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Original Research Article

Acute Impact of Aerobic and Resistance Exercise on Premenstrual Symptoms in College-Aged Non-exercising Eumenorrheic Females

Grace Palubicki[1], Nevaria Rumery[1], Emily Flaskrud[1], Emily Lamarche[1], Ashley Hall[1], Saori Braun[1], Jeffrey Janot[1]

Department of Kinesiology, University of Wisconsin Eau Claire, Eau Claire, WI, USA

Abstract

Introduction: Premenstrual syndrome (PMS) includes cyclic characteristics of physical, cognitive, affective, and behavioral symptoms and occurs in 90% of females. There is a growing need for research on how forms of therapy can mitigate PMS symptoms. In past literature, there was an emphasis on aerobic exercise (AE). The purpose of this study was to compare resistance exercise (RE) to AE and determine the acute effect that each modality has on PMS symptoms. **Methods:** Subjects were 11 college-aged, non-exercising females. Subjects engaged in exercise 2 days before and during menses. A total of 4 exercise sessions were completed, 2 AE and 2 RE. Instrumentation included daily basal body temperature tracking and a menstrual symptom questionnaire (MSQ) that included 8 domains. PMS symptoms were tracked pre-, post-, and 2-hrs post-exercise. **Results:** A two-way ANOVA indicated a difference in *pain* at pre-menstruation ($p=0.034$) and during menstruation ($p=0.020$). For *negative affect,* there was a significant change in symptoms pre-menstruation ($p=0.006$) based on the timing of exercise. This effect was also observed for *concentration and water retention* pre-menstruation ($p = 0.004$). The difference between modalities (RE and AE) was not significant for any domain. **Conclusion:** Both RE and AE mitigate PMS symptoms in these specific domains: *pain, concentration, water retention, and negative affect*. There was no significant difference between the modes of exercise, indicating that AE may not be superior to RE when mitigating PMS symptoms. Therefore, a combined exercise program involving a minimum of two days of AE and two days of RE (two sets of eight repetitions for eight exercises), both at moderate intensities (AE: 40-60% HRR; RE: session RPE of 5-6), should be prescribed as a management strategy to alleviate PMS symptoms.

Key Words: Aerobic Exercise, Menstruation, Menstrual Pain, Negative Affect, Physical Activity.

Introduction

Premenstrual syndrome (PMS) occurs in 90% of reproductive-aged females, with 20% experiencing symptoms so severe that their discomfort disrupts their daily activities[1,2]. PMS includes cyclic characteristics of physical, cognitive, and behavioral symptoms. This is a time of pain and discomfort which often impacts one's quality of life (QOL). Symptoms typically begin during the luteal phase of the menstrual cycle and continue into the menstrual phase[2,3].

Current remedies or treatments of PMS include surgical treatments, drug treatments, and non-drug therapies[3,4]. These remedies can cause a variety of adverse effects, such as depression, fatigue, and insomnia[4,5]. Due to this, there is a growing focus on how alternative therapies can potentially mitigate PMS symptoms. Çiçek and others[6] examined the difference between regularly exercising females and sedentary females and found that individuals who regularly exercise had less frequent and less severe symptoms compared to sedentary females. This supports that exercise is an alternative therapy that is effective in improving PMS symptoms. Although Çiçek and others[6] research demonstrated that regular exercise could mitigate PMS symptoms, direction on exercise parameters such as modality, intensity, frequency, and duration were lacking.

Research examining the effect of exercise on PMS symptoms have primarily studied aerobic exercise (AE) and found this type of exercise to mitigate PMS symptoms and alleviate adverse effects[2,7-8]. Akbaş and Erdem[7] implemented a four-week AE program on university students in Turkey with 50 minutes of exercising three times a week. Vishnupriya and Rajarajeswaram[2] found that both moderate- and vigorous-intensity AE improved PMS symptoms in 15- to 25-year-old females in India. The last study from Dehnavi and colleagues[8] tested AE for eight weeks, three times a week, and found a significant decrease in some of the physical symptoms in university-aged students in Iran. These studies revealed that an implemented aerobic exercise program improves perceived pain and discomfort from PMS symptoms in females; however, the effectiveness of other exercise modalities is yet to be explored.

Lack of exploration of other exercise modalities sparked interest in the effects of resistance exercise (RE). Resistance exercise has multiple health benefits such as improving the musculoskeletal system, maintaining functional ability, preventing osteoporosis, sarcopenia, lower back pain, and other comorbidities[5]. Past studies have noted that there is improvement in PMS symptoms from aerobic exercise, although the effects of resistance exercise have gone understudied[2,7-8].

Prior research studies vary in the timing of data collection. Akbaş and Erdem[7] recorded symptoms after each menstrual cycle within an 8-week period. This study did not focus on the effect of exercise immediately after the daily intervention, limiting knowledge on when exercise impacts one's perception of PMS symptoms. Although there is past research on the effects of exercise on PMS symptoms, the acute effects are still understudied.

After reviewing the past literature, two gaps in the research were apparent. There is a lack of research focusing on how RE would impact PMS symptoms compared to AE. Additionally, the literature fails to state the acute impacts of an exercise intervention on PMS symptoms with most studies recording symptoms after several days. A study focusing on RE would illuminate the potential need to participate in or avoid RE while one is experiencing PMS symptoms. By engaging in 30 minutes of moderate-intensity resistance exercise two days before and two days during menstruation, PMS symptoms will acutely diminish in young eumenorrheic females similar to engaging in 30 minutes of moderate-intensity walking. PMS includes cyclic characteristics of physical, cognitive, affective, and behavioral symptoms and occurs in 90% of females.

There is a growing need for research on how forms of therapy can mitigate PMS symptoms. In past literature, there was more emphasis on AE. Thus, the primary purpose of this study was to investigate whether 30 minutes of moderate-intensity RE would improve PMS symptoms immediately after and 2 hours after exercise. The secondary purpose of this study was to assess if engaging in 30 minutes of moderate-intensity RE would improve premenstrual symptoms in young eumenorrheic females compared to moderate aerobic exercise.

Methods

Participants

Subjects of this study were young female adults (N=11), aged 17 to 23 years who experienced PMS on a consistent basis. Most subjects were recruited from a higher education institution, with two subjects recruited from the local community. Recruitment methods consisted of mass emails, presenting the study to various classes, posting on social media, and word of mouth. There were 17 subjects initially recruited to participate in this study. Six subjects were excluded due to not meeting the inclusion criteria or voluntarily dropped from the study. To achieve a moderate effect size (Cohen's d) at an alpha level of .05, a sample size of 12 total subjects was needed to maintain a statistical power of .80. Prior to study intervention, all subjects ensured they met the eligibility criteria to participate. Individuals were eligible if they experienced a regular menstrual cycle, menstruated once every 23 to 32 days, and experienced common premenstrual symptoms, such as abdominal cramps, bloating, acne, and pain in the breasts[8-9]. Individuals were excluded from the study if they already participated in regular physical activity, defined as exercising for 30 minutes, 3 times a week for the past 3 months[10]. As for females on a contraceptive, they were still eligible to participate if they had a regular menstrual cycle and experienced premenstrual symptoms. This study protocol was approved by the university's Institutional Review Board (IRB).

Experimental Design

Participation in this study included a 1-hr familiarization session, recording temperature each morning (about two minutes), and exercising for four (two AE and two RE) exercise sessions totaling 30 minutes each. In each session, subjects completed the MSQ, which required 10-15 minutes of time. In total, the overall time commitment for each subject to complete the study was approximately five hours. For the familiarization session, subjects arrived at the exercise physiology laboratory where researchers explained the approved IRB consent form, answered any questions from the subjects, and then subsequently asked subjects to sign if willing to participate. Following the provision of consent to participate, researchers went over information regarding the measurement and recording of body temperature each morning and the exercises to be completed for each AE and RE session.

Procedures

Basal Body Temperature Measurement

Two methods were utilized to estimate the time in which subjects would begin experiencing PMS symptoms. The first method consisted of temperature tracking, to see what day the participant ovulated, counting 14 days from then to estimate when they would begin menstruating. To do so, each participant was provided an oral thermometer, the Microlife Basal Digital Thermometer Model #MT16I2 (Microlife USA Inc., Clearwater, FL). Subjects were instructed to take their temperature immediately after waking to capture their most accurate basal body temperature (BBT). A study conducted by Shiliah and others suggested that temperature recordings are most accurate when taken in the morning to reduce changes from circadian temperature shifts. Regarding this same study, 86% of subjects had an observed spike in BBT temperature reflecting their ovulation period[11].

Along with tracking one's BBT, researchers asked each subject to estimate their typical cycle length and the first day of their last menstrual cycle. This information allowed both the participant and researcher to approximate when the participant would start their next menstrual cycle. By utilizing both methods, subjects were able to begin exercise, in most cases, two days before they menstruated. This increased the likelihood of subjects experiencing their most severe symptoms when they began exercising, as well as capturing their perception of PMS symptoms before the symptoms subsided naturally.

To measure the severity of symptoms before and after exercise intervention, subjects filled out a questionnaire measuring PMS symptoms (Figure 1). The Menstrual Symptom Questionnaire (MSQ) is split into 8 domains: *pain*, *concentration, behavioral change, autonomic reactions, water retention, negative affect, arousal, and control*[2]. The first domain of *pain* measured muscle stiffness, headache, cramps

	Severe problem	Moderate problem	Mild problem	Hardly problem	No problem
PAIN					
1. Muscle stiffness	☐	☐	☐	☐	☐
2. Headache	☐	☐	☐	☐	☐
3. Cramps	☐	☐	☐	☐	☐
4. Backache	☐	☐	☐	☐	☐
5. Fatigue	☐	☐	☐	☐	☐
6. Breast tenderness	☐	☐	☐	☐	☐
7. General aches & pains	☐	☐	☐	☐	☐
CONCENTRATION					
1. Insomnia	☐	☐	☐	☐	☐
2. Forgetfulness	☐	☐	☐	☐	☐
3. Confusion	☐	☐	☐	☐	☐
4. Lowered judgment	☐	☐	☐	☐	☐
5. Difficulty in concentrating	☐	☐	☐	☐	☐
6. Distractable	☐	☐	☐	☐	☐
7. Accidents	☐	☐	☐	☐	☐
8. Lowered motor coordination	☐	☐	☐	☐	☐
BEHAVIOURAL CHANGE					
1. Lowered college or work Performance	☐	☐	☐	☐	☐
2. Stay at home	☐	☐	☐	☐	☐
3. Avoid social activities	☐	☐	☐	☐	☐
4. Decreased efficiency	☐	☐	☐	☐	☐
AUTONOMIC REACTIONS					
1. Dizziness, faintness	☐	☐	☐	☐	☐
2. Cold sweats	☐	☐	☐	☐	☐
3. Nausea/vomiting	☐	☐	☐	☐	☐
4. Hot flashes	☐	☐	☐	☐	☐
WATER RETENTION					
1. Weight gain	☐	☐	☐	☐	☐
2. Skin disorders	☐	☐	☐	☐	☐
3. Painful breasts	☐	☐	☐	☐	☐
4. Swelling	☐	☐	☐	☐	☐
NEGATIVE EFFECT					
1. Crying	☐	☐	☐	☐	☐
2. Loneliness	☐	☐	☐	☐	☐
3. Anxiety	☐	☐	☐	☐	☐
4. Restlessness	☐	☐	☐	☐	☐
5. Irritability	☐	☐	☐	☐	☐
6. Mood swings	☐	☐	☐	☐	☐
7. Depression	☐	☐	☐	☐	☐
8. Tension	☐	☐	☐	☐	☐
AROUSAL					
1. Affectionate	☐	☐	☐	☐	☐
2. Orderliness	☐	☐	☐	☐	☐
3. Excitement	☐	☐	☐	☐	☐
4. Feelings of well-being	☐	☐	☐	☐	☐
5. Bursts of energy, activity	☐	☐	☐	☐	☐
CONTROL					
1. Feeling of suffocation	☐	☐	☐	☐	☐
2. Chest pains	☐	☐	☐	☐	☐
3. Ringing in ears	☐	☐	☐	☐	☐
4. Heart pounding	☐	☐	☐	☐	☐
5. Numbness, tingling	☐	☐	☐	☐	☐
6. Blind spots, fuzzy vision	☐	☐	☐	☐	☐

Thank you for completing this questionnaire

Figure 1. This questionnaire was adopted from Vishnupriya and Rajarajeswaram. This form was utilized to track premenstrual symptoms during different intensities of exercise in the original study. The current study employed this questionnaire to track symptoms based on the timing of exercise and modality used. *Premenstrual Symptom Questionnaire*

backache, fatigue, breast tenderness, and general aches and pains. The second domain of *concentration* measured insomnia, forgetfulness, confusion, lowered judgement, difficulty in concentrating, distractable, accidents, and lowered motor coordination. The third domain of *behavioral change* measured lowered performance in school or work, stay at home, avoid social activities, and decreased efficiency. The fourth domain of *autonomic reactions* measured dizziness/faintness, cold sweats, nausea/vomiting, and hot flashes. The fifth domain of *water retention* measured weight gain, skin disorders, painful breasts, and swelling. The sixth domain of *negative affect* measured crying, loneliness, anxiety, restlessness, irritability, mood swings, depression, and tension. The seventh domain of *arousal* measured affection, orderliness, excitement, feelings of well-being, and bursts of energy/activity. The eight domains of *control* measured feeling of suffocation, chest pain, ringing in ears, heart pounding, numbness/tingling, and blind spots/fuzzy vision. The spelling of each domain is synonymous with the spelling used by the authors of the questionnaire. Vishnupriya and Rajarajeswaram[2] found a reliability of 0.88 for the MSQ in young adults. Paired with the MSQ, the severity of each symptom will equate to a number by utilizing the Likert scale, which ranges from no problem to severe problem. Attached to the Likert categories are linked numerical values, so the outcome measures are quantitative instead of qualitative (No Problem=0, Hardly=1, Mild=2, Moderate=3, Severe Problem=4). Subjects were required to report their symptoms before exercise, immediately post-exercise, and two hours post-exercise, measuring the acute changes in symptom severity. See the appendix to view the MSQ.

Exercise Intervention

During the familiarization session, subjects had their resting heart rate (HR) measured via the radial pulse for 15 seconds. Hwu and colleagues[12] found measuring radial pulse for a 15-sec interval leads to an accurate approximation of a HR. Maximum HR was calculated using the prediction formula from Gellish and others [206.9 - (.67 x age)][13]. Once a participant's resting HR was recorded, researchers were able to calculate an estimated intensity utlizing the Karvonen formula[10]. Individual intensities were set at the moderate-intensity of 40-60% HR reserve (HRR). When reviewing the resistance exercises, subjects were asked to choose dumbbell loads based on their ratings of perceived exertion (RPE). This allowed subjects to choose a weight that follows a moderate intensity during exercise. The scale utilized was the Borg CR-10 Scale from 0-10 with 0 being no effort, such as at rest, and 10 being maximal effort[14]. Subjects were able to choose a weight for each individual exercise that ensured their RPE was between 5-6, known as moderate intensity.

To monitor HR during exercise and ensure subjects remain in their target zone, subjects wore a Polar T31 (Polar, RS800CX, Professorintie 5, Kempele, Northern Ostrobothnia 90440, Finland) HR monitor and paired watch. This allowed them to adjust their exercise intensity based on their target HR. Montes and Navalta[15] suggested that the Polar T31 provided reliable measures at rest, walking, and jogging in both a free motion and treadmill setting. This finding demonstrates that the Polar T31 would provide accurate readings during this study.

When the subjects began experiencing symptoms, they started their 4-d period of exercise. The intervention consisted of two days of RE and two days of AE. Subjects were randomized into two groups to determine the order they completed modes of exercise. The first group performed a pattern of RE and then AE, while the second group performed the opposite pattern of AE then RE. Each modality of exercise was performed on the same indoor track while a respective research leader was present to guide the session.

Before the start of each exercise session, subjects were required to complete a pre-exercise questionnaire. Upon questionnaire completion, subjects engaged in a 5-min dynamic warm-up to increase HR and improve blood flow to muscles to optimize performance. The dynamic warm-up was implemented as a less aerobic means of exercise, limiting the crossover between each modality of exercise. After completing the dynamic warm-up, subjects engaged in their designated mode of exercise. On RE days, subjects were provided with a 30-min program including eight different exercises, most incorporating multi-joint movements. Paoli and colleagues suggested that multi-joint exercises provide increased muscle gain when compared to single-joint exercises and are proven to present better adaptations[16]. Due to an exercise period of 30 minutes, the inclusion of multi-joint exercises allowed for an effective RE program in the allotted time. These exercises consisted of kettlebell squats, dumbbell lateral lunge, resistance band glute bridge, dumbbell shoulder raises, dumbbell lateral raises, dumbbell bent over row, dumbbell contralateral straight-leg dead bug, and weighted pull through in plank position.

Both RE days consisted of the same full-body program, which included three super-sets of upper-body, lower-body, and core movements. Subjects were encouraged to complete two sets and eight reps of each exercise and were allowed rest when needed. If a participant finished all exercises before 30 minutes passed, they were prompted to continue exercising until the duration of the exercise session was achieved. On days the subjects were not engaged in RE, they completed 30 minutes of walking as the control. The subjects were monitored to stay at their target HR during AE and at their RPE value for RE. After either modality, subjects were given a post-exercise questionnaire that mirrored the pre-exercise questionnaire. Once completed, researchers provided each individual with a third questionnaire to complete within two hours after the exercise session. After the two hours had passed, each questionnaire was sent to the subject's assigned researcher.

Statistical analyses

This study was designed as a 2x3 randomized group design. The independent variables were the modality of exercise affecting the outcome of PMS after completing exercise and time. Premenstrual symptom percentiles were categorized based on numerical rating and the form of intervention being completed. A two-way factorial repeated measures ANOVA analysis was conducted to determine if there is a difference in PMS symptoms between RE and AE across time (baseline, immediate post, and 2-hr post). If a significant difference was identified, a secondary analysis was applied using a paired t-test to determine where the difference was within the dependent variables. All statistical analyses were performed using the Statistical Package for Social Sciences (SPSS) (v24; SPSS Inc., Armonk, NY) version 24.0 with an alpha level set at $p<0.05$.

Results

From the initial recruitment, 11 subjects participated throughout the entirety of the intervention. Almost all subjects menstruated during the data collection period apart from two subjects who were excluded from the study due to menstruation not occurring. Additionally, five subjects removed themselves from the study for personal reasons. Of the subjects remaining, three subjects did not engage in premenstrual exercise due to the onset of menses. These subjects missed premenstrual exercise due to not experiencing premenstrual symptoms until they began menstruating or from overestimating the predicted start day of menses. Due to the timing constraints of data collection, subjects engaged in exercise based on the estimated first day that symptoms should arise. Regardless of engaging in premenstrual exercise, all subjects engaged in all four sessions of exercise (premenstrual RE, premenstrual AE, during menstruation RE, during menstruation AE).

When tracking BBT, researchers looked for a spike around day 14 of one’s cycle. On average, there was a 0.19 ^{0}F increase in BBT from day 13 to 14 of one’s cycle. Figure 2 displays each participant’s BBT throughout data collection. The x-axis represents the first day of data collection for each participant and the y-axis shows the BBT for each participant on that day. Nevertheless, the day of ovulation was exhibited in temperature tracking for every participant.

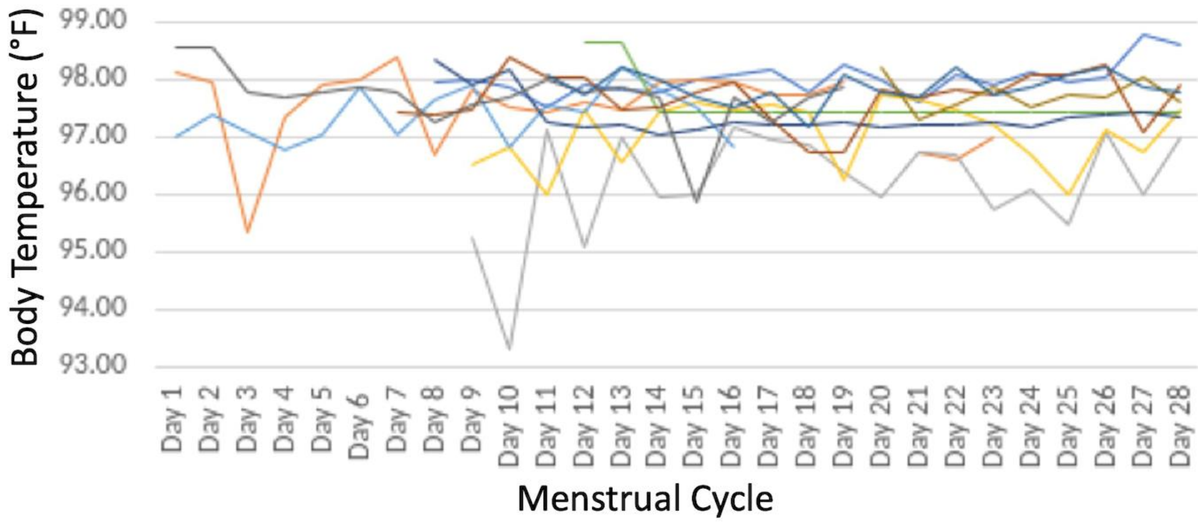

Figure 2: Basal Body Temperature throughout days of the menstrual cycle. Each line indicates each participant (N=11).

The MSQ consisted of 46 symptoms that were grouped into eight domains based on subtypes of symptoms. The domains specified in this questionnaire are *pain, concentration, behavioral change, autonomic reactions, water retention, negative affect, arousal* and *control*. From there the Likert scale was applied from 0 to 4, to measure the severity of symptoms from no problem to severe problem. When analyzing the questionnaires, the researchers followed the procedures outlined by Vishnupriya and Rajarajeswaram[2] who utilized the same questionnaire as in the current study. The symptoms categorized under each domain were added as a sum according to the severity of symptoms. These were then added together based on type (RE or AE) and time (pre-exercise, post-exercise, or 2-hr post-exercise) of exercise, where the mean and standard deviation of each domain was recorded for all subjects.

Changes in Eight Domains of Premenstrual Symptoms

Pain

A two-way ANOVA indicated no significant interaction between *pain* and modality of exercise pre-menstruation, $F(1,10) = 0.29$, $MSE=5.47$, $p = .604$; however, a main effect difference between *pain* and time pre-menstruation was detected, $F(1,15.32) = 4.63$, $MSE = 95.33$, $p = .034$. The two-way ANOVA also indicated no significant interaction between *pain* and the modality of exercise during menstruation, $F(1,10) = 1.87$, $MSE = 14.56$, $p = .202$, but showed a main effect difference for time, $F(1.59,15.92) = 5.48$, $MSE = 69.82$, $p = .020$. Refer to Figure 3a to view data for pre-menstruation and during menstruation *pain* by type and time.

After determining that a significant difference existed in the ANOVA model, a post-hoc analysis was conducted using a

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paired samples *t* test, which indicated that *pain* in relation to pre-AE for pre-menstruation (M = 7.91; SD = 4.85) became less of a problem (mean difference = 3.36) when compared to 2-hr post-AE for pre-menstruation (M = 4.55; SD = 2.84), *t*(df) = 2.57 (10), *p* = .028. The paired samples *t* test also indicated that pre-RE during menstruation (M = 7.36; SD = 5.20) was less of a problem (mean difference = 3.36) when compared to post-RE during menstruation (M = 4.00; SD = 3.19), *t*(df) = 2.93 (10), *p* = .015.

Concentration

A two-way ANOVA indicated no significant interaction between *concentration* and the modality of exercise pre-menstruation, F(1,10) = 0.02, *MSE* =0.14, *p* =.905. The main effect between *concentration* and time pre-menstruation was shown to be significantly different, *F*(2,20), = 7.42, *MSE* = 16.20, *p* = .004. There was also no significant interaction between *concentration* and the modality of exercise during menstruation, *F*(1.86,18.56) = 2.52, *MSE* = 3.54, *p* = .111. The main effect for time was not significantly different, *F*(1,10) = 0.31, *MSE* = 0.74, *p* = .588. Refer to Figure 3b to view data for pre-menstruation and during menstruation *concentration* by type and time.

After determining that a significant difference existed in the ANOVA model, a post-hoc analysis was conducted using a paired samples *t* test, which indicated that *concentration* pre-RE for pre-menstruation (M = 3.91; SD = 5.19) was improved (mean difference = 1.46) over post-RE for pre-menstruation (M = 2.45; SD = 3.86), *t*(df) = 2.52 (10), *p* = .031. The paired samples *t* test also indicated that *concentration* pre-AE for pre-menstruation (M = 4.45; SD = 5.17) was improved (mean difference = 2.46) over post-AE for pre-menstruation (M = 2.00; SD = 2.97), *t*(df) = 2.36 (10), *p* = .040.

Behavioral Change

The two-way ANOVA indicated that there was not a significant interaction between *behavioral change* and the modality of exercise pre-menstruation, F(1,10) = 1.26, *MSE* =3.41, *p* =.288 and the main effect between *behavioral change* and time pre-menstruation was also not significantly different, *F*(1.26,12.59) = 2.90, *MSE* = 16.93, *p* = .107. Additionally, no significant difference for the main effect, *F*(1.14,11.43) = 1.64, *MSE* = 10.29, *p* = .229 or interaction, *F*(1,10) = 3.38, *MSE* = 3.41, *p* = .096 between *behavioral change* and the modality of exercise during menstruation was identified. Refer to Figure 3c to view data for pre-menstruation and during menstruation *behavioral change* by type and time.

Autonomic Reactions

The two-way ANOVA indicated that there was not a significant interaction between *autonomic reactions* and the modality of exercise pre-menstruation, *F*(1,10) = 0.30, *MSE* =0.38, *p* =.593. Similarly, the main effect between *autonomic reactions* and time pre-menstruation was not significantly different, *F*(1.61,16.06) = 0.72, *MSE* = 2.40, *p* = .471. No significant difference for the main effect, *F*(2,20) = 0.04, *MSE* = 0.05, *p* = .958 or interaction, *F*(1,10) = 0.21, *MSE* = 0.14, *p* = .653 between *autonomic reactions* and the modality of exercise during menstruation was detected by the ANOVA. Refer to Figure 3d to view data for pre-menstruation and during menstruation *autonomic reactions* by type and time.

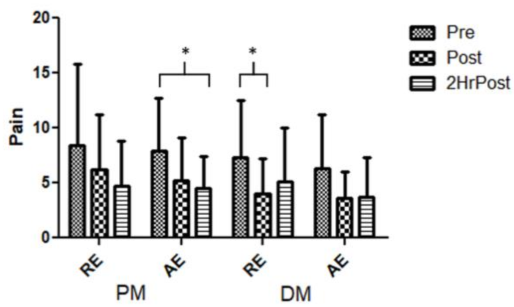

Figure 3a: Pain

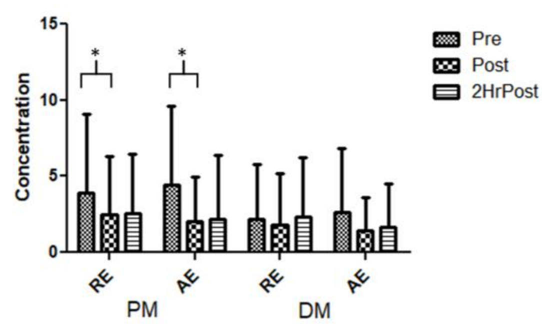

Figure 3b: Concentration

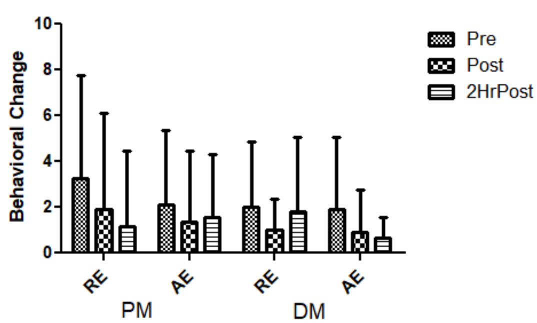

Figure 3c: Behavioral Change

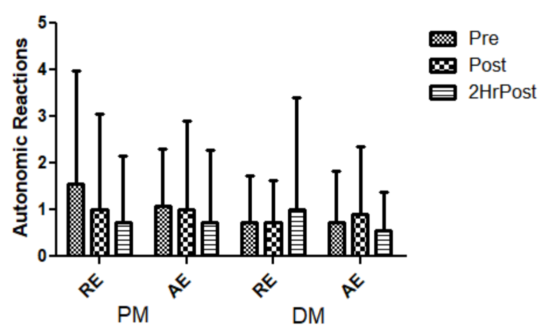

Figure 3d: Autonomic Reactions

Figures 3a-d. Pain, Concentration, Behavioral Change, and Autonomic Reactions domains by exercise type and timing for pre-menstruation and during menstruation (N=11). Key: RE: resistance exercise, AE: aerobic exercise; PM: premenstruation; DM: during menstruation. *Post-exercise timing (immediate post or two hours post) significantly different than pre-exercise timing.

Water Retention

The two-way ANOVA indicated that there was not a significant interaction between *water retention* and the modality of exercise pre-menstruation, *F*(1,10) = 0.02, *MSE* =0.14, *p* =.905. However, the main effect between *water retention* and time pre-menstruation was significant, *F*(2,20) = 7.42, *MSE* = 26.20, *p* = .004. The two-way ANOVA also indicated no significant difference for the main effect, *F*(1,10), = 0, *MSE* = 0, *p* =1.00 or interaction, *F*(1.51,15.06) = 2.33, *MSE* =2.68, *p* =.140 between *water retention* and the modality of exercise during menstruation. Refer to Figure 4a to view data for pre-menstruation and during menstruation *water retention* by type and time.

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After determining that a significant difference existed in the ANOVA model, a post-hoc analysis was conducted using a paired samples *t* test, which indicated that *water retention* pre-RE for pre-menstruation (M = 3.36; SD = 2.87) was different (mean difference = 1.91) when compared to 2-hr post-RE for pre-menstruation (M = 1.45; SD = 2.21), *t*(df) = 2.99 (10), *p* = .014. The paired samples *t* test also indicated that *water retention* pre-RE for pre-menstruation (M = M = 3.36; SD = 2.87) was also different (mean difference = 0.81) when compared to post-RE for pre-menstruation (M = 2.55; SD = 3.83), *t*(df) = 3.23(10), *p* = .009.

Negative Affect

The two-way ANOVA indicated that there was not a significant interaction between *negative affect* and the modality of exercise pre-menstruation, *F*(1,10)=*0.04*, *MSE* = 0.24, *p* =.560. Comparatively, the main effect between *negative affect* and time pre-menstruation was significant, *F*(1.45,14.46) =*8.60*, *MSE* = 164.98, *p* = .006. No significant difference for the main effect, *F*(1.13,11.26) =*1.17*, *MSE* = 34.21, *p* = .311 or interaction, *F*(1,10) =*4.48*, *MSE* = 24.24, *p* = .060 between *negative affect* and the modality of exercise during menstruation was determined by the ANOVA. Refer to Figure 4b to view data for pre-menstruation and during menstruation *negative affect* by type and time.

After determining that a significant difference existed in the ANOVA model, a post-hoc analysis was conducted using a paired samples *t* test, which indicated that *negative affect* pre-RE for pre-menstruation (M = 7.55; SD = 5.72) was less of a problem (mean difference = 5.00) when compared to post-RE for pre-menstruation (M = 2.55; SD = 3.83), *t*(df) = 3.23 (10), *p* = .009. The paired samples *t* test also indicated that *negative affect* pre-RE for pre-menstruation (M = 7.55; SD = 5.72) was less of a problem (mean difference = 4.00) when compared to 2-hr post-RE for pre-menstruation (M =3.55; SD =4.68), *t*(df) = 2.66 (10), *p* = .024. Additionally, the paired samples *t* test indicated *negative affect* pre-AE for pre-menstruation (M =6.73; SD =6.90) was less of a problem (mean difference = 3.73) when compared to post-AE for pre-menstruation (M =3.00; SD =3.16), *t*(df) =2.78 (10), *p* = .020.

Arousal

The two-way ANOVA indicated that there was not a significant interaction between *arousal* and the modality of exercise pre-menstruation, *F*(1,10) =0.17, *MSE* = 0.55, *p* =.692; whereas, the main effect between *arousal* and time pre-menstruation was significant, *F*(1.97,19.69) = 5.11, *MSE* = 24.36, *p* = .017. The two-way ANOVA also indicated no significant difference for the main effect, *F* (1.83,18.25) = 2.36, *MSE* = 1.40, *p* = .126 or interaction, *F*(1,10) = 0.25, *MSE* = 0.55, *p* = .625 between *arousal* and the modality of exercise during menstruation. Refer to Figure 4c to view data for pre-menstruation and during menstruation *arousal* by type and time. After determining that a significant difference existed in the ANOVA model, a post-hoc analysis was conducted using a paired samples *t* test, which indicated that there was no significant difference post-RE for pre-menstruation when compared to 2-hr post-RE for pre-menstruation.

Control

The two-way ANOVA indicated that there was not a significant interaction between *control* and the modality of exercise for pre-menstruation, $F(1.11,11.13) = 1.31$, $MSE = 3.02$, $p = .282$. The main effect between *control* and time for pre-menstruation also was not significantly different, $F(1,10) = 1.05$, $MSE = 1.51$, $p = .331$. The two-way ANOVA also indicated no significant difference for the main effect, $F(1,10) = 0.74$, $MSE = 0.38$, $p = .410$ or interaction, $F(1.60,15.94) = 2.15$, $MSE = 2.07$, $p = .155$ between *control* and the modality of exercise during menstruation. Refer to Figure 4d to view data for pre-menstruation and during menstruation *control* by type and time.

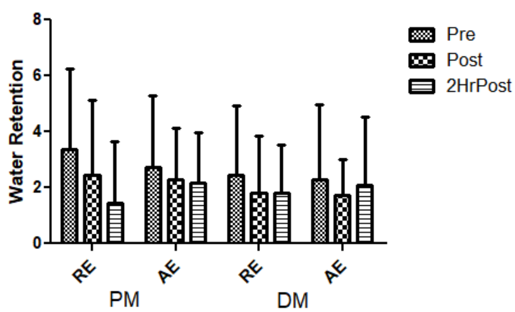

Figure 4a: Water Retention

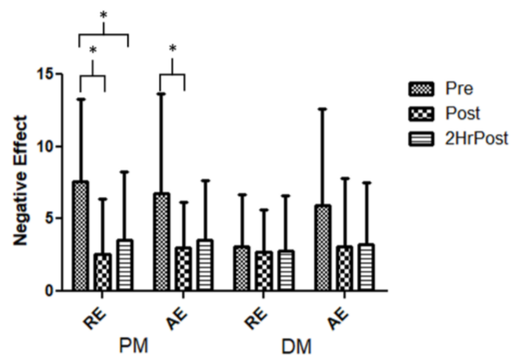

Figure 4b: Negative Affect

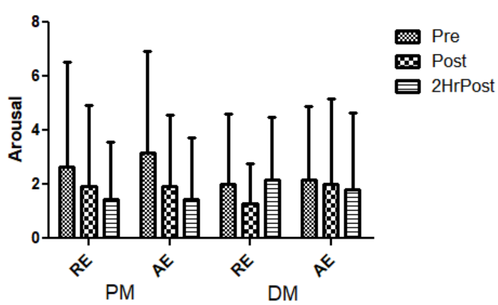

Figure 4c: Arousal

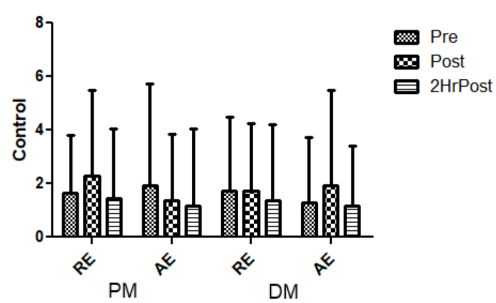

Figure 4d: Control

Figures 4a-d. Water Retention, Negative Affect, Arousal, and Control domains by exercise type and timing for pre-menstruation and during menstruation (N=11). Key: RE: resistance exercise, AE: aerobic exercise; PM: premenstruation; DM: during menstruation. *Post-exercise timing (immediate post or two hours post) significantly different than pre-exercise timing.

Discussion

In this study, evidence was found supporting both resistance exercise and aerobic exercise as effective modalities for mitigating PMS symptoms (*pain, concentration, water retention,* and *negative affect*). It was found that timing of exercise was more important than type. Two time periods were measured in this study: pre-menstruation and during menstruation. Within premenstrual exercise, there were significant improvements in *pain* during the AE condition from pre-exercise to two hours post-exercise and with RE from pre-exercise to directly post-exercise. *Concentration* improved in both AE and RE pre- to post-exercise, resulting in *concentration* improving immediately after exercise. Other improvements were observed with the RE condition in the premenstrual period in *water retention* from pre- to post-exercise and pre-exercise to two hours following exercise. The greatest improvement in symptoms was seen in *negative affect* during RE for pre- to post-exercise and pre-exercise to two hours after exercise. AE also improved *negative affect* from pre- to post-exercise. For the period during menstruation, the only symptom domain that had significant improvement was pain within the RE condition from pre- to post-exercise. The symptoms domains of *behavioral change, autonomic reactions, arousal,* and *control* had no significant changes between the exercise modes or timing, signifying that exercise did not mitigate symptoms in these domains. Since there was no significant difference between the modes of exercise, this indicates that AE may not be superior to RE when mitigating PMS symptoms as other literature may suggest[1,4,6,17,19]. It was also clear that exercise can be prescribed to mitigate premenstrual symptoms, as this was the time period when most changes were observed.

Vishnupriya and Rajarajeswaram[2] found similar results compared to the current study. Despite the intensity, the domains of pain, concentration, behavioral change, and negative affect were significantly impacted by exercise. Based on the findings, it was postulated that these improvements were due to hormonal regulation and antioxidant adaptation. Adaptations to exercise could also lead to decreased inflammation due to an increase in utilization of antioxidant systems responding to reactive oxygen species within the muscle[11,17]. This leads to the suggestion for females to participate in regular exercise to mitigate their PMS symptoms. When interpreting the reason behind the lack of change within the other domains of the questionnaire, this could be a result of not enough subjects experiencing severe enough PMS symptoms in those categories.

According to Akbaş and Erdem[7], pain symptoms yielded positive results from exercise within their 4-wk aerobic training study involving those with dysmenorrhea, which were similar findings compared to the current study regarding the pain trend with exercise. Pain has been the most reported variable linked to PMS. During menstruation, pain arises from uterine contractions by an increase in prostaglandin, causing vasospasm of the uterine arterioles. The vasospasm causes ischemic events towards the abdominal area

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evoking menstrual abdominal cramps. In comparison, traditional means to manage the symptoms of PMS range from smoking cessation, less alcohol consumption, pain medications (e.g. NSAIDs), decreasing sodium in the diet or taking diuretics, hormonal contraceptives (e.g. progesterone or low dose estrogen), and in rare cases, gonadotropin-releasing hormone (GnRH) agonists[18]. Non-traditional means include herbal remedies, dietary supplements, and relaxation techniques such as meditation. Many of these options have not been rigorously studied in high-quality, controlled trials; thus, many of these recommendations are done through trial and error to see what works for the individual. Exercise has been shown to increase blood flow to muscles and organs, most importantly the uterus, thereby decreasing abdominal cramp pain. Pain can also be decreased by exercise through the benefits of endorphin release and increasing lung capacity and metabolic changes. The findings of both Akbaş and Erdem[7] and the current study reveal that exercise can be a natural and more holistic treatment to mitigate pain in PMS.

Dehnavi and others[8] examined the effect of eight weeks of AE on the severity of physical symptoms of PMS. This study utilized techniques of instrumentation to the current study, such as a questionnaire, to observe changes in perceived PMS symptoms. The results showed that, among the physical symptoms of PMS in the intervention group compared to the control group, a significant reduction in headache, nausea, constipation, diarrhea, and swelling was elicited through engagement in physical activity. Comparisons between intervention and control for bloating, vomiting, hot flashes, and increase in appetite were not found to be significantly different. Overall, this study indicated that AE can be a useful method in the reduction of numerous PMS symptoms. The significance of pain and water retention reduction from engaging in exercise in the current study aligns with these outcomes.

Bianchi and colleagues[19] conducted a review of the literature and found three studies showing positive changes in psychological symptoms related to PMS, specifically improvements in negative mood states, following engagement in exercise. In a systematic review by Saglam and Orsal[1], it was determined that psychological symptoms such as anxiety and anger were improved with regular exercise. The domain of negative affect in the current study resembles these psychological symptoms, which was the variable associated with the most significant change following exercise. Connecting the findings from both literature reviews to the current study, it appears that RE alleviates symptoms within the negative affect domain, which is associated with symptoms like depression and anxiety, and could lead to enhancement of quality of life. Future research should involve both RE and AE to compare psychological symptoms within the negative affect domain and study which modality is the most impactful on overall PMS symptoms.

According to the first hypothesis, it was expected that PMS symptoms would acutely diminish due to engaging in RE, similarly to that of AE, through 30 minutes of moderate-intensity resistance training exercise two days before and two days during menstruation. This hypothesis was mostly supported by the data because neither AE nor RE significantly improved symptoms more effectively than the other. Overall, these findings suggest that both modes of exercise are comparable when the goal is to improve PMS symptoms. Thus, the recommendation should be not to avoid RE due to fear of worsening one's symptoms.

The second hypothesis focused on the timing of improvements in symptoms and stated that symptoms would be improved both immediately after and two hours following exercise. The current data demonstrated improvements in select PMS symptoms from both pre- to post-exercise and pre-exercise to two hours post-exercise. This shows that both time post-exercise time periods were associated with improvements within at least one domain; however, the pre- to post-exercise time period showed the most consistent changes in symptoms. Nevertheless, the hypothesis was supported by the data as PMS symptoms did not worsen as time went on.

Strengths and Limitations

A strength of this study was that each exercise session took place in a controlled environment where equipment was provided to the subjects and researchers were able to monitor activity. This ensured subjects were following study protocols. As for potential limitations, subjects were self-reporting PMS symptoms using a questionnaire to rate their symptom severity within each domain. Implementation of a questionnaire could result in misinterpretation of questions and severity levels with a lack of understanding of symptom definitions and the Likert scale. However, this questionnaire was a validated tool based on previous research in this area[2]. Additionally, predicting subjects' start of menstruation was challenging due to some subjects' unawareness of their previous cycles. It would have been ideal to begin exercise with exact predictions of when symptoms would begin, but this was not achievable based on data collection time constraints.

Future Research

This research study has explored areas within female research and the female menstrual cycle. Further research could expand upon our findings and the findings from Çiçek and colleagues[6] by discovering a recommendation of the best intensity, frequency, duration, and modality of exercise to alleviate premenstrual symptoms. A more specific prescription of the FITT-VP (frequency, intensity, time, type, volume, pattern) variables should be designed to emphasize psychological and physiological symptoms. Continued research on the menstrual cycle can incorporate other factors besides PMS. The timing of exercise should be evaluated to find specific parameters within the menstrual cycle where females can perform at their best during exercise. With the menstrual cycle being a major physiologic function within the female anatomy, it is important for females to become more knowledgeable about how their body functions and how they can lead a healthy lifestyle despite effects from their menstrual cycle.

Conclusion

In the current study, the evidence supports that both RE and AE mitigate PMS symptoms in these specific domains: *pain, concentration, water retention, and negative affect.* There was no significant difference between the modes of exercise, indicating that AE may not be superior to RE when mitigating PMS symptoms as other literature may suggest. The data supports that exercise is more likely to mitigate symptoms during the pre-menstruation period, rather than during menstruation. The timing of exercise sessions is a factor that could be used to improve symptoms from prior to exercise to after exercise and prior to and after two hours after exercise. Based on these findings, it is recommended to prescribe a minimum of two days of moderate intensity (40-60% HRR) AE and two days of moderate intensity (session RPE of 5-6) RE (two sets of eight repetitions for eight multi-joint exercises involving upper body, lower body, and core musculature) as potential modalities to alleviate PMS symptoms before alternative strategies are needed. This study also demonstrated that RE is another suitable modality to improve PMS beyond just aerobic methods.

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Address for Correspondence

Jeffrey M. Janot, PhD, ACSM CEP, Department of Kinesiology, University of Wisconsin-Eau Claire, Eau Claire, WI 54702. Phone: (715) 836-5333;
Email: janotjm@uwec.edu

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