Programs of the Federal Motor Carrier Safety Administration (FMCSA) encompass a range of issues and disciplines related to motor carrier safety and security. FMCSA's Office of Analysis, Research and Technology defines a "research program" as any systematic study directed toward fuller scientific discovery, knowledge, or understanding that will improve safety, and reduce the number and severity of commercial motor vehicle crashes. Similarly, a "technology program" is a program that adopts, develops, tests, and/or deploys innovative driver and/or vehicle best safety practices and technologies that will improve safety and reduce the number and severity of commercial motor vehicle crashes. An "analysis program" is defined as economic and environmental analyses done for agency rulemakings, as well as program effectiveness studies, state-reported data quality initiatives, and special crash and other motor carrier safety performance-related analyses. A "large truck" is any truck with a Gross Vehicle Weight rating or Gross Combination Weight rating of more than 10,000 pounds.

Currently, the FMCSA Office of Analysis, Research and Technology is conducting programs in order to produce safer drivers, improve safety of commercial motor vehicles, produce safer carriers, advance safety through information-based initiatives, and improve security through safety initiatives. The study described in this Tech Brief was designed and developed to support the strategic objective to produce safer drivers. The primary goals of this initiative are to ensure that commercial drivers are physically qualified, trained to perform safely, and mentally alert.

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Duration Restart Period Needed to Recycle with Optimal Performance: Phase II

The objective of this Phase II project was to determine whether a restart period involving two biological nights of sleep would be more effective in restoring performance in individuals working night shifts under the hours of service (HOS) regulations governing property-carrying commercial motor vehicle (CMV) drivers than the current 34-hour restart provision. Building on the Phase I project, which evaluated the 34-hour restart using two groups of drivers, one operating in daylight and one at night, this new study with nocturnal duty periods and a restart period that includes two biological nights was undertaken using a within-subjects in-laboratory experimental study design with testing of cognitive performance task and high-fidelity driving simulator performance.

BACKGROUND

The current Federal Motor Carrier Safety Administration HOS regulations for property-carrying CMV drivers prescribe that drivers: 1) may drive 11 hours in a 14-hour window after coming on duty following 10 consecutive hours off duty; 2) may not drive after 60/70 hours on duty in 7/8 consecutive days; and 3) may restart a 7/8 consecutive day period after taking 34 or more consecutive hours off duty (the 34-hour restart rule). However, the 34-hour restart rule only partially addresses circadian rhythms in both performance and sleep propensity.

The Phase I research project showed that while the 34-hour restart was effective at maintaining performance during daytime duty periods, it was generally not effective at maintaining performance in individuals scheduled to be awake during the night. The primary outcome variable was performance on the well-validated, 10-minute psychomotor vigilance test (PVT), which was administered eight times per duty period. Subjects were randomized to one of two study conditions. In the "best case" condition involving daytime duty periods, PVT performance was statistically indistinguishable during the "week" (5 days with 14 duty hours per day) before and after a 34-hour restart period. In contrast, in the "worst case" condition involving nighttime duty periods, PVT performance was significantly degraded during the "week" after the 34-hour restart period.

The total duration of the sleep opportunities in the 34-hour restart period was the same for the "worst case" condition as for the "best case" condition. However, the 34-hour restart period in the "worst case" condition included only one biological night (i.e., nocturnally placed sleep opportunity), whereas the 34-hour restart period in the "best case" condition included two biological nights.

METHODOLOGY

A sample of 12 healthy male subjects was studied in a within-subjects comparison of two 5-day work periods separated by a restart period containing two biological nights. The two 5-day work periods entailed nighttime wakefulness and work (14-hour/day) and daytime sleep. The restart break involved temporarily transitioning back to a daytime schedule.

The main goal of the study was to evaluate whether the two-night restart period was effective at maintaining performance. To this end, performance on a variety of cognitive performance tasks and on a high-fidelity driving simulator was measured throughout the study. The primary performance outcome measure was the number of lapses (reaction times greater than 500 milliseconds) on a 10-minute PVT.

Average PVT performance in the 5-day work period after the restart break was not significantly different from that in the 5-day work period before the restart break, indicating that the two-night restart period was effective at maintaining performance. However, there was a transient, modest degradation of performance on the day immediately following the two-night restart period. Further, the restart period was only partially effective with respect to other outcome measures, including lane deviation in a high-fidelity driving simulator.

Secondary analyses compared the study results to the effects of a 34-hour restart period as examined previously in the Phase I research project. These analyses indicated that, in the context of nighttime wake/work schedules, the inclusion of two nights in the restart break was an improvement over the 34-hour duration across a range of outcome measures. The extra sleep opportunity (i.e., second biological night) associated with the restart period appeared to be responsible for this improvement.

KEY FINDINGS

This Phase II study followed up on the findings of Phase I, which revealed that the effectiveness of the 34-hour restart provision in the HOS regulations depends on circadian timing. Specifically, the Phase I study revealed that 34 hours off duty was insufficient to restore performance for a 5-day work schedule involving nighttime wakefulness (and daytime sleep), while transitioning back to a daytime schedule during the restart period. The present Phase II study investigated whether for such a schedule, extending the restart period by 24 hours, to include an additional biological night, would result in greater recuperation. In keeping with the experimental procedures established in Phase I, an in-residence laboratory research study was conducted in Phase II to examine the effects of the two-night restart, using the results of Phase I for reference.

The effectiveness of the restart period containing two biological nights in maintaining performance overall across the two 5-day work periods does not imply that there were no performance deficits during these nocturnal work periods. In agreement with key principles of sleep/wake physiology, PVT performance deteriorated during each nighttime waking period. However, the level of nocturnal performance deterioration was not significantly greater after the 58-hour restart period that the study used than before. This is in contrast with the 34-hour restart period examined in Phase I, which was not as effective at preserving performance across two 5-day nighttime work periods. As such, extending the restart period from 34 hours to 58 hours constituted an improvement with regard to the effectiveness of the restart period in the context of working nights.

Important for the interpretation of the findings from the Phase II study is the fact that transition sleep opportunities were scheduled as part of the revised restart period. These essentially served as prophylactic naps, which are known to be effective countermeasures for cognitive performance impairment. It is possible that without such strategic napping, performance following the restart period would have shown increasing deficits. It should also be noted that the research subjects were carefully screened healthy young males. Had the researchers studied a sample with sleep apnea or other medical conditions, the expected performance deficits would have been greater.

It should be noted that the driving simulator scenarios (roads, routes, events, conditions, etc.) were standardized, with randomized pedestrian/dog crossing events, across the driving performance time points of the Phase II study (using the same scenarios as employed in Phase I). The scenarios did not control for the lower traffic density or reduced visibility typically associated with nighttime driving. As such, the driving simulator findings should be interpreted as indicative of basal capability for driving rather than actual driving performance in the real world. Further research is needed to study the effectiveness of the tested restart break in terms of real-world driving performance, safety, and cost.

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Duration of Restart Period Needed to Recycle with Optimal Performance: Phase II (Report No. FMCSA-RRR-10-062)

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CONCLUSIONS

The study data showed no significant difference in PVT lapses between the pre-restart and post-restart work periods overall, indicating that a restart period that includes two nights was effective at maintaining performance. Thus, the null hypothesis that the tested restart period would be effective at maintaining performance was not rejected.

A caveat to this finding is that there was a transient, modest degradation of performance on the day immediately following the restart period. This effect was not seen in Phase I following the 34-hour restart period, suggesting that the increased effectiveness of the two-night restart period for nighttime work schedules comes at the cost of minor difficulty to re-adjust to a nighttime schedule after the daytime-oriented restart break. If a nighttime wake schedule were to be maintained during the two-night restart period, it is possible that gradual circadian adjustment would have occurred, potentially eliminating the post-restart transient performance degradation. The real-world utility of this possibility is questionable, though, as it is improbable that many individuals would elect to maintain a permanent night shift schedule if given the choice.

Objective performance and subjective sleepiness and mood outcomes varied in the extent to which they were preserved during the experimental 5-day nocturnal work period following the restart break. Thus, whereas the tested restart break was more effective at maintaining waking function than the 34-hour duration previously studied in Phase I, whether the effectiveness was sufficient depended on which outcome measure was considered. For lane deviation during simulated driving, which may have been the most operationally relevant outcome measure in this laboratory study, the two-night restart break was not fully effective as compared to the daytime work condition studied previously in Phase I. However, whether increasing the duration of the restart period even more would make a substantive difference is not certain, as circadian factors may prevent further improvement in nighttime work schedules.

The research subjects in this study were healthy young adults with no sleep disorders, and their scheduled sleep times were protected from outside interruptions. However, sleep apnea and other medical conditions are common among CMV drivers. Furthermore, drivers may experience logistical difficulties protecting time to sleep because of family and other responsibilities; and they may obtain less or degraded sleep when sleeping in a sleeper berth or in unfamiliar environments. Nevertheless, it would still be expected to hold that a two-night recovery period entails a relative improvement over 34 hours for the duration of the restart period in the context of nighttime operations. That said, validation of the study findings in a sample of CMV drivers in a real-world field study is important.

Although this study specifically examined the effectiveness of a 58-hour restart period, it is important to note that the restart period included two biological nights of sleep. Given what is currently known about sleep, circadian rhythms and cognitive performance, it is clear that the observed benefits of the 58-hour restart period (relative to 34 hours) were not simply a function of having increased time off. Rather, they were due to the fact that the 58-hour restart allowed for two sleep periods with circadian timing conducive for sleep (i.e., nighttime on the biological clock). Therefore, when considering the findings of this study in operational scheduling practices, the restart period does not necessarily need to be 58 hours in duration—the critical factor is that the restart period should include two opportunities for sleep during biological night. The study findings highlight the importance of considering the principles of sleep/wake physiology and circadian effects on fatigue and performance in HOS regulations.