Karya J Health Sci. 2024; 5(2): 45-50
RESEARCH ARTICLE/ARAŞTIRMA MAKALESİ doi: 10.52831/kjhs.1462237 e-ISSN:2717-9540

KARYA JOURNAL OF HEALTH SCIENCE

journal homepage: www.dergipark.org.tr/kjhs

DOES EXERCISE HABIT AFFECT CENTRAL SENSITIZATION AND PREMENSTRUAL SYMPTOMS IN ADULT WOMEN? NON-EXERCISING VERSUS (IR)REGULAR-EXERCISING

EGZERSİZ ALIŞKANLIĞI YETİŞKİN KADINLARDA SANTRAL SENSİTİZASYON VE PREMENSTRÜEL SEMPTOMLARI ETKİLER Mİ? EGZERSİZ YAPMAYANLAR İLE DÜZENLİ/DÜZENSİZ EGZERSİZ YAPANLARIN KARŞILAŞTIRILMASI

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ABSTRACT

Objective: The aim of this study was to investigate central sensitization (CS) and premenstrual symptoms in adult women based on exercise habits.

Method: A hundred- two adult women (mean age of 25.9 (8) years) were included in the study. The participants were divided into three groups based on exercise habits: the non-exercising group (NG), the irregular-exercising group (IG), and the regular-exercising group (RG). The CS-related and CS positivity was assessed using the Central Sensitization Inventory (CSI-A and CSI-B). Premenstrual symptom severity was determined with the Premenstrual Syndrome Scale (PSS).

Results: Sociodemographic and menstrual cycle characteristics were comparable among the groups ($p>0.05$). There was a significant difference in the CSI-A ($p<0.001$), the CSI-B ($p=0.023$) and CS positivity ($p<0.001$) among the groups. The CSI-A was higher in the NG compared to the RG ($p<0.001$) and IG ($p=0.001$). The CSI-B was higher in NG compared to the RG ($P=0.002$). CS positivity was common in NG (67.6%) compared to IG (23.7%) and RG (26.7%). The median PSS total score was lowest in RG (120.5) while no significant differences were found in PSS total score ($p=0.375$) or PMS positivity ($p=0.624$) among the three groups. PSS total score correlated to CSI-A ($p=0.001$, $r=0.334$) and menstrual pain severity ($p=0.002$, $r=0.310$). The CSI-A and PSS scores are similar in terms of the phase of the menstrual cycle, and use of the medication for menstrual pain ($p>0.05$).

Conclusion: Premenstrual symptom severity is associated with CS symptoms and menstrual pain in adult women. Adopting an exercise habit may be a protective approach that reduces symptoms associated with CS and improves premenstrual symptoms.

Key Words: Exercise, Pain, Central sensitization, Premenstrual symptom

ÖZ

Amaç: Çalışmanın amacı yetişkin kadınlarda egzersiz alışkanlığının santral sensitizasyon ve premenstrüel semptomlar üzerine etkisinin araştırılmasıdır.

Yöntem: Yüz iki yetişkin kadın (ortalama yaş 25.9 (8) yıl) çalışmaya dahil edildi. Katılımcılar egzersiz alışkanlıklarına göre üç gruba ayrıldı: egzersiz yapmayan grup (NG), düzensiz egzersiz yapan grup (IG) ve düzenli egzersiz yapan grup (RG). Santral sensitizasyon ve santral sensitizasyon pozitifliği, Santral Sensitizasyon Ölçeği (SSÖ-A ve SSÖ-B) kullanılarak değerlendirildi. Premenstrüel semptom şiddeti Premenstrüel Sendrom Ölçeği (PSÖ) ile belirlendi.

Bulgular: Gruplar sosyodemografik ve menstrüel siklus özellikleri bakımından benzerdi ($p>0.05$). Gruplar arasında SSÖ-A ($p<0.001$), SSÖ-B ($p=0.023$) ve santral sensitizasyon pozitifliği ($p<0.001$) açısından anlamlı fark bulundu. SSÖ-A skoru NG'de RG ($p<0.001$) ve IG'ye ($p=0.001$) göre daha yüksekti. SSÖ-B skoru NG'de RG'ye göre daha yüksek bulundu ($p=0.002$). Santral sensitizasyon pozitifliği NG'de (%67,6) IG (%23,7) ve RG'ye (%26,7) göre daha yaygındı. Medyan PSÖ toplam skoru RG'de en düşük iken (120,5), üç grup arasında PSÖ toplam skoru ($p=0,375$) veya premenstrüel sendrom pozitifliği ($p=0,624$) bakımından anlamlı bir fark bulunmadı. PSÖ toplam puanı, SSÖ-A ($p=0.001$, $r=0.334$) ve menstrüel ağrı şiddeti ($p=0.002$, $r=0.310$) ile anlamlı korelasyon gösterdi. SSÖ-A ve PSÖ skorları menstrüel döngünün fazı ve menstrüel ağrıda ilaç kullanımı bakımından benzer bulundu ($p>0.05$).

Sonuç: Premenstrüel semptom şiddeti, yetişkin kadınlarda santral sensitizasyon semptomları ve menstrüel ağrı ile ilişkilidir. Egzersiz alışkanlığı edinmek, santral sensitizasyon ile ilişkili semptomları azaltan ve adet öncesi semptomları iyileştiren koruyucu bir yaklaşım olabilir.

Anahtar Kelimeler: Egzersiz, Ağrı, Santral sensitizasyonu, Premenstrüel semptom

Article Info/Makale Bilgisi

Submitted/Yükleme tarihi: 31.03.2024, **Revision requested/Revizyon isteği:** 30.04.2024, **Last revision received/Son düzenleme tarihi:** 06.05.2024, **Accepted/Kabul:** 03.06.2024
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INTRODUCTION

Central sensitization (CS) is defined as an increased response in the central nervous system to stimuli that are not normally perceived as painful or irritating [1]. This phenomenon, seen in various chronic pain disorders, leads to sensory abnormalities and suggests the presence of certain signs and symptoms [2]. These signs and symptoms include various complaint such as broad pain, fatigue, sleep disorders, headache, cognitive difficulties, and other symptoms [2,3]. Furthermore, few studies have indicated that pain stimuli during the menstrual cycle may lead to CS [3,4].

Occurring during the luteal phase of the menstrual cycle, premenstrual syndrome (PMS) affects many women of reproductive age and is characterized by physiological and psychological symptoms. The syndrome typically begins approximately 7–14 days before the onset of menstruation and usually resolves spontaneously with the onset of menstruation. Symptoms of PMS include irritability, fatigue, headache, breast tenderness, depressive mood, and intense anxiety, among various physiological and psychological symptoms [5].

There are various potential causes for PMS, including estrogen and progesterone imbalances, hyperprolactinemia, prostaglandin deficiency, psychosomatic issues, and serotonin deficiency [5,6]. The condition may be related to the interaction of smoking, alcohol consumption, physical activity level, age, length of menstrual flow, dysmenorrhea, employment status, living area, and marital status. PMS may manifest with severe symptoms that can affect women's daily lives and have a negative impact on work, family, and social relationships [6-8]. Due to the unclear pathophysiology of PMS, there is currently no precise treatment available, and management typically focuses on alleviating individual symptoms. Treatment modalities can generally be categorized into pharmacological treatments (including analgesics, hormonal therapies, or antidepressants), and non-pharmacological therapies (lifestyle modifications, exercise, etc.) [6].

Exercise increases endorphin levels, regulates progesterone and estrogen, and stimulates the production of anti-inflammatory substances. Moreover, exercise offers supplementary advantages such as enhanced overall fitness, social interaction opportunities, and mitigation of depressive symptoms, all of which may contribute to mitigating the problems associated with PMS [9,10]. A study investigated the impact of aerobic exercise of varying intensity levels (low, moderate, and high) on women diagnosed with PMS over a 6-week period. Their findings revealed a significant reduction in PMS symptoms among participants engaging in moderate-intensity aerobic exercise [11]. Also, available evidences suggest that physical activity may improve pain and pain perception [12]. Participants who engaged in physical activity, such as walking for more than one hour per day, showed reduced levels of CS [13]. Besides, a systematic review indicated that aerobic exercise reduces pain sensitization in participants with musculoskeletal pain [14]. However, limited knowledge is available on the effect of exercise habits on CS and premenstrual symptoms in adult women. Furthermore, little is known about the relationship between CS and premenstrual symptoms in adult women.

METHOD

Study Design

The comparative cross-sectional study.

Participants

One hundred-two women (34 non-exercising, 38 irregular-exercising, and 30 regular-exercising) were included in the present study. The inclusion criteria were women aged between 18 and 40 who agreed to participate in the study. Women who were utilizing medication such as hormonal drugs and antidepressants, had irregular menstrual cycle (defined as lasting less than 21 days or more than 35 days and/or missing three or more cycles in a row and/or a gap of more than 4 days between cycles) [15] had alcohol dependence or chronic disease such as fibromyalgia syndrome, thyroid dysfunction, diabetes mellitus, and psychiatric disorders, had any rheumatological disease, were pregnant, or were taking oral contraceptives were excluded from the present study.

Exercise habits were considered to be more than 30 minutes at least 2 days a week for at least 3 months [16,17]. Exercise regularity was asked as two options: regular exercise or irregular exercise. Regular exercise habit is considered as a percentage of total number of exercise session (high attendance is defined as >75%) available over the 12-week period [18]. Participants were considered non-exercise if they were except for these conditions. All women were divided into three groups: Non-exercising group (NG), regular exercising group (RG) and irregular exercising group (IG).

Outcome Measures

Sociodemographic Characteristics: Age (year), height (cm), weight (kg), body mass index (BMI; kg/m^2), education level, smoking (none, active-smoker, ex-smoker) were recorded. The phase of the menstrual cycle was obtained as follows: The premenstrual period was considered as the 7- 14 days before the first day of menstruation; menstrual period was considered as the first to last day of menstruation; and postmenstrual period was considered as the day after the end of menstruation to the day before the premenstrual period [19]. The frequency of menstrual cycle (days), duration of menstrual flow (days), perceived menstrual pain on the first day of menstruation, and use of medication for menstrual pain, were recorded. Due to the study design, the CS, premenstrual symptoms, and menstrual pain were assessed in all participants, regardless of the day of the menstrual cycle. All assessments lasted approximately 4 to 7 minutes.

Central Sensitization and Positivity: The Central Sensitization Inventory (CSI) consists of a two-part questionnaire designed to assess symptoms associated with central sensitivity syndromes. The CSI aims to quantify the severity and frequency of symptoms related to CS, which include conditions such as fibromyalgia, irritable bowel syndrome, chronic fatigue syndrome, and migraine. The inventory comprises two parts: Part A comprises a 25-item scale examining the frequency of various health-related symptoms experienced by the individual, while Part B inquires about specific diagnosed disorders. Each item in Part A is scored from 0 (never) to 4 (always). Total points on the CSI vary between 0 and 100, with higher points demonstrating a greater severity of symptoms associated with CS. The cut-off point of the CSI is 40 points and ≥ 40 is defined as CS positivity [20,21].

Premenstrual Symptoms: The Premenstrual Syndrome Scale (PSS) is a widely used instrument to evaluate the severity of premenstrual symptoms experienced by women. The scale, which consists of 44 items with nine sub-domains (depressive mood, anxiety, fatigue, nervousness, depressive thoughts, pain, changes in appetite, changes in sleep pattern, and bloating), is of the 5-point Likert type. Total score ranges from 44 to 220 points. Scoring 110 points or more signifies the presence of PMS [22].

Menstrual Pain Severity: Menstrual pain was assessed using the Visual Analogue Scale (VAS). VAS typically consists of a 10-cm horizontal line. In pain severity assessment, 0 represents "no pain severity," while 10 indicates "worst pain severity imaginable." Participants were asked to indicate the point corresponding to their perceived menstrual pain on the first day of menstruation over the past three months. The higher scores show greater intensity or severity of pain [23].

Ethical Approval

The study received ethical approval from the Bingöl University Ethics Committee (date: 26/09/2023, no. 23/19) in line with the principles outlined in the Helsinki Declaration. The study was conducted from October, 2023 to January, 2024. All participants completed an informed consent form through an online form.

Statistical Analysis

A priori sample size analysis was performed with G Power software (Version 3.1.9.2, Franz Faul, University of Kiel, Kiel, Germany). Premenstrual symptom score was determined as the primary outcome measure in agreement with the study by Mizuta et al. [16] [exercise group: mean (standard deviation) =54.1 (19.1); non-exercise group: mean (standard deviation) = 60.2 (23.3)]. The total sample size of at least 102 individuals was found to have a power of 0.80, an effect size of 0.50 (medium), and an alpha value of 0.05 (one-tailed).

The statistical analyses were performed utilizing IBM SPSS Statistics 22 (IBM Corp., Armonk, NY, USA). The normality of the distribution of the data was assessed with visual and analytical methods. Sociodemographic and menstrual cycle characteristics were represented as the mean (standard deviation) or median (interquartile range). A one-way ANOVA test was used for the comparison of the CSI-A scores among groups. The Levene test was used to assess the homogeneity of the variances. Paired post hoc tests were performed using the Tamhane test as the variances were not homogeneous.

A Kruskal-Wallis test was used for PSS scores, and the Mann-Whitney U test was used to compare the differences between the groups. A p-value<0.016 was considered significant for the pairwise comparison. A Pearson's chi-square test was used for categorical data. Spearman correlation test was performed for the relationship between PSS, CSI-A, and menstrual pain. The Spearman correlation test was interpreted as follows: indicating negligible correlation for values between 0 and 0.29, poor correlation for values between 0.30 and 0.49, moderate correlation for values between 0.50 and 0.69, good correlation for values between 0.70 and 0.89, and excellent correlation for values between 0.90 and 1.00 [24]. Also, the A one-way ANOVA test or Kruskal-Wallis test was used for comparison of the CSI-A and PSS scores regarding menstrual period. A significance level was set at $p<0.05$ to indicate statistical significance.

RESULTS

A hundred-two adult women [mean age of 25.9 (8) years, mean BMI of 22.1 (3.9) kg/m^2] were included in the study. The groups according to exercise habit were similar in terms of age (p=0.163), BMI (p=0.928), education level (p=0.346), smoking (p=0.123), menstrual pain (p=0.454), cycle (p=0.962), and duration (p=0.073). The sociodemographic and menstrual cycle characteristics of groups are shown in Table 1.

The CSI-A, CSI-B, CS positivity, PSS, and PMS positivity results indicated a significant difference in CSI-A (p<0.001), CSI-B (p=0.023) and CS positivity (p<0.001) among the groups. The post hoc analysis showed that CSI-A was higher in the NG group compared to the RG (p<0.001) and IG groups (p=0.001). Also, the CSI-B was higher in NG compared to the RG (p=0.002). CS positivity was common in NG (67.6%) compared to IG (23.7%) and RG (26.7%). The median PSS total score was lowest in RG (120.5) compared to NG (126) and IG (136.5). No significant differences were found in PSS total score (p=0.375) or PMS positivity (p=0.624) among the three groups (Table 2).

PSS total score significantly correlated to CSI-A (p=0.001, r=0.334) and menstrual pain severity (p=0.002, r=0.310). The correlation analysis among PSS, CSI-A, and menstrual pain severity is indicated in Table 3. The CSI-A and PSS scores are similar based on the phase of the menstrual cycle (p=0.237 of CSI-A, p=0.374 of PSS) and use of medication for menstrual pain (p=0.873 of CSI-A, p=0.240 of PSS) (Figure 1).

Table 1. Sociodemographic and menstrual cycle characteristics of groups

Characteristics	All participants n=102	Non-exercising group (NG) n=34	Irregular-exercising group (IG) n=38	Regular-exercising group (RG) n=30	p value
Age (year), mean (SD)	25.9 (8)	27.1 (8.7)	24 (6.6)	27.1 (8.5)	0.163*
BMI (kg/m^2), mean (SD)	22.1 (3.9)	22 (4)	22 (3.9)	22.3 (3.8)	0.928*
Education level, n (%)					
Primary School	2 (2)	1 (2.9)	0 (0)	1 (3.3)	
Middle School	1 (1)	0 (0)	0 (0)	1 (3.3)	
High School	9 (8.8)	6 (17.6)	1 (2.6)	2 (6.7)	0.346[a]
University	72 (70.6)	22 (64.7)	31 (81.6)	19 (63.3)	
Master's degree	8 (7.8)	2 (5.9)	2 (5.3)	4 (13.3)	
Doctorate	10 (9.8)	3 (8.8)	4 (10.5)	3 (10)	
Smoking, n (%)					
None	78 (76.5)	26 (76.5)	32 (84.2)	20 (66.7)	0.123[a]
Active-smoker	17 (16.7)	7 (20.6)	2 (5.3)	8 (26.7)	
Ex-smoker	7 (6.9)	1 (2.9)	4 (10.5)	2 (6.7)	
Premenstrual period, n (%)	33 (32.4)	11 (32.4)	14 (36.8)	8 (26.7)	0.673[a]
Menstrual period, n (%)	19 (18.6)	8 (23.5)	5 (13.2)	6 (20)	0.515[a]
Postmenstrual period, n (%)	50 (49)	15 (44.1)	19 (50)	16 (53.3)	0.754[a]
Use of medication for menstrual pain, n (%)	56 (54.9)	18 (52.9)	23 (60.5)	15 (50)	0.661[a]
Frequency of menstrual cycle (days), median (IQR)	28 (26-30)	28 (26-30)	28 (25-30)	28 (26-30)	0.962[b]
Duration of menstrual flow (days), median (IQR)	6 (5-7)	7 (6-7)	6 (5-7)	6 (5-7)	0.073[b]
Menstrual pain (cm), median (IQR)	6 (5-8)	6 (5-7)	7 (5-8)	6 (3-8)	0.454[b]

*SD:Standard Deviation, IQR:Interquartile range, *One-way ANOVA test, a:Pearson chi-square test, b:Kruskal-Wallis test*

Table 2. Comparison of CSI and PSS scores based on exercise habits

Variables	Non-exercising group (NG) n=34	Irregular-exercising group (IG) n=38	Regular-exercising group (RG) n=30	p value
CSI-A (point), mean (SD)	48.6 (18.1)	33.3 (13.4)	32.5 (12.2)	**<0.001***
CSI-B (point), median (IQR)	0 (0-2)	0 (0-1)	0 (0-1)	**0.023[b]**
CS positivity, n (%)	23 (67.6)	9 (23.7)	8 (26.7)	**<0.001[a]**
PSS Total (point), median (IQR)	126 (104-151)	136.5 (100-160)	120.5 (91-148)	0.375[b]
Depressive mod	24 (16-28)	27.5 (20-32)	26 (18-31)	0.278[b]
Anxiety	23.5 (17-29)	24.5 (15-28)	19 (13-28)	0.334[b]
Fatigue	19 (15-22)	22.5 (16-27)	18 (13-24)	0.118[b]
Nervousness	14 (10-20)	15 (11-20)	13.5 (10-19)	0.726[b]
Depressive thoughts	20.5 (12-22)	20.5 (13-25)	14.5 (10-23)	0.386[b]
Pain	9 (8-12)	9 (7-12)	9 (6-12)	0.838[b]
Appetite changes	7.5 (6-14)	11 (9-13)	7 (6-12)	0.210[b]
Sleep changes	6 (3-9)	8 (6-11)	7 (6-11)	0.156[b]
Bloating	7 (3-11)	8 (6-12)	10 (7-12)	0.074[b]
PMS positivity, n (%)	23 (67.6)	27 (71.1)	18 (60)	0.624[a]

*PSS:Premenstrual Syndrome Scale, PMS:Premenstrual Syndrome, CSI-A:Central Sensitization Inventory Part A, CSI-B:Central Sensitization Inventory Part B, CS:Central Sensitization, SD:Standard Deviation, IQR Interquartile range, *One-way ANOVA test, a:Pearson chi-square test, b:Kruskal-Wallis test, p<0.05 is defined as significant.*

Table 3. Correlation among PSS, CSI-A and menstrual pain severity

Correlation	CSI-A		Menstrual pain severity	
	r	p	r	p
PSS total score	0.334	**0.001**	0.310	**0.002**

*PSS:Premenstrual Syndrome Scale, CSI-A:Central Sensitization Inventory part A, *Spearman's correlation test.*

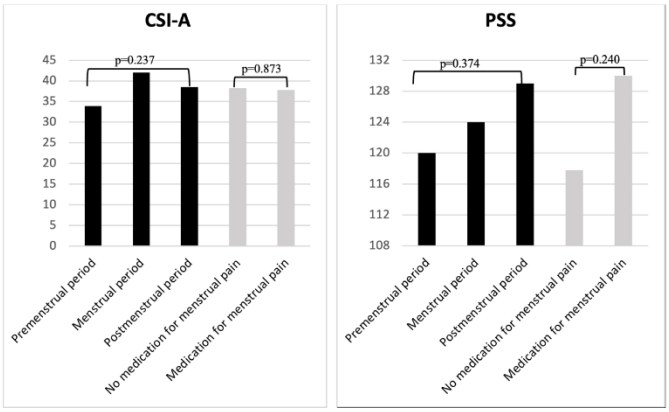

Figure 1. Comparison of the CSI-A and PSS scores based on the phase of the menstrual cycle and use of medication for the menstrual pain

DISCUSSION

The present study showed that CS was more common in non-exercising than in regular or irregular exercising and that premenstrual symptom severity was not affected by exercise habit in adult women, although PSS scores were lower in regular exercising than non-exercising and irregular exercising. Also, premenstrual symptom severity was associated with CS and menstrual pain severity, while the phase of the menstrual cycle and the use of medication for menstrual pain did not affect CS and PMS symptoms.

A review highlighted that exercise potentially modulates pain perception through activation of various endogenous systems [25]. Participants with an exercise habit exhibited elevated levels of daily well-being [26]. Current evidence indicates that physical activity and exercise may improve pain and function in daily activities [12]. A study indicated that participants who engaged in physical activity, such as walking for more than one hour per day, demonstrated lower levels of CS [13]. In the present study, CS and CS-related diseases were more common in adult women who were non-exercising than those who were regular- or irregular-exercising, consistent with the results of Haruyama et al. [13]. However, available evidence is limited regarding exercise habits and central sensitization in healthy adult women.

The present study has provided a valuable insight into the adoption of exercise habits as a protective approach to CS, thereby addressing a gap in the current literature.

A study showed that premenstrual symptoms were similar in regular exercisers and those who did not exercise regularly in women with dysmenorrhea [27]. Hwang et al. showed that there was an inverse relationship between the symptoms of PMS and exercise frequency for women in their 30s and 40s [28]. Besides, previous studies indicated that physical activity levels were similar in participants with and without PMS in Turkish women [29,30] and that there was no relationship between physical activity levels and the presence of PMS [31]. Also, a study showed that physical activity level was similar based on menstrual pain intensity in Turkish women with primary dysmenorrhea [32]. Another study determined that increased physical activity level was associated with less severe pain in Turkish women [33]. The present study was consistent with the previous studies. Although the PSS scores of regular exercisers were lower than those of non-exercisers and irregular- exercisers, there was no difference in PSS scores depending on exercise habit. These results may be related to the type of exercise performed by the participants. In future studies, the effect of different exercise types on PMS symptoms may be evaluated. As the scores of the regular exercise group were low, it is important for the participants to adopt regular exercise habits to reduce PMS symptoms.

A study found that participants with PMS exhibited a higher tendency for somatization compared to those without PMS [34]. Another study revealed that the severity of menstrual pain, sleep disturbances, and eating attitude problems influenced PMS [27]. A study suggested that there was a relationship between PMS and the risk of depression in university students [35]. Furthermore, a study showed that students with PMS experienced more menstrual pain than those without PMS and that menstrual pain was approximately 4.7 times a risk factor for PMS [36]. Consistent with previous studies, the present study found that PMS symptom severity was associated with CS and menstrual pain severity. The presence of CS in individuals with PMS should be monitored carefully.

A comprehensive cross-sectional study found that central sensitivity symptoms are prevalent in about half of the women and are linked with menstrual characteristics including dysmenorrhea-related pain severity, cycle regularity, and the presence of dysmenorrhea, along with gynecological diseases in Brazilian women [4]. Consistent with the previous study [4], the phase of the menstrual cycle and use of medication for menstrual pain did not affect CS scores in the present

study. A study in the Turkish population indicated that menstrual pain and use of analgesics for menstrual pain were not different in women with PMS and without PMS [7]. In the present study, PMS total scores were similar for being in the menstrual or premenstrual period or the use of medication for menstrual pain, in agreement with the previous study's results [7].

Limitations

The study has some limitations. Firstly, the type of exercise in regular- and irregular-exercising groups were not evaluated in detail. The type of exercise may alter not only PMS symptoms but also CS-related symptoms. Further studies should be evaluated to determine the effect of different exercise types on PMS symptoms and CS. Secondly, PMS is influenced by various factors such as diet, sleep quality, use of alcohol, and anemia. In the present study, these factors were not determined; therefore, future studies should take into consideration these factors. Thirdly, the international physical activity questionnaire or activity hours were not used when grouping participants according to their exercise habits. Lastly, the present study cannot definitively establish whether exercise habits can effectively treat symptoms of PMS due to study design. Besides, we are unable to determine whether women with symptoms may exercise more to manage their PMS symptoms, as exercise is recommended by the American College of Obstetricians and Gynecologists [37].

CONCLUSION

The regular exercise habits may be protective in reducing CS and CS-related symptoms and improving the severity of PMS symptoms. The results of this study may encourage regular exercise, a non-pharmacological approach, to improve health, reduce central sensitization and deal with premenstrual symptoms in adult women.

Ethical Approval: *2023/23-19 Health Sciences Scientific Research and Publication Ethics Committee of Bingöl University*

Conflict of Interest: *The authors have no conflicts of interest to declare.*

Funding: *None.*

Acknowledgements: *None.*

Author Contribution: Concept: *ZBA;* ***Design:*** *ZBA,FS;* ***Data collecting:*** *ZBA,FS;* ***Statistical analysis:*** *ZBA;* ***Literature review:*** *ZBA,FS;* ***Writing:*** *ZBA,FS;* ***Critical review:*** *ZBA,FS.*

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