Changes in the Objective Measures of Sleep between the Initial Nights of Menses and the Nights during the Mid-follicular Phase of the Menstrual Cycle in Collegiate Female Athletes

Short title: Sleep parameters during menses in collegiate female athletes

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Abstract:

Study Objectives: Sleep is an important recovery period for athletes. Women, including athletes, have reported sleep disturbances around menses. Thus, the aim of this study was to assess the changes in the objective sleep parameters in the nights during menses and in the mid-follicular phase of the menstrual cycle of young female athletes.

Methods: Female collegiate athletes with regular menstrual cycles were recruited. The participants underwent home electroencephalogram monitoring during the first and second nights after the onset of menses (M1 and M2, respectively) and during one night between the seventh and 10th night after menses onset (mid-follicular phase).

Results: Data of 45 athletes were analyzed. The total sleep time was significantly reduced and sleep onset latency was significantly prolonged in M2 compared with those in the night during the mid-follicular phase. Sleep efficiency was significantly reduced in M1, when compared with that in the night during the mid-follicular phase. Changes in the percentage of deep sleep across menstrual cycles differed among the participants with and without menstrual symptoms or concerns for sanitary products; moreover, such participants spent a lower percentage of time in deep sleep in M1 when compared to the other nights.

Conclusions: Collegiate female athletes with regular menstrual cycles are likely to have trouble falling asleep, tend to sleep less, and when concerned about sanitary products, have less deep sleep during menses. Even in young female athletes with regular menstrual cycles, sleep can be disturbed during menses. Interventions to restore or improve sleep should be considered.

Keywords: electroencephalogram; menstruation; sports; women

Brief summary

Current Knowledge/Study Rationale: Female athletes showed poorer self-reported sleep quality than their male counterparts. However, limited data are available regarding electroencephalogram-based sleep parameters during the menstrual cycle of female athletes.

Study Impact: We assessed the changes in objective sleep measures based on the EEG monitoring during and following menses in collegiate female athletes and established that they are likely to have trouble falling asleep, tend to sleep less, and when concerned about sanitary products, have less deep sleep during menses. Even in young female athletes with regular menstrual cycles, sleep can be disturbed during menses.

Introduction

Sleep plays a crucial role in recovery following exercise.[1, 2] However, few studies have investigated the scientific aspects of sleep in athletes.[3, 4] In general, women are more likely to be dissatisfied with their sleep quality.[5, 6] Indeed, female athletes showed poorer self-reported sleep quality than their male counterparts in some studies.[7, 8] Although the reasons for these differences remain unclear and are thought to be multifactorial, menstruation and its related symptoms and issues may be one such reason.[9]

In studies evaluating self-reported sleep in women, sleep disturbances were reported during the last few premenstrual days and the initial few days after the onset of menses.[10, 11] In studies objectively evaluating sleep in women, electroencephalogram (EEG)-based sleep parameters during the mid-follicular (MF) phase and those during the mid- or late-luteal phase were generally compared, and no differences were noted in most sleep parameters except for a minor reduction in rapid eye movement (REM) sleep during the mid- or late-luteal phase.[12-14] Because sleep disturbances were reported during the initial few days after menses onset[10, 11] and since menstruation is an important predictor of short sleep duration in female athletes,[15] objective assessments of sleep during menses are of interest. However, few studies have assessed EEG-based sleep parameters during menses and have reported inconsistent results.[16-18] In addition, no specific data in athletes are available. Thus, we aimed to assess the changes in objective sleep measures based on EEG monitoring during and following menses in collegiate female athletes. Our specific hypotheses included that collegiate female athletes are more likely to have poor objective sleep quality during menses and that such poor sleep quality can be

obvious in participants with some symptoms and concerns related to menses and/or sanitary products.

Methods

Participants

Healthy female collegiate athletes with regular menstrual cycles defined according to the Japanese Society of Obstetrics and Gynecology (i.e., menstrual cycles between 25 and 38 days in length and variation of each cycle within 6 days) were recruited from the Juntendo University School of Health and Sports Science. The exclusion criteria included the use of any drugs including hormonal contraceptives, premenstrual dysphoric disorder, dysmenorrhea, other gynecological pathologies that may interfere with sleep patterns, shift work, and transmeridian travel within the past 3 months and during study periods. This study was approved by the Research Ethics Committee of Juntendo University. Informed consent was obtained from all participants.

Sleep-related baseline assessments

Sleep-related baseline assessments using the following tools were conducted once at the time of enrollment in all participants. The Pittsburgh Sleep Quality Index was used to assess self-reported sleep quality over a 1-month period.[19, 20] The total score of the seven components ranges from 0 to 21; a total score ≥6 indicates poor sleep quality.[19, 20] The Epworth Sleepiness Scale (ESS)[21] is an established tool for evaluating self-reported sleepiness over a few weeks to months.[22] In this study, significant self-reported sleepiness was defined as an ESS score of ≥11. Restless legs syndrome was assessed based on the international criteria and a positive

answer to all five-interview questions.[23] Moreover, the participants were asked following question (1) have you snored during the past one month? “No,” “<1 night per week,” “1–2 nights per week,” or “>2 nights per week”; and (2) have you displayed apneas during sleep? “No,” “<1 night per week,” “1–2 nights per week,” or “>2 nights per week.”

Sleep monitoring

All participants underwent overnight home sleep monitoring using a two-channel portable EEG device (ZA-9. Proassist, Ltd., Osaka, Japan), which consists of two pairs of electrodes connecting to a transmitter and a receiver; this provides EEG, electrooculogram, and submental electromyogram. The home EEG monitoring was set up by the participants themselves in their usual sleep environments. Sleep parameters obtained from this device showed high agreement with those from polysomnography.[24, 25]

All data were manually scored by an experienced sleep technologist based on widely used criteria.[26] For sleep stages, the percentages of REM sleep, light sleep (i.e. combined N1 and N2), and deep sleep (i.e. N3) per total sleep time (TST) were determined. TST was calculated as the total sleep period minus the time spent awake during the sleep period. Sleep onset latency (SOL) was defined as the time from bedtime to sleep onset. Sleep efficiency (SE) was evaluated as the TST as a percentage of the total time in bed (TIB). Wake after sleep onset (WASO) was calculated as the total wakefulness time between initial sleep onset and final sleep offset. Arousal index (ArI) was calculated as the number of microarousals per hour of sleep.

The participants underwent EEG monitoring during the following four occasions: (1) the first night at any time during the menstrual cycle to adapt to the EEG monitoring system; the obtained data were not scored or used (i.e. TEST); (2) the first night after menses onset (i.e. M1); (3) the second night after menses onset (i.e. M2); and (4) one night between the seventh and tenth nights after menses onset (i.e. MF phase). The MF phase was chosen because in previous studies, while objectively evaluating sleep in women, EEG-based sleep parameters during the MF phase and those during the mid-luteal phase were generally compared, and no differences were noted except for a minor reduction in REM sleep during the mid-luteal phase,[12-14] moreover, it is generally easier to capture MF than the mid-luteal phase. Following the TEST, the order of starting from MF to M1/2 (i.e. MF first) or from M1/2 to MF (i.e. menses first) was dependent on the participants. We asked all participants to perform each EEG monitoring during the league's regular season.

Menstruation-related data

All participants answered the following questions: (1) Do you have any unpleasant symptoms during menses? "Yes" or "No." If "Yes," what types of symptoms do you have? (2) What types of sanitary products did you use during the M1 and M2? (3) What types of sanitary products do you regularly use? Do you have any of the following concerns when you sleep during menses (i) menstrual blood leak, (ii) stuffiness around the crotch associated with sanitary products, and (iii) dislodgement of sanitary products from underwear?

Statistical analysis

The continuous variables were summarized using the mean and standard deviation or median (interquartile range) as appropriate. The categorical variables are shown as percentages. Variations in sleep parameters across occasions were assessed using repeated-measures one-way analysis of variance (ANOVA) and the Tukey test for multiple comparisons. SOL and WASO were natural log-transformed because they were non-normally distributed. To assess the effect of the order (early first or late first) on sleep parameters and to assess the effects of menses-related symptoms/issues on the alteration of sleep parameters, the first-order interactions in two-way repeated-measures ANOVA models were examined by entering interaction terms between the instances of EEG monitoring (i.e. time) and order (i.e. time-by-order interaction) and by entering interaction terms between the instances of EEG monitoring and subgroups (i.e. time-by-subgroup interaction). If significant time-by-subgroup interactions were found, repeated-measures ANOVA was performed within each subgroup. $P < 0.05$ was considered statistically significant. All analyses were conducted using SPSS v.23 (SPSS Inc., Chicago, IL, USA).

Results

Participant characteristics

Overall, 52 healthy female collegiate athletes with regular menstrual cycles were enrolled. All had been instructed to record their menstrual cycles regularly by their team, which allowed us to confirm a regular menstrual cycle and no use of oral contraceptives. The data of seven female athletes could not be used because they could not complete all EEG monitoring occasions due to personal reasons. Thus, data of 45 female athletes were finally analyzed. Their characteristics are summarized in Table 1. None of them had any restless legs syndrome symptoms.

Four (8.8%) reported snoring <1 night per week, two (4.4%) reported snoring 1–2 nights per week for the previous one month, and none reported experiencing apnea during sleep. Thirty-one participants (68.9%) reported unpleasant symptoms during menses; twenty-seven (60.0%) reported menses-related pain during the initial two days of menses, and five (11.1%) reported general fatigue within a day prior to and/or the first day of menses. All participants used sanitary pads during sleeping in M1 and M2, and they used the same sanitary pads regularly. Thirty-six participants (80.0%) had concerns regarding menstrual blood leak, nine (20.0%) reported stuffiness around the crotch associated with sanitary products, and thirteen (28.9%) experienced the dislodgement of sanitary products from the underwear.

Sleep parameters in M1, M2, and MF

TIB varied significantly across the menstrual cycle and was significantly reduced in M2 compared with M1 and MF; no difference was observed between M1 and MF (Figure 1A). No time-by-order interaction was found ($p = 0.318$). TST varied significantly across the menstrual cycle and was significantly reduced in M2 compared with MF; no difference was observed between M1 and MF (Figure 1B). No time-by-order interaction was found ($p = 0.234$). SOL varied significantly across the menstrual cycle and was significantly prolonged in M2 compared with MF; no difference was observed between M1 and MF (Figure 1C). No time-by-order interaction was found ($p = 0.453$). SE varied significantly across the menstrual cycle and was significantly reduced in M1 compared with MF; no difference was observed between M2 and MF (Figure 1D). No time-by-order interaction was found ($p = 0.487$). WASO, percentages of N3 and REM sleep, and ArI were similar across the

menstrual cycle (Table 2). No time-by-order interactions were noted (p = 0.532, 0.215, 0.089, and 0.472, respectively).

Subgroup analyses

Although no significant within-subgroup changes in the percentage of N3 sleep were found in the athletes with or without unpleasant symptoms during menses, a significant time-by-subgroup interaction between the changes in the percentages of N3 sleep and the presence/absence of unpleasant symptoms during menses was observed (p = 0.038) (Table 3). No time-by-subgroup interactions were found between the changes in all sleep parameters and the presence/absence of concerns regarding menstrual blood leak or stuffiness around the crotch associated with sanitary products (Table S1 and S2). However, a significant interaction between changes in the percentage of N3 sleep and the presence/absence of concerns regarding dislodgement of sanitary products from underwear was found (p = 0.038) (Table 4). Likewise, changes in the percentage of N3 sleep within participants concerned with the dislodgement of sanitary products from underwear differed significantly across the menstrual cycle, with a lower percentage of N3 sleep in M1 than in other phases (Table 4).

Discussion

Menstrual cycle and the associated variations of reproductive hormones, particularly progesterone, which is low in the follicular phase and increases during the luteal phase, may play some roles in sleep variations.[27] Thus, in previous studies in which EEG-based sleep parameters were evaluated, data from the MF phase and those from the mid- or late-luteal phase were generally compared.[28] However, not all

studies found effects of menstrual cycle on sleep or found only small effects including a small reduction in REM sleep during the mid- or late-luteal phases,[12-14] possibly due to individual variabilities in sleep and issues across menstrual cycles. Conversely, women reported sleep disturbance during the initial few days of menses in addition to the late-luteal phase.[10, 11] A few small-scale studies have performed EEG-based objective sleep assessments during menses.[16-18] In a study comparing eight women with premenstrual syndrome (PMS) and eight age-matched control women without PMS, both groups experienced less deep sleep and more intermittent awakening during menses and in the premenstrual phases. In a study assessing EEG-based sleep parameters throughout a full cycle in nine healthy women, no significant changes were noted in any sleep parameters during menses compared with the other phases.[17] In a study comparing 10 women with dysmenorrhea and 8 women with normal menstrual cycles, the latency to deep sleep was longer in menses than in the mid-luteal phase, there was less REM sleep in menses than in the mid-luteal and MF phases, and these associations were more prominent in women with dysmenorrhea.[18] Small sample size and individual variations of menstruation and related symptoms were the possible reasons for these findings. From this perspective, a strength of the present study is the relatively large number of homogeneous (i.e. all participants were collegiate female athletes with regular menstrual cycles) participants enrolled. Furthermore, no data are available regarding objective sleep assessment during menses in collegiate female athletes. Thus, this is the first study assessing objective sleep quality and quantity in menses and in the MF phase. In addition, the results of the present study highlight that improving the quality of sleep during menses can be an important issue in conditioning for female athletes.

Results of the subgroup analysis in which participants with concerns regarding sanitary products had less deep sleep during menses and the results of a previous study[18] in which impairments of sleep quality in menses were prominent in symptomatic participants lead to the consideration of interventions to relieve symptoms or the use of individually fit sanitary products. However, in a randomized crossover trial comparing objective sleep parameters between nights with sanitary pads designed for night use and nights with those designed for day use,[29] there were no differences in any objective sleep parameters between those two sanitary pads. Nevertheless, the effects of other sanitary products (other types of pads, tampons, and menstrual cups, etc.) should be assessed in further studies. Controlling menstruation with oral contraceptives might be another option against sleep disturbances during menses. However, in athletes, oral contraceptives may reduce IGF-1 levels, which is an important bone trophic hormone; thus, they are not good for bone health.[30] A recent meta-analysis[31] reported that a longer sleep duration resulted in beneficial effects on subsequent sports-specific performance measures,[32] whereas napping, sleep hygiene, and post-exercise recovery strategies provided inconsistent results, suggesting that sleep interventions or sleep disturbances may play important roles, but not all athletes or all types of intervention may be beneficial in their sport-specific performance. The data suggest that menses may not influence the performance of young female athletes.[33, 34] However, this may not be true in some female athletes, presumably those with self-reported or objective sleep disturbances in menses. Whether interventions for sleep disturbance during menses provide benefits for sports-specific performance should be evaluated in further studies.

Our study has some limitations. First, a lack of overnight polysomnography is a major limitation. When sleep-related baseline assessments were conducted, only two participants reported snoring 1-2 nights per week, while none of them reported experiencing apnea during sleep, had restless legs syndrome symptoms, the presence or absence of sleep disorders such as sleep apnea, and sleep-related movement disorders were not confirmed formally. Conversely, the strength of our study is the inclusion of TEST to exclude the first night's effect of sleep recordings, and although the order of recordings in M1/M2 and MF were based on the participants' selection, no time-by-order interactions were confirmed. Second, we lacked data on productive hormone levels and body temperatures. Because all of our participants have regular menstrual cycles based on regularly recorded cycles, and since we focused on the first and second days after menses onset and the seventh and tenth nights after menses onset, their phases were adequately captured. Third, in the present study, all participants used sanitary pads in M1 and M2. Variation of sleep parameters when tampon and other sanitary products are used remains to be elucidated. Thus, the results of some subgroup analyses based on the response to questions regarding menstruation-related issues may not be applicable if sanitary products other than sanitary pad were used.

In conclusion, collegiate female athletes with regular menstrual cycles have difficulty falling asleep and sleep less in the nights during menses. Sleep quality could be impaired because of a few symptoms and concerns related to menses and/or sanitary products. Sleep assessment is emphasized in young female athletes even with a regular menstrual cycle. Some interventions should be considered, particularly alternative sanitary products, and further studies should investigate whether their sleep was restored or improved by those interventions.

Abbreviations

ANOVA, analysis of variance

ArI, arousal index

EEG, electroencephalogram

ESS, Epworth Sleepiness Scale

M1/2, 1st or 2nd night after menses onset

MF, mid-follicular

PMS, premenstrual syndrome

REM, rapid eye movement

SE, sleep efficiency

SOL, sleep onset latency

TIB, time in bed

TST, total sleep time

WASO, wake after sleep onset

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Figure legends

Figure 1: Changes in TIB, TST, SE, and SOL across M1/2 and MF

A) TIB: TIB varied significantly (p for ANOVA, 0.005) across the menstrual cycle and was significantly reduced in M2 compared with M1 and MF. Values represent the mean ± SD.

B) TST: TST varied significantly (p for ANOVA, 0.003) across the menstrual cycle and was significantly reduced in M2 compared with MF. Values represent the mean ± SD.

C) SE: SE varied significantly (p for ANOVA, 0.019) across the menstrual cycle and was significantly reduced in M1 compared with MF. Values represent the mean ± SD.

D) SOL: SOL varied significantly (p for ANOVA, 0.026) across the menstrual cycle and was significantly reduced in M2 compared with MF. Values represent the median and interquartile range.

Abbreviations: ANOVA, analysis of variance; M1/2, 1st and 2nd night after menses onset; MF, mid-follicular phase; SE, sleep efficiency; SOL, sleep onset latency; TIB, time in bed; TST, total sleep time

Table 1: Subject characteristics.

N = 45	
Age, years	20.2 ± 1.1
Height, cm	162.0 ± 5.7
Weight, kg	56.1 ± 5.7
BMI, kg/m^2	21.4 ± 1.6
Age at first menstruation, years	12.6 ± 1.7
Menstrual cycle, days	28.2 ± 3.7
Duration of menses, days	5.8 ± 1.0
Type of sports	
Soccer, %	15 (33.3)
Track & Field, %	12 (26.7)
Kendo, %	9 (20.0)
Basketball, %	8 (17.8)
Softball, %	1 (2.2)
PSQI score	4.5 ± 1.8
% of athletes with poor sleep quality, %	13 (28.9)
ESS score	10.3 ± 3.3
% of athletes with sleepiness, %	21 (46.7)

Note: Continuous data are summarized using the mean ± SD

Abbreviations: BMI, body mass index; PSQI, Pittsburgh Sleep Quality Index; ESS, Epworth Sleepiness Scale

Table 2: Changes in WASO, percentage of REM, and N3 sleep across M1/2 and MF.

	M1	M2	MF	P for ANOVA
WASO, min	9.0 (11.6)	9.5 (11.0)	7.0 (8.0)	0.194
% of REM sleep, %	26.8 ± 6.6	25.7 ± 5.9	27.3 ± 4.2	0.273
% of N3 sleep, %	24.2 ± 9.1	24.6 ± 8.1	24.6 ± 6.5	0.939
ArI, events/h of sleep	7.4 ± 2.8	6.7 ± 2.5	6.7 ± 2.3	0.063

Note: Continuous data are summarized using the mean ± SD or median (interquartile range).

No differences in each pairwise comparison.

Abbreviations: ANOVA, analysis of variance; ArI, arousal index; M1/2, 1st and 2nd night after menses onset; MF, mid-follicular phase; N3, deep non-REM sleep; REM, rapid eye movement; WASO, wake after sleep onset

Table 3: Subgroup analysis in participants with and without unpleasant symptoms during menses

		M1	M2	MF	P for interaction
TIB, min	Yes (N = 31)	404.7 ± 69.0	358.6 ± 78.3	391.3 ± 78.9	0.150
	No (N = 14)	383.8 ± 41.7	378.9 ± 53.0	413.4 ± 61.4	
TST, min	Yes (N = 31)	361.5 ± 68.2	321.7 ± 75.4	362.9 ± 74.1	0.136
	No (N = 14)	346.8 ± 46.2	352.6 ± 50.9	382.4 ± 57.6	
SOL, min	Yes (N = 31)	14.5 (15.8)	16.5 (19.3)	9.0 (9.8)	0.221
	No (N = 14)	15.0 (24.5)	11.5 (18.0)	14.5 (23.0)	
SE, %	Yes (N = 31)	89.4 ± 7.7	89.9 ± 7.3	93.4 ± 5.3	0.332
	No (N = 14)	90.5 ± 8.9	93.1 ± 4.1	92.7 ± 5.5	
WASO, min	Yes (N = 31)	10.0 (12.5)	8.0 (10.3)	7.0 (7.9)	0.585
	No (N = 14)	7.5 (10.0)	10.3 (12.0)	6.3 (8.0)	
% of REM sleep, %	Yes (N = 31)	27.9 ± 6.2	25.7 ± 5.5	27.0 ± 4.5	0.084
	No (N = 14)	24.2 ± 7.1	25.6 ± 6.9	27.9 ± 3.4	
% of N3 sleep, %	Yes (N = 31)	22.1 ± 8.9	23.5 ± 6.6	24.8 ± 6.7	0.038
	No (N = 14)	28.8 ± 7.8	27.0 ± 10.7	24.2 ± 6.3	
Ar I, events/h of sleep	Yes (N = 31)	7.7 ± 2.7	7.1 ± 2.5	7.0 ± 1.8	0.865
	No (N = 14)	6.7 ± 2.9	5.7 ± 2.3	6.0 ± 3.2	

Note: Continuous data are summarized using the mean ± SD or median (interquartile range).

Abbreviations: ArI, arousal index; M1/2, 1st and 2nd night after menses onset; MF, mid-follicular phase; N3, deep non-REM sleep; REM, rapid eye movement; SE,

sleep efficiency, SOL, sleep onset latency; TST, total sleep time; WASO, wake after sleep onset

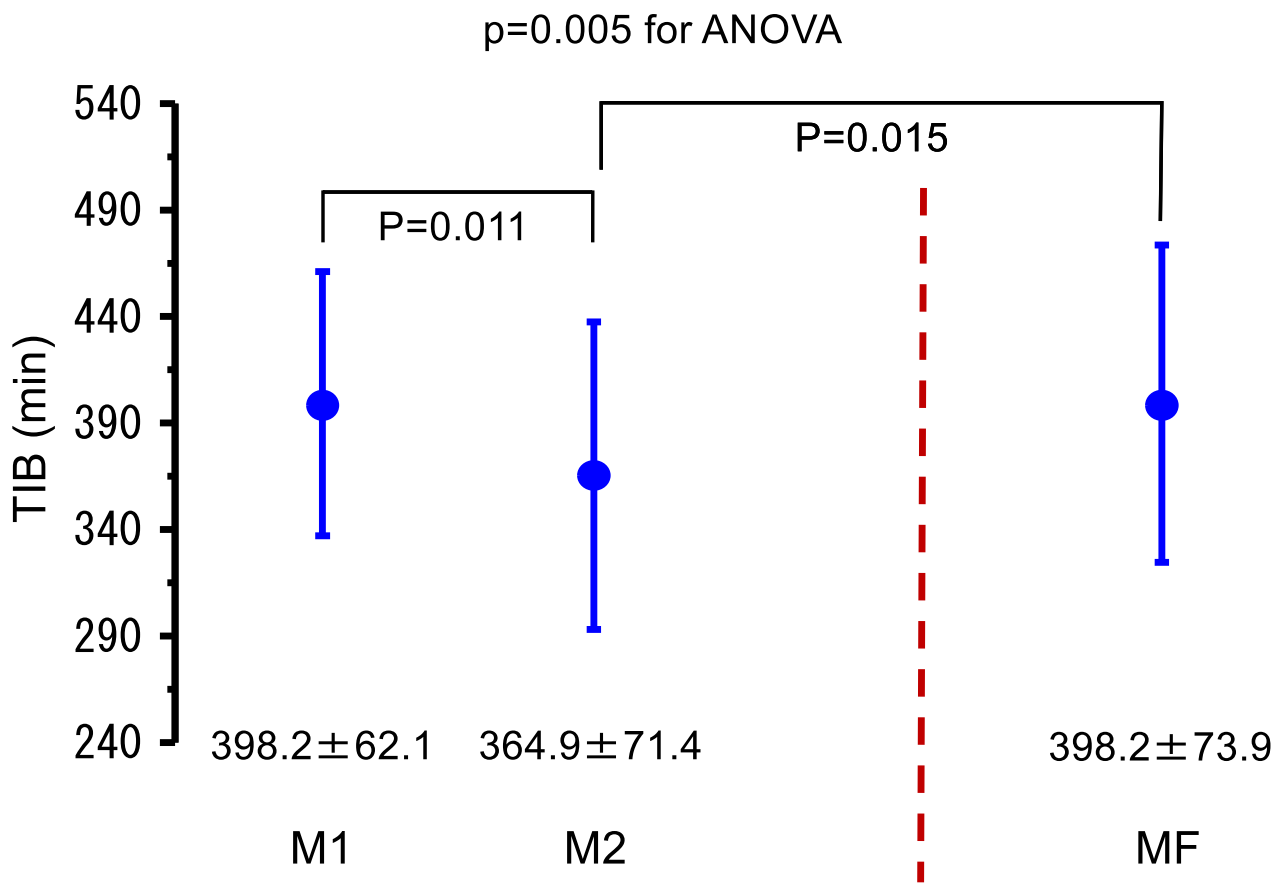
Table 4: Subgroup analysis in participants with and without concerns regarding dislodgement of sanitary products from underwear

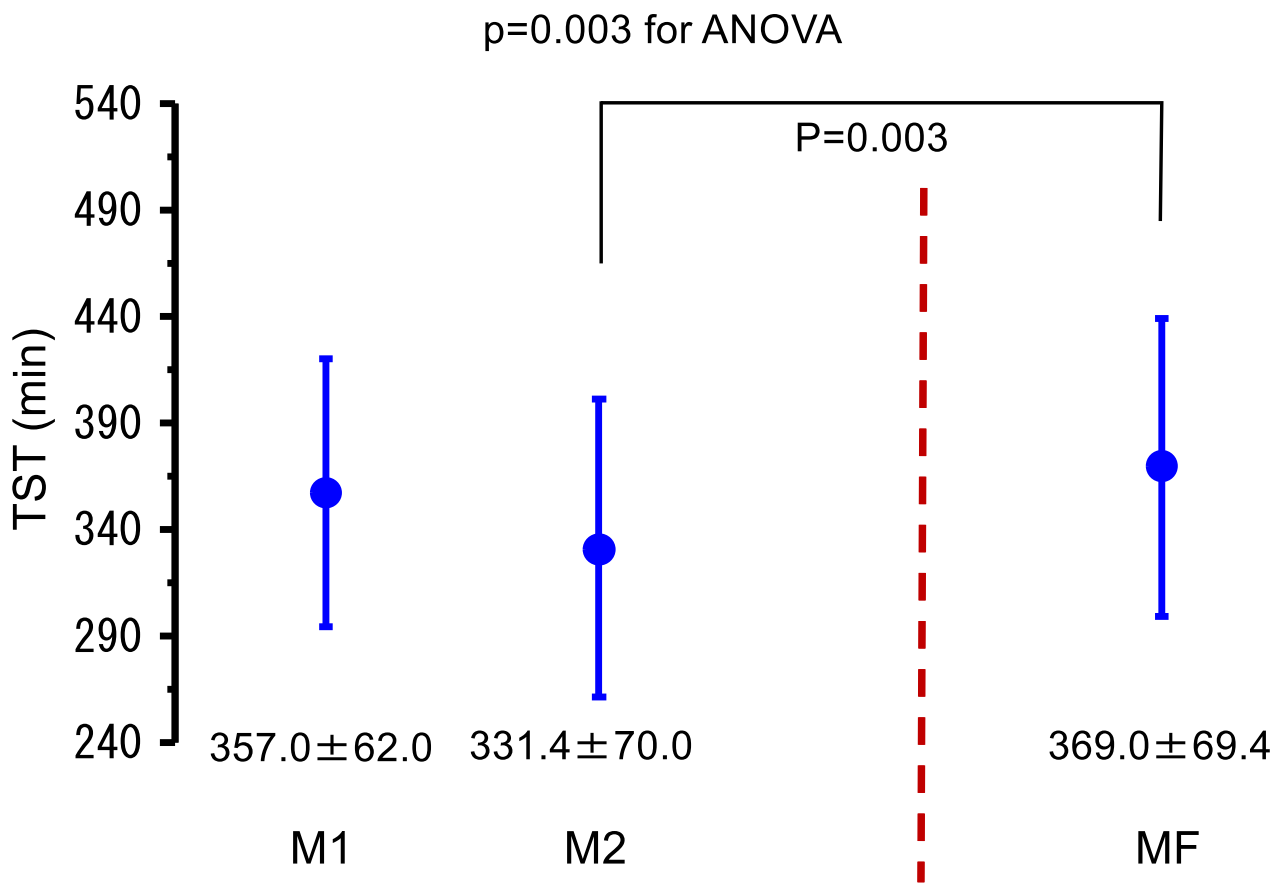
		M1	M2	MF	P for interaction
TIB, min	Yes (N = 13)	406.9 ± 69.5	366.9 ± 67.1	380.0 ± 93.1	0.307
	No (N = 32)	394.7 ± 59.7	364.1 ± 74.1	405.6 ± 64.9	
TST, min	Yes (N = 13)	371.2 ± 58.1	331.3 ± 63.9	357.5 ± 85.2	0.333
	No (N = 32)	351.2 ± 63.5	331.4 ± 72.9	373.6 ± 62.8	
SOL, min	Yes (N = 13)	11.5 (19.5)	12.5 (17.3)	8.5 (10.4)	0.872
	No (N = 32)	15.0 (21.0)	16.5 (14.3)	12.8 (14.8)	
SE, %	Yes (N = 13)	91.6 ± 6.0	90.8 ± 9.1	94.4 ± 4.4	0.555
	No (N = 32)	89.0 ± 8.6	90.9 ± 5.4	92.6 ± 5.6	
WASO, min	Yes (N = 13)	9.5 (13.5)	9.5 (10.3)	5.5 (8.1)	0.534
	No (N = 32)	8.8 (11.5)	8.8 (13.0)	7.0 (9.0)	
% of REM sleep, %	Yes (N = 13)	27.6 ± 6.5	25.7 ± 5.9	27.2 ± 4.5	0.799
	No (N = 32)	26.4 ± 6.7	25.7 ± 6.0	27.3 ± 4.1	
% of N3 sleep, %	Yes (N = 13)*	21.7 ± 8.7	26.4 ± 7.7	26.9 ± 8.1	0.038
	No (N = 32)	25.2 ± 9.2	23.8 ± 8.3	23.6 ± 5.6	
Ar I, events/h of sleep	Yes (N = 13)	8.3 ± 3.2	7.7 ± 2.7	6.9 ± 1.7	0.231
	No (N = 32)	7.0 ± 2.5	6.3 ± 2.4	6.6 ± 2.6	

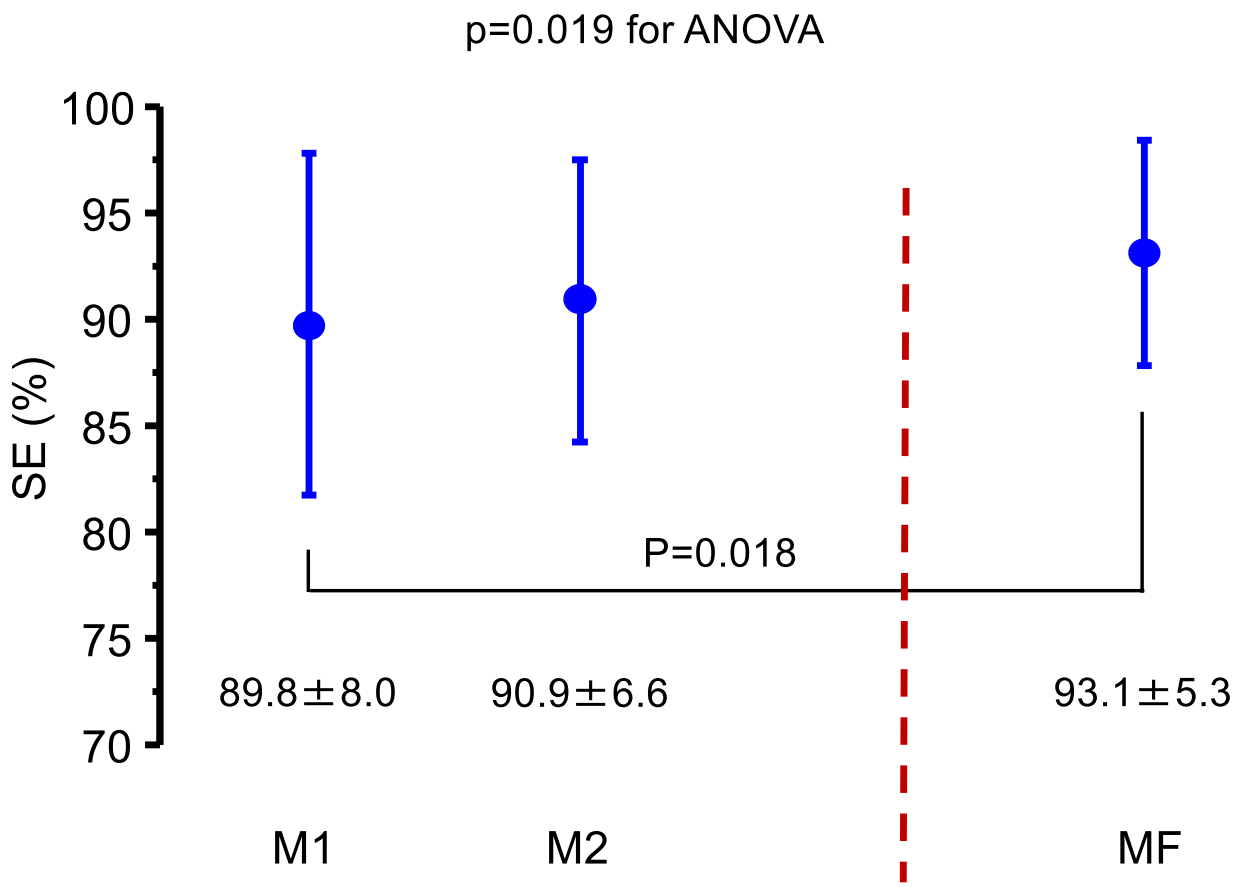
Note: Continuous data are summarized using the mean ± SD or median (interquartile range). *P<0.05 for analysis of variance within subgroups

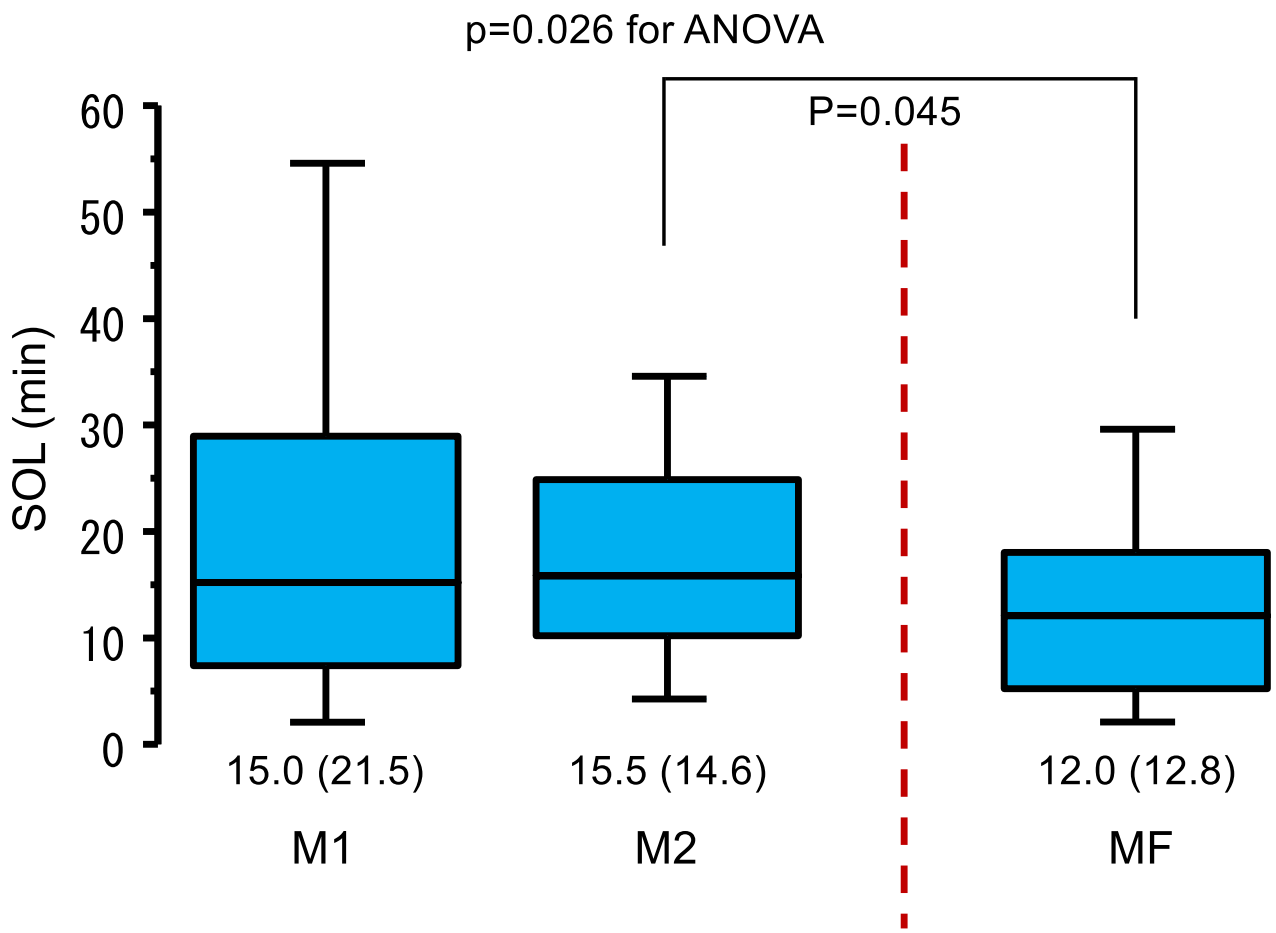
Abbreviations: ArI, arousal index; M1/2, 1st and 2nd night after menses onset; MF, mid-follicular phase; N3, deep non-REM sleep; REM, rapid eye movement; SE,

sleep efficiency, SOL, sleep onset latency; TST, total sleep time; WASO, wake after sleep onset


p=0.005 for ANOVA
P=0.015
P=0.011
TIB (min)
540
490
440
390
340
290
240
398.2±62.1
364.9±71.4
398.2±73.9
M1
M2
MF


p=0.003 for ANOVA
P=0.003
TST (min)
540
490
440
390
340
290
240
357.0±62.0
331.4±70.0
369.0±69.4
M1
M2
MF


p=0.019 for ANOVA
100
95
90
85
80
75
70
SE (%)
P=0.018
89.8±8.0
90.9±6.6
93.1±5.3
M1
M2
MF


p=0.026 for ANOVA
P=0.045
SOL (min)
60
50
40
30
20
10
0
15.0 (21.5)
15.5 (14.6)
12.0 (12.8)
M1
M2
MF