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# Positive impact of cyclic meditation on subsequent sleep

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A Study Design
B Data Collection
C Statistical Analysis
D Data Interpretation
E Manuscript Preparation
F Literature Search
G Funds Collection

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## Summary

**Background:** Cyclic meditation (CM) is a technique that combines yoga postures interspersed with supine rest. This combination is based on ancient texts and is considered easier for beginners to practice.

**Material/Methods:** Whole-night polysomnographic measures and the self-rating of sleep were studied on the night following a day in which 30 male participants practiced CM twice (ca. 23 minutes each time). This was compared with another night when they had had two sessions of supine rest (SR) of equal duration on the preceding day. The sessions were one day apart and the order of the sessions was randomized. Recordings were from the F4, C4, and O2 electrode sites referenced to linked earlobes and bipolar electroculography and electromyography sites.

**Results:** In the night following CM, the percentage of slow-wave sleep (SWS) was significantly higher than in the night following SR, whereas the percentage of rapid-eye-movement (REM) sleep and the number of awakenings per hour were less. Following CM the self-rating of sleep based on visual analog scales showed an increase in the feeling that the sleep was refreshing, an increase in feeling "good" in the morning, an overall increase in sleep duration, and decreases in the degree to which sleep was influenced by being in a laboratory as well as any associated discomfort.

**Conclusions:** Practicing cyclic meditation twice a day appeared to improve the objective and subjective quality of sleep on the following night.

**key words:** **polysomnography measures • self-rated sleep • cyclic meditation • supine rest**

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## Background

Meditation has been shown to reduce stress and increase feelings of peace and calm [1]. This suggests several applications and possible benefits related to practicing meditation. One of them is possibly an improvement in sleep. This assumption may be made based on the fact that real-world stress influences cardiorespiratory functions during sleep, hence influencing the restorative function of sleep [2]. In keeping with this, meditation techniques have been found to improve the quality of sleep, though this was chiefly based on subjective measures [3].

The association between sleep and meditation has been of interest and an early study actually showed that experienced practitioners of Transcendental Meditation (TM) spent appreciable parts of meditation sessions in sleep stages 2, 3, and 4 [4]. However, this did not further the understanding about whether practicing meditation can actually alter the sleep structure. A more recent study on TM practitioners using standard polysomnography did attempt to answer this question [5]. There were eleven long-term practitioners, nine short-term practitioners, and eleven non-practitioners. While there were no significant differences among the groups in standard sleep measures, visual inspection of slow-wave EEG records did show specific differences among the groups for the first three cycles of stages 3 and 4 of slow-wave sleep. The long-term practitioners had significantly greater theta 2-alpha 1 relative power than the other two groups. In this report the increased theta-alpha activity coexisting with delta activity of deep sleep was interpreted as suggestive of the practitioners having reached periods of transcendental consciousness.

Changes in sleep architecture related to the practice of meditation were described in another study [6]. Meditators were categorized as young (20–30 years of age) and middle-aged (31-55 years). Comparisons were made with age-matched non-meditators. The middle-aged practitioners of two types of meditation techniques, i.e. *Vipassana* and *Sudarshan Kriya* Yoga (SKY), spent 12.0% of the time in slow-wave sleep (S3 and S4) while the age-matched non-meditators spent 3.7% of the time in those stages. *Vipassana* meditators also spent significantly more time in rapid-eye-movement (REM) sleep than the SKY meditators and non-meditators. The study was interpreted as suggesting that yoga practice helps to retain slow-wave sleep and enhance the REM sleep state in middle-aged meditators.

Meditation is actually the seventh stage in the classical eight stages to reach a stage of final mental liberation described in traditional yoga texts [7]. Some people find it easier to practice the earlier stages, such as yoga postures (*asanas*). Based on this, a technique was evolved called cyclic meditation which combines yoga postures interspersed with periods of supine rest, when the person is given instructions to help reach a meditative state [8]. In normal volunteers, practicing cyclic meditation reduced psychophysiological arousal based on a decrease in oxygen consumption [9,10] and changes in heart rate variability suggestive of a shift towards vagal dominance [11]. Despite these changes suggestive of reduced physiological arousal, practitioners performed better in a cancellation task requiring selective attention [12] and showed an increase in the P300 event-related potential amplitude following the practice [13], also suggestive of enhanced sustained and selective attention. More directly, a two-day yoga program which involved cyclic meditation decreased occupational stress levels and baseline autonomic arousal [14]. Specifically, when participants were categorized based on the occupational stress index (OSI) at baseline, those with high OSI levels showed a decrease in breath rate and a change in heart rate variability suggestive of vagal dominance, while those with low OSI levels to begin with showed no change.

Since cyclic meditation appears to help in stress reduction and since stress influences sleep, the present study was designed to assess whether practicing cyclic meditation would influence the sleep structure in normal persons. Also, in the study cited earlier which compared the sleep structure of yoga practitioners with that of non-yoga practitioners (controls), controls showed a reduction in SWS (S3 and S4), whereas the age-matched yoga practitioners did not show such a decrease [6]. This suggested that experience in yoga would make a difference to the sleep structure. The present study was designed to test the hypothesis that practicing a particular yoga technique during the day could influence subsequent sleep, particularly SWS, in subjects experienced in yoga.

## Material and Methods

### Participants

The participants were 30 male volunteers (age range: 20–33 years, mean ±*SD*: 26.3±4.6 years). All participants were in normal health based on a routine examination and were not on medication. All of them were undergoing training at a residential yoga center and had a minimum of experience in practicing cyclic meditation and relaxation in a position for supine rest (*shavasana*, the corpse posture), which was the "control" intervention, at least once a day for four days a week for a year. During the study period all of them had a high-fiber low-fat vegetarian diet and did not consume caffeinated drinks, alcohol, or tobacco in any form. Apart from their interest in yoga, they were all typical of Indian males of comparable age, with similar interests (e.g. sports) and hobbies. The design of the study was explained to the participants and their signed consent was received. The study was approved by the Institutional Ethics Committee.

### Study design

Participants were assessed on three separate nights in a sleep laboratory. The first night was for acclimatization to the laboratory environment. The electrodes were connected as for a standard recording, but no recording was taken. The other two recording sessions were three days apart. On one day the participants were asked to practice cyclic meditation two times a day, i.e. at 6 a.m. and 6:45 p.m. After that they were asked to report to the sleep laboratory at 9 p.m. and a whole-night recording was made. On the other day of recording the participants were asked to practice unguided supine rest in *shavasana* (SR), as a control for cyclic meditation, twice in the day and at the same time and for the same duration as the cyclic meditation sessions. Similarly, the participants reported to the sleep laboratory at 9 p.m. and a whole-night polysomnographic record was taken. The order of the sessions was randomized using a random



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number table. On both recording days, i.e. cyclic meditation (CM) and supine rest (SR), participants were asked to avoid all other physical activity (e.g. walking, jogging, or other yoga practices). However, they continued with the rest of their routine (e.g. listening to lectures on yoga). Since all of them were residing in the same yoga center, the rest of their routine was relatively comparable.

### Assessments

#### *Polysomnographic recordings*

The participants reported to the sleep laboratory at 9 p.m. on each of the three nights. By 9: 45 p.m. an electrode montage was attached at the electroencephalogram sites F4, C4, and O2 referenced to linked earlobes and with the bipolar electroculograph (EOG) and electromyography (EMG) sites. The bed times and wake times were based on the schedule at the yoga center, to which all the participants were accustomed. The electroencephalogram signals were filtered with a low-pass of 0.1 Hz and a high-pass filter of 35 Hz, for EOG the low-pass was 0.01 and high-pass 10.0 Hz, and for EMG the low-pass was 0.1 and high pass 1 KHz (Nicolet Ultrasom, USA).

#### *Self-rating of sleep*

For both recording nights the participants were asked to self-rate their sleep during the previous night in two ways: using a four-item questionnaire with four closed-ended questions and using four visual analog scales. The four-item questionnaire had the following questions: 1) How long did you take to fall asleep? 2) How many times did you wake up during the night? 3) How long did you sleep from start to finish? and 4) How many dreams do you remember that you had? The four visual analog scales (VAS) required the participants to rate their sleep by making a vertical mark on a 10-cm line. This linear visual analog scale is a continuous scale. Visual analog scales are considered useful to measure phenomena before and after an intervening event. The four descriptions of sleep which had to be marked on the VAS were: 1) feeling that sleep was refreshing, 2) feeling good in the morning on awakening, 3) the degree to which sleep was influenced by being in a laboratory, and 4) discomfort induced by sleeping with electrodes.

### Data extraction

#### *Polysomnographic recordings*

The 60 polysomnographic recordings (i.e. 2 sessions with 30 participants) were subdivided into 30-second epochs and the sleep stages were scored according to the standard criteria of Rechtschaffen and Kales [15] used in recent studies [16,17]. The following 11 variables were evaluated: time in bed (TIB), sleep period time (the time from sleep onset to sleep end, where sleep onset is defined as the first of two consecutive epochs of sleep stage 1 or one epoch of any other stage), total sleep time (TST, the time from sleep onset to the end of the final sleep epoch minus time awake), sleep onset latency (the time from lights out to sleep onset), REM latency (the time from sleep onset to the first REM sleep epoch), number of awakenings/hour, sleep efficiency (the percentage ratio between total sleep time and time in bed: TST/TIB×100), the percentage of sleep period time in wakefulness after sleep onset (WASO percentage), and the percentages of SPT spent in sleep stages 1 (S1 percent) and 2 (S2 percent), SWS percent, and REM sleep percent.

#### *Self-rating of sleep*

The four-item questionnaire consisted of questions whose responses were either the number of times or the time in minutes and hence did not require further data extraction. The four VAS values were scored by measuring the distance from the "0" end of the scale to the mark made by the participant. All the values were in cm.

### Interventions

#### *Cyclic meditation*

Throughout the practice the participants kept their eyes closed and followed pre-recorded instructions. The instructions emphasized carrying out the practice slowly, with awareness and relaxation. The practice began by repeating a verse (40 s) from the yoga text *Mandukya Upanisad* [18], followed by isometric contraction of the muscles of the body ending with supine rest (1 min), slowly coming up from the left side and standing at ease (called *tadasana*), and "balancing" the weight on both feet (called centering) (2 min). Then the first actual posture, bending to the right (*ardhakaticakrasana*, 80 s), a gap of 70 s in *tadasana* with instructions about relaxation and awareness, bending to the left (*ardhakaticakrasana*, 80 s), a gap (70 s), forward bending (*padahastasana*, 80 sec), another gap (70 s), backward bending (*ardhacakrasana*, 80 s), and slowly coming down in the supine posture with instructions to relax different parts of the body in sequence (10 min). The postures were practiced slowly, with awareness of all sensations that are felt. The total duration of the practice was 22 min 30 s [9].

#### *Supine rest*

During the supine rest session, the subjects lay supine with their legs apart and arms from the side of the body in the corpse posture (*shavasana*) with eyes closed. This practice lasted 22 min 30 s, so that the duration was the same as for CM.

### Data analysis

Data were analyzed using SPSS version 16.0. Since the CM and SR sessions were conducted on the same individuals on separate days, they were compared for differences using a *t* test for paired data. The variables assessed by the individuals' self-rating of sleep, based both on the four-item questionnaire and the VAS on separate days (i.e. CM and SR), were compared using the non-parametric Mann-Whitney test for independent data sets.

## Results

### Polysomnography (PSG)

The variables recorded during the whole-night PSG session following the day during which the participants practiced

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**Table 1.** Polysomnographic related variables recorded on the nights following cyclic meditation (CM) practice and supine rest (SR). Values of group means ±SD.

| Variables | Sessions | |
|---|---|---|
| | Recording after Cyclic Meditation (CM) Mean ±SD | Recording after Supine Rest (SR) Mean ± SD |
| Age (years) | 26.27±4.61 | 26.27±4.61 |
| Bedtime, clock time | 22:24 | 22:18 |
| Wake-up time, clock time | 05:24 | 05:28 |
| Total time in bed (TIB), min | 406.10±33.88 | 412.73±34.10 |
| Sleep period time (SPT), min | 377.03±34.76 | 382.27±35.74 |
| Sleep-onset latency (SOL), min | 17.6±19.91 | 18.8±15.41 |
| Total sleep time (TST), min | 352.77±41.35 | 353.03±35.90 |
| Sleep efficiency (SE), % | 86.92±7.59 | 85.85±6.25 |
| **Sleep stages in minutes** | | |
| 1 (S1) | 61.85±33.17 | 61.78±28.83 |
| 2 (S2) | 117.25±36.38 | 114.80±28.21 |
| SWS | 105.62±29.16** | 82.85±28.91 |
| REM | 58.22±20.82*** | 79.63±20.53 |
| REM latency, min | 149.90±46.77 | 146.13±38.27 |
| Number of awakenings/hr. (AWN/hr.) | 1.67±0.55* | 2.03±0.72 |
| **Sleep stages in %** | | |
| Wake after sleep onset (WASO) | 5.31 | 7.44 |
| 1 (S1) | 16.40 | 16.16 |
| 2 (S2) | 31.09 | 30.03 |
| SWS | 28.01 | 21.67 |
| REM | 15.44 | 20.83 |

*** $p<0.001$, ** $p<0.01$ using an independent t test and * $p<0.05$, Mann-Whitney U test, comparing the nights following CM practice with those following SR practice.

CM (called "CM-PSG") were compared with those recorded during the PSG session following SR (called "SR-PSG"). The CM-PSG showed a higher SWS percentage ($p<0.001$), lower REM percentage ($p<0.001$), and fewer awakenings per hour ($p<0.05$) than the SR-PSG. The group mean values ±*SD* are given in Table 1.

**Self-rated sleep**

Self-rated sleep based on the four-item questionnaire showed that the duration of sleep following CM was more than that following SR ($p<0.01$). Self-rated sleep based on the subjective VAS rating showed that the following were better after CM than after SR: a feeling of being refreshed after sleep ($p<0.001$), feeling good in the morning ($p<0.01$), feeling less disturbed by sleeping in a laboratory ($p<0.001$), and less inconvenience experienced related to the electrodes used for recording. The group mean values ±*SD* are given in Table 2.

## Discussion

In persons who were already experienced in yoga practice, including meditation, practicing a technique called cyclic meditation (CM) increased the percentage of time spent in slow-wave sleep (SWS), decreased the time spent in rapid-eye-movement (REM) sleep, and reduced the number of awakenings per hour. The participants' subjective rating of sleep was also better following CM compared with the other recording day, after SR.

The basis for assessing whether yoga practiced during the day would influence the following night's sleep was a study which assessed the relation between recovery experiences during leisure time, sleep, and affect the next morning [19]. Psychological detachment from work on the preceding day predicted negative activation and fatigue the next morning, whereas mastery experiences during the evening predicted



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**Table 2.** Scores in the self-rating of sleep on night after practicing cyclic meditation (CM) compared with practicing supine rest (SR). Values are group means ± SD.

| Variables | Sessions | |
|---|---|---|
| | Recording after Cyclic Meditation (CM) | Recording after Supine Rest (SR) |
| **Part-I** | | |
| Feeling that sleep was refreshing | 7.49±1.46*** | 5.63±1.80 |
| Feeling 'good' in the morning on awakening | 7.73±1.65** | 6.45±2.07 |
| Degree to which sleep was influenced by being in a laboratory | 2.05±1.63*** | 3.99±2.32 |
| Discomfort induced by sleeping with electrodes | 1.82±1.33*** | 3.44±2.17 |
| **Part-II** | | |
| Time taken to fall asleep | 20.90±15.17 | 28.63±25.99 |
| Number of awakenings | 2.33±1.56 | 2.80±1.65 |
| Duration of sleep from start to finish | 6.08±0.80** | 5.52±1.16 |
| Number of dreams recollected | 1.87±1.33 | 2.50±1.93 |

*** $p<0.001$, ** $p<0.01$, CM session compared with SR using a Mann-Whitney $U$ test for independent data sets.

positive activation and relaxation predicted serenity. Also, sleep quality showed a relation with all affective variables. The results hence suggest that events on a particular day impact the quality of sleep in the night and affect the next day. In the present study, in a group of yoga trainees whose daily activities, diet, and living conditions were similar, the addition of a specific yoga practice, i.e. CM, improved both subjective and objective indicators of sleep.

The factors which influence sleep have different behavioral, biological, and chemical origins [20]. Slow-wave sleep in particular is influenced by intense exercise and sleep deprivation in the subsequent sleep period [21]. High-intensity exercise resulted in a significant increase in the sleep-promoting substance adenosine. In the present study, cyclic meditation is definitely not a high-intensity exercise, despite the increase in oxygen consumption during the practice [10] and heart rate variability changes suggestive of a shift towards sympathetic dominance [11], which also occurred during the practice. At this stage it is not possible to say whether CM may have acted as some form of exercise and this may have explained the increase in SWS percentage on the day the participants practiced CM. It is also not entirely possible to rule out that subjects had micro-sleep or even slept during the two SR practice sessions, which may have led to less SWS in the subsequent night. However, there are two factors which may support the notion that the subjects did not actually sleep during SR. The high-frequency (HF) power of the heart rate variability (HRV) increased following both CM and SR practice, which is considered to suggest increased vagal tone [11]. However, there was a marginally greater increase following CM (4.4%) than following SR (1.0%). In the same study the low-frequency (LF) power, which is believed to correlate with sympathetic activity, was significantly less following both CM (1.8% decrease) and SR (0.3% decrease). In another study on the effects of CM and SR on oxygen consumption, while the oxygen consumption increased during CM and reduced during SR [10], following CM there was a greater magnitude of decrease in oxygen consumption (19.3% decrease) compared with following SR (4.8% decrease).

Hence, based on the HRV, following the practice of CM and SR there was an increase in vagal dominance which was marginally more following CM. Also, after (but not during) the practices the change in oxygen consumption suggested that after both practices there was a period of physiological relaxation which was more after CM than after SR. A different trend may have been expected if the subjects were asleep or had micro-sleep during SR sessions. However, the subjects in the two studies cited above (i.e. on HRV [10] and oxygen consumption [11]) were different from the subjects of the present study and no direct extrapolation can be made. Also, all the changes cited above occurred after, not during, the practices. Another factor which may be considered to suggest that the subjects may not have slept during the SR sessions is that all of them were trained yoga practitioners and maintaining awareness is considered an important part of *shavasana* practice [22]. However, whether the subjects did sleep or not during the SR sessions remains an unresolved limitation of the study. Other limitations in interpreting the findings include the facts that the sample was restricted to a selected group of yoga practitioners with over one year of meditation experience and the subjects were not assessed on a separate day without any intervention.

Despite these limitations, the present findings suggest that CM practice during the day increases SWS in the subsequent night. The possible implications of such an increase are given below. An increase in SWS following day-time CM practice could be expected to positively influence the behavioral performance in motor and sensory tasks, as SWS deprivation has influenced the performance in a cognitive test, a simple auditory reaction-time task, and a finger tapping task [23].

The decrease in the percentage of time spent in REM sleep on the nights following CM practice is also of interest. Data



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from fragmented sleep studies from three sleep laboratories indicated that the REM cycle is primarily governed by a sleep-dependent oscillator, with the possibility that endogenous or environment factors can influence the REM cycle [24]. An increase in REM sleep was shown to be related to an increased arousal index within the total sleep time in people with primary insomnia [25]. More persons with primary insomnia subjectively estimated wake times as longer than obtained from the polysomnographic recordings, also when they were compared with "good sleeper" controls. Hence REM sleep time contributed significantly to subjective wake times and to subjectively disturbed sleep, particularly in those with primary insomnia. These findings may help to explain why the participants subjectively rated their sleep as better (i.e. higher ratings of feeling refreshed on the VAS) and also subjectively rated fewer times of waking up on the days they practiced CM compared with SR, as these days also had less REM percent time. While an increase in REM percent time correlated with subjective arousal from sleep in persons with primary insomnia, it is known that idiopathic REM sleep disorder is associated with cognitive impairment [26], and an association between REM sleep and proper memory function is known [27]. Hence it is difficult to say whether the decrease in the percentage of time spent in REM sleep in the present study is a beneficial or a not so beneficial change.

However, the practice of CM (approximately 23 minutes twice a day) improved the subjectively rated quality of sleep as well as decreased the subjectively rated discomfort related to sleeping in the laboratory. A definite limitation in interpreting these findings is that the yoga trainees would probably have been aware of the previous published findings on the effects of cyclic meditation compared with supine rest. This could be expected to have influenced their subjective ratings of sleep on the nights following the practice of cyclic meditation or supine rest in *shavasana*. The objective differences, based on polysomnography, are less likely to be based on the participants' knowledge of the effects of CM. Since CM includes the practice of specific yoga postures, it may have acted as a form of mild exercise which may have facilitated SWS.

Another factor of importance is that on both days (i.e. subsequent to both CM and SR) the REM latency was longer than usual (149.9 minutes on the CM day and 146.1 minutes on the SR day). Also, the amount of time spent in SWS S1 was longer than is usually expected on both days; it was 16.4% of total sleep time on the CM day and 16.2% on the SR day. The normal percentage of SWS S1 of TST is 2–5% [28]. The fact that on both days S1 was increased and REM latency prolonged may be explained as follows. In a study which evaluated the simultaneous effect of the prior time awake and the time of the day on subsequent sleep, a positive correlation was found between REM latency and the amount of slow-wave sleep [29]. SWS in fact appeared to expand at the cost of REM onset. Hence REM onset was considered to be homeostatically regulated and possibly secondary to the need for SWS. The authors stated that a preeminent need for SWS is the determinant of REM latency. However, in interpreting these findings the authors also mentioned that the short maximum wake span (i.e. 12 hours) and the restriction of time in bed to 4 hours would have curtailed the effects and hence the authors did not recommend generalization to full sleep episodes and long wake spans. Despite these limitations, it is possible that in the present study the increase in SWS (particularly SWS S1, which constituted 16.4% (PSG-CM) and 16.3% (PSG-SR) of the total sleep time in the present study, compared with the normal range of 2–5%) may be related to the prolonged REM latency, with the REM latency also being dependent on the amount of SWS S1. For this to be considered plausible, the REM latency and total SWS time would need to be considered interdependent. In the research cited above [28], the interdependence was particularly demonstrable for longer periods of prior time awake to a maximum of 12 hours.

In the present study the participants were routinely used to waking up in the morning at approximately 5:30 and going to sleep at approximately 22:30. This would constitute a long span of prior time awake. This explanation (of an increase in REM latency being related to an increase in SWS time, with the two varying with the prior time awake) may be considered supported by the fact that in both sessions, i.e. following cyclic meditation and following supine rest, the amount of time spent in SWS S1 and the REM latency were comparable.

Apart from this, another explanation may be considered. It has been found that, although not strictly related to prior sleep history, the first night of a polysomnographic sleep evaluation is often associated with a disruption of the distribution of the sleep states [29]. One common characteristic is a delayed onset of REM sleep. This delay may take the form of missing the first REM episode of the night. In other words, in such a sleep cycle the NREM sleep stages progress normally, but the first cycle ends with an episode of SWS S1 or a brief arousal instead of the expected brief REM episode. In the present study all the participants had a session for acclimatization. So this explanation cannot be directly applicable. However, despite the acclimatization or adaptation to the laboratory environment, the present group of healthy volunteers may have still been sensitive to the laboratory environment on the day of recording. This may be related to the fact that yoga practice is often associated with increased responsivity and sensitivity to environmental stimuli [30]. This explanation may seem contradictory, as yoga practice is supposed to help practitioners remain undisturbed and less distractible [31]. However, yoga practice is also known to increase awareness of body sensations and facilitate an attentional stance towards sensations as a form of detached observation [32]. The yoga practitioners may hence have remained more sensitive than expected to the laboratory environment despite an adaptation session. Further studies are required to understand the long-term effects of practicing CM and also to know whether the sleep architecture of long-term practitioners differs from non-practitioners.

## Conclusions

Practicing cyclic meditation appeared to increase slow-wave sleep and lower the percentage of time in rapid-eye-movement sleep. Also, the number of awakenings per hour was less. Hence the present study suggests that the practice of cyclic meditation twice a day appears to improve the objective and subjective quality of sleep on the following night.



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