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A Combined Field and Laboratory Design for Assessing the Impact of Night Shift Work on Police Officer Operational Performance

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Objectives: This study assessed the utility of a combined field and laboratory research design for measuring the impact of consecutive night shift work on the sleepiness, vigilance, and driving performance of police patrol officers.

Design: For police patrol officers working their normal night shift duty cycles, simulated driving performance and psychomotor vigilance were measured in a laboratory on two separate occasions: in the morning after the last of five consecutive 10.7-h night shifts, and at the same time in the morning after three consecutive days off duty. Order of participation in conditions was randomized among subjects.

Setting: Subjects experienced manipulation of sleep schedules due to working night shifts in a real operational environment, but performance testing was conducted under controlled laboratory conditions.

Participants: N = 29 active-duty police patrol officers (27 male, 2 female; age 37.1 ± 6.3 years) working night shift schedules participated in this study.

Results: Simulated driving performance, psychomotor vigilance, and subjective sleepiness were significantly degraded following 5 consecutive night shifts as compared to 3 consecutive days off duty, indicating that active-duty police officers are susceptible to performance degradation as a consequence of working nights.

Conclusions: This combined field and laboratory research design succeeded in bridging the gap between the realism of the operational environment and the control of laboratory performance testing, demonstrating that this is a useful approach for addressing the relationship between shift work induced fatigue and critical operational task performance.

Keywords: Night and shift work, research design, police, operational performance, high fidelity driving simulator, motor vehicle crash risk, psychomotor vigilance test (PVT), performance impairment, subjective sleepiness

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INTRODUCTION

Police officers frequently work irregular and extended shifts,[1] including night shifts that conflict with the endogenous circadian (24-hour) rhythm in sleep propensity and waking alertness. As with all shift workers, police officers on night shifts are subject to the adverse neurobiological effects of this circadian conflict on nighttime performance and their ability to sleep during the day. Research also indicates that police shift work is associated with a high prevalence of sleep disorders, adverse health outcomes, and self-reported drowsy driving.[2] Thus, police officers, like other shift working populations, experience adverse sleep and performance effects that are likely to degrade driving ability[3] and decision-making[2] under even the best of circumstances. However, prior epidemiological, field, and survey research techniques have not been able to determine the *extent* to which these risk factors affect the ability of police to perform operational tasks such as driving and decision making in emergency situations and confrontations, or their general ability to interact effectively with people.

Each of the roughly 800,000 sworn police officers serving in nearly 18,000 independent agencies across the United States[1] is required to perform and make decisions in high-risk, complex, ambiguous, and highly variable situations which unfold rapidly in uncontrolled environments. Every one of the dozens of encounters that officers have with people each day contains the possibility of serious injury or death.[2] The highly variable nature of police work, combined with the necessity for shift work and 24-h a day operations can be expected to diminish operational performance, judgment, and decision-making—and increase the probability of serious injury or death for officers, suspected criminals, and bystanders.

In this pilot study, we tested the utility of a novel combined field and laboratory research design for assessing performance risks associated with police patrol work by exploring the impact of consecutive night shifts on officers' driving, vigilance, and deadly force decision-making. Operational performance was assessed using high-fidelity driving and deadly force training simulators that are widely used by police agencies, which we have adapted for use as laboratory measurement devices. The results reported here confirm the usefulness of this novel research design for studying the impact of shift work on police operational performance.

METHODS

Twenty-nine active-duty police patrol officers (27 male, 2 female; age 37.1 ± 6.3 years) participated in this study. All subjects were recruited from a single, larger-sized (> 200 officer) police department in the state of Washington that is representative of similarly sized agencies in the United States. Officers were fit for duty by their department's standards and were working night patrol assignments starting between 19:00 and 20:00. The Institutional Review Board of Washington State University reviewed and approved the study. Each

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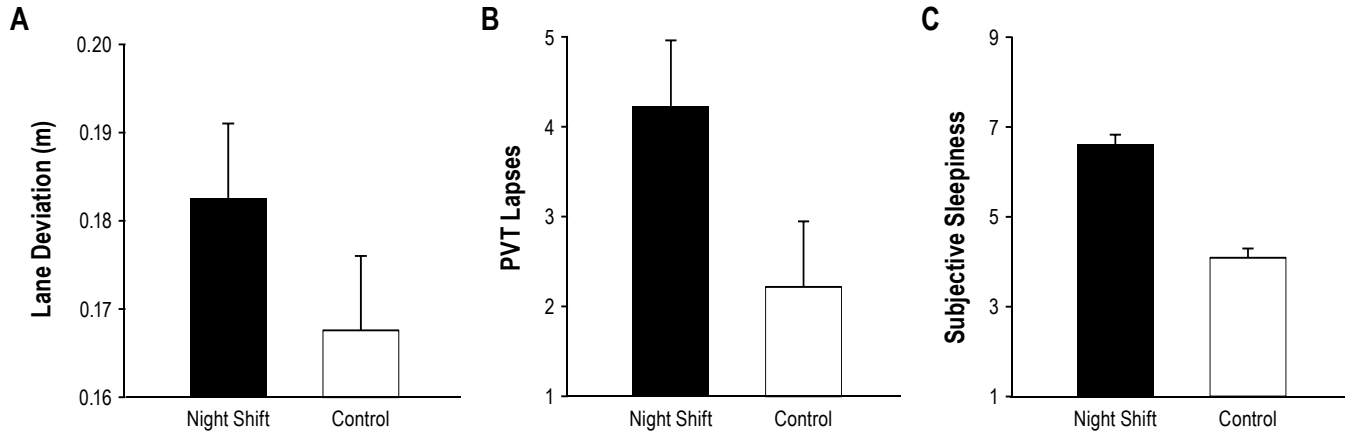

Figure 1—Means (and standard errors) of **(A)** high-fidelity driving simulator performance, **(B)** psychomotor vigilance test (PVT) performance, and **(C)** Karolinska Sleepiness Scale (KSS) subjective sleepiness, in the morning after the last of 5 consecutive night shifts (black) and after 3 consecutive days off duty (white).

subject gave written informed consent prior to participation in the study.

Officers participated in 2 separate testing sessions during their normal night shift duty cycle of 5 consecutive nights on duty, followed by 4 or 5 consecutive days off duty. In the post-shift condition, subjects reported to the laboratory for performance testing immediately following the last of 5 consecutive 10.7-h night shifts. In the control condition, the same subjects reported to the laboratory for performance testing at the same time in the morning after 3 consecutive days off duty. Each testing session began between the hours of 06:00 and 07:30 and lasted approximately 2 h, ending between 08:00 and 09:30. The order of conditions was randomized among the subjects and used as a covariate in the analysis of the data. Officers were allowed to use caffeine normally while in the field, out of concern for their safety because of the high prevalence of caffeine use as a fatigue countermeasure, but were restricted 1 h prior to and during each testing session.

In each of the 2 conditions, officers performed 2, 30-min driving sessions in a high-fidelity driving simulator, and 4, 10-min psychomotor vigilance test (PVT) bouts.

They also completed the Karolinska Sleepiness Scale (KSS) questionnaire twice. To approximate the rigors of the operational environment in a standardized fashion, a 20-min simulated deadly force decision-making task was incorporated into the study design. The testing sequence was KSS, PVT, deadly force simulation, PVT, driving simulation, PVT, driving simulation, PVT, KSS.

Driving performance was tested using a PatrolSim IV high-fidelity driver training simulator (L3, Salt Lake City, UT.) adapted by us to enable research data collection. Subjects drove standardized driving scenarios on low-traffic rural highways which were developed for previous research exploring the effects of fatigue on simulated driving performance.[3] Because of the relatively low distraction load of these drives, we consider them to be a conservative test of driving performance among this occupational group. Lane deviation, calculated as the standard deviation of lateral lane position (expressed in meters), was used as the primary measure of simulated driving performance.[3] The 10-min PVT was administered on a hand-held smartphone device, and performance on this task was calculated as the number of lapses of attention (reaction times > 500 ms). The Karolinska Sleepiness Scale was administered with paper and pencil, and yielded a subjective sleepiness score ranging from 1 (very alert) to 9 (very sleepy).

Subjects were introduced to the driving simulator task and the PVT during a screening session conducted prior to the first laboratory testing session. During screening, officers were acclimated to the simulator by a 10-min test drive followed by a full 30-min practice drive, with a break of approximately 20 min between the 2 drives. Subjects were also taught to operate the PVT, and practiced the task for 5 min. Additionally, they completed a Pittsburgh Sleep Quality Inventory (PSQI), an Epworth Sleepiness Scale (ESS), and a Multivariate Apnea Prediction Screening (MAPS) questionnaire. The values from the PSQI (M = 6.03, SD = 2.64) and the ESS (M = 8.00, SD = 2.67) indicated that this group was experiencing both diminished sleep quality[4] as well as high levels of fatigue.[5] Additionally, the MAP values (M = 0.32, SD = 0.20) showed a high apnea prediction rate[6] among this group of police officers. These risk factors are consistent with findings from other research on police sleep and fatigue in the United States.[1,7]

Mixed-effects ANOVA was used to analyze the effects of condition on driving simulator lane deviation, number of PVT lapses, and subjective sleepiness score. Order of conditions (post-shift first versus control first) was included as a covariate in the analysis of all 3 dependent measures. Additionally, simulator device also was used as a covariate in the analysis of driving performance to control for any difference between the 2 driving simulators. Two subjects crashed during simulator driving in the post-shift condition, providing a dramatic example of performance impairment following night shift work. However, crashing ended those driving simulations sessions prematurely and thus rendered their data incomplete. To be conservative in hypothesis testing, we discarded the driving data from the 2 subjects who crashed. Five subjects' PVT data were discarded because they performed an abbreviated 5-min version of the PVT instead of the full 10-min version, due to an inadvertent deviation from the study protocol. Therefore, for data analysis, we included driving data from 27 subjects, PVT data from 24 subjects, and KSS data from all 29 subjects.

RESULTS

There were significant effects for condition on the 3 dependent measures: driving simulator lane deviation ($F1,78 = 6.78$, $P = 0.011$), PVT lapses of attention ($F1,161 = 16.4$, $P < 0.001$), and subjective sleepiness ($F1,84 = 97.0$, $P < 0.001$). As Figure 1 shows, simulator driving and PVT performance were degraded considerably, and subjective sleepiness was higher in the post-shift condition relative to the control condition. Subjective sleepiness also increased significantly across KSS administrations during each testing session ($F1,84 = 70.1$, $P < 0.001$), and showed a significant condition by session interaction ($F1,84 = 8.3$, $P = 0.005$) with the increase across KSS administration being steepest for the post-shift condition. Additionally, lane deviation ($F1,78 = 10.43$, $P = 0.002$) and PVT lapses ($F1,161 = 10.30$, $P < 0.001$) also increased across administrations during each testing session, although no significant condition by session interaction effect was found for either variable.

DISCUSSION

This unique study tested the utility of using a combination of controlled laboratory-based measures of driving performance, vigilance and sleepiness with active-duty police officer subjects whose fatigue was obtained in the field by working actual night shifts as part of their normal duty cycle. Officers exhibited significantly degraded simulated driving performance, impaired vigilance, and increased subjective sleepiness in the morning following 5 consecutive night shifts, as compared to the same time of day following 3 days off duty.

Degraded driving simulator performance and impaired vigilance have real-world implications for police officers operating motor vehicles. Despite declining motor vehicle fatality rates for the general public, rates for police officers have trended upward over the past 2 decades[8] and account for more than one-third of all police fatalities.[9] These on-duty collisions are most common between midnight and 08:00 and generally are *not* associated with emergency driving.[10] This is worth noting because it highlights the elevated risks of driving home at the height of fatigue for police, medical personnel and other night-shift workers.

Our findings suggest that increased police crash rates seen in the overnight hours may be a consequence of significant functional deficits accrued when working night shifts. Thus, the motor-vehicle related accident risk of police officers could be reduced through improved fatigue risk management approaches that account for prior sleep and for work-shift timing, such as those being implemented by the military and the transportation industries.

Shift workers in general have an elevated risk for performance impairment due to circadian rhythm conflicts, long work hours, and diminished sleep quality and duration. Many of them work in complex operational environments where performance errors can have catastrophic effects, making them especially important populations to investigate. However, it often is difficult to study these workers in controlled laboratory settings because of the expense and inconvenience of taking them off of the job for extended periods of time. It also is difficult to adequately replicate fatigue accumulated in the diverse, complex, high-risk, low-information, real-world operational settings such as police and similar occupational groups work. Field study designs provide a way to overcome these difficulties, but are less controlled and thus more subject to bias, unintentional confounds and measurement noise. Combining controlled laboratory testing with actual shift work done in the field can provide an efficient and accurate way to assess the effects of shift work on operational performance. Using high-fidelity training simulators as research tools in designs such as this adds additional benefits, because the face validity of realistic training simulators is obvious to practitioners, administrators, policy makers and the public, which facilitates translation of research to practice.

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