

Sleep architecture of consolidated and split sleep due to the dawn (*Fajr*) prayer among Muslims and its impact on daytime sleepiness

Ahmed S. BaHammam¹, Munir M. Sharif¹, D. Warren Spence²,
Seithikurippu R. Pandi-Perumal^{1,3}

¹University Sleep Disorders Center, College of Medicine, King Saud University, Riyadh, Saudi Arabia,
²Department of Sleep Medicine, 323 Brock Avenue, Toronto,
³Department of Sleep Medicine, Somnogen Canada Inc, College Street, Toronto, Canada

Address for correspondence:

Prof. Ahmed S. BaHammam,
University Sleep Disorders Center, College of Medicine, King Saud University, Riyadh, Saudi Arabia. E-mail: ashammam2@gmail.com

Submission: 15-07-11
Accepted: 04-09-11

Access this article online

Quick Response Code:



Website:

www.thoracicmedicine.org

DOI:

10.4103/1817-1737.91560

Abstract:

BACKGROUND: Muslims are required to wake up early to pray (*Fajr*) at dawn (approximately one and one-half hours before sunrise). Some Muslims wake up to pray *Fajr* and then sleep until it is time to work (split sleep), whereas others sleep continuously (consolidated sleep) until work time and pray *Fajr* upon awakening.

AIM: To objectively assess sleep architecture and daytime sleepiness in consolidated and split sleep due to the *Fajr* prayer.

SETTING AND DESIGN: A cross-sectional, single-center observational study in eight healthy male subjects with a mean age of 32.0 ± 2.4 years.

METHODS: The participants spent three nights in the Sleep Disorders Center (SDC) at King Khalid University Hospital, where they participated in the study, which included (1) a medical checkup and an adaptation night, (2) a consolidated sleep night, and (3) a split-sleep night. Polysomnography (PSG) was conducted in the SDC following the standard protocol. Participants went to bed at 11:30 PM and woke up at 7:00 AM in the consolidated sleep protocol. In the split-sleep protocol, participants went to bed at 11:30 PM, woke up at 3:30 AM for 45 minutes, went back to bed at 4:15 AM, and finally woke up at 7:45 AM. PSG was followed by a multiple sleep latency test to assess the daytime sleepiness of the participants.

RESULTS: There were no differences in sleep efficiency, the distribution of sleep stages, or daytime sleepiness between the two protocols.

CONCLUSION: No differences were detected in sleep architecture or daytime sleepiness in the consolidated and split-sleep schedules when the total sleep duration was maintained.

Key words:

Consolidated sleep, daytime sleepiness, *Fajr* prayer, sleep architecture, split sleep

Most people sleep continuously at night for 7 to 8 hours and stay awake during the day (consolidated sleep). For various reasons, others split their sleep into two or more periods while maintaining the same total sleep duration. A previous study in mammals demonstrated that consolidated sleep is necessary for proper waking performance.^[1] However, some investigators have shown that split sleep may improve daytime function. The first documented report of splitting sleep, published in 1897, reported that splitting sleep while maintaining the same sleep duration enhances the recuperative benefits.^[2] Subsequently, several studies reported that total sleep duration is the main determinant of the restorative function of sleep, as reflected by alertness and performance.^[3,4]

The sleep schedules of Muslims are influenced by prayer times.^[5] Muslims have five obligatory prayers per day, and, because the first prayer (*Fajr*) is at dawn (approximately one and one-half

hours before sunrise), they are obliged to wake up early on weekdays and weekends. The last prayer (*Isha*) is in the evening, approximately two hours after sunset. Summer nights have an earlier dawn and shorter nights, so Muslims may have less nighttime sleep during the summer. As a result, during the summer, some Muslims wake up to pray *Fajr* and stay awake for 30 to 45 minutes and then sleep until work time (split sleep), while others sleep continuously (consolidated sleep) until work time and pray the *Fajr* upon awakening. Data on the effect of split sleep due to the *Fajr* prayer do not exist. However, some experimental studies have compared the effect of consolidated and split sleep on alertness and neurobehavioral function under controlled conditions. In most of those studies, published in the space and aviation literature and dealing with astronauts, the investigators assessed the daytime performance and cognitive function of the participants involved in the two sleep protocols. In general, these previous studies have

demonstrated that daytime performance and function depend on total sleep duration, independent of whether the sleep was consolidated or split.^[6]

Some people think that interrupting sleep for the *Fajr* prayer and then going back to sleep disturbs their sleep quality, which may impair their daytime alertness. The split-sleep pattern that some Muslims practice during the summer is distinct from the experimental pattern described in the above studies, as the duration and timing of the split is different from that used in experimental studies. Therefore, we designed this study to objectively assess the sleep architecture, the circadian pattern of REM (rapid eye movement) sleep, the REM density, and daytime sleepiness in subjects obtaining consolidated and split sleep due to the *Fajr* prayer.

Methods

Study population

In this cross-over study, we studied eight healthy volunteers with no history of sleep disorders or medical problems and with a mean age of 32.0 ± 2.4 years (range of 25-35 years). One week preceding the start of the study, the subjects were asked to go to bed at approximately 11:30 PM and get up at approximately 7:30 AM. Furthermore, every subject was asked to fill out a daily sleep diary in addition to wearing a wrist actigraphy monitor (Mini Mitter Company, Inc.) to assure that their sleep pattern was regular and that they slept for 7 to 8 hours per day. This regimen was established to avoid the effects of prior sleep deprivation. Individuals with sleep complaints or disturbed sleep patterns, those who had worked night shifts during the previous two years, those who had traveled across time zones in the previous two months, smokers, and consumers of more than one cup of caffeinated beverage per day or any alcohol were excluded.

All participants were medically examined before enrollment and were asked to complete questionnaires related to their demographics and sleep habits. Subjective sleepiness was assessed using the Epworth Sleepiness Scale (ESS), a specialized, validated sleep questionnaire containing eight items that ask for self-reported disclosure of the expectation

of dozing in a variety of situations.^[7] The ESS measurements were conducted at approximately 10:00 AM (two hours after awakening) to avoid the effects of sleep inertia.^[8]

Study protocol

Participants reported to the Sleep Disorders Center (SDC) on three occasions. On the day of the sleep studies, participants were asked to avoid napping during the day. During each visit, the subjects spent approximately 24 hours in the SDC for the following purposes:

1. A baseline visit to have a medical checkup and to adapt to the environment (data were not included in the analysis).
2. A consolidated sleep night followed by administration of a multiple sleep latency test (MSLT).
3. A split-sleep night followed by administration of an MSLT.

The order of consolidated and split-sleep schedules was random (simple random).

Figure 1 shows the consolidated and split-sleep protocols. For the consolidated sleep protocol, participants reported to the SDC at approximately 9:00 PM. The lights were turned off at 11:30 PM and turned on at 7:00 AM. During the split-sleep protocol, participants reported to the SDC at approximately 9:00 PM. The lights were turned off at 11:30 PM. The first sleep period finished at 3:30 AM, and the participants were awakened for 45 minutes, during which time a simulation of the real practice of praying the *Fajr* was performed. The participants were asked to visit the bathroom and make ablution (*Wudoo*), walk for 50 m, pray the *Fajr*, and then walk for another 50 m. The light intensity was less than 50 lux during the wake period between the two sleep periods. At 4:15 AM, the lights were turned off, and the participant was asked to sleep until the lights were turned on at 7:45 AM. The total time in bed (TIB) was the same in both protocols. Breakfast and dinner were served at the same time during the two protocols, and the meals had a fixed caloric content based on ideal body weight.

Polysomnography

Standard in-lab polysomnography (PSG) was performed using Alice® 5 diagnostic equipment (Respironics Inc., Murrysville,

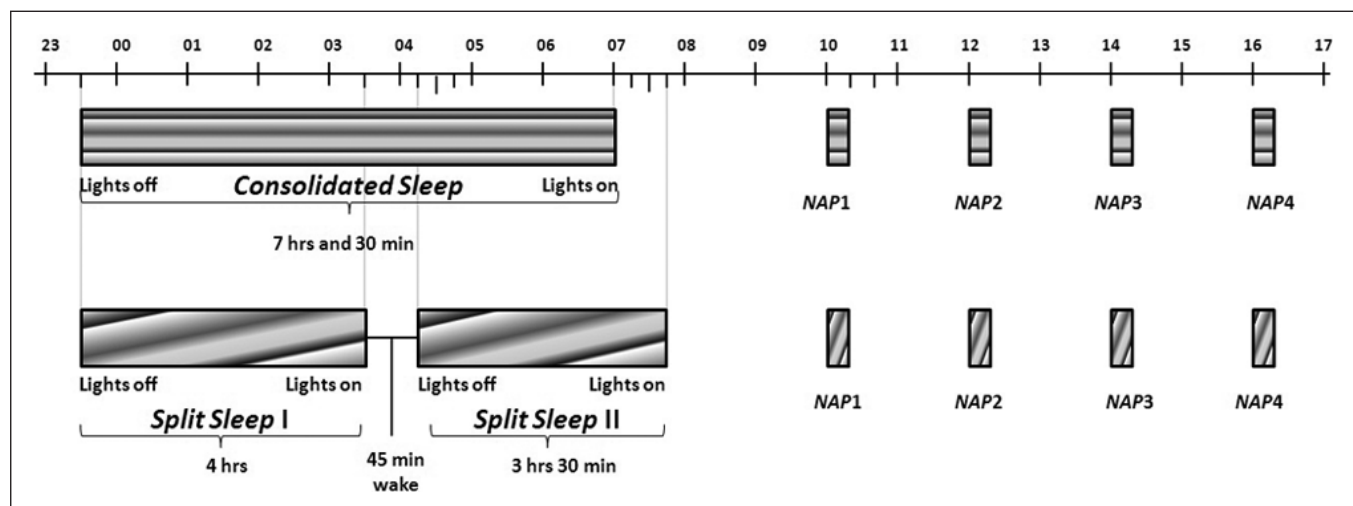


Figure 1: Distribution of the polysomnographic and multiple sleep latency test recordings of both protocols

Pennsylvania, USA) in the SDC at King Khalid University Hospital. The following parameters were monitored during PSG: Brain activity (electroencephalogram with electrodes placed at C3A2, C4A1, O1A2, O2A1, F3A2, F4A1), muscle tone (electromyogram of the chin and both legs), eye movements (electrooculogram), heart rate (electrocardiogram), oxygen saturation (finger pulse oximeter), chest and abdominal-wall movements (thoracic and abdominal belts), airflow (thermistors and nasal prong pressure transducer), sleep position (body position sensor), and snoring (microphone).

Analysis and scoring of the sleep studies

The analysis and scoring of the electronic raw data was performed manually. The key monitored events included the time points or duration of the lights-off period, lights-on period, TIB, total sleep time (TST), sleep period time, and sleep latency. The following parameters were scored: The sleep stages and percentage of TST, sleep latency, slow-wave sleep (SWS) latency and duration, REM latency and duration, REM cycles, wake after sleep onset (WASO), and arousals according to established criteria.^[9,10] All sleep studies were analyzed by two trained technicians and were reviewed by the principal investigator to ensure inter-scorer and intra-scorer reliability.

To score REM density, we adopted the criteria used by Khalsa *et al.*^[11] REM density was scored by counting the total number of REMs for each 30 seconds of REM sleep (epoch). Then, the REM density was expressed as the number of eye movements per minute. Each eye movement that was noticeable above the background noise and followed a rapid time course appearing simultaneously on both (right and left) EOG channels was counted, regardless of the amplitude of eye movement.^[12-14] Rapidly cycling left and right REMs, in the same direction of the gaze, were counted as separate eye movements. The REM density was scored by two independent technicians, and the mean of the two scores was used in the analysis.

Multiple sleep latency test

The multiple sleep latency test (MSLT) has been a validated and accepted objective method used to assess daytime sleepiness. A standard MSLT was performed in accordance with the American Academy of Sleep Medicine.^[15] Four tests (naps) were performed two hours apart, beginning two hours after awakening. Routine tests were performed after the leg EMG, and cardiorespiratory parameters were omitted. The technician performed calibrations prior to each test. After awakening, participants were asked to get out of bed, get dressed in street clothes, avoid sleeping between naps, and avoid any vigorous activity for 15 minutes before each nap. Participants were not allowed to ingest any caffeinated beverages during the study. At the beginning of each nap, the participants were asked to remove their shoes, loosen their clothing, and lie in bed for 5 minutes before the lights were turned off. If sleep occurred, the nap was continued for 15 minutes after sleep onset. Sleep onset was determined by the first epoch of any stage of sleep, which included Stage 1. If no sleep occurred, the nap was terminated after 20 minutes.

The MSLT scorers were blinded to the sleep protocol used the night before. The individual sleep latency of each nap and average sleep latency of the four naps were reported. In

general, a mean MSLT score of less than 5 minutes indicated pathological daytime sleepiness (normal scores ranged from 10 to 20 minutes).

Statistical analysis

The data were expressed as the mean±SD. To compare the split-sleep protocol PSG parameters with the consolidated sleep PSG parameters, we added the measured parameters for the two sleep periods (TIB, TST, WASO, and REM cycles). To calculate the sleep efficiency, we divided the TST of the two sleep periods by the TIB of the two sleep periods. To determine the proportion of sleep stages, we divided the total duration of each stage by the total TST of the two periods and multiplied by 100. The Arousal Index was calculated by dividing the total number of arousals for both periods by the TST in hours of the two periods. Comparisons between the two sleep protocols with regard to the PSG and MSLT parameters were calculated using a Student's paired sample *t*-test. If the normality test failed, a Mann-Whitney test was used. A *P* value ≤0.05 was considered significant.

Results

The participants had a mean age of 32.0 ± 2.4 years and a mean body mass index of 24.2 ± 2.0 kg/m². The mean duration of nocturnal sleep prior to starting the study was 7.2 ± 0.6 hours. Table 1 presents a comparison between the sleep parameters during consolidated sleep and combined sleep of the split-sleep protocol. There were no differences in sleep efficiency or in the distribution of sleep stages between the two protocols. Table 2 shows a comparison between the sleep parameters in the first and second sleep (sleep after the *Fajr* prayer) periods of the split-sleep protocol. The sleep latency in the second period of the split-sleep protocol was 24.8 ± 9.2 minutes, and the REM latency was 32.2 ± 29.9 minutes. Table 3 shows a comparison of the second period of the split-sleep protocol with the corresponding last 3.5 hours of the consolidated sleep condition. There was no difference in the sleep efficiency, arousal index, or the sleep stages.

Table 1: Comparison of consolidated sleep and split-sleep schedules

Variables	Split	Consolidated	<i>P</i> value
Time in bed (min)	456.4 ± 42.9	439.4 ± 9.5	NS
Total sleep time (min)	352.4 ± 43.7	341.3 ± 36.6	NS
Sleep latency (min)	30.7 ± 22.4	36.7 ± 15.6	NS
WASO (min)	27.6 ± 20.4	48 ± 28.9	NS
REM latency (min)	72.7 ± 46.9	69.3 ± 19.2	NS
Sleep efficiency (%)	80.7 ± 8.8	77.8 ± 8.8	NS
Stage 1 (%)	5.7 ± 3.2	6.6 ± 2.9	NS
Stage 2 (%)	50.6 ± 11.7	50.4 ± 11.3	NS
Stage N3 (%)	18.5 ± 7.4	17.1 ± 9.4	NS
REM (%)	25.2 ± 5.7	26 ± 7.6	NS
REM cycles	3.8 ± 1.3	3.8 ± 0.8	NS
Arousal index	13.3 ± 9.0	15.2 ± 3.9	NS
ESS	4.0 ± 3.0	3.8 ± 2.5	NS

The two periods of sleep during the split-sleep protocol were added in this analysis. WASO = Wake after sleep onset; REM = Rapid eye movement; ESS = Epworth sleepiness scale

The ESS scores of the split and consolidated sleep conditions were not different (3.0 ± 3.0 vs 4.2 ± 2.9 , respectively). Table 4 presents the MSLT analysis of the two sleep protocols. There were no significant differences in the sleep latency of the individual naps or their mean values between the consolidated sleep and split sleep protocols (7.1 ± 5.2 minutes and 8.5 ± 3.7 minutes, respectively).

The REM density in the last third (two hours) of sleep time revealed no difference between the split and consolidated sleep protocols (7.7 ± 1.7 /min vs 8.2 ± 2.2 /

min, P value=0.20).

Discussion

This study explored a special practice engaged in exclusively by Muslims and evaluated its influence on their sleep patterns. No study has examined the effect of sleep interruption due to the *Fajr* prayer on sleep architecture or daytime sleepiness. Our findings demonstrated that splitting sleep because of the *Fajr* prayer does not affect sleep architecture or increase daytime sleepiness when the total TIB and sleep duration are maintained.

There was no difference between the two sleep patterns in terms of subjective or objective daytime sleepiness. For objective assessment of daytime sleepiness, an MSLT was used. The MSLT is a sensitive test that has been used to assess daytime sleepiness and has also been used in previous studies to assess daytime alertness after various naps and split-sleep protocols.^[16] Previous studies that tested experimental split-sleep protocols reported no impact on daytime vigilance when the total sleep duration was fixed. In a protocol by Nicholson *et al.* that compared consolidated (8 hours) and split sleep (two 4-hour sleep periods separated by 10 hours of nocturnal wakefulness) in six healthy volunteers, no difference in daytime performance between the two protocols was reported.^[17] In addition, two experimental studies reported an increase in subsequent daytime performance after the split-sleep protocol compared with the consolidated protocol when the total sleep duration was maintained.^[16,18] However, neither study controlled for the duration of prior wakefulness at the time of testing, which might have influenced the measured endpoints (daytime performance).^[6] To avoid this problem, we monitored the participants' sleep patterns one week before the start of the study to assure the adequacy and regularity of prior sleep and to avoid the effects of prior sleep deprivation. Recent experimental data support the view that performance is a function of total daily TIB, independent of whether the sleep was consolidated or split.^[19] On the other hand, circadian phase has a profound effect on both the efficiency and structure of sleep.^[20] However, this effect was negligible in our study in as much as the sleep periods of the two protocols almost coincided, with a difference of only 45 minutes. Sleep inertia is another important factor that may influence the interpretation of experiments designed to measure the impact of split-sleep protocols on neurobehavioral performance.^[21] To avoid the potential effects of sleep inertia, the participants in this study took their first MSLT nap at the same time of the day, approximately two hours after waking up.

While SWS dominates at the beginning of the night (the first one third), REM sleep episodes are longest in the last third of the night. The preferential distribution of SWS toward the beginning of a sleep episode is not thought to be mediated by circadian processes, but shows a marked response to the length of prior wakefulness.^[22] The SWS pattern reflects the homeostatic sleep system (sleep debt), which is highest at sleep onset and diminishes across the night as the sleep pressure wanes. This explains the higher proportion of stage N3 in the first sleep period in the split-sleep protocol. On the other hand, rapid REM sleep follows a circadian pattern,^[23-25]

Table 2: Comparison of the first and second parts of split sleep

Variables	Split sleep 1 st part	Split sleep 2 nd part	*P value
Time in bed (min)	251.6 ± 28.4	204.8 ± 16.4	0.009*
Total sleep time (min)	177.5 ± 45.2	174.9 ± 22.3	NS
WASO (min)	28.8 ± 15.7	4.6 ± 3.5	0.027*
Sleep latency (min)	30.7 ± 22.4	24.8 ± 9.2	NS
REM latency (min)	72.7 ± 46.9	32.2 ± 29.9	0.047*
Sleep efficiency (%)	76.2 ± 16.2	85.2 ± 4.5	NS
Stage 1 (%)	6.8 ± 5.2	4.9 ± 3.0	NS
Stage 2 (%)	51.1 ± 10.4	49.7 ± 15.3	NS
Stage N3 (%)	25.5 ± 6.2	11.5 ± 9.6	0.047*
REM (%)	16.6 ± 4.9	34 ± 7.7	0.009*
REM cycles	1.8 ± 0.8	2 ± 0.7	NS
Arousal index	15.1 ± 12.1	11.9 ± 7.5	NS

NS = Non-significant; *P value based on the Mann-Whitney test; WASO = Wake after sleep onset; REM = Rapid eye movement

Table 3: Comparison of the second sleep period of split sleep and the corresponding sleep duration of consolidated sleep

Variables	2 nd sleep period of split sleep	Corresponding sleep period during consolidated sleep	P value
Total sleep time (min)	174.9 ± 22.3	149.9 ± 38.1	NS
Sleep efficiency (%)	85.2 ± 4.5	73.2 ± 18.3	NS
Stage 1 (%)	4.9 ± 3.0	9.6 ± 3.3	NS
Stage 2 (%)	49.7 ± 15.3	48 ± 14.9	NS
Stage N3 (%)	11.5 ± 9.6	5.9 ± 9.1	NS
REM (%)	34 ± 7.7	36.5 ± 13.0	NS
REM cycles	2 ± 0.7	2.2 ± 0.8	NS
Arousal index	11.9 ± 7.5	14.4 ± 3.1	NS

NS = Non-significant; REM = Rapid eye movement

Table 4: MSLT analysis of the split and consolidated protocols

NAPS	Split sleep	Consolidated sleep	P value
Mean sleep latency naps (minutes)	7.1 ± 5.2	8.5 ± 3.7	NS
Sleep latency Nap 1 (min)	8.8 ± 7.8	6.3 ± 4.5	NS
Sleep latency Nap 2 (min)	5.7 ± 5.5	8.7 ± 3.2	NS
Sleep latency Nap 3 (min)	6.3 ± 6.6	11.1 ± 5.4	NS
Sleep latency Nap 4 (min)	6.1 ± 3.4	6.5 ± 4.4	NS

NS = Non-significant; MSLT = Multiple sleep latency test

in which it increases in the morning during the last third of sleep when the pressure for sleep is less.^[23] The effect of a split-sleep schedule on REM has not been properly assessed. As expected, the proportion of REM sleep was significantly higher in the second sleep period in the split-sleep protocol, and the REM sleep latency was shorter; however, the overall REM percentage and duration were not different between the consolidated and split-sleep protocols. Evidence has supported a difference between REM density and REM sleep.^[11] Although REM sleep has exhibited a circadian pattern, it has been hypothesized that REM density is an index of sleep need and sleep satiety and is much less susceptible to circadian modulation.^[11] There is a sleep-dependent modulation of REM density, with the greatest density occurring when the sleep pressure is low. We found no difference between the sleep protocols in terms of REM density in the last third of sleep time (last two hours of sleep). This finding suggests that the sleep pressure in the last third of sleep in both protocols was comparable.

The WASO was significantly lower in the second sleep period of the split-sleep protocol. This could be related to the timing of sleep. In experimental studies, nap timing has been shown to have a significant effect on sleep efficiency and WASO.^[16,26] Kubo *et al.* assessed the effect of nap timing on sleep efficiency and found that the sleep efficiency is greater and lower WASO scores occur when naps are taken between 4:00 and 6:00 AM than when naps are taken earlier in the night.^[26]

There are limitations of this study that need to be addressed. First, some Muslims are used to wake up for *Fajr* prayer and do not go back to sleep. Intentionally, this group was not investigated in this study, as they usually have shorter sleep duration, which may affect their daytime function and sleepiness. During summer in Riyadh city, night prayer (*Esha*) ends around 9:00 PM and *Fajr* prayer comes around 3:30 AM. Another limitation is the fact that the mean sleep latency during MSLT of the studied group was on the lower side (7-8.5 minutes). It is agreed that a mean sleep latency of <5 minutes during MSLT indicates a pathological degree of sleepiness. On the other hand, sleep latencies between 5 and 10 minutes imply moderate sleepiness with less well-defined pathology and consequences.^[27,28] It is known that there is variation in the range of mean sleep latency among populations, which may be related to individual differences in sleep tendency.^[27,29] To control for that effect, we used the same controls in a cross-over design. In addition, we ruled out disorders that may increase daytime sleepiness prior to enrollment and monitored sleep duration using actigraphy before commencing the study to eliminate the possible effect of prior sleep deprivation. The current study supported our hypothesis that splitting sleep for the *Fajr* prayer does not affect daytime sleepiness when the total sleep duration was maintained. The sleep architecture of both protocols was similar. The findings of the current investigation indicated that further studies of the effects of the two schedules on neurobehavioral and cognitive function are merited.

Acknowledgments

This work was supported by a grant from The National Plan for Sciences and Technology (King Abdulaziz City for Science and

Technology and King Saud University).

References

1. Rechtschaffen A, Gilliland MA, Bergmann BM, Winter JB. Physiological correlates of prolonged sleep deprivation in rats. *Science* 1983;221:182-4.
2. Michelson E. Untersuchungen über die Tiefe des Schlafes, *Psychol. Arb.* 2:84-117.
3. Carskadon MA, Dement WC. Nocturnal determinants of daytime sleepiness. *Sleep* 1982;5 Suppl 2:S73-81.
4. Jewett ME, Dijk DJ, Kronauer RE, Dinges DF. Dose-response relationship between sleep duration and human psychomotor vigilance and subjective alertness. *Sleep* 1999;22:171-9.
5. BaHamam A. Sleep from an Islamic perspective. *Ann Thorac Med* 2011;6:187-92.
6. Ficca G, Axelsson J, Mollicone DJ, Muto V, Vitiello MV. Naps, cognition and performance. *Sleep Med Rev* 2010;14:249-58.
7. Johns MW. A new method for measuring daytime sleepiness: The Epworth sleepiness scale. *Sleep* 1991;14:540-5.
8. Tassi P, Muzet A. Sleep inertia. *Sleep Med Rev* 2000;4:341-53.
9. EEG arousals: Scoring rules and examples: A preliminary report from the sleep disorders atlas task force of the American sleep disorders association. *Sleep* 1992;15:173-84.
10. Iber C, Ancoli-Israel S, Chesson AL Jr, Quan SF. The AASM manual for the scoring of sleep and associated events: Rules, terminology and technical specifications, 1st ed. Westchester, Illinois: American Academy of Sleep Medicine; 2007.
11. Khalsa SB, Conroy DA, Duffy JF, Czeisler CA, Dijk DJ. Sleep- and circadian-dependent modulation of REM density. *J Sleep Res* 2002;11:53-9.
12. Aserinsky E. The maximal capacity for sleep: Rapid eye movement density as an index of sleep satiety. *Biol Psychiatry* 1969;1:147-59.
13. Aserinsky E. Relationship of rapid eye movement density to the prior accumulation of sleep and wakefulness. *Psychophysiology* 1973;10:545-58.
14. Hong CC, Gillin JC, Dow BM, Wu J, Buchsbaum MS. Localized and lateralized cerebral glucose metabolism associated with eye movements during REM sleep and wakefulness: A positron emission tomography (PET) study. *Sleep* 1995;18:570-80.
15. Littner MR, Kushida C, Wise M, Davila DG, Morgenthaler T, Lee-Chiong T, *et al.* Practice parameters for clinical use of the multiple sleep latency test and the maintenance of wakefulness test. *Sleep* 2005;28:113-21.
16. Bonnet MH, Arand DL. Consolidated and distributed nap schedules and performance. *J Sleep Res* 1995;4:71-7.
17. Nicholson AN, Pascoe PA, Roehrs T, Roth T, Spencer MB, Stone BM, *et al.* Sustained performance with short evening and morning sleeps. *Aviat Space Environ Med* 1985;56:105-14.
18. Hartley LR. A comparison of continuous and distributed reduced sleep schedules. *Q J Exp Psychol* 1974;26:8-14.
19. Mollicone DJ, Van Dongen HP, Rogers NL, Dinges DF. Response surface mapping of neurobehavioral performance: Testing the feasibility of split sleep schedules for space operations. *Acta Astronaut* 2008;63:833-40.
20. Dijk DJ, Czeisler CA. Contribution of the circadian pacemaker and the sleep homeostat to sleep propensity, sleep structure, electroencephalographic slow waves, and sleep spindle activity in humans. *J Neurosci* 1995;15:3526-38.
21. Ficca G, Axelsson J, Mollicone DJ, Muto V, Vitiello MV. Naps, cognition and performance. *Sleep Med Rev* 2010;14:249-58.
22. Weitzman ED, Czeisler CA, Zimmerman JC, Ronda JM. Timing of REM and stages 3 + 4 sleep during temporal isolation in man. *Sleep* 1980;2:391-407.

23. Czeisler CA, Zimmerman JC, Ronda JM, Moore-Ede MC, Weitzman ED. Timing of REM sleep is coupled to the circadian rhythm of body temperature in man. *Sleep* 1980;2:329-46.
24. Johnson LC. The REM cycle is a sleep-dependent rhythm. *Sleep* 1980;2:299-307.
25. Zuley J. Distribution of REM sleep in entrained 24 hour and free-running sleep-wake cycles. *Sleep* 1980;2:377-89.
26. Kubo T, Takeyama H, Matsumoto S, Ebara T, Murata K, Tachi N, et al. Impact of nap length, nap timing and sleep quality on sustaining early morning performance. *Ind Health* 2007;45:552-63.
27. Sullivan SS, Kushida CA. Multiple sleep latency test and maintenance of wakefulness test. *Chest* 2008;134:854-61.
28. Afifi LK, Carskadon M. MSLT. In: Kushida C, editors. *Sleep deprivation: Clinical issues, pharmacology, and sleep loss effects*. New York, NY: Informa Health Care; 2005.
29. Arand D, Bonnet M, Hurwitz T, Mitler M, Rosa R, Sangal RB. The clinical use of the MSLT and MWT. *Sleep* 2005;28:123-44.

How to cite this article: BaHammam AS, Sharif MM, Spence DW, Pandi Perumal SR. Sleep architecture of consolidated and split sleep due to the dawn (*Fajr*) prayer among Muslims and its impact on daytime sleepiness. *Ann Thorac Med* 2012;7:36-41.

Source of Support: The National Plan for Sciences and Technology (King Abdulaziz City for Science and Technology and King Saud University). **Conflict of Interest:** None declared.

New features on the journal's website

Optimized content for mobile and hand-held devices

HTML pages have been optimized of mobile and other hand-held devices (such as iPad, Kindle, iPod) for faster browsing speed.

Click on **[Mobile Full text]** from Table of Contents page.

This is simple HTML version for faster download on mobiles (if viewed on desktop, it will be automatically redirected to full HTML version)

E-Pub for hand-held devices

EPUB is an open e-book standard recommended by The International Digital Publishing Forum which is designed for reflowable content i.e. the text display can be optimized for a particular display device.


Click on **[EPub]** from Table of Contents page.

There are various e-Pub readers such as for Windows: Digital Editions, OS X: Calibre/Bookworm, iPhone/iPod Touch/iPad: Stanza, and Linux: Calibre/Bookworm.

E-Book for desktop

One can also see the entire issue as printed here in a 'flip book' version on desktops.

Links are available from Current Issue as well as Archives pages.

Click on  View as eBook