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Application of a portable test battery in the assessment of fatigue in laboratory and worksite studies of 12-hour shifts

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Several investigations have demonstrated the disruptive effects of night and shift work on various physiological, psychological, and social circadian rhythms (1, 2). These effects, when combined with evolving industrial needs and demands for larger blocks of leisure time, have stimulated interest in alternatives to the common 5-d workweek of 8 h per day (3). Many alternative work schedules "compress" the workweek into a smaller number of days by adding more work hours per day (usually 10—12 h). For the shiftworker, the extra days off afforded by these work schedules presumably allow larger blocks of time for recuperation from night work, for family and friends, and for other leisure pursuits. A disadvantage of such schedules, however, is the potential for excessive fatigue from long workshifts leading to safety or health hazards (4). Night workers may be especially at risk because fatigue from a long workshift could combine with reduced alertness associated with the night-time low-point in endogenous arousal. Because of concerns about excessive fatigue, we developed a research program aimed at the worksite evaluation of extended workshifts. The present report summarizes the results of laboratory and worksite comparisons of 8-h and 12-h shifts. Detailed reports of these studies have been published or are in press (5—9).

Methods

Our approach was more extensive than the brief surveys of job satisfaction, health, or productivity that are often employed in studies of work-schedule changes (4). We measured worker performance on a battery of standard performance tests and self-report scales. The availability of portable microcomputers allowed us to place this test battery directly at the worksite where workers took brief breaks from their jobs to self-administer the tests. With this approach, we were able to track worker alertness and fatigue on all shifts so that "around-the-clock" alertness could be monitored over a period of several weeks.

The computerized test battery is a flexible instrument designed to evaluate a range of psychological functions. Included in the battery are tests of cognitive abilities (grammatical reasoning, digit addition, time perception), perceptual motor skills (simple- and choice-reaction time), and motor functions (finger tapping, hand steadiness) and rating scales to measure subjective alertness or fatigue. All of the measures are brief to minimize interference with the worker's regular job. Several different tests are included in the battery so that any subset of tests can be selected as general performance measures or as analogues to specific job demands. Detailed descriptions of the test battery can be found in published reports (5, 6).

Laboratory studies. Prior to the worksite studies, we evaluated the test battery in the laboratory to establish the sensitivity of each of the measures to work-related fatigue (5, 6). In each of two laboratory studies, subjects worked in experimenter-paced data-entry job simulation and took periodic breaks to perform the various tasks of the test battery. One study compared 12-h workshifts to restdays with no work, and another study compared 12-h workshifts to 8-h workshifts. In both studies, deteriorating performance in the data-entry job, and subjective reports of increasing fatigue across the workweek, indicated that the work regimen was fatiguing. Test battery performance paralleled these results. In the study comparing 12-h workdays to restdays, for example, grammatical reasoning was less accurate, digit addition was slower, reaction time was slower, and hand steadiness decreased on the workdays. In the other study, performance was poorer and subjective fatigue was higher during 12-h shifts compared with 8-h shifts.

Worksite studies. Field studies of the fatigue effects of extended (12-h) workdays were conducted at two worksites using rotating shift workers. At each worksite, a newly instituted 12-h rotating shift schedule

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(with two to four consecutive workdays) was compared to the previous 8-h rotating shift schedule (with five to seven consecutive workdays). Measures of performance and subjective alertness were collected with the test battery, which was self-administered by the worker. Tests for addition speed, grammatical reasoning, auditory reaction time, hand steadiness, and subjective sleepiness were included in the 20-min battery.

The first worksite study occurred at a power plant (7). Control room operators doing sedentary, mentally demanding tasks served as the subjects. Test battery measurements were obtained during the original 8-h shift schedule, seven months after the change to the 12-h shift schedule, and 3.5 years after the change to the 12-h shift schedule. At the seven-month assessment, significant declines in performance and alertness, attributable to the longer workshift, were observed during the 12-h shift schedule. These decrements were especially apparent on the nightshift when fatigue from extended workhours combined with reduced arousal from the endogenous circadian rhythm. After 3.5 years on the 12-h shift schedule, declines in performance and alertness with time on shift were still apparent, and no improvements were observed relative to the seven-month test phase (8).

The second worksite study took place at a natural gas utility (9). Control room operators doing sedentary, mentally demanding tasks and field operators doing active, physically demanding tasks served as the subjects. Comparisons of the 12-h shift rotation with the original 8-h shift rotation were made at this worksite after 10 months of adaptation to the new schedule. Decrements in performance and alertness, attributable to the extra 4 h on shift, were also seen at this worksite. As observed at the first worksite, these decrements were especially apparent on the nightshift. Figure 1 illustrates the parallel increases in reaction time and subjective sleepiness observed during the 8-h and 12-h night shifts at this worksite.

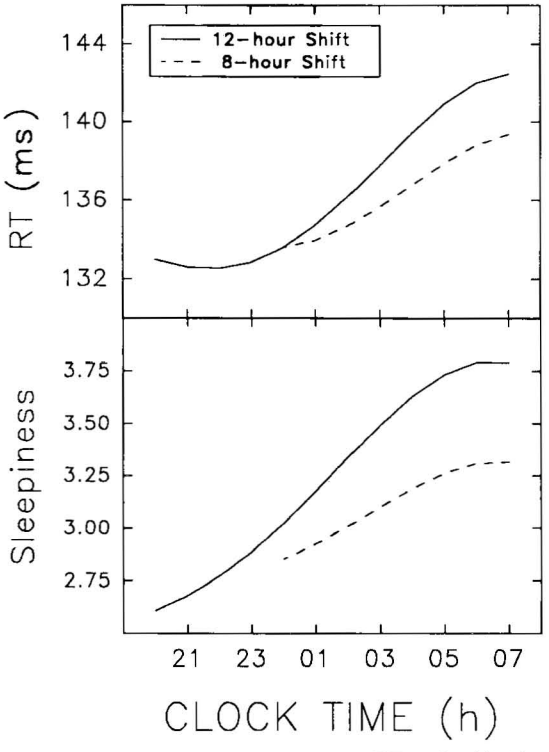

Figure 1. Simple auditory reaction time (RT) and subjective sleepiness for 8-h and 12-h night shifts at the natural gas utility. (Note: values derived from multiple regression prediction equations. See reference 9 for details)

Discussion

The studies demonstrate the utility of the test battery for long-term, around-the-clock worksite assessments. Consistent declines in alertness after shift length was increased by 50% were demonstrated in the two worksite studies. These declines were the most apparent at night when lowered circadian arousal potentiates fatigue resulting from hours of work. The results emphasize the importance of scheduling critical or hazardous activities early in the shift (whenever possible) to minimize the risk of fatigue-related errors or accidents.

Despite the increased fatigue associated with 12-h shifts, it is our impression that the compressed workweeks are popular at both of the organizations studied. At the first worksite, more than 80% of the employees voted to retain the new work schedule. At the second worksite, other groups have requested that a compressed workweek be scheduled. Because of the popularity of the compressed workweek, personnel at the first worksite have expressed their willingness to tolerate the increased fatigue that results from 12-h workdays. Management is in favor of the compressed workweek because they expect a popular work schedule to reduce attrition. Retention of experienced workers is considered an advantage because of reduced training costs and because experienced workers are assumed to work more safely and efficiently than inexperienced workers. Management has agreed to a permanent schedule change based on their analysis showing continued safe and efficient plant operation under the 12-h schedule. When the first worksite is compared to the second, however, two cautions should be considered. First, many workers at the second worksite have more physically demanding jobs than workers at the first worksite. The combination of high physical demands and 12-h shifts could produce extremely high levels of fatigue. We planned to test this possibility at the second worksite, but the number of participants doing light or heavy physical work was insufficient for statistical analysis. The second caution is that fatigue is an issue both on and off the job. For example, workers in the dense urban location of the second worksite must commute to their jobs in heavy traffic. Excessive fatigue may be a greater concern in that location than in the semirural location of the first worksite.

These conditions point to the need for long-term monitoring of work-related and nonwork-related accidents and injuries as a function of extended workshifts.

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