Napping on the Night Shift: A Study of Sleep, Performance, and Learning in Physicians-in-Training

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Abstract

Background Physicians in training experience fatigue from sleep loss, high workload, and working at an adverse phase of the circadian rhythm, which collectively degrades task performance and the ability to learn and remember. To minimize fatigue and sustain performance, learning, and memory, humans generally need 7 to 8 hours of sleep in every 24-hour period.

Methods In a naturalistic, within-subjects design, we studied 17 first- and second-year internal medicine residents working in a tertiary care medical center, rotating between day shift and night float every 4 weeks. We studied each resident for 2 weeks while he/she worked the day shift and for 2 weeks while he/she worked the night float, objectively measuring sleep by wrist actigraphy, vigilance by the Psychomotor Vigilance Task test, and visual-spatial and verbal learning and memory by the Brief Visuospatial Memory Test-Revised and the Rey Auditory-Verbal Learning Test.

Results Residents, whether working day shift or night float, slept approximately 7 hours in every 24-hour period. Residents, when working day shift, consolidated their sleep into 1 main sleep period at night. Residents working night float split their sleep, supplementing their truncated daytime sleep with nighttime on-duty naps. There was no difference in vigilance or learning and memory, whether residents worked day shift or night float.

Conclusions Off-duty sleep supplemented with naps while on duty appears to be an effective strategy for sustaining vigilance, learning, and memory when working night float.

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Editor's Note: The online version of this article contains the schematic of the study design.

Introduction

Residents must perform, learn, and remember, despite sleep loss, working nights, and high workload.[1,2] Night shift workers experience fatigue and degraded cognitive performance across multiple occupations and work settings.[3–9] Total sleep time in a 24-hour period is the primary sleep-related determinant of performance, whether that sleep is in a consolidated single bout of 7 to 8 hours or split into 2 or 3 bouts.[10–12] Split sleep, including main off-duty daytime sleep with on-duty naps, may sustain resident performance when working nights. We studied the amount and distribution of sleep in residents working day shift and night float and the effects on their vigilance performance (reaction time) and their ability to learn and remember.

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Methods

Setting and Participants

Seventeen internal medicine residents working in a tertiary care hospital were studied (4 women, 13 men; mean ± SD age for women was 29.25 ± 3.59 years old and 30.77 ± 6.00 years old for men; mean age for the entire study sample of 17 was 30.41 ± 5.47 years old [range 26–50 years; interquartile range 28–31 years]). There was no significant difference in age between the women and the men ($t = 0.62$; $df = 8.748$; $P = .55$). The proportion of women to men in the study sample did not differ significantly from that of the cohort from which the study sample was drawn (17 women to 22 men) as indicated by test results for equality of proportions, which approached but did not reach significance (χ^2 test = 3.59; $df = 1$; $P = .06$). The study sample included all residents in the overall cohort of 39 who were willing to volunteer. One male participant was 50 years old and an outlier with respect to age.

What was known

Residents may experience fatigue due to limited or disrupted sleep while working night shifts, which may affect cognitive abilities.

What is new

A study examines first- and second-year internal medicine residents' cognitive abilities on day and night shifts over a 4-week period.

Limitations

Small sample, single-institution study limit generalizability.

Bottom line

Residents' cognitive abilities did not differ between day and night shifts. Sleep averaged 7 to 8 hours in a 24-hour period during both shifts, with naps supplementing sleep on the night shifts.

Intervention

Residents alternated between day shift and night float rotations, each rotation lasting 4 weeks. Residents on the day shift worked from 7:00 AM to 6:00 PM, 6 days a week. Residents on night float worked from 5:30 PM to 7:00 AM the following day, 5 days a week. This was a normal rotation schedule; there was no experimental schedule manipulation. No formal provision for on-shift napping or protected time for sleep was provided, although residents were allowed to sleep when they could. On-call rooms were available. Each resident was studied 4 times: (1) during the last week of a day shift rotation; (2) during the first week of the subsequent night float rotation; (3) during the last week of this night float rotation; and (4) during the first week of the subsequent day shift rotation (a schematic of the study design is provided as online material).

The Institutional Review Board at Washington State University and the Office of Research Protections of the United States Army Research and Materiel Command approved the research protocol and consent form.

Outcomes

Sleep Data Each resident wore a wrist activity monitor (actigraph; Micro Motionlogger Sleep Watch; Ambulatory Monitoring Inc, Ardsley, NY) continuously to measure sleep. The actigraph activity record was scored by a sleep/wake scoring algorithm (Action W-2 software; Ambulatory Monitoring). This yielded a minute-by-minute continuous sleep/wake history, documenting main sleep and naps. Actigraphy accurately measures total sleep time per 24 hours and is comparable to polysomnography in this respect.[13–16] Total sleep time per 24 hours was calculated by summing main sleep and naps from noon to noon for each day of day shift and from midnight to midnight for each day of night float. Off-duty sleep was calculated by adding the number of minutes of sleep occurring outside of the resident's work shift. On-duty sleep was calculated by adding the number of minutes slept during the resident's work shift. On- and off-duty times were derived from the time stamps of the Psychomotor Vigilance Task (PVT) tests taken going on shift and going off shift.

Vigilance Performance Residents completed a 10-minute PVT test at shift beginning and shift end for all shifts during the studied periods. The PVT test is a serial reaction time test implemented on a smart phone. Each PVT is date and time stamped. The PVT test is a measure of vigilance and is sensitive to sleep loss.[17–20]

Learning The Rey Auditory-Verbal Learning Test (RAVLT) is a test of verbal learning and memory measuring immediate memory span, new learning, susceptibility to interference, and recognition memory.[21] The Brief Visuospatial Memory Test-Revised (BVMT-R) is a test of visual memory measuring visual learning and memory via immediate recall, acquisition rate, delayed recall, and recognition.[21] The RAVLT and the BVMT-R were administered 4 times, once at the end of each studied week.

Analysis

Data were analyzed using mixed effects analysis of variance.[22,23] Each resident served as his or her own control by working in both day shift and night float rotations, increasing statistical power.

Results

The residents (n = 17) worked longer hours on the night float (TABLE). Actigraphically measured total sleep times

TABLE **Primary Outcomes—Hours Worked/24 Hours, Total Sleep Time/24 Hours (On-Shift and Off-Shift), Vigilance Performance, and Verbal and Visual-Spatial Learning and Memory in Residents Working Day Shift and the Same Residents Working Night Float**

Primary Outcome	Day Shift	Night Float	F Value, *df*, and *P*
Hours worked/24 h[a]	9.0 ± 0.2 SEM	13.4 ± 0.2 SEM	F[1,277] = 506.4; *P* < .01
Total sleep time (h)/24 h	7.0 ± 0.3 SEM	6.8 ± 0.2 SEM	F[1,225] = 0.27; *P* = .60
No. of on-shift sleep h/24 h[a]	0.1 ± 0.2 SEM	2.6 ± 0.2 SEM	F[1,166] = 167.4; *P* < .01
No. of off-shift sleep h/24 h[a]	6.8 ± 0.2 SEM	3.8 ± 0.2 SEM	F[1,166] = 144.9; *P* < .01
Psychomotor Vigilance Task (PVT) test reaction time (ms)[b]	382 ± 28 SEM	393 ± 28 SEM	F[1,500] = 2.81; *P* = .09
Visuospatial learning (total recall)—BVMT-R	25.5 ± 1.1 SEM	26.6 ± 1.1 SEM	F[1,50] = 0.98; *P* = .33
Visuospatial learning (memory/delayed recall)—BVMT-R	10.0 ± 0.3 SEM	9.5 ± 0.3 SEM	F[1,50] = 1.09; *P* = .30
Visuospatial learning (% information retained)—BVMT-R	96.5 ± 2.2 SD	92.5 ± 2.2 SD	F[1,50] = 1.65; *P* = .20
Visuospatial learning (recognition index)—BVMT-R	5.9 ± 0.1 SEM	5.8 ± 0.1 SEM	F[1,50] = 1.81; *P* = .18
Verbal learning (total recall)—RAVLT	59.2 ± 1.6 SEM	57.7 ± 1.6 SEM	F[1,50] = 1.47; *P* = .23
Verbal learning (memory/delayed recall)—RAVLT	12.3 ± 6.5 SEM	12.2 ± 6.5 SEM	F[1,50] = 0.10; *P* = .75
Verbal learning (% information retained)—RAVLT	90.3 ± 3.4 SD	89.1 ± 3.4 SD	F[1,50] = 0.26; *P* = .61
Verbal learning (recognition index)—RAVLT	13.2 ± 0.5 SEM	13.1 ± 0.5 SEM	F[1,50] = 0.08; *P* = .77

Abbreviations: SEM, standard error of the mean; SD, standard deviation; BVMT-R, Brief Visuospatial Memory Test-Revised; RAVLT, Rey Auditory-Verbal Learning Test.

[a] Denotes statistical significance.

[b] There were no significant changes in PVT test times from shift beginning to shift end (mean PVT test times at shift beginning = 382 ms ± 28 SEM; mean PVT test times at shift end = 392 ms ± 28 SEM; F[1,500] = 2.35; *P* = .13) and no interactions between shift beginning and shift end and rotation (night float or day shift); F[1,500] = 0.59; *P* = .44. As a result, PVT test times averaged across beginning and end of shift were used for this analysis.

per 24 hours did not differ between day shift and night float (TABLE). Although sleep time did not differ, how sleep was divided between on- and off-duty times did differ between night float and day shift. For 16 residents, for whom we had PVT time stamps going on and off shift, we were able to determine not only total sleep time per 24 hours but also how this sleep was divided between on- and off-duty times. Residents working night float split their sleep into a main off-duty daytime sleep and supplemental on-duty nighttime naps. Residents working day shift consolidated their sleep into a main off-duty nighttime sleep without appreciable daytime nap supplementation (TABLE).

PVT test administration at shift beginning and shift end occurred on average at 8:40 AM and 4:49 PM for the day shift and at 5:57 PM and 7:15 AM the following day for night float. Thus, testing occurred at approximately the same time of day for both rotations. There was no change in PVT reaction time from shift beginning to shift end and no interaction between shift beginning/shift end and rotation (day shift or night float). Given the lack of main effect and interaction, we averaged going-on-shift and going-off-shift reaction time values and used them in the analysis. Vigilance as measured by PVT reaction time did not differ between the night float and day shift (TABLE).

For both the verbal learning (RAVLT) and the visual-spatial tests (BVMT-R), a score consisting of total correct for all trials on each test (total recall) was calculated. A memory score was also tabulated (delayed recall). There were no significant differences in these measures in residents when working night float versus when working day shift (TABLE).

Discussion

Residents maintained equivalent total sleep time per 24 hours, vigilance performance, and ability to learn and remember verbal and visual spatial information working night float and day shift.

The equivalent total sleep time per 24 hours resulted from different sleep strategies, with residents working the day shift consolidating their sleep into a single, nighttime main sleep and splitting their sleep into a daytime main sleep supplemented by nighttime, on-duty naps when working night float.[24] The addition of on-duty, nighttime sleep to off-duty daytime sleep when working night float yielded an equivalent total sleep time per 24 hours compared to day shift, apparently sustaining vigilance performance, learning, and memory equivalent to that observed when working day shift. Existing strategies of fatigue mitigation focus on the relationship between work hours and performance. The present study focused on total sleep time, shifting the strategy of fatigue mitigation from rules regulating work hours to policy and procedures ensuring adequate sleep.

The present results were obtained under naturalistic conditions without mandated on-duty napping or protected time for on-duty sleep. Two prior studies have examined mandated, protected sleep time for residents working extended shifts. In the first study,[25] residents were provided 4 hours of protected sleep time during a 36-hour shift. No increase in total sleep time or change in performance was found. A more recent study[26] offered residents 7 hours of protected sleep time during a 30-hour shift. Only 22% of interns took the offered sleep opportunity, citing a desire to care for their own patients and concerns about continuity of care. Thus, there could be unforeseen consequences of scheduled, mandated napping, especially in smaller residency programs. In a still more recent randomized controlled trial,[27] 106 interns and senior medical students worked a normal intern schedule or a protected sleep schedule (protected time from 12:30 AM to 5:30 AM). There was good compliance with the protected schedule. The protected sleep period increased overnight sleep duration and improved subsequent alertness relative to the normal schedule.

By self-report, the residents in our study indicated that the timing of admissions determined their ability to obtain on-duty sleep. The most desirable time was the period between 1:00 AM and 5:00 AM, if admission-free. Our findings suggest that the opportunity to sleep on duty enabled residents working night float to supplement their daytime, off-duty sleep and maintain their total sleep time, vigilance performance, and ability to learn. The present exploratory, naturalistic study suggests that on-duty napping could mitigate the effects of fatigue from extended work hours and night shift work. Further research is needed to determine the utility of nighttime on-duty napping as a formal, mandated strategy for fatigue mitigation.

Limitations of our study include a small sample of residents at a single institution and few women in the study sample. Also, the lack of a difference in total sleep time per 24 hours, vigilance performance, and ability to learn and remember verbal and visual spatial information between day shift and night float could reflect inadequate statistical power, given the small sample size. Finally, our measures of vigilance, memory, and learning may not equate to clinical or procedural performance.

Conclusion

Our findings suggest a new approach to fatigue mitigation, shifting the focus of fatigue mitigation from limiting work hours to ensuring adequate sleep.

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