS, however medical organizations such as the American College of Obstetrics and Gynecology can work alongside exercise professionals to provide educational material to healthcare professionals and encourage them to incorporate structured exercise as a routine part of PMS management through collaborative efforts to develop tailored exercise programs for women with PMS.

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