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Original article

# Association Between Shift Work and Clean Room Environment on Self-reported Premenstrual Symptoms and Menstrual Pain in Taiwan

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ABSTRACT

*Background:* Limited research has delved into the effects of work characteristics on premenstrual symptoms (PMS) in women, which can influence work performance and overlook potential hazards for women in their work environments. This study aimed to investigate the impact of shift work and working in a clean room on premenstrual symptoms, menstrual status, and menstrual pain among employed females in an electronics manufacturer.

*Methods:* A retrospective cohort study was conducted on menstruating female employees between August and December 2014, aged 18–55, who received regular employee health checks. Questionnaires were designed to collect information on demographics, personal lifestyle, menstrual status, menstrual pain scores, and self-reported premenstrual symptoms.

*Results:* Among 7,193 participants, 18.6% reported moderate to severe menstrual pain affecting their work. Female workers who reported shift work showed an increased prevalence of moderate to severe premenstrual symptoms, including fatigue (RR = 1.20), somatic discomforts (RR = 1.04), diarrhea (RR = 1.04), and tension (RR = 1.05). Additionally, shift work was associated with an elevated risk of experiencing a moderate or significant impact of menstrual pain on work (RR = 1.03), menstrual irregularity (RR = 1.30), and high menstrual pain (RR = 1.23). Working in a clean room was associated with an increased risk of high menstrual pain (RR = 1.13). Subjects working shifts in a clean room had the highest pain scores compared to the other groups.

*Conclusion:* This study underscores the association of work-related factors on PMS in female employees. Our findings contribute to a better understanding of premenstrual symptoms in female workers with different work characteristics, emphasizing the potential hazards of work-related factors on female employees.



## 1. Introduction

Women in child-bearing age, irrespective of race, or socioeconomic status, commonly face challenges associated with menstrual periods, including premenstrual symptoms (PMS). PMS, occurring during the late luteal phase of the menstrual cycle, involves emotional, behavioral, and physical symptoms that typically subside after menstruation [1,2]. Approximately 80% to 90% of women experience at least one PMS symptom [3–5]. These symptoms encompass changes in appetite, bloating, pain, headaches, breast swelling, nausea, anxiety, irritability, fatigue, mood swings, and concentration difficulties [6]. The severity varies, but a significant proportion of reproductive-aged women report distressing symptoms monthly, impacting their quality of life [7,8]. Concurrent mood problems can exacerbate these issues, contributing to long-term depression risk [9,10].

PMS heightens vulnerability in women, especially in the workforce [11]. It significantly affects work performance, leading to the need for leave, including official leave of absence and sick leave requests [12]. A UK study revealed that severe PMS symptoms were associated with poor presenteeism, intent to reduce working hours, and increased work absence, and moderate to severe symptoms also correlated with challenges in work–life balance, lower psychological resilience, and reduced control over work [13]. Work-

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related factors like stress, long hours, and excessive responsibilities contribute to an elevated risk of PMS [14,15]. Preventing work-related premenstrual syndrome (PMS) in women workers is extremely important for not only their work performance but also for keeping them safe from potential hazards in their working environment. Moreover, it is essential to detect PMS as it may indicate underlying gynecological disorders such as endometriosis and adenomyosis. The bidirectional causal relationship between work and PMS suggests the need for further exploration, as work-related factors continue to impact women's well-being [16].

Previous research has delved into the factors correlating with the occurrence and severity of menstruation-related symptoms [17–23]. Studies have revealed that heightened stress levels and increased caffeine intake in women correspond to elevated rates of dysmenorrhea [17], while inadequate sleep, late bedtime, and skipping breakfast have also been linked to heightened dysmenorrhea prevalence [18]. Findings from a survey conducted in China underscored that elevated life stress, trait anger, alcohol consumption, and menstrual cycles lasting $\leq$24 days are associated with PMS [19]. Moreover, moderate physical activity or exercise, such as aerobic exercise and yoga, has shown promise in mitigating PMS symptoms [20–22]. In a recent systematic review and meta-analysis [23], researchers aimed to pinpoint risk factors. They identified notable variables, including age $\geq$20 years, a body mass index (BMI) $<$ 18.5 kg/m$^2$, prolonged menstrual periods, irregular menstrual cycles, a family history of primary dysmenorrhea, stress, smoking, inadequate sleep ($<$7 hours), and bedtime after 23:01.

This study aims to investigate the impact of shift work on premenstrual symptoms, menstrual status, and menstrual pain among female employees in a Taiwanese electronics manufacturer. Our hypothesis is that female employees with shift schedules and those working in clean rooms may experience elevated levels of premenstrual symptoms and menstrual pain. The findings will enhance the understanding of environmental health professionals and employers regarding the potential effects of work-related factors on female employees.

## 2. Methods

### 2.1. Research setting and subjects

This retrospective cohort study assessed premenstrual symptoms among female employees at a prominent electronics manufacturing company in Taiwan from August to December 2014. The study focused on employed women aged 18–55 who attended regular health check-ups. Company C, with approximately 19,000 employees (41% female), located in the Tainan Science Park, Southern Taiwan, was chosen for its size, stability, and significant female workforce in reproductive age. The company, recognizing the impact of premenstrual symptoms on productivity, readily agreed to participate. The researchers first sent an explanatory letter about the research project to the company and then visited the employee health management department director of the company to explain the purpose of the research. After obtaining consent from the employee health management department, occupational and environmental health nurses helped distribute and collect the questionnaires during an employee health check. Excluding employees on unpaid leave such as self-care, involving a serious health condition, and family emergency, all eligible employed women aged 18–55 who attended a regular employee health check ($n$ = 7,299) were invited to participate. A total of 7,219 subjects agreed to participate in this study and written and signed informed consent was obtained before their health check. 26 participants who reported being postmenopausal in the questionnaire were excluded from the analysis. A total of 7,193 valid questionnaires were analyzed in this study. The study protocol was approved by the Institutional Review Board of E-Da Hospital (Taiwan).

### 2.2. Data collection

1. Demographics, personal lifestyle, and work characteristics

We gathered self-reported information on demographics, personal lifestyle, and work characteristics from the participants. According to primary care physicians, who encourage their patients to engage in adequate physical activity [24], adults should perform muscle-strengthening activities of moderate intensity or higher that involve all major muscle groups for 2 or more days per week. Sparse exercise was defined as occurring between 1–2 times per week. In this study, participants were asked about their physical activity status, and those who performed $\geq$2 times/week were considered to have a regular exercise habit. Female employees held positions as office workers or clean-room workers, the latter involving environments meticulously maintained to minimize contaminants. Employment status data included worksite (office or clean room) and shift work (yes/no).

2. Menstrual status, menstrual pain scores, and self-reported premenstrual symptoms

Regarding menstrual status, the study collected information on various aspects, including:

age at menarche, menstrual regularity (cycle regularity), self-reported perception of the impact of menstrual pain on work, categorized as "no impact," "little impact," "moderate impact," or "great impact," and menstrual pain scores assessed using a visual analog scale (rated from 0 to 100; higher scores indicate more pain). Analgesics usage within the last 6 months was collected. The number of days menstrual pain interfered with normal life and activities (participants were asked, "During the past month, how many days did menstrual pain interfere with your normal life and activities?"). Furthermore, perceived self-reported premenstrual symptoms (PMS) in the questionnaire were developed for this study and included screening questions related to self-reported premenstrual symptoms over a 6-month period, including 19 physical premenstrual symptoms and 5 psychological premenstrual symptoms. Participants were asked to rate the severity of these symptoms as "not at all," "mild," "moderate," or "severe." Subjects with premenstrual symptoms were subsequently categorized into two groups: "moderate to severe premenstrual symptoms" and 'no/mild premenstrual symptoms." Before formally commencing the investigation, we conducted a pilot study with 30 participants. The test-retest reliability of the questionnaire was assessed among 30 participants, and the reliability was confirmed (Cronbach's alpha = 0.87).

### 2.3. Statistical analysis

This study aimed to investigate the impact of shift work and a clean room worksite on self-reported moderate or severe premenstrual symptoms and menstrual pain. Descriptive characteristics were presented as percentages. Chi-square analysis was utilized to assess whether demographics, lifestyle, work characteristics, menstrual status, and menstrual pain were significantly associated with the impact of menstrual pain on work. A chi-square test was used to investigate the relationship between shift work and working in a clean room environment with self-reported premenstrual symptoms. Variables showing significance ($p \leq 0.05$) were included in multivariate modeling.

**Table 1**
Characteristics of study sample ($n$ = 7,193)

| Variables | | *N* (%) | Impact of menstrual pain on work | | |
|---|---|---|---|---|---|
| | | | Moderate or great ($N$ = =1,336) | No or little ($N$ = 5,857) | *p*-value |
| All subjects | | | 18.6% | 81.4% | |
| Age group, years | ≤29 | 2,051 (28.5%) | 39.2% | 26.1% | <0.0001 |
| | 30–39 | 4,500 (62.5%) | 55.2% | 64.2% | |
| | 40+ | 642 (9.0%) | 5.5% | 9.7% | |
| Shift work | Yes | 4,981 (69.3%) | 76.8% | 67.5% | <0.0001 |
| Worksite | Clean room | 4,329 (60.2%) | 67.1% | 58.6% | <0.0001 |
| | Office | 2,864 (39.8%) | 32.9% | 41.4% | |
| Exercise habit | Yes | 1,524 (21.2%) | 18.3% | 21.9% | 0.0038 |
| Menstruation regularity | Regular | 3,543 (49.3%) | 50.5% | 49.0% | 0.3044 |
| | Irregular | 3,650 (50.7%) | 49.5% | 51.0% | |
| Menstrual pain scores (0–100 score, Visual analog scale) | High: 80–100 | 337 (4.7%) | 22.8% | 0.6% | <0.0001* |
| | Median: 50–79 | 2,765 (38.4%) | 71.0% | 31.0% | |
| | Low: <50 | 4,091 (56.8%) | 6.2% | 68.4% | |
| During the past 1 month, how many days did menstrual pain interfere with your normal life and activity? | 0 days | 5,836 (81.1%) | 43.6% | 89.7% | <0.0001* |
| | 1–2 days | 1,217 (16.9%) | 50.0% | 9.4% | |
| | 3 or more days | 140 (2.0%) | 6.4% | 0.9% | |
| Analgesics used | Yes | 419 (5.8%) | 25.5% | 1.3% | <0.0001* |
| | No or seldom | 6,774 (94.2%) | 74.5% | 98.7% | |

*Fisher's exact test.

To further explore the impact of different work characteristics on the impact of menstrual pain on work, menstrual status, and menstrual pain, subjects were categorized into four groups based on their work characteristics (Group 1: Working shifts in a clean room; Group 2: Working shifts in a non-clean room; Group 3: Non-shift work in a clean room; Group 4: Non-shift work and not in a clean room). A comparison of menstrual indicators among employees with different work characteristics was conducted.

Shift work and clean room worksite variables that exhibited a significant association ($p \leq 0.05$) with self-reported moderate or severe premenstrual symptoms in the chi-square analysis were included in the multivariate modeling. Estimated relative risk (RR) and 95% confidence intervals (CIs) for shift work and a clean room worksite concerning self-reported moderate or severe premenstrual symptoms and menstrual pain were calculated using multiple logistic regressions after adjusting for potential confounding factors. The dependent variables included self-reported moderate or severe premenstrual symptoms, perceived moderate or great impact of menstrual pain on work, menstrual irregularity, higher menstrual pain scores (>50 scores), analgesics used, and three or more days menstrual pain interfered with normal life and activities, while the independent variables were shift work and a clean room worksite. Each regression was adjusted for factors such as age, and exercise habits. Statistical analysis was conducted using Statistical Analysis System (SAS 6.12; SAS Institute, Cary, NC) software.

## 3. Results

A total of 7,193 participants completed the questionnaire, with an average age of 33.4 ± 5.2 years. Of the total, 1,336 (18.6%) reported a moderate or significant impact of menstrual pain on work (Table 1). Shift work (76.8% vs. 67.5%, $p < 0.0001$) and a clean room worksite (67.1% vs. 58.6%, $p < 0.0001$) were significantly associated with this impact. Regular exercise habit correlated with a lower likelihood of reporting such an impact (18.3% vs. 21.9%, $p = 0.0038$). Additionally, high menstrual pain scores (menstrual pain scores above 80, based on a visual analog scale, $p < 0.0001$), menstruation interfering with normal activities for 3 or more days in the past month ($p < 0.0001$), and consistent analgesic use during menstruation ($p < 0.0001$) were significantly linked to a moderate or great impact of menstrual pain on work.

Shift work was significantly associated with a higher prevalence of five physical premenstrual symptoms: easy to fatigue ($p = 0.0012$), abdominal cramps ($p = 0.0498$), backache ($p = 0.0026$), somatic discomfort ($p = 0.0006$), diarrhea ($p = 0.0002$), and constipation ($p = 0.0304$). Additionally, it correlated with one psychological symptom, tension (Fisher's exact test, $p = 0.0488$) (Table 2). A clean room worksite was significantly associated with an increased prevalence of four physical premenstrual symptoms: easy to fatigue ($p = 0.0159$), backache ($p = 0.0039$), somatic discomfort ($p = 0.0102$), hot flashes (Fisher's exact test, $p = 0.0101$), and diarrhea ($p = 0.0295$).

Table 3 shows variations in menstrual indicators among employees with different work characteristics, categorized by shift

**Table 2**
Prevalence of self-reported moderate or severe premenstrual symptoms according to shift work and clean room worksite among 7,193 employee study subjects

| | Total (%) | Shift work (%) | | *p*-value | Clean room (%) | | *p*-value |
|---|---|---|---|---|---|---|---|
| | | Yes | No | | Yes | No | |
| *Self-reported moderate or severe premenstrual symptoms* | | | | | | | |
| *Physical symptoms* | | | | | | | |
| Muscle stiffness | 5.0 | 5.3 | 4.3 | 0.0657* | 5.3 | 4.7 | 0.2103* |
| Faintness | 1.1 | 1.1 | 0.8 | 0.2567* | 1.0 | 1.1 | 0.6421* |
| Abdominal swelling | 17.4 | 17.3 | 18.0 | 0.5221 | 17.5 | 17.4 | 0.9652 |
| Dizziness, fuzzy version | 6.0 | 5.5 | 6.1 | 0.2850 | 5.8 | 6.4 | 0.2574 |
| Breast tensions | 9.7 | 9.7 | 9.5 | 0.7673 | 9.8 | 9.5 | 0.7241 |
| Easy to fatigue | 24.0 | 26.5 | 22.9 | 0.0012 | 25.5 | 23.0 | 0.0159 |
| Abdominal cramps | 12.4 | 12.9 | 11.3 | 0.0498 | 12.6 | 12.1 | 0.5031 |
| Leg swelling | 8.2 | 8.2 | 8.3 | 0.8617 | 8.3 | 8.1 | 0.8249 |
| Backache | 21.2 | 22.1 | 19.0 | 0.0026 | 22.3 | 19.5 | 0.0039 |
| Somatic discomforts | 9.9 | 10.7 | 8.1 | 0.0006 | 10.7 | 8.8 | 0.0102 |
| Headache | 13.9 | 13.5 | 14.7 | 0.2064 | 13.5 | 14.4 | 0.2761 |
| Palpitation | 3.0 | 3.2 | 2.6 | 0.1852* | 2.8 | 3.3 | 0.2693* |
| Skin allergies, itch | 8.6 | 8.8 | 8.0 | 0.2304 | 8.9 | 8.0 | 0.2002 |
| Cold sweats | 3.5 | 3.7 | 2.9 | 0.0859* | 3.7 | 3.1 | 0.2483* |
| Nausea, vomiting | 3.2 | 3.4 | 2.6 | 0.0612* | 3.4 | 2.8 | 0.1961* |
| Hot flashes | 2.0 | 2.2 | 1.5 | 0.0630* | 2.3 | 1.4 | 0.0101* |
| Diarrhea | 7.8 | 8.5 | 6.0 | 0.0002 | 8.3 | 6.9 | 0.0295 |
| Constipation | 6.0 | 6.3 | 5.0 | 0.0304 | 6.2 | 5.5 | 0.1979 |
| Weight gain | 6.6 | 6.6 | 6.5 | 0.8000 | 6.3 | 6.9 | 0.2568 |
| *Psychologic symptoms* | | | | | | | |
| Irritability | 12.2 | 12.7 | 11.1 | 0.0549 | 12.6 | 11.7 | 0.2903 |
| Feeling depressed | 7.2 | 7.4 | 6.8 | 0.3955 | 7.2 | 7.1 | 0.9738 |
| Crying | 1.6 | 1.6 | 1.5 | 0.9273* | 1.7 | 1.4 | 0.3714* |
| Tension | 3.6 | 3.9 | 2.9 | 0.0488* | 3.5 | 3.6 | 0.8690* |
| Emotional lability | 8.5 | 8.8 | 7.7 | 0.1067 | 8.4 | 8.5 | 0.9229 |

*Fisher's exact test.

**Table 3**
A comparison of the characteristics of menstruation among employees with different work characteristics

| Variables | Group1: Working shifts in a clean room | Group2: Working shifts in a non-clean room | Group3: Non-shift work in a clean room | Group4: Non-shift work and not in a clean room | Group difference $X^2$ test *p*-value |
|---|---|---|---|---|---|
| | *N* = 3,957 (55%) | *N* = 1,024 (14.2%) | *N* = 372 (5.2%) | *N* = 1,840 (25.6%) | |
| Moderate or great impact of menstrual pain on work | 21.1% | 18.7% | 16.4% | 13.5% | <0.0001 |
| Menstruation regularity (irregular) | 54.3% | 55.3% | 45.4% | 41.7% | <0.0001 |
| Exercise habit (yes) | 17.3% | 18.2% | 23.7% | 30.7% | <0.0001 |
| Menstrual pain scores | | | | | |
| High: 80–100 | 5.1% | 5.2% | 4.6% | 3.5% | <0.0001 |
| Median: 50–79 | 43.9% | 38.2% | 34.7% | 27.7% | |
| Low: <50 | 51.0% | 56.6% | 60.7% | 68.8% | |
| Average scores (mean ± sd) | 31.2 ± 27.4 | 29.7 ± 27.4 | 28.6 ± 26.7 | 24.6 ± 25.2 | <0.0001* |
| Analgesics used (Yes) | 6.7% | 6.4% | 6.4% | 3.5% | <0.0001 |
| Number of days menstrual pain interfered with normal life and activity during past month (3 or more days) | 2.2% | 2.1% | 1.8% | 1.3% | 0.0003 |

*Analysis of variance, ANOVA test.

work and working in the clean room. Subjects were classified into four groups based on their work situations. Those working shifts in a clean room (Group 1) had a significantly higher incidence of a moderate or great impact of menstrual pain on work ($p < 0.0001$), higher analgesic use ($p < 0.0001$), and more frequent interference of menstruation with daily activities for three or more days in the past month ($p = 0.0003$) compared to the other three groups. However, Group 1 had a notably lower rate of regular exercise ($p < 0.0001$). Subjects working shifts in a non-clean room (Group 2) exhibited a significantly higher rate of menstrual irregularities ($p < 0.0001$). Non-shift workers not in a clean room (Group 4) were more likely to report menstrual pain scores below 50 on a visual analog scale (68.8%, $p < 0.0001$). Additionally, Group 1, comprising subjects working shifts in a clean room, had the highest pain scores compared to the other groups (ANOVA test, $p < 0.0001$).

Female workers in shift work exhibited a higher prevalence of moderate to severe premenstrual symptoms, including fatigue (RR = 1.20, 95% CI = 1.07–1.35), somatic discomforts (RR = 1.04, 95% CI = 1.02–1.05), diarrhea (RR = 1.04, 95% CI = 1.03–1.05), and tension (RR = 1.05, 95% CI = 1.03–1.07), adjusting for age, worksite, and exercise habit (Table 4). After accounting for these factors, shift work was associated with an increased risk of a moderate or great impact of menstrual pain on work (RR = 1.03, 95% CI = 1.02–1.05), menstrual irregularity (RR = 1.30, 95% CI = 1.21–1.51), and high menstrual pain (menstrual pain scores above 50, RR = 1.23, 95% CI = 1.18–1.27). Working in a clean room was linked to a higher risk of high menstrual pain (menstrual pain scores above 50, RR = 1.13, 95% CI = 1.11–1.17).

## 4. Discussion

The findings of the present study indicated that both rotating work schedules and a clean room environment were associated with experiencing high menstrual pain. Additionally, shift work was associated with an elevated risk of a moderate to great impact of menstrual pain on work and menstrual irregularity. Subjects working shifts in a clean room had a significantly higher incidence of a moderate or great impact of menstrual pain on work, the highest pain scores, higher analgesic use, and more frequent interference of menstruation with daily activities for three or more days in the past month compared to the other three groups. While shift work is a common work pattern in modern society, very little research has explored the association between work characteristics and menstrual discomfort. Preventing work-related PMS in women

**Table 4**
Estimated impact (RRs and 95% CIs) of shift work and clean room worksite on self-reported moderate or severe premenstrual symptoms and menstrual pain among 7,193 employee study subjects

| Variables | Shift work (Yes)* | Clean room (Yes)† |
|---|---|---|
| | Adjusted RR* (95%CI) | Adjusted RR* (95%CI) |
| Self-reported moderate or severe premenstrual symptoms | | |
| 1. Physical symptoms | | |
| Easy to fatigue (yes) | 1.20 (1.07–1.35) | 1.02 (0.91–1.10) |
| Abdominal cramps | 1.02 (0.99–1.02) | 0.99 (0.98–1.02) |
| Backache | 1.01 (0.99–1.44) | 1.02 (0.99–1.03) |
| Somatic discomforts | 1.04 (1.02–1.05) | 1.01 (0.98–1.01) |
| Hot flashes | 1.00 (0.99–1.02) | 1.01 (0.99–1.01) |
| Diarrhea | 1.04 (1.03–1.05) | 0.99 (0.98–1.01) |
| Constipation | 1.00 (0.99–1.01) | 0.99 (0.98–1.01) |
| 2. Psychologic symptoms | | |
| Tension | 1.05 (1.03–1.07) | 0.99 (0.97–1.02) |
| Impact of menstrual pain on work (moderate or great) | 1.03 (1.02–1.05) | 1.02 (0.99–1.03) |
| Menstruation regularity (irregular) | 1.30 (1.21–1.51) | 1.03 (0.96–1.05) |
| Menstrual pain scores (>50 scores vs <50 scores) | 1.23 (1.18–1.27) | 1.13 (1.11–1.17) |
| Analgesics used (yes) | 1.02 (0.99–1.03) | 1.01 (0.99–1.02) |
| Number of days menstrual pain interfered with normal life and activity during past month (3 or more days) | 1.01 (0.99–1.03) | 1.01 (0.99–1.01) |

* Adjusted for age, exercise, and worksite.
† Adjusted for age, exercise, and shift work.

workers is crucial not only for work performance but also for protecting women from potential hazards in their working environment. These findings underscore a lack of awareness regarding the detrimental impacts of work characteristics, thus providing valuable insights for future investigations concerning premenstrual symptoms and menstrual pain within occupational settings.

Based on our findings, female workers with shift work were more likely to experience moderate or severe premenstrual symptoms, including fatigue, somatic discomforts, diarrhea, and tension. Shift work, particularly among hospital nurses, is known to affect sleep quality, with three-shift rotations linked to decreased sleep quality and increased physical burden [25–27]. Past studies have associated premenstrual symptoms with poorer sleep quality [28,29] and a higher risk of physical and psychiatric morbidity [3–6]. A study [30] has explored the potential ways in which inadequate sleep might amplify the experience of premenstrual symptoms. This may be due to the well-known effects of poor sleep on physical, cognitive, and emotional functioning. Additionally, difficulties in effectively regulating emotional responses in general could worsen the perception of somatic and mood symptoms during the premenstrual phase, leading to mood disturbances and an increased risk of negative outcomes. Furthermore, research [31] on gastrointestinal complaints in shift-working nurses aligns with our findings that female shift workers were more likely to experience fatigue, somatic discomforts, diarrhea, and tension.

Subjects working shifts in a clean room had the highest pain scores compared to other groups. Table 3 shows that, females with shift work, with or without working in a clean room, exhibited poorer menstrual indicators than those without shift work. Shift work, especially night shifts, disrupts the sleep-wake cycle, leading to various health issues, including sleep problems, psychological stress, and reproductive health concerns [27]. Disturbing the circadian rhythm in shift workers can affect follicular development, hormone regulation, and the luteal phase, potentially altering the menstrual cycle [32]. Shift work is recognized as a contributing factor to menstrual irregularities, with a 13% higher risk for every 12 months of engagement in such work [33]. Additionally, another study comparing menstrual patterns before and after starting work (for non-shift workers) or beginning work rotations (for shift workers) found that female workers experienced dysmenorrhea more frequently after starting shift work compared to those in the non-shift group [34]. Studies involving nurses in Japan [35] and Taiwan [36] have shown an increased risk of work being affected by dysmenorrhea or premenstrual symptoms among those working in rotating shifts.

Clean rooms, integral to the high-tech industry, particularly in microelectronics, provide a controlled environment with strict measures for dust and environmental control. Limited research has explored the health effects of long-term clean room work, such as increased dry eye symptoms [37], potential dry dermatitis [38], and ergonomic-related issues [39]. This study investigates the association between working in a clean room and premenstrual symptoms or menstrual pain. Results show that working in a clean room is correlated with higher menstrual pain scores (RR = 1.13) after adjusting for other factors. Possible reasons include cleanrooms typically maintaining lower temperatures, which may make some women feel cold, thereby increasing discomfort during menstruation [40]. Secondly, the work environment in cleanrooms may require a high level of focus and stress, and prolonged exposure to high-stress levels can affect women's endocrine systems, potentially leading to menstrual pain [41]. Additionally, work in cleanrooms may require maintaining prolonged standing at work or specific working postures for extended periods, putting pressure on women's pelvis and lower back, exacerbating menstrual symptoms [42]. It has been found that most workers in the clean room generally work for 12-hour shifts and have a heavy workload. The cleanroom is maintained at a relative humidity of around 55% and a temperature of around 22 °Celsius, which is slightly lower than the average temperature of the region. The region has a mild climate with less rainfall and ample sunshine throughout the year, and the average annual temperature ranges from 24 to 27 °Celsius. Personnel entering and exiting the cleanroom have to undergo strict control measures, including wearing full-body cleanroom suits, hats, and shoes, and anti-static rings on their hands to reduce product defects and improve yield rates. According to a study [39], female employees working in clean rooms tend to reduce their water intake and frequency of bathroom visits to avoid inconvenience because entering and exiting clean rooms requires redressing in cleanroom attire, leading to a prevalence of urinary tract infections. Another study [42] revealed that prolonged standing effectively reduces blood supply to the muscles, accelerating the onset of fatigue and causing pain in the muscles of the legs, back, and neck, which leads to adverse health outcomes. Table 2 shows that, according to the findings of this study, the three most prevalent premenstrual symptoms among participants who worked in the clean room included "easy fatigue" (25.5%), "backache" (22.3%), and "abdominal bloating" (17.5%). However, as this study did not collect specific ergonomic factors, such as specific working postures, and behavioral factors, such as difficulty in timely bathroom breaks, further research is needed to fully understand the relationship between cleanroom work and menstrual health in the future.

Our study has limitations. Firstly, the dichotomized classification of independent factors may oversimplify the complexity of the variables. Secondly, questions of demographics, lifestyle, menstrual characteristics, and perceived self-reported premenstrual symptoms within 6 months in the questionnaire were developed for this study. Therefore, the fact that standard instruments were not applied in the present study could have led to a misclassification of information and might have also affected the validity and reliability of the questionnaire, as well as the lack of comparability of results to those studies that have used standard instruments for premenstrual symptoms. Thirdly, this study only collected data on menstrual history, menstrual pain scores, and self-reported premenstrual symptoms. It did not gather any information on the history of gynecologic conditions diagnosed by physicians, parity, pregnancy, health behaviors (such as smoking, alcohol consumption, or BMI), psychological conditions (such as sleep disorders or depression). Consequently, we did not investigate other significant variables related to work characteristics and premenstrual symptoms, potentially leading to residual confounding. This study did not collect specific information regarding the total duration of working or work hours per day among participants. However, we know that the female employees who participated in our study were either office workers or clean-room workers. Typically, office workers have higher educational and compensation levels than clean-room workers, and they usually work about 8 hours a day. On the other hand, most clean-room workers typically work 12-hour shifts. As the electronics industry is one of the competitive industries in Taiwan, where overtime is common among both office workers and cleanroom workers, they may work longer hours in a day than initially anticipated. There may be a dose-response relationship between the total duration of working and a higher risk of PMS symptoms. We suggest that future research should explore this association. Despite these limitations, our findings underscore significant associations between work characteristics and premenstrual symptoms. Premenstrual symptoms and menstrual pain are common issues among females, but they are often overlooked in the workplace. These findings highlight insufficient awareness of the negative effects of work characteristics, serving

as a reference for further studies on premenstrual symptoms and menstrual pain in the workplace. It is important to identify PMS as it can signal underlying gynecological issues. Workplaces can implement timely interventions to enhance the quality of life of female employees.

## Ethics approval and consent to participate

This study received approval from the Institutional Review Board of E-Da Hospital in Taiwan, with written and signed informed consent obtained from each participant. Anonymity and confidentiality of the data were respected throughout the study.

## CRediT authorship contribution statement

**Su-Ying Tsai:** Writing – review & editing, Writing – original draft, Software, Methodology, Investigation, Conceptualization.

## Conflicts of interest

The authors have no proprietary interest in any aspect of the study.

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