

# The Effect of Working Serial Night Shifts on the Cognitive Functioning of Emergency Physicians

From the Department of Emergency Medicine, Geisinger Medical Center, Danville, PA.

Author contributions are provided at the end of this article.

Received for publication November 27, 2000. Revision received March 9, 2001. Accepted for publication March 27, 2001.

**Address for reprints:** David J. Dula, MD, Department of Emergency Medicine, Geisinger Medical Center, 100 North Academy Avenue, Danville, PA 17822; 570-271-6812, fax 570-271-6507; E-mail ddula@geisinger.edu.

Copyright © 2001 by the American College of Emergency Physicians.

0196-0644/2001/\$35.00 + 0

47/1/116024

doi:10.1067/mem.2001.116024

**David J. Dula, MD**  
**Nora L. Dula, PhD**  
**Clinton Hamrick, MD**  
**G. Craig Wood, MS**

**Study objective:** We sought to determine whether working 5 serial night shifts in the emergency department results in a decline in physician performance as measured with an intelligence test.

**Methods:** This study compared the cognitive functioning of emergency physicians who worked the day shift (7 AM to 5 PM) with those who worked 5 consecutive night shifts (11 PM to 7 AM). The Fluid Scale of the Kaufman Adolescent and Adult Intelligence Test (KAIT) was administered to 16 emergency medicine residents. Half of the residents (group A) were tested while working day shifts, and the other half (group B) were tested after working 5 consecutive night shifts. After a minimum interval of 2 months, the residents were retested in reverse order, with group A tested after working night shifts and group B tested while working day shifts.

**Results:** A total of 16 emergency medicine residents were tested. A paired *t* test was used to determine whether day-shift KAIT scores are different from night-shift KAIT scores. The mean day-shift KAIT score was 119.1 (SD=7.7), and the mean night-shift KAIT score was 107.2 (SD=10.2). This difference was significant (mean difference=11.9; 95% confidence interval 7.0 to 16.8; *P*<.001), with the day-shift scores being statistically higher than the night-shift scores.

**Conclusion:** Working a series of 5 night shifts results in a substantial decline in cognitive performance in physicians working in the ED.

[Dula DJ, Dula NL, Hamrick C, Wood GC. The effect of working serial night shifts on the cognitive functioning of emergency physicians. *Ann Emerg Med.* August 2001;38:152-155.]

---

## INTRODUCTION

Society has come to depend on continuous operations in many fields, such as public safety, manufacturing, transportation, and health care. To provide these services, approximately 25% of America's workforce has a rotating workshift schedule, with 10% engaged in night-shift work.<sup>1</sup> Emergency physicians are among this workforce that works night shifts and experiences the consequences of disrupted circadian rhythms.<sup>2</sup> The emergency medicine literature has highlighted the significance of shift work and its ill effects on the well-being and career longevity of physicians practicing emergency medicine.<sup>3-6</sup> The disruption of social schedules and the disturbance of sleep patterns are the major consequences of shift work. Sleepiness and decreased performances can increase vulnerability for the occurrence of unintentional incidents, such as motor vehicle crashes, fatalities, and recent disasters, such as the Three Mile Island incident and the space shuttle Challenger explosion in 1986.<sup>7</sup> It has been well documented that cumulative sleep loss leads to decreased alertness, poor performance, and negative mood and that repeatedly changing hours of work disrupts an individual's sleep and circadian rhythm.<sup>8-10</sup> According to research, night-shift workers average approximately 25% to 33% less sleep than do day workers or swing-shift workers.<sup>11</sup> Vidacek et al<sup>12</sup> found that workers tend to lose 1 to 4 hours of sleep each night for approximately 3 days after shift rotation.<sup>12</sup> Another study found that approximately 75% of night workers experience sleepiness on their shifts, and approximately 20% report falling asleep while at work.<sup>13</sup> Emergency physicians at Stanford University Hospital were found to have a decline in performance on a battery of tests after working 3 consecutive night shifts.<sup>3</sup> An article in *Academic Medicine* looked at the effects of sleep deprivation and fatigue on residents' performance and found that sleep-deprived house officers can compensate for sleep loss in crisis situations.<sup>14</sup> Sleep-deprived residents, however, were more prone to errors on routine repetitive tasks and tasks that require sustained vigilance. Previous studies to assess the functioning of emergency personnel have not adequately addressed the higher levels of functioning, such as decisionmaking and hypothesis testing.<sup>15-23</sup> Physicians with little sleep may be able to react quickly and to perform tasks previously mastered but may have more difficulty making key decisions and solving complex problems often present in the emergency situation.<sup>24</sup> The purpose of this study is to determine whether physician performance on tasks requiring higher level thinking skills declines after working 5 consecutive night shifts.

---

## MATERIALS AND METHODS

This study compared the cognitive functioning of emergency personnel who have worked no consecutive night shifts with those who have worked 5 consecutive night shifts. This study was conducted at the Geisinger Medical Center, a tertiary-care center with a residency program in emergency medicine and an ED volume of 38,000 patient visits per year. The study was reviewed and approved by the institutional review board, and informed consent was obtained from all study participants. A school psychologist administered the Fluid Scale of the Kaufman Adolescent and Adult Intelligence Test (KAIT) to 16 third-year emergency medicine residents. Test participants included 14 men and 2 women, and their ages ranged from 28 to 37 years. The Fluid Scale of the KAIT consists of 3 subtests: Rebus Learning, Mystery Codes, and Logical Steps. According to the test developers, the Fluid Scale "measures a person's adaptability and flexibility when faced with new problems, using both verbal and nonverbal stimuli." The Fluid Scale measures hypothesis testing and decisionmaking, 2 areas of extreme importance to individuals functioning in the ED. Half of the residents (group A) were tested while working the day shift (a minimum of 3 days), and the other half (group B) were tested after working 5 consecutive night shifts. Testing after the night shift was conducted immediately at the conclusion of the shift at 7 AM. After a minimum interval of 2 months, the residents were retested with the same test in reverse order: group A was tested after working nights, and group B was tested while working days.

A paired *t* test was used to determine whether day-shift KAIT scores were different from night-shift KAIT scores. A 2-sample *t* test was used to determine whether order of testing was associated with KAIT scores. SAS software (version 8.01; Statistical Analysis Systems, Cary, NC) was used for all data manipulations and analysis.

---

## RESULTS

A total of 16 emergency medicine residents were tested. Residents in group A had a mean day shift score of 117.1 (SD=7.2) versus 110.5 (SD=11.4) for the night shift. Residents in group B had a mean day shift score of 121.0 (SD=8.2) and a night shift score of 103.9 (SD=8.3). The mean KAIT score for the combined groups was 119.1 (SD=7.7) on the day shift and 107.2 (SD=10.2) on the night shift (Table). This difference was statistically significant (mean difference=11.9; 95% CI, 7.0 to 16.8; *P*<.001), with the day-shift scores being statistically higher than the night-shift scores. Residents in group B,

who were tested first after working night shifts, had a larger difference between their 2 scores than residents in group A, who were tested first on the day shift (night first: mean difference=17.1 [SD=8.6]; day first: mean difference=6.6 [SD=6.7];  $P=.017$ ). On the basis of these scores, the order of testing with the KAIT (night first or day first) did make a difference. Every physician except 1 had a decline in performance after working 5 consecutive night shifts (Figures 1 and 2). The decline in KAIT scores after working the night shift ranged from 4 to 29 points.

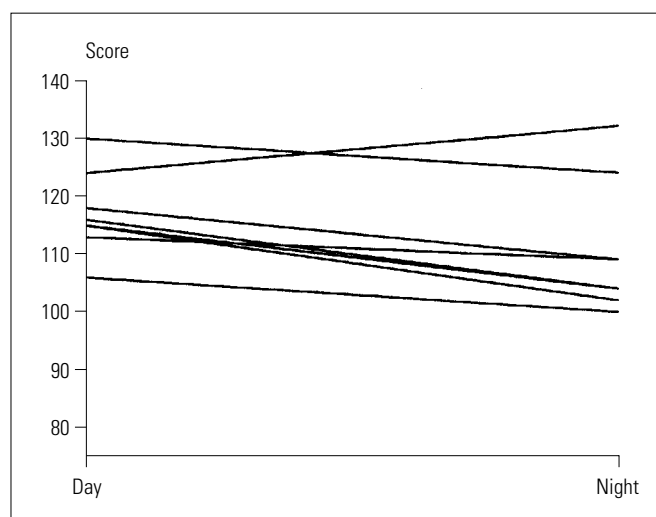
DISCUSSION

A major consideration in choosing emergency medicine as a career is the need to work night shifts. The importance of night-shift coverage is evidenced by hiring practices that stress the willingness of emergency physicians to work nights.<sup>25</sup> Working serial night shifts has a significant effect on sleep patterns. Studies show that persons working nights accumulate a sleep deficit that can lead to disruptions in both physical and mental functioning.<sup>3-6</sup> Emergency medicine groups usually work a series of nights to help the physician adjust their circadian rhythms. Unfortunately, no permanent shift in circadian rhythms occurs in shift rotations that last less than 7 days, suggesting that working a series of nights may not resolve the problems associated with working nights.<sup>6</sup> Working a string of nights for 1 month at a time may be associated with better adaptation to a night schedule and may lead to improved performance, but this has not been proven.<sup>26</sup>

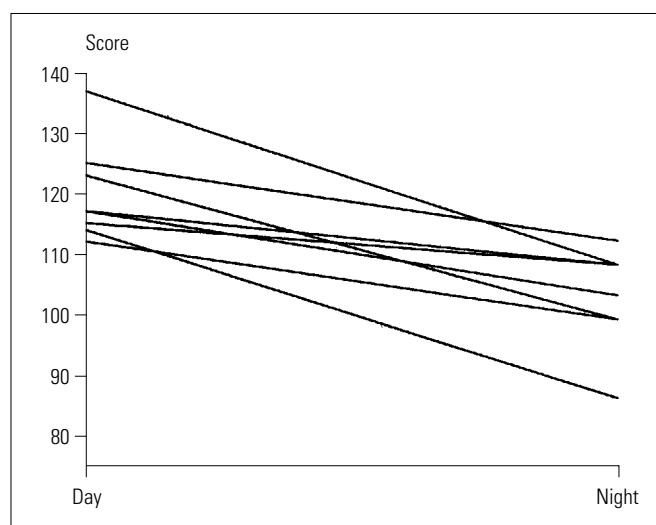
Recent literature on the effects of sleep deprivation describes some of the adverse consequences of working nights. One study of emergency physicians who worked night shifts showed a decline in manual and cognitive performance when working nights. This study involved 6

subjects, and the measure of cognitive functioning was only a hypothetical triage scenario.<sup>2</sup> The review by Samkoff and Jacques<sup>14</sup> of the literature on resident performance after working nights showed a decrease in performance on 11 of 19 short psychomotor tasks. Nursing literature confirms a decline in performance between 4 and 6 AM.<sup>8</sup> Smith-Coggins et al<sup>3</sup> found that emergency physicians

**Figure 1.** KAIT scores by resident for group A (days followed by nights).



**Figure 2.** KAIT scores by resident for group B (nights followed by days).



**Table.**

Mean KAIT scores of emergency physicians working the day shift versus those working the night shift.

	No.	Order	Day Shift (SD)	Night Shift (SD)	Difference (SD)
Group A	8	Day, night	117.1 (7.2)	110.5 (11.4)	6.6 (6.7)*
Group B	8	Night, day	121.0 (8.2)	103.9 (8.3)	17.1 (8.6)*
Total	16		119.1 (7.7)	107.2 (10.2)	11.9 (9.2)†

\* $P=.017$ , group A (mean=6.6 and SD=6.7) versus group B (mean=17.1 and SD=8.6).

†Mean difference=11.9; 95% CI, 7.0 to 16.8;  $P<.001$ .

working nights were slower at intubating a mannequin. The decline in night-shift performance may worsen with age because individuals over the age of 40 years have less ability to adjust to the physiologic effects of sleep loss.<sup>6</sup>

This study is unique because it used a standardized psychological test to evaluate the cognitive performance of physicians. The decline in performance among physicians working a series of night shifts was seen in both group A and group B, with an overall average decline of 11.9 on the KAIT. A change of 15 on a KAIT score represents 1 SD in testing performance. Study participants who took the test for a second time would be predicted to improve their scores because of a practice effect. According to the KAIT manual, individuals who are retested 1 to 3 months after the initial administration tend to score 7.9 points higher.<sup>27</sup> Despite this expected improvement, participants in group A (days followed by nights) still had lower test scores after working night shifts, indicating a substantial decline in cognitive performance after working serial night shifts. Several of the participants in group B (nights followed by days) reported a perception that they performed better after taking the test a second time, when in fact they had done worse. This may be an important factor in emergency medicine scheduling because physicians may overestimate their ability to be effective in working serial night shifts. The cognitive reasoning skills presented to the participants in the KAIT are comparable with those needed in an ED setting. An emergency physician must be able to perform complex problem solving, which includes generating a differential diagnosis and formulating a treatment plan. Emergency physicians working night shifts may still be effective in performing the procedures associated with emergency medicine but may have more difficulty with the more complex cognitive aspects of emergency medicine. More studies are needed to determine when and how sleep deprivation leads to mental fatigue. Measures to mitigate this decline in cognitive performance in physicians who work night shifts need to be studied. Some possible solutions to maintaining physician performance include working shorter stretches of night shifts or working fewer hours on the night shift.

In summary, working a series of 5 continuous night shifts results in a substantial decline in cognitive performance in physicians working in the ED.

Author contributions: DJD designed the study with the assistance of NLD and CH. DJD and CH wrote the proposal. DJD wrote the manuscript, with NLD and CH assisting in its preparation. NLD performed the psychological testing of all study participants. GCW provided the statistical support and prepared the table and figures. DJD takes responsibility for the paper as a whole.

## REFERENCES

- Gordon NP, Cleary PD, Parker CE, et al. The prevalence and health impact of shiftwork. *Am J Public Health*. 1986;76:1225-1228.
- Kuhn G. Circadian rhythm, shift work, and emergency medicine. *Ann Emerg Med*. 2001;37:88-98.
- Smith-Coggins R, Rosekind MR, Buccino KR. The relationship of day versus night sleep to physician performance and mood. *Ann Emerg Med*. 1994;24:928-934.
- Thomas H, Swartz E, Whitehead DL. Eight versus twelve hour shift implications for emergency physicians. *Ann Emerg Med*. 1994;23:1096-1100.
- Smith-Coggins R, Rosekind MR, Buccino KR, et al. Rotating shift work schedules: can we enhance physician adaptation to night shifts? *Acad Emerg Med*. 1997;4:951-961.
- Michaels RD. Night shift work. *Ann Emerg Med*. 1984;13:201-202.
- Dinges DF. Sleepiness and accidents: an overview. *J Sleep Res*. 1995;4(suppl 2):S4-S18.
- Novak, Auvil-Novak SE. Focus group evaluation of night nurse shift work: difficulties and coping strategies. *Chronobiol Int*. 1996;6:457-463.
- Grossman V. Defying circadian rhythm: the emergency nurse and night shift. *J Emerg Nurs*. 1997;23:602-606.
- Czeisler CA, Moore-Ede MC, Coleman RM. Rotating shift work schedules that disrupt sleep are improved by applying circadian principles. *Science*. 1982;217:460-462.
- Akerstedt T, Torsvall L. Shift work, shift-dependent well-being and individual differences. *Ergonomics*. 1981;24:269.
- Vidacek S, Kaliterna L, Radosevik B, et al. Productivity on a weekly rotating shift system: circadian adjustment and sleep deprivation effects? *Ergonomics*. 1986;29:1583-1590.
- Akerstedt T. Sleepiness at work: effects of irregular work hours. In: Monk T, ed. *Sleep, Sleepiness and Performance*. Chichester, UK: John Wiley and Sons; 1991.
- Samkoff JS, Jacques CHM. A review of studies concerning the effects of sleep deprivation and fatigue on resident's performance. *Acad Med*. 1991;66:687-693.
- Rosa RR, Bonnet MH, Cole LL. Work schedule and task factors and upper extremity fatigue. *Hum Factors*. 1998;40:150-158.
- Storer JS, Lloyd HH, Guild VL, et al. Effects of sleep deprivation on cognitive ability and skills of pediatric residents. *Acad Med*. 1989;63:29-31.
- Freidman RC, Bigger TJ, Kornfeld DS. The intern and sleep loss. *N Engl J Med*. 1971;285:201-203.
- Deniasco RA, Drummond AN, Gavenstein JS. The effect of fatigue on performance of a simulated anesthetic monitoring task. *J Clin Monit*. 1987;3:22-24.
- Bartel EJ, Sun JH, Thompson L, et al. The effect of acute sleep deprivation during residency training. *Surgery*. 1988;104:311-315.
- Robbins J, Gotley F. Sleep deprivation and cognitive testing in internal medicine house staff. *West J Med*. 1990;152:82-86.
- Jacques CHM, Lynch JC, Samkoff JS. The effects of sleep loss on cognitive performance of resident physicians. *J Fam Pract*. 1990;130:223-229.
- Asken MJ, Rahan DC. Resident performance and sleep deprivation review. *J Med Educ*. 1983;58:382-388.
- Light AI, Sun JH, McCool C, et al. Effects of acute sleep deprivation on level of resident training. *Curr Surg*. 1989;46:29-30.
- Alexander D, Bushell IW. Coping with night call: part 1: understanding the benefits and challenges of traditional call. *Hosp Physician*. 1999; November: 53-69.
- McNamara RM, Ufberg JW. Emergency physician hiring practices: the effects of certain conditions on employability. *J Emerg Med*. 2000;18:17-20.
- Scheck A. For night shift, a little or a lot works best. *Emerg Med News*. 2000; November: 41.
- Kaufman *Adolescent and Adult Intelligence Test Manual*. Circle Pines, MN: American Guidance Service, Inc; 1993.