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Editorial

Shift Work, Severe Sleepiness and Safety

Most reviews of sleep, sleepiness and safety in shift-work end up concluding that accident risk is increased and that the reason is sleepiness/fatigue. While probably correct, the picture is not complete, and we here bring up some issues for consideration.

Sleepiness at work is a major complaint in shift work and reports of sleep attacks common[1]. This is also reflected in the development of sleepiness during work shifts. Thus, for example, sleepiness across the night shift using the Karolinska Sleepiness Scale (KSS)[2] shows a steep rise from a value of 4 to 7 out of a scale from 1–9 (we use our own studies here for ease of availability)[3, 4], morning shifts are more level, but vary between 5 and 6 on the same scale, whereas afternoon shifts show a modest increase between 3 and 5. It should be mentioned that 8 or 9 on the scale is associated with pronounced increases of electroencephalogram (EEG) and electrooculogram (EOG) indicators of sleep intrusions during wakefulness[2]. The few polysomnographical field studies show that actual sleep occurs during night work in train drivers[5], paper mill workers[6], interns on call[7], and other groups.

While there is a consensus on the presence of sleepiness during night work and that there is a link to accident risk, one may wonder how bad it really is. Does high sleepiness represent danger in real work situations? Is there documentation of sleepiness immediately preceding accidents/errors in real life? There is actually a complete absence of such studies. Rather, sleepiness is usually inferred from the *setting* of an accident or an error —mainly night shifts or simply activity at night[8, 9]. One study that comes rather close to linking accidents to sleepiness at the time of accident showed that individuals who had been involved in a car accident, and were interviewed about their sleepiness before the accident, were 8 times as likely to report sleepiness drivers that had not crashed[10]. Another study, relatively close to the link, showed reductions of serious medical mistake after reductions of work shift duration[11]. Ratings and EEG indicators were also used and demonstrated sleepiness, but these were not directly linked to the mistakes[7].

For information on detailed links between sleepiness and accidents we have to resort to simulations. One glimpse of the imperative nature of sleepiness comes from a (high fidelity, moving) driving simulator study of the effects of rumble strips[12]. It was found that hitting a rumble strip in the morning after being awake during the night was associated with strong pre-hit increases in EEG alpha/theta activity, eye closure duration, lateral variability of the vehicle and high sleepiness levels (KSS=8.1 on the 1–9 graded scale). Sleepiness was at this high level during at least five minutes before hitting the rumble strip, and no further increase was seen immediately before the hit. This suggests a combination of high perceived and physiological and behavioral sleepiness, combined with state instability. Interestingly, the hit immediately reduced blink durations, sleep EEG indicators and driving variability to intermediate levels, but they returned to pre-crash levels within 2–4 min. This pattern was repeated 7 times on the average. These observations suggest that sleepiness is unrelenting and irresistible. But, a simulator is not real life.

Recently, however, a study of real driving showed that KSS levels for driving around 4am reached 7.8 and EEG-based sleep indicators doubled (Sandberg et al, in prep). No incidents occurred, however, so risk and sleepiness cannot be determined. Ongoing work suggests that time at the wheel may be an important additional factor. Sagaspe *et al*. (2008) have demonstrated pronounced such effects on line crossings and KSS when driving at night[13]. Also, while of great practical importance, studies of driving may not be representative of other tasks common in industry, health care and service. Possibly, driving may constitute a "worst case" scenario because of demands on sustained attention.

The severity discussion raises the question of whether there is a quantitative level of sleepiness that might be dangerous. The physiological sleepiness indicators available today differ too much between individuals to be used for inferring sleepiness norms[14]. Subjective ratings are more consistent between individuals, but there still are differences[14], even if the levels 8 and 9 on the KSS seem to be related to danger, at least in simulator studies.

One may also consider norms for well-being in shift work, that is, what level of sleepiness is "unacceptable", considering a putative right of individuals to lead their lives at reasonable levels of alertness. One approach to such an issue might be to look at individuals with a very negative attitude to shift work[3]. In the latter study such a group reached a maximum of KSS=7.2 on the night shift, 5.2 on the afternoon shift and 5.9 on the morning shift, while they fell below 4 during days off. The corresponding values for those with a positive attitude was 5.7,

3.9, 4.8 and <4, respectively. Similarly, Czeisler *et al*. (2005) showed that workers diagnosed with shift work disorder (SWD) had a mean KSS value of 7 out of 9 on the night shift[15]. The latter are averages (no end-of-shift values were given), which probably means that the maximum may have been considerably higher. One might also compare the shift work values with the daytime values of 5–6 that characterize subjects high on burnout[16].

Judging by the sleepiness levels of negative shift workers and burnout subjects, one might arrive at KSS levels of 5–6 constituting a reduced quality of living, particularly if these levels dominate the working week. Based on group mean data from different studies of shift workers it seems that two-hourly ratings of sleepiness in connection with night work may result in 3 out of 8 ratings above 5. During days with morning shifts, most ratings (7) may exceed 5. In connection with evening shifts there may occur 2 such ratings (during the last part of the shift), while days of day work may involve 1 such rating. A well adjusted shift worker with two shifts of each type and two days off would then accumulate 26 above-5 ratings out of 48 possible ratings (54%). Shift workers with a low tolerance appear to show 5, 8, 4 and 1 such ratings, respectively, that is 36/48 (75%), while burnout subjects may show 48/48 such ratings (during day work). A tentative level for acceptability could then be estimated at approximately 65% of the ratings. Further work is needed for refinement and validation in terms of prediction of exits from shift work.

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Torbjörn ÅKERSTEDT, PhD
Advisory Editor of INDUSTRIAL HEALTH
Stress Research Institute, Stockholm University, Stockholm, Sweden
Clinical Neuroscience, Karolinska Institutet, Stockholm, Sweden

Göran KECKLUND, PhD
Stress Research Institute, Stockholm University, Stockholm, Sweden
Clinical Neuroscience, Karolinska Institutet, Stockholm, Sweden