EVALUATION OF A FAST FORWARD ROTATING SHIFT SCHEDULE IN THE STEEL INDUSTRY WITH A SPECIAL FOCUS ON AGEING AND SLEEP

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The aim of this study was to explore the effect of a change in the speed and direction of shift rotation on the sleep and wakefulness of younger and older workers. A continuous three-shift schedule was changed from a slow backward rotating (EEE-MMMNNN-- --) to a fast forward rotating system (MMEENN-- -- --). Sixteen subjects (mean age 42 years) were studied before and one year after the change in schedule. Two age groups were compared: ten younger men (mean age 35 years) and six older men (mean age 53 years). The effects of the new work schedule were evaluated by a questionnaire (modified SSI), and on-site registrations with an actigraph and sleep log for one shift cycle (10-15 days) before and after the new schedule. After the change in schedule, subjective sleep problems decreased and alertness increased during the morning shifts. The change in schedule influenced sleep differently in the two age groups. Both the subjective and objective quality of sleep improved among the older workers. The results indicate that a fast forward rotating shift schedule is more suitable for older workers than a slower backward rotating system.

Introduction

Ageing is associated with changes in sleep-wake rhythm, health, and social life. To compensate for the problems in circadian adaptation to shift work, forward rotation of the shifts (morning, evening, night shifts, and days off) has been recommended for continuous three-shift work (KNAUTH, 1997). The recommendation is based on physiological evidence. Delaying the phase of shifts suits the natural endogenic circadian rhythm better (WEVER, 1979). Another reason for the superiority of the forward rotation of shifts is the leisure time of 24 hours between the different shifts.

The forward rotation of shifts is associated with less physical, social and psychological problems, less fatigue, and better quality of sleep (KNAUTH, 1995), as well as less risk of coronary heart disease (ORTH-GOMER, 1983). Studies on sleep symptoms favour the forward rotation of shifts, the delaying order of shifts (morning, evening and night shifts) leading to longer sleep (BARTON and FOLKARD, 1993) between the shifts. Workers with experience in both forward and backward rotation have preferred the forward rotation (EPSTEIN et al., 1991). The forward rotation of shifts is associated with better physiological and psychological well-being (BARTON and FOLKARD, 1993; BARTON et al., 1994).

Additionally, the fast rotation of shifts is more recommendable in three-shift work, because the adaptation of people to shift work is only partial even in continuous night work (KNAUTH, 1997). With fewer successive night shifts the environmental synchronisers stay the same, and the circadian rhythms return to the normal day rhythm more quickly (KNAUTH, 1997).

Individual characteristics, especially age, are related to circadian adaptation to shift work (HÄRMÄ et al., 1994). There is an obvious lack of research on age-specific shift scheduling. However, based on the knowledge of age-related changes in circadian rhythms, health and well-being, it has been speculated that fast rotating shift systems should be preferred for older workers (HÄRMÄ and ILMARINEN, 1997).
The aim of the present study was to compare a fast forward rotating shift system to a slower backward rotating system in terms of sleep and wakefulness. In addition, the interaction between age and the change in schedule was studied. The idea of improving the shift schedule was originally initiated by the workers themselves. The hypothesis was that a fast and forward rotating shift schedule would decrease the negative effects of three-shift work, especially among older workers.

**Methods**

A continuous three-shift schedule was changed from the slower backward rotating system (EEE–MMMNNN– – – – –) to a faster forward rotating system (MMEENN– – – –) in a Finnish steel manufacturing plant (M morning shift, E evening shift, N night shift, and – day off). The factory manufactures steel billets from pure iron ore for high-quality wire rod and bar rolling. The duration of the shifts was eight hours, starting at 0700, 1500 and 2300 hours in both cases.

The sleep and wakefulness of 16 subjects (mean age 42 years) was studied before and one year after the changeover to the new schedule. Two age groups were compared: 10 younger men (mean age 35 years, range 30–39 years) and six older men (mean age 53 years, range 44–56 years).

The change in shifts was studied by questionnaire and field studies before and after the new shifts. The questionnaire (modified Standard Shiftwork Index, Barton et al., 1995) included questions on sleep and alertness in different shifts. An actigraph (Ambulatory Monitoring Inc., Ardsley, New York) for recording daily sleep periods, and a sleep log for recording feelings when retiring to bed and rising were used for a shift cycle period (including days off) of 15 days during the old slow backward system, and for 10 days during the new fast forward rotating system.

The effects of the change in schedule (slow backward vs. fast forward), the age group (younger vs. older), and their interactions were examined with analysis of variance with repeated measures.

**Results**

In the questionnaire, all the subjects assessed the quality and amount of their sleep and their alertness to be worst during the morning shifts compared to the evening and night shifts. After the change in schedule, subjective sleep problems decreased and alertness increased during the morning shifts (Fig. 1). The self-evaluated amount and quality of sleep or alertness did not change in the evening (Fig. 2) and night shifts (Fig. 3) or on the days off during the new shift schedule.

According to the sleep log, the subjective quality of sleep was related to the interaction between the change in schedule and the subjects' age (F=8.48, df 1, 12, p<0.013). The quality of sleep of the older subjects improved as a result of the intervention (Fig. 4).

According to the actigraph recordings, sleep length varied between the shifts (F=17.19, df 14, 158, p<0.0001), and the change in schedule did not alter the amount of sleep (Fig. 5). The sleep efficiency depended on the change in schedule (F=6.73, df 1, 12, p<0.02). All subjects slept more efficiently during the new schedule (Fig. 6). The number of awakenings depended on the shift (F=2.04, df 14, 156, p<0.02), and decreased in all subjects according to the change in schedule, but not significantly (Fig. 7).
Fig. 1. Sleep quality and alertness after morning shifts (questionnaire, N=16).

Fig. 2. Sleep quality and alertness after evening shifts (questionnaire, N=16).

Fig. 3. Sleep quality and alertness after night shifts (questionnaire, N=16).

Fig. 4. Quality of sleep (sleep log, N=10 and N=6 respectively).
Discussion

The results show that a change from the slower backward rotating shift system to the faster forward rotating system had a positive effect on sleep and wakefulness. The beneficial effects of the new shift system were most obvious during the morning shifts and among the older (44–56 years) workers. After 12 months on the new schedule, 88% of the workers voted in favour of the new shift schedule. In fact, the effects were so positive that the other departments of the factory soon adopted the new shift system also.

In this study, the morning shifts of the new schedule started after four consecutive days off, while in the old schedule the morning shifts started after three evening shifts followed by a single free-day. The results agree with earlier observations that delaying the order of shifts leads to better physiological and psychological well-being (BARTON and FOLKARD, 1993; BARTON et al., 1994). According to the majority of field studies, circadian adaptation to shift work takes place by
phase delay (HÄRMA, 2000). It is possible that the workers in this study could not sufficiently induce phase advance of their sleep-wake rhythm to the morning shifts in the old schedule. In the new shift system, the morning shifts started immediately after the days off, and probably the rapid rotation did not induce phase delay as much as the old slower backward rotating system.

During the fast forward rotating system, the sleep of the older subjects improved more than the sleep of the younger workers. Based on the actigraph registration, the sleep efficiency of the older workers improved and wakening during the sleep decreased. In our experimental shift-work study (HÄRMA et al., 1994), older shift workers, aged 53–59 years, were not able to phase-delay their circadian rhythm of body temperature during the three consecutive night shifts as well as the younger shift workers. It can thus be hypothesized that optimal physiological coping during a rapid rotating shift schedule means the avoiding of circadian adjustment. The older workers with a lower ability for circadian adaptation therefore ought to benefit from the new system. Our results also agree with the study of KANDOLIN and HUIDA (1996), who showed that the turn of the shift schedule from backward to forward rotation decreased the mental strain of the work; the positive effects of the new schedule were most evident among the older shift workers during the morning and evening shifts.

The fast rotation of shifts seems to improve the well-being of older shift workers. In our study, all the workers accepted the new schedule, and they agreed to continue with the fast forward rotating system even after the trial period. The use of fast forward rotating shift systems should be encouraged especially in older shift worker populations with more sleep problems.

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References
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