

Subjective alertness and sleep quality in connection with permanent 12-hour day and night shifts

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Objectives The aim of this study was to compare permanent 12-hour day and night shifts (shift change over times at 0500 and 1700) in a shift system with 3 work periods followed by 4 free days.

Methods Sleep diaries were collected after main periods of sleep, and sleepiness ratings [Karolinska sleepiness scale (KSS)] were obtained 4 times during the last free day and also during the following 3 workshifts. Eighteen to twenty night workers and 8–10 day workers (depending on the instrument) participated.

Results The day workers were significantly sleepier during their workdays. Times for going to bed and for rising differed between the groups. The amount of sleep per week did not differ between groups, but the pattern across days did in that the day workers had a short sleep (5 hours) before the first day and 6 hours of sleep after the other two. Night workers slept long (9 hours) before the first shift and had 6.5-hour sleep periods after the other shifts. During free time the day workers slept around 9 hours and the night workers around 8 hours. Sleep quality and ease of awakening showed no group differences in overall levels, but the day workers had difficulties awakening before their shifts. The night workers had little variation in sleep quality or difficulties awakening.

Conclusions The suggested explanation for the greater sleepiness and difficulties awakening among the day workers was the early start of the shift and the difficulties the workers had with phase advancing their sleep-wake rhythm.

Key terms shift work, sleepiness, subjective sleep quality, 12-hour shifts.

Compressed workhours based on 12-hour shifts have increased in popularity (1) in recent years. The reasons for this trend may be the associated longer periods of free time and shorter commuting time. For the company, production may become more efficient due to fewer shift changes. It has, however, been shown that long workhours, especially at night, are related to increased sleepiness and degraded performance (2). Rotating 12-hour shift systems have been found to affect alertness negatively (3, 4), but positive effects have been observed as well (5). Permanent 12-hour day and night shifts have also been studied (6, 7), but not with on-shift alertness ratings and sleep diaries. The aim of the present study was to compare the subjective alertness and sleep habits of permanent 12-hour day workers with permanent 12-hour night workers at the same worksite.

Methods

The worksite was fairly small ($N \approx 40$) and manufactured electronic components. Approximately 35 workers were

invited to participate. The shift system included three 12-hour shifts in a row followed by 4 free days. The permanent day shift started at 0500 and the night shift at 1700. The shift system had been in use for approximately 10 years at the time of the study, and the employees had been active in selecting the system. The worktasks were the same for both shifts. Data were collected during 3 identical measurement periods, 6 months apart. However, due to changes in production, only 5 to 7 subjects (depending on the measurement instrument) participated during all 3 measurement periods. To retain as many subjects as possible in the computations, data from 1 measurement period for each subject (the only period or, for subjects participating more than once, whichever period that came first) were chosen and pooled to form data sets for further analyses. Repeated measures analyses of variance (ANOVA) did not reveal any changes across the measurement periods for the 5 to 7 subjects participating during all 3 periods.

Three types of measurements were obtained from the self-report instruments, which were chosen to assess sleepiness and sleep quality because, apart from practi-

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cal reasons, complaints in connection with different shift systems are based on subjective experience. *Sleep diaries* (the Karolinska Sleep Diary) (8) were filled out daily after each main sleep for 28 days (ie, 4 shift cycles). Bedtimes, times of rising, and sleep duration were obtained from these diaries. In addition, 2 indices were formed using items in the diary. The first index, reflecting ease of awakening, was formed using the items "ease awakening" and "well rested", respectively. The 2nd index was an overall measure of sleep quality containing the items "how was your sleep", "calm sleep", "ease of falling asleep", and "slept throughout", respectively.

Ratings of sleepiness [Karolinska sleepiness scale (KSS) (9); 1= very alert, 9=very sleepy, fighting sleep, an effort to stay awake] were obtained 4 times a day during the last free day and the 3 workshifts of the last shift cycle. The subjects were instructed to rate their sleepiness at the start of the shift, during the 1st and 2nd 30-minute rest periods and at the end of the shift. During their free time, they were to rate their sleepiness upon arising, at lunch time, during the afternoon, and during the early evening. The times for the rating are shown in figure 1. Finally, before the start of each measurement period, the subjects filled out a general work-environment questionnaire (10) containing questions on background variables, satisfaction with work and worktimes, sleep habits, general health, and the like. Questionnaire data were obtained from 20 night workers and 10 day workers. Of these subjects 18 night workers and 8 day workers completed the sleep diaries, and 17 night workers and 9 day workers completed the sleepiness ratings.

The questionnaire was used to obtain background factors and other items describing the 2 study groups (table 1). Age, gender, marital status, and number of children were similar for both groups. The duration of employment was between 5 and 6 years for both groups. The day workers, however, had shorter experience with their shift than the night workers had. Few workers had tried to change their workhours. Satisfaction with work times were on the positive side of the scale for both groups. Even though general satisfaction with the work situation was high for both groups, it was higher for the night workers. Commuting times were short and similar for both groups. The reasons for choosing the current employment and workhours differed between the day and night workers on 2 items. Salary was more important for the night workers, and the day workers could less easily choose which shift they wanted to work.

The data were analyzed using ANOVA. The sleepiness data from the workshifts were analyzed with "type of shift" (day or night work) as a between-group factor and "shift" (3 shifts) and "time of day" (4 times) as within-group factors. For sleepiness during the last free day, the ANOVA used "type of shift" as a between factor and "time of day" as a within factor. The difference in

sleepiness between workshifts (collapsed over 3 workdays) and free days were tested in a separate ANOVA for each group, using "type of shift" as a between factor and "workshift-free day" as a within factor. The sleep diary ANOVA had "type of shift" as a between factor

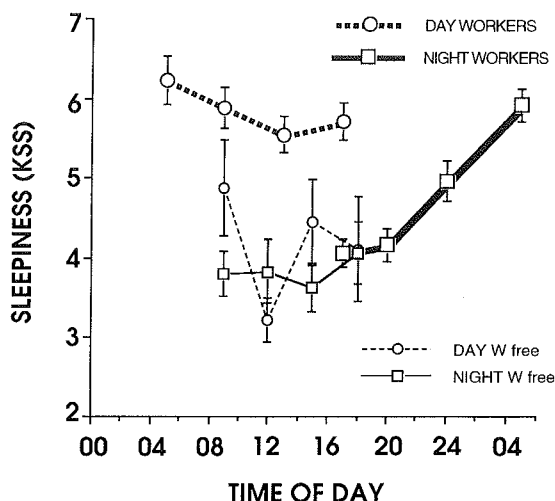


Figure 1. Means of self-rated sleepiness on the Karolinska sleepiness scale (KSS) during workshifts (heavy lines) for the day and night workers. The means were calculated across subjects and across 3 consecutive workdays. Also shown are the mean subjective ratings for both groups during the immediately preceding free day (thin lines). The vertical bars denote standard errors.

Table 1. Means and standard errors (SE) or frequencies of the background variables and of items from the general questionnaire.

	Day workers (N=10)			Night workers (N=20)		
	N	Mean	SE	N	Mean	SE
Age (years)		32.9	2.1		36.5	1.9
Married (number of subjects)	5			15		
Gender (number of female/male)	3/9			7/11		
Having children (number of subjects)	3			8		
Duration of employment (months)		67.6	18.9		74.1	9.2
Duration of current worktimes (months)		15.2	10.2		54.8	8.9
Tried to change shift (number of subjects)	-			4		
Satisfaction with worktimes (1 very high-5 very low)		3.3	0.5		4.0	0.3
General satisfaction with work (1 very high-5 very low)		3.7	0.3		4.4	0.1
Commuting time (minutes)		20.4	5.7		18.9	2.9
Reason for choosing current employment and worktimes (3 to a high degree, 2 to some degree, 1 not at all)						
Salary		1.3	0.2		2.1	0.2
Long free periods		2.3	0.2		2.6	0.1
Could not get another job		1.8	0.3		1.3	0.2
Could not choose shift		1.9	0.3		1.2	0.1
Diurnal type (1 evening-4 morning)		2.2	0.2		1.9	0.1
Sleep need (hours)		6.8	0.6		6.9	0.4

and "week" (4 weeks) and "day" (7 days) as within factors. When appropriate, Huynh-Feldt epsilon correction was used to adjust the degrees of freedom for the calculations of the P-values. The uncorrected degrees of freedom are, however, given in the text. Unpaired t-tests were used to analyze the differences between the day and night workers for the questionnaire data. The significance level was set at 0.05 in all cases.

Results

A 3-way ANOVA (type of shift $\times$ shift $\times$ time of day) applied to workshifts only showed that the day workers, on the average, reported significantly greater sleepiness during work than the night workers did [type of shift, degrees of freedom (df)=1, 24, $F=12.6$, $P<0.002$]. There were no significant differences between the 3 workshifts (shift, df=2, 48, $F=0.16$, not significant). Hence the changes in sleepiness across the workshifts are shown in figure 1 as averages of the 3 workshifts. A significant interaction (df=3, 72, $F=9.8$, $P<0.0001$) between type of shift and time of day and a significant time of day effect (df=3, 72, $F=4.1$, $P<0.01$) supported the impression (figure 1) of a slight decrease in sleepiness for day workers and a steep increase in sleepiness for night workers across the shift. Note that the 1st rating for the day workers was as high as the last rating for the night workers.

A separate ANOVA of sleepiness during free days did not show any significant differences between types

of shift (df=1, 24, $F=0.7$, not significant) or across time of day (df=3, 72, $F=1.6$, not significant). Both groups were significantly more sleepy during their workshifts than during their free days, as shown by a separate ANOVA for each group (day workers: df=1, 8, $F=29.9$, $P<0.001$; night workers: df=1, 16, $F=14.5$, $P<0.002$).

The sleep diary data were similar across the 4 weeks. Neither the factor "week" nor the interaction terms containing "week" were significant for any of the 5 variables studied [the F-values for the factor week (df=3, 72) ranging between 0.03 and 1.73, the F-values for the interaction type of shift $\times$ week (df=3, 72) ranging between 1.1 and 2.0, and the F values for the interaction week $\times$ day (df=18, 450) ranging between 0.8 and 1.6]. The data were therefore averaged to yield means across weeks for each of the 7 days within a shift cycle (table 2). The time patterns for going to bed and getting up differed between the groups for obvious reasons. Note that the day workers went to bed as late as between 2224 and 2320 before workdays. The amount of sleep per week did not differ between the groups, but the pattern across days was clearly different (significant interaction) in that the day workers had a short sleep (around 5 hours) before the 1st day and 6-hour periods of sleep after the other 2 days. The night workers had a long sleep (nearly 10 hours) before the first shift and 6.5-hour periods of sleep after the other shifts. During free days the day workers slept between 9 and 10 hours, that is, approximately 1 hour longer than the night workers. The overall sleep quality and rated ease of awakening showed similar results, namely, no

Table 2. Means and standard errors (SE) of the sleep diary data and the results of the analysis of variance (ANOVA) of its variables (day workers N=8, night workers N=18). (NS = not significant)

Variable	After 1st workday		After 2nd workday		After 3rd workday		After 1st free day		After 2nd free day		After 3rd free day		Before 1st workday		Degrees of freedom, F-values and levels of significance ^a
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	
Bedtimes (h; decimal times)															
Day workers	22.24	0.21	22.50	0.23	23.77	0.35	24.30	0.33	23.94	0.22	24.58	0.32	23.20	0.26	Group (1, 4)=632.0*** Day (6, 144)=338.0*** Gr×Day(6,144)=261.0***
Night workers	05.99	0.09	06.07	0.10	05.85	0.11	23.34	0.56	23.96	0.37	00.16	0.36	00.21	0.30	
Rising time (h; decimal times)															
Day workers	04.16	0.07	04.49	0.33	09.19	0.27	09.23	0.35	08.84	0.29	09.41	0.30	04.38	0.14	Group (1, 24)=93.0*** Day (6, 144)=28.0*** Gr×Day(6,144)=106.0***
Night workers	12.61	0.11	12.58	0.15	11.91	0.15	09.06	0.35	08.29	0.16	08.61	0.26	09.72	0.22	
Sleep duration (h; decimal times)															
Day workers	05.98	0.18	06.10	0.26	09.58	0.38	08.84	0.26	08.88	0.25	08.76	0.23	05.11	0.21	Group (1, 24)=0.4 NS Day (6, 144)=29.0*** Gr×Day(6,144)=40.0***
Night workers	6.60	0.10	06.52	0.13	06.06	0.14	08.03	0.21	08.00	0.13	07.86	0.16	09.04	0.26	
Ease of awakening (1=very difficult, 5=very easy)															
Day workers	2.07	0.14	2.09	0.16	3.38	0.12	3.68	0.14	3.86	0.12	3.52	0.17	2.32	0.12	Group (1, 24)=0.8 NS Day (6, 144)=15.0*** Gr×Day(6,144)=20.0***
Night workers	3.23	0.09	3.01	0.10	2.67	0.09	2.96	0.10	3.32	0.10	3.32	0.11	3.59	0.11	
Sleep quality (1=very low 5=very high)															
Day workers	4.21	0.10	4.38	0.11	4.52	0.10	4.63	0.07	4.61	0.06	4.59	0.08	3.87	0.14	Group (1, 24)=0.3 NS Day (6, 144)=3.3** Gr×Day(6,144)=6.5***
Night workers	4.30	0.08	4.33	0.07	4.34	0.07	4.28	0.08	4.35	0.07	4.23	0.08	4.45	0.07	

^a Since none of the ANOVA effects for week or for the interaction terms group $\times$ week and day $\times$ week were significant, these effects were not included in the table.

* $P<0.05$, ** $P<0.01$, *** $P<0.001$. P-values after Huynh-Feldt correction.

group differences in levels, but highly significant interactions ($P < 0.0001$). The significant interactions may be explained by the day workers' slightly lower sleep quality and more difficulties awakening before shifts, and the high quality and few problems awakening during days off when compared with the night workers who had little variation in sleep quality and difficulties awakening across the 7 days. Both groups had high overall sleep quality, however, 4 or higher on a 5-point scale.

Discussion

While the times for going to bed and getting up in connection with work differed between groups for obvious reasons, they were similar during free days. The day workers' pattern of sleep duration across the 7 days was characterized by short periods of sleep before workdays (especially the first) and long sleep after free days. Night workers were characterized by a long sleep before the first shift and 6.5-hour sleeps after the other shifts.

The day workers had short periods of sleep because they did not phase advance their bed times before shifts and their shift started early. Such failures to phase advance bedtimes on morning shifts have been described earlier (11). Night workers might have been favored, however, by the early changeover time, permitting a relatively long sleep before sleep was terminated by the circadian upswing (12). In addition, the early bedtime was close to the presumed circadian alertness trough (13—15) when short sleep latencies could be expected (16).

The day workers seemed to compensate for their short sleep by sleeping longer on days off, whereas night workers slept longer before the first night shift, presumably for "prophylactic" reasons. Overall sleep quality was high for both groups, approximately 4 or higher on the 5-point scale, but the day workers had slightly lower sleep quality before workdays (especially the first). The day workers also experienced more difficulties awakening before shifts (especially the 1st shift), while the night workers had the least problems awakening before their workshifts. The difficulties the day workers had with awakening may have been a consequence of the failure to phase advance bed times and therefore having to rise close to the (presumed) circadian alertness trough. The night workers may have experienced fewer problems since they could sleep until spontaneously awakened.

Our findings on sleep patterns are similar to those observed in connection with morning and night shifts in 3-shift systems (17), and they agree with data from experiments that manipulated the timing of sleep (12). Finally, the sleep diary data showed a stable pattern across the 4 identical cycles of 3 workshifts and 4 free days.

Contrary to expectations, the day workers were sleepier than the night workers on their workshifts. The day

workers were as sleepy at the start of their shift as the night workers were at the end of their night shift, and the level of sleepiness remained high for the day workers throughout the day. One probable explanation of the high level of sleepiness among the day workers is the early start of the shift. High levels of sleepiness as a consequence of early rising have been described earlier (18, 19). The subjects were required to rise around 0430, and, since their bedtime was not phase advanced, 1—2 hours of sleep were lost. Several studies have shown negative effects on alertness from such moderate reductions in sleep duration (20, 21). Another contributor to the high levels of sleepiness, especially at the start of the day shift, may have been the closeness to the presumed trough in the circadian rhythm of alertness (13—15). Night workers, on the other hand, were fairly alert at the start of the shift but experienced a steady increase in sleepiness across the shift. Similar results on alertness during night work have been obtained with the same instruments in earlier studies in both field (22) and experimental (23) settings. Both groups reported similar levels of sleepiness during the last of the 4 free days. In both cases sleepiness was clearly lower than during work and therefore indicated that both groups had recovered and maintained day-oriented rhythms during free days.

An additional contributor to the high level of sleepiness among the day workers may have been the short experience with their shift system, which might have made adaptation difficult. Indeed, the lack of phase advance of bedtimes before workdays and the long sleep and late awakening during free days suggest a lack of adaptation. However, since they already had a mean experience of 15 months, it does not seem likely that a further increase of exposure would significantly improve adjustment. Another reason for the day workers' inability to adapt may have been that they had not been able to choose their shift and that they apparently did not have the diurnal type characteristics suited to early morning rising.

The statistical analyses did not reveal any changes in sleepiness across the 3 successive workshifts, neither for the day nor for the night workers. Hence there were no tendencies towards a gradual adaptation to night work among the night workers. However, as several studies have shown, it may take more than 3 night shifts in a row to affect the circadian phase (24—26). Presumably, the 4 free days helped to maintain a day-oriented rhythm. Furthermore, the day workers did not seem to accumulate sleepiness, as might have been expected from experiments on moderate sleep reduction (20, 21). Regarding the latter results, it should, however, be remembered that the number of day workers was relatively small, and therefore statistical power would have been reduced.

A comparison with other studies shows that the workers in my study resembled workers on other work sched-

ules in several important aspects. For instance, satisfaction with the work situation and worktimes was similar to that seen for 3-shift work (27), and the satisfaction of the night workers was close to that of 8-hour day workers (28). Furthermore, sleep quality was high for both and equal to that of 8-hour day workers (27). Sleepiness during the 12-hour night shift resembled that of rotating shift workers on an 8-hour night shift (28). On the whole, then, the present work schedules seemed to be tolerated well.

To summarize, my data indicate that the permanent 12-hour shifts in the type of rota studied were tolerated well. There was, however, an important exception. Day workers experienced unexpectedly high levels of sleepiness during their workdays. In fact, the overall level of sleepiness was higher during the day shift than during the night shift. The likely explanation for this phenomenon is the early start of the shift and the lack of phase advance of bedtime, which, in turn, led to shorter sleep and higher levels of sleepiness. Hence, the timing of especially 12-hour day shifts, may be crucial to sleepiness on the shift, and, depending on the phase relation to the circadian rhythm, relatively small changes in timing may evoke significant increases in sleepiness.

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