EXTENDED WORKDAYS: EFFECTS OF 8-HOUR AND 12-HOUR ROTATING SHIFT SCHEDULES ON TEST PERFORMANCE, SUBJECTIVE ALERTNESS, SLEEP PATTERNS, AND PSYCHOSOCIAL VARIABLES

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ABSTRACT

A newly instituted 3-4 day/12-hr rotating shift schedule was compared to the previous 5-7 day/8-hr schedule using standard laboratory-type measures of performance and alertness, and a questionnaire on sleep patterns and other personal habits. After seven months adaptation to the new schedule, a preliminary analysis indicated that there were some decrements alertness, reductions in sleep, and disruptions of other personal activities during 12-hr workdays. Gastro-intestinal state improved during night shift, however, and increases in self-reported stress were reduced by the shortened workweek. These results are discussed in terms of trade-offs between longer workdays and shorter workweeks. It is emphasized that, at this time, no determination can be made of the extent of risk associated with these changes in alertness.

The interest of the National Institute for Occupational Safety and Health (NIOSH) in extended workdays is in response to increasing implementation of 'compressed' workweeks employing workshifts of 10-12 hrs. The use of extended workdays has led to concerns about safety and health hazards attributable to cumulative fatigue. Consequently, NIOSH has embarked upon a research program evaluating the effects of 12-hr days on performance efficiency and subjective alertness and fatigue. We have developed a battery of standardized measures which can be administered on portable microcomputers at the worksite to assess changes in performance and subjective alertness in relation to hours of work. Laboratory simulations have indicated that these measures are sensitive to long hours of work. The present study is the first field investigation where the test battery is being used to compare 8-hr to 12-hr rotating shifts. It occurred at the Fast Flux Test Facility, a U.S. Department of Energy research nuclear reactor managed by the Westinghouse-Hanford Corporation. In an attempt to make shiftwork more tolerable, the plant was recently switched from a 5-7 day workweek with three 8-hr rotating shifts to a 3-4 day workweek with two 12-hr rotating shifts. In cooperation with Pacific Northwest Laboratory, NIOSH provided assistance in evaluating the new schedule in terms of the health and alertness of the operators. Specifically, we implemented 'round-the-clock testing of performance and subjective alertness, and administered a daily questionnaire quantifying subjective reports of sleep patterns and other personal habits affected by shiftwork. This paper is a preliminary report on the results of the evaluation. Another preliminary report on the effect of the schedule change on plant performance, additional measures of subjective alertness, attrition, etc. is presented in another paper in this volume (Lewis and Swaim).

Performance and Alertness Tests

The NIOSH computerized test battery is a flexible instrument designed to evaluate a range of psychological functions including : cognitive, perceptual-motor, and motor skills as well as subjective alertness or fatigue. The measures are brief to minimize interference with the worker's regular job. Any number of tests can be selected as general performance measures or as analogs to specific job demands. It was our impression that reactor control room operation placed a large demand on cognitive and monitoring abilities. Therefore, a test of mental arithmetic (digit addition) and a test of grammatical reasoning while simultaneously monitoring a signal (dual task) seemed appropriate. Simple auditory reaction time and a hand steadiness task were included as more general indices of fatigue. Six computers were distributed in the control room and other accessible places where the operators completed the 15-20 min tests once or twice on random days. Testing times were at the participant's convenience although some effort was made to test at the beginning, middle, and end of the workshift and the workweek.

Data were collected in two phases. The first phase occurred during the final five weeks on the 8-hr schedule and the first five weeks of the 12-hr schedule. The second phase occurred after approximately seven months on the 12-hr schedule and lasted ten weeks. The critical comparisons were between the 8-hr schedule during phase 1 and the 12-hr schedule during phase 2, after 7 months of adaptation to the new schedule. Thirty-four operators participated consistently under both schedules.

Several parameters affected by work scheduling and assumed to influence performance and alertness were analysed including: 1) type of shift schedule, 2) hours worked or time-on-shift, 3) consecutive days worked, 4) the circadian rhythm of arousal (peak in late afternoon, trough in early morning), 5) amount of sleep prior to work, and 6) time since awakening from sleep. The concerted effects of these parameters on each dependent measure were tested using multiple regression. This was desirable because 1) the parameters can be assumed to be correlated, 2) operator participation rates varied, and 3) practice effects on the performance tasks could be controlled by including an asymptotic performance curve as one parameter in the regression equation. To control for serially correlated error terms, individual regression equations were calculated for each participant for each dependent measure. The distribution of beta weights for each parameter for each measure was then tested for difference from zero with sign-rank tests.

Results indicated statistically significant effects for type of schedule, time on-shift, the circadian rhythm, and various interactions. After statistically controlling for practice, overall scores were worse under the 12-hr schedule for the following tasks: grammatical reasoning was slower (by about .3 sec or 11%) but similar in accuracy, reaction time in the dual task was slower (by about 34 msec or 13%), and simple reaction time was faster (by about 5 msec or 4%) but more signals were missed (0.18% vs 0.12%). Test performance and alertness generally declined with time on-shift as reflected in speed of digit addition (5% slower after 12 hrs work vs 3% slower after 8 hrs work), simple reaction time (18 msec or 16% slower after 12 hrs vs 13 msec or 10% slower after 8 hrs), hand steadiness (50% less steady after 12 hrs vs 34% less steady after 8 hrs), and self-reported sleepiness (41% more sleepy after 12 hrs vs 27% more sleepy after 8 hrs). Time spent on-shift also interacted with the circadian rhythm producing more pronounced decrements at night in simple reaction time, hand steadiness, and self-reported sleepiness. In addition to the interactions discussed above, speed of grammatical reasoning displayed a circadian rhythm where response speed slowed at night and accelerated during the day under both the 8-hr and 12-hr schedules.

In summary, there were statistically significant schedule differences in several dependent variables reflecting cognitive, perceptual-motor, and motor abilities and subjective sleepiness. There were also statistically significant schedule differences in performance and alertness with time-on-shift. Thus, the extra work time per day seems to be a major factor producing poorer scores during the 12-hr schedule. Boredom with the tasks may have also contributed to poorer performance since most operators had performed the tasks more than 50 times by the end of the seven month evaluation. Boredom with the tasks does not easily explain declines with time-on-shift, however, because the operators rarely took the battery more than once or twice a day. In any case, the 12-hr schedule did not improve alertness.

Although some of the tests indicate declines in alertness under the 12-hr schedule, a separate analysis of consecutive days worked shows that there are trade-offs in the two schedules. Statistically significant decrements (analyses of variance) in performance during the latter days of an 8-hr/5-7 day workweek may make the 8-hr schedule less tolerable. Other trade-offs in the schedule depend on operational considerations. For example, at 1600 hrs the individuals on the 8-hr swing shift are fresh while those on the 12-hr day shift are more fatigued. At 1900 hrs the 12-hr night shift is fresh and the 8-hr swing shift is somewhat fatigued. Thus, advantages of either schedule might depend on what is required of the operator at those times. Night shift is still night shift, however, and the early morning hours may be worse, and certainly no better, under the 12-hr shift because the operators have worked more consecutive hours by that time.

Daily Sleep and Habits Questionnaire

This instrument was given daily during the weeks of computerized testing. Fifty operators responded consistently under both schedules. Responses were tested for differences attributable to shift or work schedule, and for changes across the workweek, using analyses of variance. Significant effects included a decrease in total sleep time across the 12-hr/4-day week paralleled by a decrease in compensatory napping, a slight decrease in time taken to fall asleep, and an increase in subjective depth of sleep. Self-reported stress tended to increase on day shift across the workweek under either schedule but this increase was greater under the 8-hr schedule because the workweek was longer. Nighttime reports of gastro-intestinal state improved under the 12-hr schedule. Absenteeism attributable to shift did not differ between the schedules. Mealtime adjustments increased, other personal schedule adjustments decreased, and exercise during the workweek decreased from the 8-hr to the 12-hr schedules.

Overall, the questionnaire results present a mixture of advantages and disadvantages attributable to the new schedule. Measures reflecting quantity of sleep generally declined but one measure of sleep quality (depth of sleep) showed potential improvement under the 12-hr schedule. As a group, the operators reported normal sleep but not enough of it. That is, they reported being able to fall asleep easily, they did not awaken often, and they rated their sleep as fair to good. Since there are few waking hours left after the 12-hr workday, it seems that the operators could do little more than work, eat, and sleep in order to obtain enough sleep. A closer look at times of retiring under the different schedules reveals that the operators only partially adjusted their sleep times to the longer workshift. Median bedtime after night shift was adjusted 2 hrs earlier (0923 vs 1108 hrs) under the 12-hr schedule while bedtime after day shift remained virtually the same (2144 vs 2147 hrs).

When considering the other questionnaire measures, we find that scheduling of personal activities showed mixed results. Self-reported stress increases, however, were not as high as previously. Most measures were poorest at night and remained that way under the new schedule. One exception was the improved gastro-intestinal rating during the 12-hr night which was comparable to the daytime rating. The other exception was stress which was consistently higher during the daytime.

Conclusion

The evidence suggests both costs and benefits to working 12-hr days. The computerized tests show some degree of decreased alertness under the new schedule which may be attributed to the extra 4 hours of work per day. At this point, however, we are not in a position to speculate on the magnitude of risk associated with this decrement because there is currently no research relating these laboratory-type measures to actual job performance. Furthermore, the cost incurred by the longer workday may be offset by the shortening of the workweek. On-going analysis of the computerized tests of alertness in relation to job-related record keeping errors hopefully will provide some linkage between those abstract measures and operational performance.

The questionnaire results leave the overall impression that little else can be accomplished during 12-hr workdays unless sleep and possibly exercise are sacrificed. Since we did not survey workers during their days off, we can not determine whether the participants were able to compensate for these losses. Consequently, loss of sleep may contribute, along with longer working hours, to reduced on-the-job alertness. We emphasize, however, that while statistically significant changes were determined from the testing, plant performance appears to be unchanged under the new schedule (see Lewis and Swaim in this volume).