BMJ Open

Effect of sleep quality on the severity of perimenstrual symptoms in Japanese female students: a cross-sectional, online survey

Sakura Oda ,[1] Noriaki Maeda,[1] Tsubasa Tashiro ,[1] Rami Mizuta,[1] Makoto Komiya,[2] Satoshi Arima ,[1] Takaaki Nagasawa,[3] Koichi Naito,[4] Yukio Urabe[1]

To cite: Oda S, Maeda N, Tashiro T, *et al*. Effect of sleep quality on the severity of perimenstrual symptoms in Japanese female students: a cross-sectional, online survey. *BMJ Open* 2025;**15**:e093197. doi:10.1136/bmjopen-2024-093197

► Prepublication history and additional supplemental material for this paper are available online. To view these files, please visit the journal online (https://doi.org/10.1136/bmjopen-2024-093197).

Received 02 September 2024
Accepted 23 January 2025

For numbered affiliations see end of article.

Correspondence to
Tsubasa Tashiro;
tsubasatashiro716@hiroshima-u.ac.jp

ABSTRACT

Objectives To investigate the relationship between sleep quality and perimenstrual symptoms among Japanese female students.

Design Observational, cross-sectional, online survey

Setting We used an online questionnaire to collate responses from Japanese female students on sleep quality and perimenstrual symptoms.

Participants A total of 298 female students aged 18–25 years in Japan were included in this study.

Primary and secondary outcome measures The Menstrual Distress Questionnaire (MDQ) was used to assess the severity of perimenstrual symptoms for three periods—premenstrual, menstrual and postmenstrual—and the Japanese version of the Pittsburgh Sleep Quality Index was used to assess sleep quality. The MDQ scores were compared between two groups (normal-sleep quality and low-sleep quality) using Mann-Whitney U test. In addition, multiple logistic regression analysis was performed, and the MDQ subscales that showed significant differences between the groups were used as independent variables. The MDQ subscale that was strongly associated with sleep quality was calculated.

Results Of the female students, 160 were classified into the normal-sleep quality group and 138 into the low-sleep quality group. The total MDQ scores were significantly higher in the low-sleep quality group at all phases of the menstrual cycle (respectively $p<0.05$). Among the MDQ subscales, 'pain' during menstruation and 'concentration' in the premenstrual and postmenstrual stages were associated with sleep quality (respectively $p<0.05$).

Conclusions Improving sleep quality was one possible strategy to reduce the severity of perimenstrual symptoms. These results may provide useful information for Japanese female students who suffer from perimenstrual symptoms.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ This study conducts an online survey among female students aged 18–25 years in Japan.

⇒ This study adhered to the recommendations of the Checklist for Reporting Results of Internet E-Surveys.

⇒ As this study involved a retrospective online survey about past sleep quality and perimenstrual symptoms, recall bias may have influenced the findings in this study.

⇒ Since it was a cross-sectional study, the causal relationship between sleep quality and perimenstrual symptoms could not be clearly established.

INTRODUCTION

Perimenstrual symptoms are varied and comprise physical, emotional and behavioural symptoms. They occur during premenstrual, menstrual and postmenstrual periods. Approximately 16–91% of women experience perimenstrual symptoms, such as irritability, depression, weight gain and back pain.[1] These are important health issues that can lead to a decline in the quality of life of young women, including students.[2] Additionally, missing classes due to dysmenorrhoea and other perimenstrual symptoms causes a decline in the academic performance of female students.[3]

Unhealthy lifestyle habits can affect perimenstrual symptoms.[4] Throughout the menstrual cycle, changes in the secretion of female hormones, including oestrogen and progesterone, occur.[5] These changes have various effects on a woman's body and mind, causing perimenstrual symptoms. An example of lifestyle influences on these symptoms is the consumption of trans-fatty acids, which are abundant in fast food and increase the levels of prostaglandins, consequently causing dysmenorrhoea and highlighting that an unbalanced diet can lead to increased pain.[4] Exercise could also be associated with perimenstrual symptoms. Reportedly, the secretion of estradiol during exercise increases serotonin secretion, which reduces the negative effects of perimenstrual symptoms.[6] These reports suggest that lifestyle habits are related to perimenstrual symptoms in terms of hormone secretion.

Sleep, one of the lifestyle habits, is an important aspect of human life, with approximately one-third of life's existence spent sleeping.[7] The hypothalamus plays an important role in sleep and is a regulator of sleep and wakefulness.[8] It contains gonadotropin-releasing hormone (GnRH) neurons, which drive the menstrual cycle by secreting GnRH, which helps regulate female hormone levels.[9] Additionally, a direct synaptic connection exists between the sleep centre of the brain and GnRH neurons, and deep sleep activates GnRH pulse generators.[10] Thus, it is possible that sleep and perimenstrual symptoms, which are both regulated by the hypothalamus, may be closely related.

Sleep is characterised by sleep duration and quality, and distinguishing between these two characteristics is essential.[11] Compared with sleep quality, sleep duration assesses sleep objectively and refers to the duration of sleep.[12] In contrast, sleep quality is evaluated subjectively and is defined as a sense of rest on waking and satisfaction with sleep.[12] Although some overlap exists between these two characteristics, they are considered distinct and independent.[13] Reportedly, short sleep duration (<6 hours/day) is associated with moderate-to-severe dysmenorrhoea, revealing a relationship between sleep duration and perimenstrual symptoms.[14] However, no study has examined the relationship between sleep quality and perimenstrual symptoms. Therefore, this study aimed to examine the involvement of sleep quality in perimenstrual symptoms in Japanese female students and propose strategies to alleviate perimenstrual symptoms.

METHODS

Patient and public involvement

The questionnaire design involved female students. After the questionnaire was drafted, it was pretested with 20 Japanese female students who were not included in the main study. The study was conducted with female students residing throughout Japan and was not restricted to any region, such as prefectures. We plan to widely disseminate the findings of this study to the public by sharing information on social media and so on.

Study design

An observational, cross-sectional, online survey of Japanese female students aged 18–25 years was conducted from 8 November 2022 to 2 February 2023 in Japan. The survey was conducted using Google Forms (Alphabet Inc., Mountain View, CA, USA) (see online supplemental file 1). An online survey was disseminated nationwide to female students aged 18–25 years using the URL of the questionnaire through a snowball sampling method, without identifying the geographical area. Before the survey questions began, a summary of the survey instructions, the purpose of the survey, the time required to complete it and the following instructions to the participants were provided: participants can answer questions anonymously, answer just once and could decline participation at any point during the survey. Responses were used solely for research purposes. Participants could commence the questionnaire after checking a consent box, thereby agreeing to participate in the study. Only those who consented to participate in the survey after reviewing the survey summary and instructions proceeded to answer the questions. Examples of statements were provided for questions that participants found difficult to understand to prevent incorrect inputs. Data files containing responses were secured with a password to enhance protection. The inclusion criteria were (a) agreeing to participate in this study, (b) Japanese female students aged between 18 and 25 years and (c) residing in Japan at the time of the survey. The exclusion criteria were (a) had a current history or history of gynaecological disorders or possible secondary dysmenorrhoea,[15] (b) had a current history or history of psychiatric disorders and (c) current history of daily hormonal pill intake. Based on the self-reported responses of the participants, their eligibility for the inclusion and exclusion criteria was determined. This study adhered to the recommendations of the Checklist for Reporting Results of Internet E-Surveys.[16]

Question items

The question items were mainly related to sleep quality and the severity of perimenstrual symptoms. They included basic information and sociodemographic and lifestyle characteristics. Basic information included age, age at menarche, height and weight for body mass index (BMI; kg/m^2) calculation, duration of dysmenorrhoea, current history and history of gynaecological or psychiatric disorders, and medications for internal use related to these disorders. Sociodemographic characteristics included questions regarding part-time job (yes/no) and living status (alone/with others). Lifestyle characteristics included questions regarding alcohol intake (low/high: no alcohol consumption or up to two drinks per week/more), smoking (yes/no), breakfast (eating/not eating), eating between meals (eating/not eating), caffeine consumption (yes/no: ≥3 times/week), studying until bedtime (yes/no: ≥3 times/week), watching TV until bedtime (yes/no: ≥3 times/week) and screen time (min/day) related to leisure and study.[17,18]

The Japanese version of the Pittsburgh Sleep Quality Index (PSQI-J) was used to rate sleep quality in the past month. The PSQI-J has been used and validated in a previous study that assessed sleep quality.[19,20] Participants answered questions regarding their sleep over the past month, and the overall score (range, 0–21) was calculated as the total score of seven factors presented in questions 1–7: subjective sleep quality, time to fall asleep, sleep duration, sleep efficiency, sleep difficulty, use of sleeping pills and difficulty in staying awake during the day. Subjective sleep quality was assessed using one question rated on a four-point Likert scale (very good, quite good, quite bad and very bad). Time to fall asleep was assessed using two questions regarding the time from bedtime to falling asleep. Sleep duration was rated in four stages (>7 hours; >6 hours but ≤7 hours; ≥5 hours but ≤6 hours and <5 hours). Sleep efficiency was calculated by dividing sleep duration by the total number of hours in bed. Sleep difficulty was assessed using nine questions regarding waking up in the middle of the night, difficulty falling asleep soon after going to bed, feeling cold, having bad dreams, getting up to use the restroom, difficulty in breathing correctly, snoring loudly and coughing, feeling pain or having other reasons for sleep disorders. The use of sleeping pills and difficulty in staying awake during the day were rated on a four-point Likert scale (not once, less than once per week, once or twice per week and three or more times per week). A total PSQI-J score of 5 and below indicates normal-sleep quality, and 6 and above indicates low-sleep quality.[19]

The Menstrual Distress Questionnaire (MDQ) has long been used as a measure to evaluate the severity of perimenstrual symptoms, and its Japanese version has been validated.[21 22] The index assesses responses to 46 questions on eight subscales of perimenstrual symptoms.[23] Responses on the most recent symptoms were rated on a six-point scale (1: no reaction at all; 6: acute or partially disabling). High scores indicated increased severity of perimenstrual symptoms. We used six subscales comprising pain, water retention, autonomic reaction, negative affect, concentration and behavioural change; two subscales (mood elevation and control), with higher scores indicating better symptoms, were excluded. Each symptom was assessed for three periods: premenstrual, menstrual and postmenstrual.

Statistical analysis

The respondents were divided into normal-sleep quality and low-sleep quality groups based on the PSQI-J cut-off value of six points.[19] Data collected from the survey were processed using IBM SPSS V.28.0 for Windows (IBM Japan Co., Ltd., Tokyo, Japan). Before conducting the analysis, the Shapiro-Wilk test was used to assess the normality of all data. Basic information and lifestyle characteristics, MDQ total scores and subscales in each menstrual period were compared between both groups using the Mann-Whitney U test. The required sample size was calculated using G*Power 3.1. The analysis, with an effect size of d=0.5 and an alpha level of α=0.05, indicated a statistical power of 0.801, with each group requiring a sample size of 67. χ^2 tests were used to assess sociodemographic and lifestyle characteristics. Effect sizes were calculated to assess not only whether the differences and associations were statistically significant but also the practical significance of these effects. Specifically, the phi coefficient 'ϕ' was used for the χ^2 test and the correlation coefficient (r) for the Mann-Whitney U test as indicators of effect size. These effect size measures provided additional context, contributing to the interpretation of the magnitude of the observed effects and their practical relevance beyond mere statistical significance. Multiple logistic regression analysis was conducted separately for each menstrual phase (premenstrual, menstrual and postmenstrual) to identify the relationship between the MDQ subscale scores and sleep quality. For analysis, a PSQI-J score<6 was coded as 0, and a PSQI-J score≥6 was coded as 1. Normal- or low-sleep quality was set as the dependent variable, and MDQ subscales demonstrated statistically significant differences (p-values<0.05) between the normal- and low-sleep quality groups in group comparisons and were selected as independent variables for the analysis (crude model). Additionally, adjustments were made for age (adjusted model) as hormonal balance changes with age.[24] The variance inflation factor, a statistic used to measure possible multicollinearity among predictors or independent variables, was computed.[25] Multiple variables were employed as independent variables, and to address the potential issue of multiple comparisons, Bonferroni correction was applied. ORs were determined only for the logistic regression analysis to assess the strength and direction of the associations. For all statistical tests, 95% CIs were calculated to evaluate the precision and reliability of the estimates. Regarding sample size calculation, the number of participants per independent variable should be ≥10 based on a previous study.[26] In the present study, 4–7 MDQ subscales were used as independent variables. Therefore, it was necessary to include at least 70 participants each in the normal- or low-sleep quality groups. The significance level was set at 0.05.

RESULTS

The survey was distributed among 850 participants, of which 366 (response rate: 43.1%) provided responses. Of the respondents, 68 were excluded (34 respondents had a current history or history of gynaecological disorders or possible secondary dysmenorrhoea, 32 respondents were taking hormone medication, 1 respondent had a current history or history of psychiatric disorders and 1 respondent answered insufficiently). Thus, 298 respondents were included in the final analysis. Of the 298 participants, 160 were classified into the normal-sleep quality group and 138 into the low-sleep quality group based on the PSQI-J cut-off value points (figure 1).

Basic information, sociodemographic characteristics and lifestyle characteristics

No significant differences in age, age at menarche, BMI, part-time job and living status were observed between the two groups, as shown in table 1.

As shown in table 1, no significant differences in alcohol intake, smoking, eating between meals, caffeine consumption, studying until bedtime, watching TV until bedtime and screen time were observed between the two groups. In contrast, a significant difference in breakfast consumption was observed between the two groups, with a significantly higher number of students eating breakfast in the normal-sleep quality group compared with that in the low-sleep quality group (p=0.023).

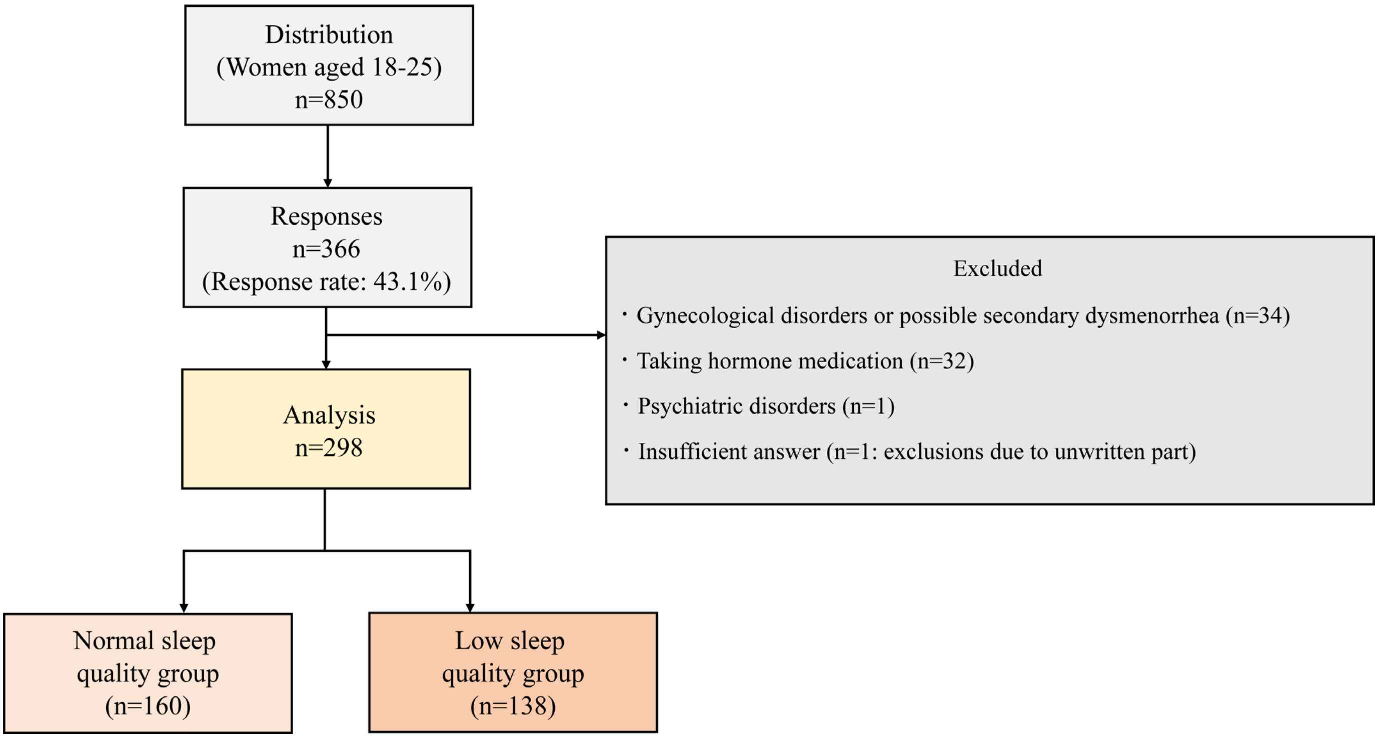

Figure 1 Flowchart of this study.

Comparison of MDQ total scores and subscale scores between the two groups during the premenstrual, menstrual and postmenstrual periods

Figure 2 shows the comparison of the total MDQ scores. The mean total MDQ scores for the normal-sleep quality group and low-sleep quality group were 68.5 points (SD=22.4) and 79.8 points (SD=37.6), respectively, during the premenstrual phase (p=0.006, 95% CI: –16.000, 2.000). During menstruation, the mean total MDQ scores for the normal-sleep quality group and low-sleep quality group were 73.3 points (SD=34.2) and 93.7 points (SD=40.6), respectively (p<0.001, 95% CI: –29.000, 11.000). The mean total MDQ scores in the postmenstrual phase were 51.2 points (SD=24.6) in the normal-sleep quality group and 60.2 points (SD=33.0) in the low-sleep quality group (p=0.005, 95% CI: –6.000, 0.000).

Figure 3 presents the results of the comparison of MDQ subscale scores during the premenstrual phase. The mean MDQ subscale scores in the normal-sleep quality group and low-sleep quality group of the various items were as follows: pain, 12.8 points (SD=6.6) and 15.1 points (SD=8.0), respectively (p=0.016, 95% CI: –3.000, 0.000); water retention, 10.0 points (SD=5.0) and 11.0 points (SD=5.2), respectively (p=0.091, 95% CI: –2.000, 0.000); automatic reaction, 5.5 points (SD=2.9) and 6.5 points (SD=4.0), respectively (p=0.050, 95% CI: 0.000, 0.000); negative affect, 15.8 points (SD=9.2) and 17.9 points (SD=10.0), respectively (p=0.025, 95% CI: –3.000, 0.000); concentration, 12.8 points (SD=7.0) and 15.7 points (SD=8.5), respectively (p<0.001, 95% CI: –3.000, 0.000); and behavioural change, 11.6 points (SD=6.6) and 13.6 points (SD=7.3), respectively (p=0.013, 95% CI: –3.000, 0.000).

Figure 4 shows the results of the comparison of MDQ subscale scores during menstruation. In the normal-sleep quality group and low-sleep quality group, the mean MDQ subscale scores of the various items were as follows: pain, 15.4 points (SD=7.6) and 19.8 points (SD=8.6), respectively (p<0.001, 95% CI: –7.000, –2.000); water retention, 9.3 points (SD=4.6) and 11.1 points (SD=5.2), respectively (p=0.002, 95% CI: –3.000, –1.000); automatic reaction, 6.2 points (SD=3.7) and 7.8 points (SD=4.6), respectively (p<0.001, 95% CI: –1.000, 0.000); negative affect, 15.6 points (SD=8.7) and 20.2 points (SD=10.6), respectively (p=0.025, 95% CI: –6.000, –2.000); concentration, 13.8 points (SD=7.7) and 18.3 points (SD=10.2), respectively (p<0.001, 95% CI: –5.000, –1.000); and behavioural change, 13.0 points (SD=6.9) and 16.6 points (SD=7.7), respectively (p<0.001, 95% CI: –5.000, –2.000).

Figure 5 provides the results of the comparison of MDQ subscale scores in the postmenstrual phase. In the normal-sleep quality group and low-sleep quality group, the mean of the MDQ subscale scores for the items is as follows: pain, 9.9 points (SD=6.0) and 11.4 points (SD=7.2), respectively (p=0.027, 95% CI: –1.000, 0.000); water retention, 6.8 points (SD=4.0) and 7.3 points (SD=3.9), respectively (p=0.086, 95% CI: –1.000, 0.000); automatic reaction, 4.9 points (SD=2.1) and 5.7 points (SD=3.4), respectively (p=0.072, 95% CI: 0.000, 0.000); negative affect, 11.4 points (SD=6.3) and 13.2 points (SD=8.0), respectively (p=0.011, 95% CI: 0.000, 0.000); concentration, 10.2 points (SD=4.2) and 12.8 points

Table 1 Basic information, sociodemographic characteristics and lifestyle characteristics

Variables	Normal-sleep quality group (n=160)	Low-sleep quality group (n=138)	χ^2	P value	Effect size	95% CI	
						Lower	Upper
Age (years)	20.8±1.4	20.7±1.3		0.666	−0.025	0.000	0.000
Age at menarche (years)	12.5±1.7	12.5±1.5		0.839	0.012	0.000	0.000
Body mass index (kg/m^2)	20.5±2.6	20.8±2.6		0.884	0.008	−0.521	0.459
Part-time job							
Yes	135 (84.4)	123 (89.1)	1.442	0.230	0.070	0.004	0.168
No	25 (15.6)	15 (10.9)					
Living status							
Alone	57 (35.6)	46 (33.3)	0.172	0.678	0.024	0.002	0.143
With others	103 (64.4)	92 (66.7)					
Alcohol intake							
Low	145 (90.6)	129 (93.5)	0.815	0.367	0.052	0.003	0.169
High	15 (9.4)	9 (6.5)					
Smoking							
No	152 (95.0)	133 (96.4)	0.337	0.562	0.034	0.002	0.149
Yes	8 (5.0)	5 (0.6)					
Breakfast							
Eating	114 (71.3)	81 (58.7)	5.163	0.023*	0.132	0.016	0.245
Not eating	46 (28.7)	57 (41.3)					
Eating between meals							
Eating	101 (63.1)	95 (68.8)	1.075	0.300	0.060	0.004	0.172
Not eating	59 (36.9)	43 (31.2)					
Caffeine consumption (≥3 times/week)							
Yes	74 (46.3)	57 (41.3)	0.736	0.391	0.050	0.031	0.234
No	86 (53.7)	81 (58.7)					
Studying until going to bed (≥3 times/week)							
Yes	37 (23.1)	32 (23.2)	0.000	0.990	0.001	0.016	0.183
No	123 (76.9)	106 (76.8)					
Watching TV until going to bed (≥3 times/week)							
Yes	44 (27.5)	29 (21.0)	1.685	0.194	0.075	0.023	0.206
No	116 (72.5)	109 (79.0)					
Screen time							
Leisure (min/day)	256.4±204.2	252.1±144.0		0.578	0.032	−30.000	30.000
Study (min/day)	105.9±129.8	107.1±124.4		0.265	0.064	−20.000	0.000

Data are expressed as mean±SD, or n (%).
*Statistically significant.

(SD=7.4), respectively (p<0.001, 95% CI: −1.000, 0.000); and behavioural change, 8.1 points (SD=4.6) and 9.8 points (SD=6.1), respectively (p=0.005, 95% CI: −1.000, 0.000).

Multiple logistic regression analysis

To show the associations of sleep quality with the MDQ subscales, multiple logistic regression analysis in the crude model was performed (table 2). The MDQ concentration scores during the premenstrual period (β=0.068; p=0.034; OR 1.070; 95% CI: 1.005 to 1.140), pain during menstruation (β=0.057; p=0.040; OR 1.059; 95% CI: 1.003 to 1.117) and concentration during the postmenstrual period (β=0.165; p=0.003; OR 1.179; 95% CI: 1.058 to 1.313) were significantly associated with sleep quality.

Furthermore, to assess the relationship between sleep quality and MDQ subscales, multiple logistic regression analysis was conducted in the adjusted model (table 3). In the premenstrual phase, a significant relationship with

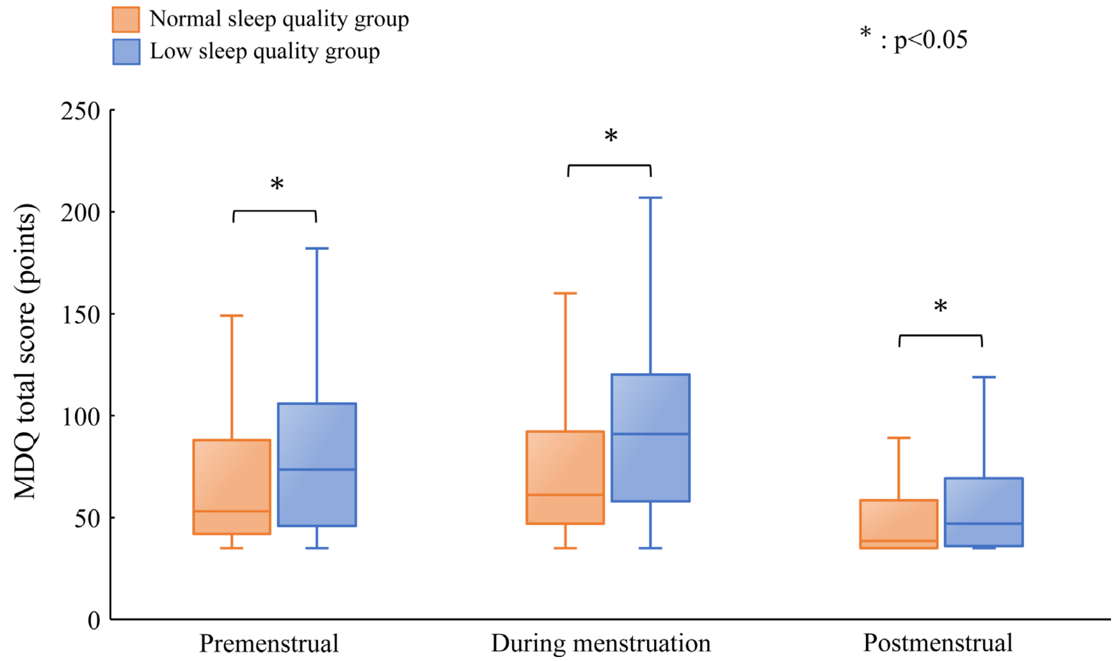

Figure 2 Comparison of Menstrual Distress Questionnaire (MDQ) total scores.

sleep quality was identified for concentration (β=0.071; p=0.028; OR 1.073; 95% CI: 1.008, 1.143). During menstruation, a significant relationship with sleep quality was detected for pain (β=0.058; p=0.038; OR 1.059; 95% CI: 1.003, 1.118). The MDQ concentration score during the postmenstrual phase was significantly associated with sleep quality (β=0.164; p=0.003; OR, 1.178; 95% CI: 1.058, 1.312).

DISCUSSION

The aim of this study was to investigate the relationship between sleep quality and perimenstrual symptoms among Japanese female students. The main findings of this study revealed that lower sleep quality was associated with increased severity of perimenstrual symptoms. Furthermore, among the MDQ components, significant associations with sleep quality were observed for pain during menstruation and concentration during the premenstrual and postmenstrual periods. The Japanese population is known to have poor sleep habits, and in particular, college students are prone to disrupting their sleeping habits.[27] Therefore, confirming whether sleep quality is associated with perimenstrual symptoms among Japanese female students and identifying perimenstrual symptoms most strongly related to sleep quality are important.

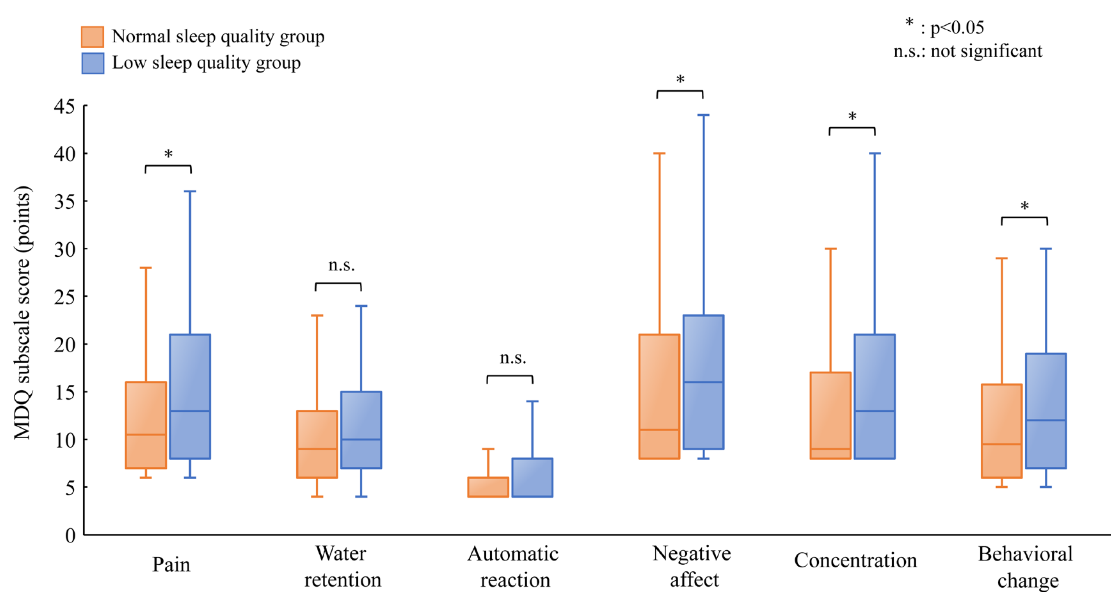

Figure 3 Comparison of Menstrual Distress Questionnaire (MDQ) subscale scores: premenstrual.

Oda S, et al. BMJ Open 2025;15:e093197. doi:10.1136/bmjopen-2024-093197

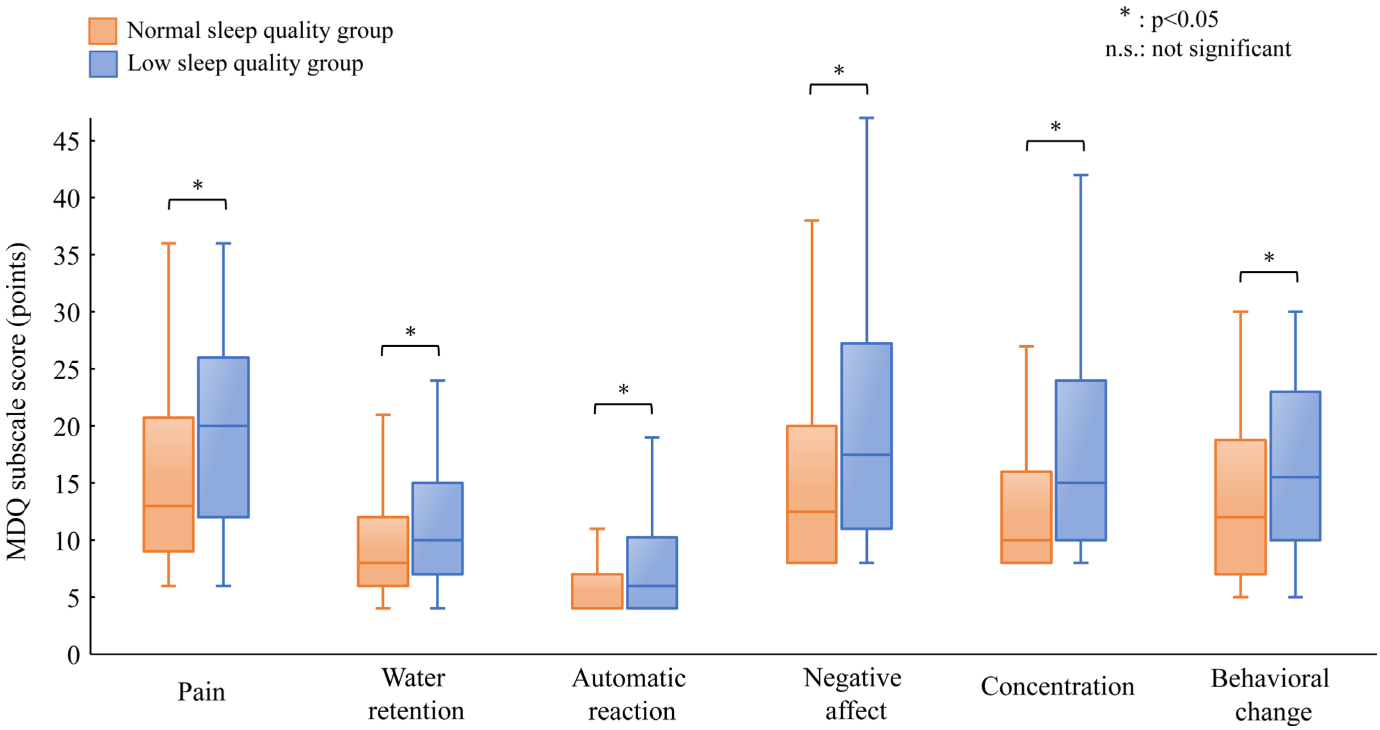

Figure 4 Comparison of Menstrual Distress Questionnaire (MDQ) subscale scores: during menstruation.

First, this study compares its results with previous research investigating the association between sleep quality and perimenstrual symptoms. In a study among female university students, comparing PSQI scores with and without dysmenorrhoea showed that the group with dysmenorrhoea had higher PSQI scores and lower sleep quality ($p<0.05$).[28] In another study focusing on premenstrual syndrome (PMS), women with severe PMS had lower subjective sleep quality in the late luteal phase.[29] As seen in previous studies, some investigations have explored the relationship between perimenstrual symptoms and sleep quality. However, no studies have definitively confirmed which symptoms are particularly relevant among the various perimenstrual symptoms. This study not only examined the association between perimenstrual symptoms and sleep quality but also identified which

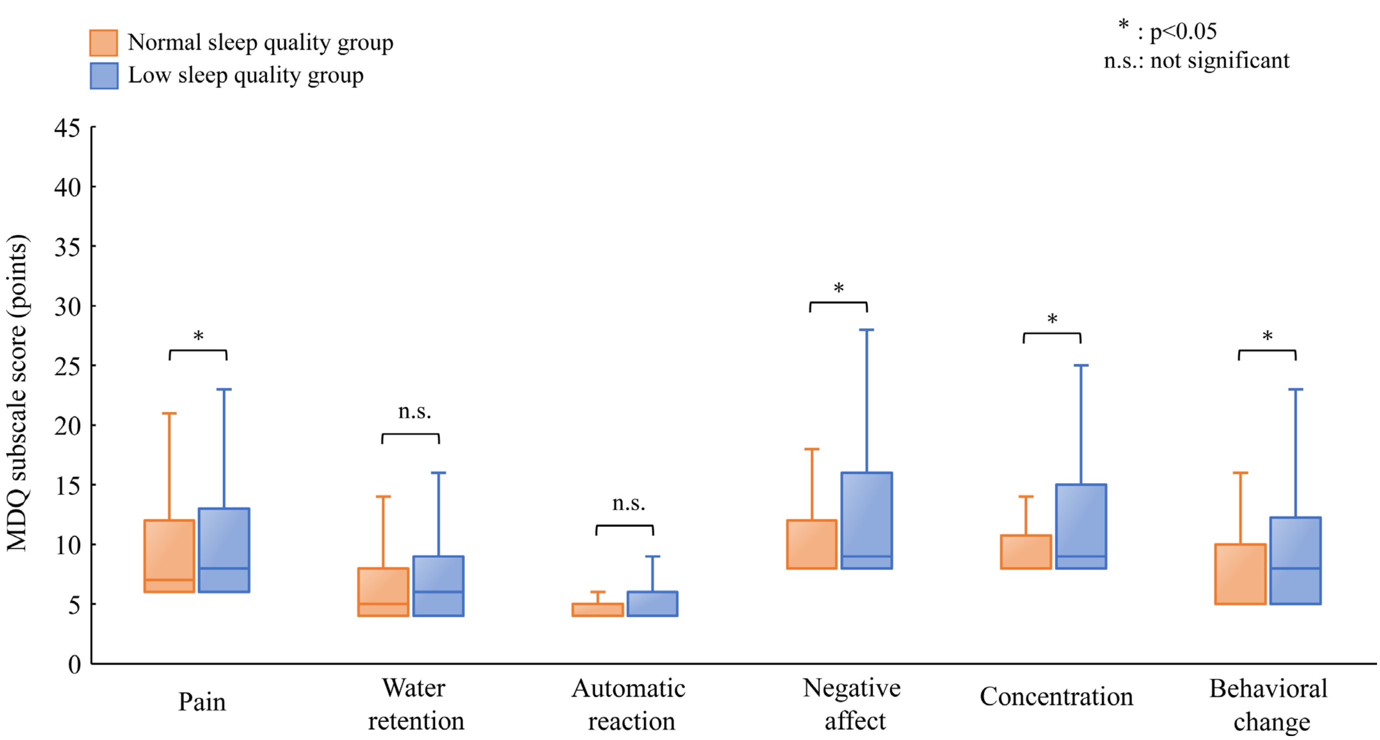

Figure 5 Comparison of Menstrual Distress Questionnaire (MDQ) subscale scores: postmenstrual.

Table 2 Multiple logistic regression analysis for the association of sleep quality with Menstrual Distress Questionnaire subscales in the crude model

							95% CI	
	β	SE	Wald	df	P value	OR	Lower	Upper
Premenstrual								
Pain	0.022	0.026	0.722	1	0.396	1.022	0.972	1.075
Negative affect	−0.040	0.027	2.221	1	0.136	0.961	0.913	1.013
Concentration	0.068	0.032	4.493	1	0.034*	1.070	1.005	1.140
Behavioural change	0.006	0.036	0.030	1	0.864	1.006	0.937	1.081
During menstruation								
Pain	0.057	0.028	4.229	1	0.040*	1.059	1.003	1.117
Water retention	−0.030	0.038	0.630	1	0.427	0.970	0.901	1.045
Autonomic reaction	−0.011	0.044	0.064	1	0.801	0.989	0.907	1.079
Negative affect	0.009	0.023	0.158	1	0.691	1.009	0.965	1.056
Concentration	0.029	0.026	1.215	1	0.270	1.029	0.978	1.083
Behavioural change	−0.003	0.033	0.006	1	0.937	0.997	0.935	1.064
Postmenstrual								
Pain	−0.013	0.037	0.115	1	0.735	0.987	0.918	1.602
Negative affect	−0.082	0.043	3.540	1	0.060	0.922	0.846	1.003
Concentration	0.165	0.055	8.968	1	0.003*	1.179	1.058	1.313
Behavioural change	0.024	0.063	0.140	1	0.709	1.024	0.904	1.159

Variation inflation factor (premenstrual): pain, 2.679; negative affect, 4.429; concentration, 4.167; behavioural change, 4.569. During menstruation: pain, 3.668; water retention, 2.452; automatic reaction, 2.344; negative affect, 3.614; concentration, 3.812; behavioural change, 4.212. Postmenstrual: pain, 3.872; negative affect, 5.161; concentration, 4.701; behavioural change, 7.171.
*Statistically significant.
df, degree of freedom; β, partial regression coefficient.

symptoms were most strongly associated with sleep quality during each menstrual cycle. By focusing on specific perimenstrual symptoms, such as pain during menstruation and concentration difficulties during the premenstrual and postmenstrual phases, this study provides a more detailed understanding of the relationship between sleep quality and perimenstrual symptoms.

A previous study of female undergraduate and graduate students in Taiwan found that normal- or low-sleep quality was associated with the onset of perimenstrual symptoms, and 51.4% of female students were indicated to have normal-sleep quality (PSQI<6) and 48.6% indicated to have low-sleep quality (PSQI≥6).[30] These results suggest a relationship between sleep quality and perimenstrual symptoms. In our study, the severity of perimenstrual symptoms was lower in the normal-sleep quality group than in the low-sleep quality group, which is similar to the results of the previous study.[30] Moreover, 53.7% of the participants were classified into the normal-sleep quality group and 46.3% into the low-sleep quality group, suggesting no participant bias when investigating sleep quality compared with that in previous studies. The average MDQ scores in Japanese young women aged 18 years and older[6] are 57.2 points in the premenstrual, 63.0 points in the menstrual and 42.5 in the postmenstrual periods. In the present study, the average MDQ total scores were 74.2 points in the premenstrual, 83.5 points in the menstrual and 55.8 in the postmenstrual periods, which were higher than those reported in the previous study.[6] A higher percentage of female college students have severe perimenstrual symptoms,[31] which may explain the relatively high MDQ total scores of our study.

The MDQ total scores and several subscale scores were higher in the lower-sleep quality group than in the normal-sleep quality group during all the menstrual periods. The most likely explanation for the association between sleep quality and perimenstrual symptoms is the influence of melatonin. Melatonin, which is responsible for inducing sleep, decreases with low-sleep quality.[32] It is also involved in reproductive functions and plays a role in regulating the levels of oestrogen and progesterone.[33] Thus, the decrease in melatonin secretion due to low-sleep quality might have led to a disturbance in the regulatory mechanism of female hormone levels, which might have resulted in the higher severity of perimenstrual symptoms in the low-sleep quality group. However, these discussions are predominantly speculative since this was a cross-sectional study based on an online survey, making it impossible to measure melatonin secretion or variations.

Multiple logistic regression analysis showed that the MDQ subscale during menstruation related to sleep quality was 'pain', suggesting a relationship between

Table 3 Multiple logistic regression analysis for the association of sleep quality with Menstrual Distress Questionnaire subscales in the adjusted model

							95% CI	
	β	SE	Wald	df	P value	OR	Lower	Upper
Premenstrual								
Pain	0.022	0.026	0.747	1	0.387	1.023	0.972	1.076
Negative affect	−0.041	0.027	2.373	1	0.123	0.960	0.911	1.011
Concentration	0.071	0.032	4.808	1	0.028*	1.073	1.008	1.143
Behavioural change	0.008	0.036	0.047	1	0.828	1.008	0.938	1.083
Age	−0.085	0.090	0.904	1	0.342	0.918	0.770	1.095
During menstruation								
Pain	0.058	0.028	4.304	1	0.038*	1.059	1.003	1.118
Water retention	−0.034	0.038	0.781	1	0.377	0.967	0.897	1.042
Autonomic reaction	−0.009	0.044	0.044	1	0.835	0.991	0.908	1.081
Negative affect	0.009	0.023	0.137	1	0.712	1.009	0.964	1.055
Concentration	0.028	0.026	1.200	1	0.273	1.029	0.978	1.083
Behavioural change	0.000	0.033	0.000	1	0.996	1.000	0.937	1.067
Age	−0.089	0.092	0.924	1	0.336	0.915	0.764	1.096
Postmenstrual								
Pain	−0.015	0.038	0.151	1	0.698	0.986	0.916	1.061
Negative affect	−0.082	0.043	3.600	1	0.058	0.921	0.846	1.003
Concentration	0.164	0.055	8.925	1	0.003*	1.178	1.058	1.312
Behavioural change	0.026	0.064	0.169	1	0.681	1.027	0.906	1.163
Age	−0.043	0.091	0.221	1	0.638	0.958	0.802	1.144

Variation inflation factor (premenstrual): pain, 2.679; negative affect, 4.431; concentration, 4.167; behavioural change, 4.589; age, 1.012. During menstruation: pain, 3.668; water retention, 2.474; automatic reaction, 2.349; negative affect, 3.616; concentration, 3.813; behavioural change, 4.236; age, 1.016. Postmenstrual: pain, 3.924; negative affect, 5.162; concentration, 4.708; behavioural change, 7.219; age, 1.024.
*Statistically significant.
df, degree of freedom; β, partial regression coefficient.

sleep and dysmenorrhoea. In dysmenorrhoea without organic disease, the cause of pain could be excessive uterine contractions caused by prostaglandins released from the menstrual blood and uterine mucosa during menstruation. It is possible that the low-sleep quality group had more pain during menstruation because the prostaglandin system is activated when adequate sleep is not achieved.[34]

The MDQ subscale in the premenstrual and postmenstrual periods related to sleep quality was 'concentration'. Female hormone levels are associated with cognitive function. For example, the change in estradiol levels with the menstrual cycle causes changes in cognitive function such as memory.[35] Additionally, rapid changes in hormone levels during pregnancy alter cognitive abilities.[36] These findings indicate that changes in female hormone levels are involved in memory and other cognitive functions. As discussed earlier, decrease in sleep quality decreases the secretion of melatonin, which plays a role in regulating female hormones, suggesting that sleep quality may be linked to concentration, a perimenstrual symptom.

Decreased sleep duration and long-term sleep deprivation are common in the Japanese modern society. In a previous study involving Japanese college students, the mean sleep duration on weekdays was 5.9 hours; approximately 16% of the participants were categorised as evening-type individuals and 56.1% felt sleepy during the day.[27] This seemingly represents the unhealthy sleeping habits of Japanese students. Perimenstrual symptoms are commonly experienced by female college students.[31] Based on the results of our study, which demonstrates a relationship between sleep quality and perimenstrual symptoms, the need to improve sleep quality among Japanese female students is high. Sleep problems are caused by the blue light emitted from mobile phones and personal computers,[37] humidity in the bedroom, bedding, background noise, human voices, lighting, etc.[38] Particularly, the age group targeted in this study is one where smartphone usage is prevalent, making the issue of blue light exposure an important concern. About 2 hours before bedtime, the secretion of melatonin, a hormone that promotes sleep, begins. Exposure to light or the use of smartphones during this period, which emits blue light, has been reported to suppress the secretion of melatonin. This suppression disrupts the sleep-wake cycle, causing a delay in sleep onset and hindering the ability to fall asleep.[39] Consequently, minimising blue light exposure from smartphone use at night could be a beneficial intervention. However, considering contemporary trends, it would be challenging to propose restrictions on smartphone use for students. Previous studies have demonstrated that regular aerobic exercise, such as walking or cycling, can enhance sleep quality by regulating circadian rhythms and decreasing sleep onset latency. Based on the results of a study by Lu in 2023, aerobic exercise significantly improved sleep quality in a sample of 719 college students, with a regression coefficient of −0.37 ($p<0.001$), as determined by regression analysis.[40] Additionally, optimising the sleep environment, such as using comfortable bedding and controlling room temperature, has been linked to better sleep quality and efficiency. In a study by Bert *et al*, it was found that switching to a new bedding system significantly improved sleep quality and comfort, with improvements becoming more prominent over time.[41] These findings suggest that the use of appropriate bedding could be an important factor in enhancing sleep quality. Along with reducing blue light exposure, such interventions may offer effective strategies for improving sleep among young adults.

The present study had some limitations. First, the causal relationship between sleep quality and perimenstrual symptoms was not clarified. Second, the menstrual cycle at the time the participants completed the questionnaire was not considered, rendering this survey a cross-sectional one. However, the indicators used in this survey were established and confirmed to have no problems as retrospective formulas.[22] Third, since this was a retrospective study, recall bias might have occurred during the recall of perimenstrual symptoms and sleep conditions in each menstrual period. To minimise recall bias, respondents were asked to respond to items related to sleep conditions and perimenstrual symptoms within the last month. Fourth, the survey used a snowball sampling method, raising questions about the potential lack of randomness and the representativeness of the sample in terms of individual status. Although the survey was broadly disseminated to mitigate regional or demographic biases, the snowball sampling approach may have introduced selective bias as participants likely shared the questionnaire with individuals possessing similar characteristics. A fifth limitation of this study is the relatively low response rate of 43.1% for the online survey. Although the questionnaires were distributed without geographical limitations, these fourth and fifth limitations may indicate particular characteristics of the respondents. As such, the results should be interpreted cautiously, and future studies with higher response rates and more representative samples are necessary to confirm these findings. Finally, the secretion of melatonin and other body hormones was not measured. Measuring these variables could yield objective data to enhance the understanding of the physiological mechanisms underlying the relationship between sleep quality and perimenstrual symptoms. Given these limitations, future research should focus on conducting longitudinal or experimental studies to explore the causal relationships between sleep quality and perimenstrual symptoms. Expanding the sample size to incorporate a more diverse population is essential, accounting for factors such as lifestyle, education level and other characteristics that could influence the results. Additionally, incorporating objective measurements of sleep and hormonal levels, such as melatonin secretion, would provide clearer insights into the physiological mechanisms involved. These steps would bolster the validity and generalisability of future findings.

We examined the association between sleep quality and perimenstrual symptoms among Japanese female students who were divided into normal- and low-sleep quality groups based on the cut-off values of the PSQI-J. The low-sleep quality group had higher total MDQ scores and several subscale scores compared with those of the normal-sleep quality group during the premenstrual, menstrual and postmenstrual periods. In addition, multiple logistic regression analysis revealed that among the various menstrual symptoms, 'concentration' during the premenstrual and postmenstrual periods and 'pain' during menstruation were most strongly related to sleep quality. These results show that low-sleep quality may be associated with worsening perimenstrual symptoms and suggest the importance of considering and addressing these relationships in the management of women's health issues.

Author affiliations
[1]Department of Sports Rehabilitation, Graduate School of Biomedical and Health Sciences, Hiroshima University, Hiroshima, Japan
[2]Institute for Human Movement and Medical Sciences, Niigata University of Health and Welfare, Niigata, Niigata, Japan
[3]Department of Health and Nutrition, Wayo Women's University, Ichikawa, Chiba, Japan
[4]Department of Medical Science, Nagoya Women's University, Nagoya, Aichi, Japan

Acknowledgements We thank the Graduate School of Biomedical and Health Sciences, Division of Integrated Health Sciences, Hiroshima University, for their cooperation in designing the study, as well as the female students who cooperated in distributing the questionnaires and answering the questions.

Contributors The study was designed by SO, NM, TT, RM, MK, SA, TN and KN. Original drafting, reviewing and editing of the manuscript were performed by SO, TT and RM. The methodology was designed by SO, TT and RM. Formal analysis was performed by SO. The research was supervised by YU. All authors read and approved the final manuscript. SO is the guarantor.

Funding The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests None declared.

Patient and public involvement Patients and/or the public were involved in the design, or conduct, or reporting, or dissemination plans of this research. Refer to the Methods section for further details.

Patient consent for publication Not applicable.

Ethics approval This study conformed to the guidelines of the Declaration of Helsinki and was approved by the Ethical Committee for Epidemiology, Hiroshima

University (E-3791). Participants gave informed consent to participate in the study before taking part.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available upon reasonable request.

Supplemental material This content has been supplied by the author(s). It has not been vetted by BMJ Publishing Group Limited (BMJ) and may not have been peer-reviewed. Any opinions or recommendations discussed are solely those of the author(s) and are not endorsed by BMJ. BMJ disclaims all liability and responsibility arising from any reliance placed on the content. Where the content includes any translated material, BMJ does not warrant the accuracy and reliability of the translations (including but not limited to local regulations, clinical guidelines, terminology, drug names and drug dosages), and is not responsible for any error and/or omissions arising from translation and adaptation or otherwise.

ORCID iDs

Sakura Oda http://orcid.org/0000-0001-5662-4435
Tsubasa Tashiro http://orcid.org/0000-0001-8339-3652
Satoshi Arima http://orcid.org/0000-0001-9066-5310

REFERENCES

1 Ju H, Jones M, Mishra G. The prevalence and risk factors of dysmenorrhea. *Epidemiol Rev* 2014;36:104–13.
2 Mizuta R, Maeda N, Tashiro T, *et al*. Quality of life by dysmenorrhea severity in young and adult Japanese females: A web-based cross-sectional study. *PLoS One* 2023;18:e0283130.
3 Bilir E, Yıldız Ş, Yakın K, *et al*. The impact of dysmenorrhea and premenstrual syndrome on academic performance of college students, and their willingness to seek help. *Turk J Obstet Gynecol* 2020;17:196–201.
4 Indahwati AN, Muftiana E, Purwaningroom DL. Hubungan Mengonsumsi Makanan Cepat Saji (Fast Food) dengan Kejadian Dismenore Pada Remaja Putri di SMP N 1 Ponorogo. *IJHS* 2017;1:7–13.
5 Bernal A, Paolieri D. The influence of estradiol and progesterone on neurocognition during three phases of the menstrual cycle: Modulating factors. *Behav Brain Res* 2022;417:113593.
6 Mizuta R, Maeda N, Komiya M, *et al*. The relationship between the severity of perimenstrual symptoms and a regular exercise habit in Japanese young women: a cross-sectional online survey. *BMC Womens Health* 2022;22:200.
7 van de Langenberg SCN, Kocevska D, Luik AI. The multidimensionality of sleep in population-based samples: a narrative review. *J Sleep Res* 2022;31:e13608.
8 Ono D, Yamanaka A. Hypothalamic regulation of the sleep/wake cycle. *Neurosci Res* 2017;118:74–81.
9 Rance NE, Young WS III, McMullen NT. Topography of neurons expressing luteinizing hormone-releasing hormone gene transcripts in the human hypothalamus and basal forebrain. *J of Comparative Neurology* 1994;339:573–86.
10 Shaw ND, Butler JP, Nemati S, *et al*. Accumulated deep sleep is a powerful predictor of LH pulse onset in pubertal children. *J Clin Endocrinol Metab* 2015;100:1062–70.
11 Meijer AM, Habekothé HT, Van Den Wittenboer GL. Time in bed, quality of sleep and school functioning of children. *J Sleep Res* 2000;9:145–53.
12 Pilcher JJ, Ginter DR, Sadowsky B. Sleep quality versus sleep quantity: Relationships between sleep and measures of health, well-being and sleepiness in college students. *J Psychosom Res* 1997;42:583–96.
13 Dewald JF, Meijer AM, Oort FJ, *et al*. The influence of sleep quality, sleep duration and sleepiness on school performance in children and adolescents: A meta-analytic review. *Sleep Med Rev* 2010;14:179–89.
14 Kazama M, Maruyama K, Nakamura K. Prevalence of Dysmenorrhea and Its Correlating Lifestyle Factors in Japanese Female Junior High School Students. *Tohoku J Exp Med* 2015;236:107–13.
15 Ferries-Rowe E, Corey E, Archer JS. Primary Dysmenorrhea: Diagnosis and Therapy. *Obstet Gynecol* 2020;136:1047–58.
16 Eysenbach G. Improving the quality of Web surveys: the Checklist for Reporting Results of Internet E-Surveys (CHERRIES). *J Med Internet Res* 2004;6:e34.
17 Hayakawa M, Inoue K. Breslow's health index and lifestyle risk factors and their relationship to dietary habits (in Japanese). *Welfare Indicators* 2008;55:1–8.
18 Breslow L, Enstrom JE. Persistence of health habits and their relationship to mortality. *Prev Med* 1980;9:469–83.
19 Buysse DJ, Reynolds CF III, Monk TH, *et al*. The Pittsburgh sleep quality index: A new instrument for psychiatric practice and research. *Psychiatry Res* 1989;28:193–213.
20 Doi Y, Minowa M, Uchiyama M, *et al*. Psychometric assessment of subjective sleep quality using the Japanese version of the Pittsburgh Sleep Quality Index (PSQI-J) in psychiatric disordered and control subjects. *Psychiatry Res* 2000;97:165–72.
21 Akiyama A, Kayashima K. The effects of the sexual cycle on the mind and body from the perspective of the mirror drawing test (MDT)(in Japanese).
J Jpn Soc Nurs Res 1979;2:61–6.
22 Goto Y, Okuda H. Changes in complaints in the perimenstrual period. An investigation of changes using the Menstrual Distress Questionnaire (in Japanese). *Bulletin of the Faculty of Medicine and Health Sciences, Okayama University* 2005;16:21–30.
23 Moos RH. The development of a menstrual distress questionnaire. *Psychosom Med* 1968;30:853–67.
24 Horstman AM, Dillon EL, Urban RJ, *et al*. The role of androgens and estrogens on healthy aging and longevity. *J Gerontol A Biol Sci Med Sci* 2012;67:1140–52.
25 Robinson C, Schumacker RE. Interaction effects: centering, variance inflation factor, and interpretation issues. *Multiple Linear Regression Viewpoints* 2009;35:6–11.
26 Wilson Van Voorhis CR, Morgan BL. Understanding Power and Rules of Thumb for Determining Sample Sizes. *TQMP* 2007;3:43–50.
27 Kayaba M, Matsushita T, Enomoto M, *et al*. Impact of sleep problems on daytime function in school life: a cross-sectional study involving Japanese university students. *BMC Public Health* 2020;20:371.
28 Sahin S, Ozdemir K, Unsal A, *et al*. Review of frequency of dysmenorrhea and some associated factors and evaluation of the relationship between dysmenorrhea and sleep quality in university students. *Gynecol Obstet Invest* 2014;78:179–85.
29 Baker FC, Kahan TL, Trinder J, *et al*. Sleep quality and the sleep electroencephalogram in women with severe premenstrual syndrome. *Sleep* 2007;30:1283–91.
30 Cheng S-H, Shih C-C, Yang Y-K, *et al*. Factors associated with premenstrual syndrome - a survey of new female university students. *Kaohsiung J Med Sci* 2013;29:100–5.
31 Matsumoto T, Egawa M, Kimura T, *et al*. A potential relation between premenstrual symptoms and subjective perception of health and stress among college students: a cross-sectional study. *Biopsychosoc Med* 2019;13:26.
32 Ogura M, Hattori A, Yagi M, *et al*. Effects of mats with "A Distinctive 4-Layer 3-Dimensional Structure" on sleep quality and nocturnal blood glucose: a crossover trial. *Glycative Stress Res* 2019;6:49–63.
33 Romeu LRG, da Motta ELA, Maganhin CC, *et al*. Effects of melatonin on histomorphology and on the expression of steroid receptors, VEGF, and PCNA in ovaries of pinealectomized female rats. *Fertil Steril* 2011;95:1379–84.
34 Haack M, Lee E, Cohen DA, *et al*. Activation of the prostaglandin system in response to sleep loss in healthy humans: potential mediator of increased spontaneous pain. *Pain* 2009;145:136–41.
35 Sherwin BB. Estrogen and cognitive functioning in women. *Endocr Rev* 2003;24:133–51.
36 Henry JD, Rendell PG. A review of the impact of pregnancy on memory function. *J Clin Exp Neuropsychol* 2007;29:793–803.
37 Silvani MI, Werder R, Perret C. The influence of blue light on sleep, performance and wellbeing in young adults: A systematic review. *Front Physiol* 2022;13:943108.
38 Sung EJ, Tochihara Y. Effects of bathing and hot footbath on sleep in winter. *J Physiol Anthropol Appl Human Sci* 2000;19:21–7.
39 Obayashi K, Saeki K, Iwamoto J, *et al*. Effect of exposure to evening light on sleep initiation in the elderly: a longitudinal analysis for repeated measurements in home settings. *Chronobiol Int* 2014;31:461–7.
40 Li L. Effects of Aerobic Exercise on Sleep Quality and Mental Health of College Students. *Occup Ther Int* 2022;2022:1–9.
41 Jacobson BH, Wallace TJ, Smith DB, *et al*. Grouped comparisons of sleep quality for new and personal bedding systems. *Appl Ergon* 2008;39:247–54.