

Effects of Fatigue on Driving Safety: A Comparison of Brake Reaction Times in Night Float and Postcall Physicians in Training

PAUL G. TALUSAN, MD
THEODORE LONG, MD
ANDREA HALIM, MD
LAURA GULIANI, BS
NICOLE CARROLL, BS
JOHN REACH, MD

Abstract

Background Concerns about duty hour and resident safety have fostered discussion about postshift fatigue and driving impairment.

Objective We assessed how converting to a night float schedule for overnight coverage affected driving safety for trainees.

Methods Brake reaction times were measured for internal medicine and orthopaedic surgery resident volunteers after a traditional 28-hour call shift and after a night float shift. We conducted matched paired *t* tests of preshift and postshift reaction time means. Participants also completed the Epworth Sleepiness Scale pre- and postshift.

Results From June to July 2013, we enrolled 58 interns and residents (28 orthopaedic surgery, 30 internal

medicine). We included 24 (41%) trainees on night float rotations and 34 (59%) trainees on traditional 28-hour call shifts. For all residents on night float rotations, there was no significant difference pre- and postshift. An increase in reaction times was noted among trainees on 28-hour call rotations. This included no effect on reaction times for internal medicine trainees pre- and postshift, and an increase in reaction times for orthopaedic trainees. For both night float and traditional call groups, there were significant increases in the Epworth Sleepiness Scale.

Conclusions Trainees on traditional 28-hour call rotations had significantly worse postshift brake reaction times, whereas trainees on night float rotations had no difference. Orthopaedic trainees had significant differences in brake reaction times after a traditional call shift.

Introduction

Resident physician duty hours continue to be a focus of the Accreditation Council for Graduate Medical Education (ACGME).¹ In July 2011, the ACGME passed new duty hour guidelines that included a 16-hour limit on interns' length of shift. For many training programs, this change has

meant the adoption of night float, in which trainees work consecutive nights while complying with duty hour restrictions. Changes in work hours have caused significant controversy, and some opponents have cited poor continuity of care and inadequate training time for residents.²⁻⁴ Conversely, proponents of duty hour limits believe eliminating physician fatigue could minimize medical errors.⁵⁻⁷ Studies have suggested that resident physicians are prone to committing errors, and exhibit diminished surgical skills when postcall.^{8,9} Postcall orthopaedic surgery residents have been found to function at a level of impairment comparable with a blood alcohol concentration of 0.08%.¹⁰

Postcall driving safety has been shown to be an impairment for residents, with 49% of residents reporting an episode of falling asleep at the wheel.¹¹ Others have found that postcall residents had a 2.3 times higher risk of motor vehicle crash and a 5.9 times higher risk of a near miss.¹² It is unknown whether trainees on night float rotations have similar impairments as trainees on traditional 28-hour call shifts.

Using a brake reaction time simulator, we measured the brake reaction times among internal medicine and

Paul G. Talusan, MD, and Theodore Long, MD, are co-first authors. At the time of writing, Dr. Talusan was Chief Resident, Department of Orthopaedic Surgery, Yale School of Medicine, and he is now Fellow in Foot and Ankle Surgery, Medstar Union Memorial Hospital; Dr. Long is Robert Wood Johnson Clinical Scholar and Clinical Instructor, Yale School of Medicine; Andrea Halim, MD, is Orthopaedic Resident, Department of Orthopaedic Surgery, Yale School of Medicine; at the time of writing, Laura Guliani, BS, and Nicole Carroll, BS, were students at Boston College; and John Reach, MD, is Associate Professor, Orthopaedics and Rehabilitation, Department of Orthopaedic Surgery, Yale School of Medicine.

Funding: The authors report no external funding source for this study.

Conflict of interest: The authors declare that they have no competing interests.

Corresponding author: Paul G. Talusan, MD, Medstar Union Memorial Hospital, 201 E University Parkway, Baltimore, MD 21218, 617.504.9496, ptalusan@gmail.com

Received January 1, 2014; revision received April 20, 2014; accepted May 5, 2014.

DOI: <http://dx.doi.org/10.4300/JGME-D-14-00006.1>

orthopaedic surgery trainees (interns and residents) in night float and traditional overnight call shifts. Brake reaction time has been used to study how a call shift affects driving impairment.¹³ We hypothesized that trainees on night float shifts would have faster brake reaction times than those on traditional call shifts and that postshift fatigue, as measured using the Epworth Sleepiness Scale, would be increased in both groups.

Materials and Methods

Participants

Trainees in their first to fourth years of training at Yale-New Haven Hospital were approached to participate in this study. Volunteers were recruited by 2 undergraduate research assistants (L.G. and N.C.), and written informed consent was obtained. Subjects were included if they were physicians in training who had driven a car in the previous 6 months. Exclusion criteria included not driving cars regularly or injuries to the lower extremities (sprain, fracture, other lower extremity pain). Subjects were not compensated for participating.

The study protocol was approved by the Yale University Institutional Review Board.

Traditional call shifts were defined as those lasting for 28 hours, beginning at approximately 6 AM and ending the following day at approximately 10 AM. Night float shifts began at 6 PM and ended at 8 AM. We defined night float trainees as those who had worked at least 1 consecutive night prior to the current night shift, in an effort to study the effects of contiguous night shifts in a row. Both internal medicine and orthopaedic surgery trainees had night float and traditional 28-hour call shifts as part of their routine call schedule.

At the beginning of their overnight shift, subjects in internal medicine and orthopaedic surgery filled out a survey that included the Epworth Sleepiness Scale (a subjective measure of a participant’s sleepiness),¹⁴ their age, year in residency, and specialty. Following this, testing assessed preshift reaction times. Subjects were again approached between 7 AM and 9 AM the following morning for postshift survey and reaction time testing.

Driving Simulator

Brake reaction times were recorded using a driving simulator (Vericom), which is a stationary machine used to measure reaction times to a simulation on a computer screen.¹⁵ The simulator was run on a laptop computer equipped with a steering wheel, accelerator, and brake pedal system (Thrustmaster). Images were displayed on a 13-centimeter screen. Participants sat in a chair and were instructed to position the chair to simulate their normal

What was known

Postcall residents have been involved in motor vehicle accidents and near misses that are thought to result from the effects of fatigue.

What is new

A study comparing brake reaction times after traditional call and night float in internal medicine and orthopaedic residents showed no delayed reaction in residents on night float.

Limitations

The study did not assess real driving performance and did not explore other attributes of night float.

Bottom line

Night float may reduce fatigue that could impair residents’ driving performance and safety.

driving position. They were then instructed to depress the accelerator pedal with the right foot until a green light activated. At a random time within a 10-second window, a red light was activated to signal foot transfer to the brake pedal.

Participants were given verbal instructions on how to use the simulator and then underwent 5 practice trials. For the actual assessment, 10 sequential trials were recorded. The fastest and slowest times were discarded, and the researchers calculated the mean brake reaction time response for each participant from the remaining 8 trials.

Analysis

We defined several groups of interest a priori: all interns, all residents, orthopaedic interns and residents, internal medicine interns and residents, those on night float shifts, and those on traditional 28-hour call shifts; we conducted paired sample *t* tests to compare the reaction times for the preshift and postshift averages for each group. We conducted a Wilcoxon signed rank test to compare results from the Epworth Sleepiness Scale for each group. We also calculated the mean number of reported hours slept by each group in the 24-hour period prior to their shift. The threshold for statistical significance was set at *P* ≤ .05 with the null hypothesis that (1) there is no difference between preshift and postshift reaction times, and (2) there is no difference between preshift and postshift Epworth Sleepiness Scale results. Analyses were conducted using Stata version 13.0 (StataCorp LP).

Results

From June to July 2013, 61 preshift simulations and 58 postshift simulations were conducted. Three simulations were excluded from the analysis because no postshift data were recorded. Characteristics of the enrolled trainees are shown in TABLE 1.

TABLE 1 CHARACTERISTICS OF TRAINEES

Trainee Characteristics	n (%)
PGY-1	14 (24)
PGY-2	19 (33)
PGY-3	22 (38)
PGY-4	3 (5)
Internal medicine	30 (52)
Orthopaedic surgery	28 (48)
Night float shift	24 (41)
Traditional 28-hour call shift	34 (59)

Abbreviation: PGY, postgraduate year.

We found an overall increase in reaction times for postcall trainees compared to precall trainees ($P = .03$). We stratified our sample into internal medicine interns and residents, orthopaedic surgery interns and residents, all interns, and all residents (TABLE 2). We then analyzed reaction times comparing trainees on night float to trainees on traditional call shifts (TABLE 2).

We compared the preshift and postshift Epworth Sleepiness Scale results for all trainees and found a higher mean score in the postshift group ($P < .001$). We also compared mean results for all night float and non-night float trainees (TABLE 3). The number of hours slept in the 24 hours prior to the shift is displayed in TABLE 3.

Discussion

After a traditional 28-hour call shift, trainees had significantly worse brake reaction times than they did prior to their shift, whereas trainees on night float rotations had nonsignificant increases in brake reaction times postshift. Both groups had higher postshift scores on the Epworth Sleepiness Scale, which suggests that participants in each group were sleepier postshift, despite the fact that the night float group had no significant difference in brake reaction times. Our results are consistent with those of previous studies that showed impaired driving after a call shift, and our finding that there was no change postshift in the night float group suggests that driving safety after a night float shift may be improved compared to a traditional 28-hour call shift.

Several studies have examined postcall driving safety among trainees. Before the implementation of the current ACGME duty hour restrictions, 23% of pediatric residents reported falling asleep while driving, and 44% reported falling asleep while stopped at a traffic light, with 90% of these events occurring postcall.¹¹ After the ACGME duty hour restrictions, 11.3% to 18.5% of residents reported having postcall motor vehicle collisions,^{16,17} and 43.3% reported near miss incidents after a stressful day at work.¹⁷ In addition, 31% to 40% of residents reported falling asleep while driving after a call shift.^{16,18} A survey of 2737 interns found an odds ratio of 2.3 for motor vehicle collisions and 5.9 for near miss incidents postcall.¹²

Arndt et al¹³ studied a group of residents stratified into light call and heavy call groups. Using a driving simulator, participants on heavy call rotations had impairment

TABLE 2 REACTION TIMES FOR TRAINEES BY PGY AND SPECIALTY

Trainee PGY Level and Specialty	Preshift Mean (ms) $\pm$ SD	Postshift Mean (ms) $\pm$ SD	Effect Size (Difference Between Preshift and Postshift Means in ms)	P Value
All interns and residents	554 $\pm$ 10	570 $\pm$ 10	16	.03
Internal medicine interns and residents	576 $\pm$ 76	579 $\pm$ 66	3	.76
Orthopaedic surgery interns and residents	531 $\pm$ 81	561 $\pm$ 81	30	.007
All interns	552 $\pm$ 71	573 $\pm$ 55	21	.16
All residents	555 $\pm$ 84	569 $\pm$ 79	14	.09
Participants on night float shift	556 $\pm$ 0.081	561 $\pm$ 0.062	5	.65
Participants on traditional 28-hour call shift	554 $\pm$ 0.082	577 $\pm$ 0.081	23	.01

Abbreviation: PGY, postgraduate year.

TABLE 3 EPWORTH SLEEPINESS SCALE SCORES				
	Preshift Mean Score ± SD	Postshift Mean Score ± SD	P Value	Hours Slept in 24-hour Period Prior to Shift ± SD
Internal medicine interns and residents	6.862 ± 0.641	12.414 ± 0.890	< .001	6.672 ± 0.256
Orthopaedic surgery interns and residents	8.690 ± 1.023	14.827 ± 0.756	< .001	6.465 ± 0.349
All interns	8.143 ± 1.005	14.071 ± 0.788	< .001	6.714 ± 0.459
All residents	7.659 ± 0.743	13.477 ± 0.754	< .001	6.523 ± 0.245
Participants on night float shift	8.125 ± 0.960	13.375 ± 0.912	< .001	6.292 ± 0.320
Participants on traditional 28-hour call shift	7.529 ± 0.800	13.794 ± 0.806	< .001	6.765 ± 0.288

comparable to participants on light call rotations with a blood alcohol concentration of 0.04% to 0.05%.¹³ Participants on light call rotations who were not treated with alcohol performed significantly better than the other groups. In this study, the difference in brake reaction times on light call rotations with the addition of alcohol was just over 20 milliseconds, which is a similar effect size to our finding that trainees had an increase in brake reaction time of 23 milliseconds after a 28-hour call shift. This difference suggests that trainees may also have worse reaction times in other aspects of driving, similar to how alcohol ingestion is known to cause not only slower reaction times but also unsafe driving in general.¹⁹ In contrast, we did not find a significant difference in brake reaction times among trainees on night float rotations pre- and postshift. Our study supports the idea that the impairment in brake reaction times that was found in the group of trainees after a 28-hour shift may be ameliorated through implementing night float for overnight coverage.

In comparing orthopaedic trainees to internal medicine trainees, we found that orthopaedic trainees had significantly slowed postcall brake reaction times, whereas internal medicine trainees did not show a significant preshift to postshift change. Several factors may contribute to this finding, including shift intensity, hours slept at night, and number of calls in the period before the study. This suggests that the optimal shift length to promote driving safety may be different for internal medicine and orthopaedic surgery trainees. Characterizing the differences in call shifts among each of these groups could be important in designing schedules to promote driving safety.

Our study has several limitations. First, the driving simulator used in this study has not been compared to a true driving situation. Of note, other groups of participants, including patients undergoing knee arthroplasty, have used the same Vericom driving simulator and have had faster brake reaction times compared to trainees in our

study.¹⁵ Also, participants were recruited at the beginning and end of a shift, but we were not able to determine how long a resident had been on a particular rotation or in the night float schedule. Another limitation is that we were unable to control for call shift intensity, volume, or complexity of work.

Additionally, although our results suggest that driving safety may be improved by the use of night float, this conclusion should not be taken in isolation. There are educational tradeoffs with night float rotations, such as general night shift considerations and having less time for didactic learning, that are important to take into account when structuring night float and traditional call schedules.

Conclusion

Our findings support the hypothesis that residents on traditional postcall have slower brake reaction times postshift, whereas residents on a night float schedule do not exhibit a slowing of brake reaction times. Further research is needed to elucidate whether residents on night float drive more safely.

References

1 Accreditation Council for Graduate Medical Education. ACGME Duty Hours. <http://www.acgme.org/acgmeweb/tabid/271/GraduateMedicalEducation/DutyHours.aspx>. Accessed January 1, 2014.

2 Antiel RM, Reed DA, Van Arendonk KJ, Wightman SC, Hall DE, Porterfield JR, et al. Effects of duty hour restrictions on core competencies, education, quality of life, and burnout among general surgery interns. *JAMA Surg.* 2013;148(5):448–455.

3 Charap M. Reducing resident work hours: unproven assumptions and unforeseen outcomes. *Ann Intern Med.* 2004;140(10):814–815.

4 De Martino RR, Brewster LP, Kokkosis AA, Glass C, Boros M, Kreishman P, et al. The perspective of the vascular surgery trainee on new ACGME regulations, fatigue, resident training, and patient safety. *Vasc Endovascular Surg.* 2011;45(8):697–702.

5 Buysse DJ, Barzansky B, Dinges D, Hogan E, Hunt CE, Owens J, et al. Sleep, fatigue, and medical training: setting an agenda for optimal learning and patient care. *Sleep.* 2003;26(2):218–225.

6 Fletcher KE, Parekh V, Halasyamani L, Kaufman SR, Schapira M, Ertl K, et al. Work hour rules and contributors to patient care mistakes: a focus group study with internal medicine residents. *J Hosp Med.* 2008;3(3):228–237.

- 7 Mansukhani MP, Kolla BP, Surani S, Varon J, Ramar K. Sleep deprivation in resident physicians, work hour limitations, and related outcomes: a systematic review of the literature. *Postgrad Med.* 2012;124(4):241–249.
- 8 Veasey S, Rosen R, Barzansky B, Rosen I, Owens J. Sleep loss and fatigue in residency training: a reappraisal. *JAMA.* 2002;288(9):1116–1124.
- 9 Gerdes J, Kahol K, Smith M, Leyba MJ, Ferrara JJ. Jack Barney Award: the effect of fatigue on cognitive and psychomotor skills of trauma residents and attending surgeons. *Am J Surg.* 2008;196(6):813–819; discussion 819–820.
- 10 McCormick F, Kadzielski J, Landrigan CP, Evans B, Herndon JH, Rubash HE. Surgeon fatigue: a prospective analysis of the incidence, risk, and intervals of predicted fatigue-related impairment in residents. *Arch Surg.* 2012;147(5):430–435.
- 11 Marcus CL, Loughlin GM. Effect of sleep deprivation on driving safety in housestaff. *Sleep.* 1996;19(10):763–766.
- 12 Barger LK, Cade BE, Ayas NT, Cronin JW, Rosner B, Speizer FE, et al. Extended work shifts and the risk of motor vehicle crashes among interns. *N Engl J Med.* 2005;352(2):125–134.
- 13 Arnedt JT, Owens J, Crouch M, Stahl J, Carskadon MA. Neurobehavioral performance of residents after heavy night call vs after alcohol ingestion. *JAMA.* 2005;294(9):1025–1033.
- 14 Johns MW. Reliability and factor analysis of the Epworth Sleepiness Scale. *Sleep.* 1992;15(4):376–381.
- 15 Dalury DF, Tucker KK, Kelley TC. When can I drive?: brake response times after contemporary total knee arthroplasty. *Clin Orthop Relat Res.* 2011;469(1):82–86.
- 16 Fruchtman Y, Moser AM, Perry ZH. Fatigue in medical residents—lessons to be learned. *Med Lav.* 2011;102(5):455–463.
- 17 West CP, Tan AD, Shanafelt TD. Association of resident fatigue and distress with occupational blood and body fluid exposures and motor vehicle incidents. *Mayo Clin Proc.* 2012;87(12):1138–1144.
- 18 Saklani AP, Shafi M, Nagabhushan J, Delicata RJ. A survey of the safety of doctors driving home after a night 'on call'. *Hosp Med.* 2003;64(9):552–554.
- 19 Liguori A, D'Agostino RB Jr, Dworkin SI, Edwards D, Robinson JH. Alcohol effects on mood, equilibrium, and simulated driving. *Alcohol Clin Exp Res.* 1999;23(5):815–821.