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Change from an 8-hour shift to a 12-hour shift, attitudes, sleep, sleepiness and performance

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Objectives The present study sought to evaluate the effect of a change from a rotating 3-shift (8-hour) to a 2-shift shift (12 hour) schedule on sleep, sleepiness, performance, perceived health, and well-being.

Methods Thirty-two shift workers at a chemical plant (control room operators) responded to a questionnaire a few months before a change was made in their shift schedule and 10 months after the change. Fourteen workers also filled out a diary, carried activity loggers, and carried out reaction-time tests (beginning and end of shift). Fourteen day workers served as a reference group for the questionnaires and 9 were intensively studied during a week with workdays and a free weekend.

Results The questionnaire data showed that the shift change increased satisfaction with workhours, sleep, and time for social activities. Health, perceived accident risk, and reaction-time performance were not negatively affected. Alertness improved and subjective recovery time after night work decreased. The quick changes in the 8-hour schedule greatly increased sleep problems and fatigue. Sleepiness integrated across the entire shift cycle showed that the shift workers were less alert than the day workers, across workdays and days off (although alertness increased with the 12-hour shift).

Conclusions The change from 8-hour to 12-hour shifts was positive in most respects, possibly due to the shorter sequences of the workdays, the longer sequences of consecutive days off, the fewer types of shifts (easier planning), and the elimination of quick changes. The results may differ in groups with a higher work load.

Key terms activity logger, health, night work, scheduling, shift duration, shift work.

Shift work, and in particular night work, is associated with reduced alertness and performance, and also with increased accident risk (1). Recently there has been a move from the traditional 8-hour shift to 12-hour shifts, mainly because of the possibility to compress the work-week and thus gain more consecutive days off (2, 3). However, the increased length of the shift may also increase the accident risk (4), and it probably reduces alertness and performance. Scientific data are, as yet, not conclusive on how compressed workweeks and other factors modulate fatigue (5). In a study of police officers (6), no effects on wakefulness could be observed after a change from 8-hour backward rotation (8 days of work in a row) to 12-hour shifts (2 days of work, 1 day of rest). Two other studies, in nursing (7) and industry (8), gave similar results. Another study (9) found that miners did not perform worse on a 12-hour shift than when on an 8-hour shift. On the other hand, several American industries have rejected 12-hour shifts because of the (assumed) accident risk (10), and in Singapore 12-hour shifts have been rejected because of negative health effects (11).

Apparently, it is still unclear whether 12-hour shifts differ from 8-hour shifts with respect to alertness, sleep, and performance. Some of the lack of clarity may be due to the lack of reference groups in many of the studies and to the limited spectrum of variables used. In the present study the purpose was to investigate the effect of change from an 8-hour 3-shift system to a 12-hour system. Sleep diaries, actigraphy, ratings of sleepiness several times per day, reaction-time performance, and subjective estimates of health, attitudes and social functioning were used for this purpose. Apart from the extended

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workday, the new schedule also involved more rapid rotation and more free days in-between shifts. Day workers served as the reference group.

Subjects and methods

The study was carried out at a chemical plant producing industrial cleansing products. The plant was located in a small town, with very short mean commuting times [20 minutes (SD 2)]. The shift workers did light control room work with occasional bouts of more active work. The design involved a questionnaire sent to 40 shift workers and 16 day workers shortly before and 10 months after a change from 8-hour to 12-hour shifts. At the same points in time a subgroup of 14 shift workers and 9 day workers were followed using a sleep diary, 2—4 hourly sleepiness ratings, actigraphy, and reaction-time performance across part of the shift cycle. Four of the respondents to the questionnaire abstained from participation, and 2 dropped out during the course of the study, leaving 34 subjects for the analysis. The mean age was 37 (SD 1.7, range 23—58) years for the shift workers and 41 (SD 3.4, range 23—60) years for the day workers. Altogether 88% of the shift workers and 69% of the day workers were men. Most of the subjects were married or were cohabiting (shift=81%, day=77%).

To aid the selection into subgroups, the subjects were told that the study aimed to include 50% of the workers. In meetings with each shift team, 20 workers and 11 day workers agreed to participate. Only 2 workers were reluctant when asked to participate. Six shift workers and 2 day workers were excluded from the analysis due to technical failures or due to their taking other jobs (no schedule-related reasons were given for the change).

Both shift schedules comprised 35 days, the 8-hour schedule being as follows:

+AMMMM++<u>+NNNNAA+++AAMMM++</u>++NNNAA+++,

where N = night, A = afternoon, M = morning, D = day, + = free day and the underlined days = intensive measurement period. The AM and NA changes were "quick changes", with only 8 hours of rest in-between. The new 12-hour schedule was as follows:

NN+++++DD+<u>+NNN++++DDD++</u>NN+++++DD+++.

The shift change times were 0600—1400—2200 for the 8-hour shift and 0600 and 1800 in the 12-hour shift. The day workers worked Monday through Friday from 0700 to 1600. The reference group was measured during 2 workdays and 2 free days.

The questionnaire (12, 13) covered such topics as background, attitude towards work and workhours, health, sleep-wake problems, life-style (exercise, smoking), and social factors. The second questionnaire also included questions comparing the experience of the 12-hour shift with that of the 8-hour shift. The items were scored from 1 to 5 (except for a few items with 4 alternatives) with verbal anchoring as 1=never, 2=occasionally, 3=sometimes, 4=usually, 5=always. The reference group filled out a similar questionnaire but without the shift-related questions.

Activity was measured on an actigraph, or "activity logger" (Ambulatory Monitoring Inc), which detects acceleration and sums the number of accelerations per minute. Sleep episodes were identified through an automatic sleep scoring program [action 1.24, (14)], yielding data for onset-offset of sleep, sleep length and sleep efficiency. The subjects were instructed to press an event button on the logger when going to bed ("lights out"), when finally awake, and before and after naps.

Subjective sleep quality was reported upon awakening using the Karolinska sleep diary (15). The answers were given on 5-point scales with verbal anchoring, reaching from "very poor" (1) to "very good" (5) or similar adjectives. A sleep quality index was formed using the items: "ease of falling sleep", "sleep quality", "calm sleep" and "slept throughout". The awakening index comprised the 2 items "ease of rising" and "well rested".

Sleepiness ratings were made every 2—4 hours, plus at bedtime and at rising, using the Karolinska sleepiness scale (KSS) (16), which consists of a 9-point scale with verbal anchors as follows: 1=very alert, 3=alert, 5=neither alert nor sleepy, 7=sleepy but no problem staying awake, and 9=very sleepy, fighting sleep, an effort to stay awake.

A simple visual reaction-time test was carried out during the first and last hour of each shift. This test was constructed on the basis of similar tests developed by Lisper & Kjellberg (17) and Wilkinson & Houghton (18). The duration of the test was 10 minutes with 16 signals presented every minute on a PSION handheld computer. The stimulus interval varied between 2.2 and 5 seconds, and the extracted results included the 10-minute median and the mean of the 10% slowest values. If no response was given within 1 second, a new stimulus cycle was initiated, and a value of 1 second was assigned to the non-response. Before the experiment all the subjects had practiced the test.

To estimate the effect of the shift change a 2-way analysis of variance (ANOVA) with 1 grouping factor (shift-day workers) and 1 within factor was used where time A=before the shift change and time B=10 months after the change. When several days were compared, the results were corrected for violation of the assumption of equal variances and covariances (19). Post-hoc comparisons were made with the Newman-Keuls t-test.

Table 1. Results of the analysis of variance (ANOVA) for change between times A (before the shift change) and B (10 months after the change). (NS=not significant)

Variable	Shift workers		Day workers		ANOVA		
	A (8-hour shift)	B (12-hour shift)	A	B	Group	Time	Interaction
How satisfied are you with your current workhours? (1-5 very satisfied)	3.53	4.62	4.29	4.50	NS	***	*
Do you experience psychological fatigue at work? (5-1 every day)	3.72	3.91	3.57	3.86	NS	NS	NS
Do your workhours permit enough time for social (family/friends) activities? (1-4 very much)	2.65	3.02	3.25	3.02	NS	NS	*
Has it been easy to fall asleep during the last 6 months? (1-5 always)	3.59	4.12	4.31	4.23	NS	**	*
Have you been rested at awakening during the last 6 months? (1-5 always)	4.06	4.47	4.38	4.23	NS	NS	*
Do you receive sufficient sleep with your workhours? (1-5 yes, definitely enough)	3.84	3.97	3.71	3.86	NS	NS	NS
How has your health generally been in the past year? (1-5 very good)	4.34	4.44	3.86	3.79	NS	NS	NS

* P<0.05, ** P≤0.01, *** P<0.001; Df group = 1/44, GxT =1/44.

Results

Questionnaire

Table 1 summarizes the results for the main topics in the questionnaire. For attitude towards work and workhours, the results showed that the change to the 12-h shift greatly increased the satisfaction with workhours (significant interaction effect). No other significant effects were observed for this topic [for items such as psychological fatigue (in table), job demands, job control, reluctance to go to work, and the security of having a permanent job]. For social factors, the 12-hour shift yielded more time for social (family/friends) activities, but time for other free-time activities such as house work, sports, hobbies, shopping and amusements did not change. With regard to sleep-wake problems, some aspects of sleep improved. Within the health topic, no significant changes were observed for general health (in table) or complaints in respect to other health-related items. No other significant effects were found for the topics listed in table 1. In addition, the subjective recovery time after the period of night work was shorter with the 12-hour schedule, [8-hour shift=1.8 (SE 0.1) days, 12-hour=1.5 (SE 0.1) days, t-test, P<0.05)].

The retrospective evaluation of the change after 10 months showed a significant improvement for several items concerning satisfaction with the schedule, fatigue, time for family, sleep, health, and others (table 2). Altogether 77% considered the 12-hour schedule to be better, and 9% thought it was worse (chi-square, P<0.001). Physical and mental stress did not change significantly, nor did the subjects' perception of perceived accident risk or contacts with supervisors. The only significant negative effects concerned sickness benefits, which were reduced, and less contact between shift teams.

The subjects were also asked to rate the amount of difficulty with sleep and alertness when changing between different shifts (or days off). The change was rated on a 9-point scale where 9=very easy and 1=very difficult. The change from a day off to a day of afternoon work (+A) on the 8-hour schedule was easy and yielded a value of 7.7 (SE 0.4). The other changes were compared with this value using Dunnetts t-test (2-tailed). The only changeover in the 12-hour schedule that deviated significantly was that going from a day off to the first day shift [+D=6.8 (SE 0.3), P<0.05]. For the 8-hour shift, the quick change (only 8 hours of time off) between afternoon (A) and morning (M) shifts deviated strongly and negatively [AM=3.8 (SE 0.2), P<0.001], but also the quick change between the night and afternoon shifts was

Table 2. Change across last 10 months for the shift and day workers (retrospective questions only given in the second questionnaire). (SE=standard error of the mean, NS=not significant)

Variable [a]	Shift		Day		P-value[b]
	Mean	SE	Mean	SE	
Satisfaction with work schedule	4.29	0.19***	3.00	0.00	<0.001
Value of free days	4.29	0.18***	3.00	0.00	<0.001
Contact between shift teams	2.00	0.20***			
Fatigue during free days	3.91	0.14***	2.94	0.11	<0.001
Ability to relax after work	3.78	0.16***	2.94	0.17	<0.01
Possibility to arrange eating breaks	3.74	0.16***	3.12	0.09	<0.05
Health	3.50	0.16**	2.80	0.11	<0.01
Sleep quality	3.61	0.17***	3.07	0.07	<0.05
Sufficient sleep	3.50	0.18**	2.80	0.11	<0.05
Alertness	3.67	0.15***	3.00	0.00	<0.05
Stress at work	3.44	0.14***	2.88	0.18	<0.05
Mental strain	3.14	0.16	2.81	0.14	NS
Physical strain	2.89	0.14	3.06	0.06	NS
Accident risk at work	3.06	0.11	3.12	0.15	NS
Contact with supervisors	2.75	0.16	2.65	0.17	NS
Control over work process	3.47	0.14**	3.33	0.11	NS
Sick leave benefits	2.15	0.15***	3.00	0.00	<0.001

[a] 5 = very positive change, 4 = rather positive change, 3 = no change, 2 = rather negative change, 1 = very negative change.
[b] Differences between shift and day workers, t-test.
*P < 0.05, ** P < 0.01, *** P < 0.001, for t-test against no change (3).

Table 3. Results of the analysis of variance (ANOVA) for actigraphy, ratings, and performance at the end of the night shifts (within frame). (N=night, A=afternoon, +=free day, KSS = Karolinska sleepiness scale, F = F-value, e = epsilon)

	+	N	N	N	A(+)[a]	A(+)[a]	+	F/e	Schedule	Day	Interaction
Bed time (h)[b]											
8-hour	2329	0700	0700	0635	0014	0015	2337	F	0.05	2222***	1.2
12-hour	2325	0712	0648	0651	2409	23.34*	23.33	e	·	0.43	0.48
Time of rising (h)[b]											
8-hour	07.53	13.32	13.23	11.56	08.56	08.11	08.20	F	0.5	76***	1.2
12-hour	08.14	12.59	13.29	12.42	08.40	06.50*	08.05	e	·	0.80	0.64
Sleep length (h)[b]											
8-hour	7.07	5.62	5.62	4.72	7.18	6.73	7.63	F	1.9	21***	1.4
12-hour	7.73	5.28	6.30	4.90	7.68	6.27	7.23	e	·	0.68	0.87
Sleep quality index (1-5 maximum)[b]											
8-hour	4.21	4.07	4.07	3.89	4.39	4.07	4.05	F	9.1**	0.2	1.6
12-hour	4.12	4.32	4.53	4.53	4.46	4.34	4.30	e	·	0.81	0.85
Awakening index (1-5 maximum/good)[b]											
8-hour	3.61	3.00	2.79	2.32	3.07	2.71	3.00	F	1.6	11***	1.4
12-hour	3.60	2.93	3.29	2.71	3.43	2.96	2.57	e	·	0.73	0.89
Median reaction time (ms)[c]											
8-hour	·	241	244	240	·	·	·	F	0.5	0.2	0.4
12-hour	·	241	236	236	·	·	·	e	·	0.67	0.70
Mean slow reaction time (ms)[c]											
8-hour	·	404	392	430	·	·	·	F	0.05	0.02	1.7
12-hour	·	422	425	390	·	·	·	e	·	0.64	1.0
Sleepiness start shift (KSS-1-9 very sleepy)[c]											
8-hour	·	5.3	4.9	4.1	·	·	·	F	9.1**	2.5	3.2
12-hour	·	3.8*	3.9*	3.9	·	·	·	e	·	1.0	.73

[a] A=afternoon shift, 8-hour shift; + = free day, 12-hour shift.
[b] DfSchedule=1/13, Day=3/39, SxD=3/39.
[c] DfSchedule=1/13, Day=2/26, SxD=2/26.
* P < 0.05, ** P < 0.01, *** P < 0.001.

Table 4. Results of the analysis of variance (ANOVA) for actigraphy, ratings, and performance at the beginning of the day shifts (within frame). (A=afternoon, D=day shift, +=free day, KSS = Karolinska sleepiness scale, F = F-value, e = epsilon)

	A(+)[a]	A(+)[a]	D	D	D	+	F/e	Schedule	Day	Interaction
Bed time (h)[b]										
8-hour	2352	0052	0002	2235	2247	2232	F	0.1	1.3	5.7**
12-hour	2334	2328	2241*	2300	2323	2308	e	·	0.61	0.75
Time of rising (h)[b]										
8-hour	0851	0905	0504	0500	0456	0826	F	7.2*	55***	1.6
12-hour	0650*	0757*	0502	0448	0447	0730*	e	·	0.47	0.38
Sleep length(h)[b]										
8-hour	7.25	7.48	4.23	5.48	5.40	8.43	F	0.0	28***	3.5*
12-hour	6.27	7.23	5.62	5.33	4.83	7.88	e	·	0.69	0.79
Sleep quality index (1-5maximum)[b]										
8-hour	3.93	3.89	3.57	4.20	4.04	4.34	F	5.3*	3.2*	1.3
12-hour	4.34	4.30	4.33	4.43	4.52	4.46	e	·	0.73	0.94
Awakening index (1-5maximum/good)[b]										
8-hour	3.25	3.36	1.96	2.21	2.32	3.07	F	2.1	22***	1.8
12-hour	2.96	2.57*	2.43	2.39	2.11	3.46	e	·	0.82	0.78
Median reaction time (ms)[c]										
8-hour	·	·	240	239	240	·	F	0.7	0.3	0.4
12-hour	·	·	230	236	234	·	e	·	0.77	0.75
Mean slow reaction time (ms)[c]										
8-hour	·	·	402	394	435	·	F	0.5	0.9	2.0
12-hour	·	·	379	413	389	·	e	·	0.78	0.95
Sleepiness start shift (KSS-1-9maximum)[c]										
8-hour	·	·	5.8	6.0	6.6	·	F	0.0	4.0*	0.6
12-hour	·	·	5.9	6.1	6.5	·	e	·	0.95	0.87

[a] A=afternoon shift, 8-hour schedule; + = free day, 12-hour schedule.
[b] DfSchedule=1/13, Day=3/39, SxD=3/39.
[c] DfSchedule=1/13, Day=2/26, SxD=2/26.
* P < 0.05, ** P < 0.01, *** P < 0.001.

significantly more difficult [NA=4.9 (SE 0.3), P<0.05]. The rated fatigue rating showed almost exactly the same results.

Diary, actigraphy and performance

Since there was no straightforward way of comparing the entire 8- and 12-hour shifts on a day-by-day basis, we selected a sequence of comparable days from the 2 schedules — mainly the night and morning-day shifts. These selections were analyzed separately through a 2-factor repeated-measures ANOVA, with subsequent pair-wise tests using the Newman Keuls procedure. Reaction-time performance and sleepiness during work were only analyzed for the days with work. Tables 3 and 4 summarize the results, including the immediately preceding or subsequent days for comparison (not part of the ANOVA, only subjected to a pairwise t-test).

The analysis of the nightshift sequence (including the preceding day off) (table 3) showed that the schedule had a significant effect on the sleep quality index and sleepiness at the start of the shift. No other significant differences between the schedules were obtained. The effect of day was significant for most of the variables.

The analysis of the day shift sequence showed a significant effect for schedule on time of rising and the sleep quality index (table 4), with a later time of rising on the 12-hour shift and better sleep quality on the measured days. Significant interaction effects were found for bed time and sleep length. The effect of day was significant for the time of rising, sleep length, the sleep quality index, the awakening index, and sleepiness (at the start of the shift).

The frequency of napping in connection with night and morning work was considerably reduced on the 12-hour schedule. More than half the subjects took a nap on the old schedule. But after the change only 25% of the subjects took a nap (P<0.05, binomial test).

The median reaction-time performance was reduced from 236 (SE 7) ms to 244 (SE 8) ms (P=0.08) from the start to the end of the 8-hour night shift (averaged across shifts). For the 12-hour night shift the corresponding value was 226 (SE 6) to 238 (SE 7) ms (P<0.05). For the 8-hour morning shift performance improved from 240 (SE 8) to 225 (SE 7) ms (P<0.05) and for the 12-hour morning shift there was no change, 234 (SE 9) to 232 (SE 10) ms (not significant). The median reaction-time performance for the day workers changed from 227 (SE 8) to 223 (SE 6) ms (not significant).

Figure 1 shows the sleepiness pattern (KSS) across selected days of day and night work. All the days displayed showed a highly significant time of day pattern (all with P<0.001, repeated-measures ANOVA with epsilon corrections). When the sequence of the mean KSS levels of the 3 night shifts was analyzed in a 2-factor repeated-measures ANOVA, the effect of the schedule was significant ($F_{1,13}$=7.5, P<0.05), as was the effect of day ($F_{2,26}$=4.8, P<0.05), whereas the interaction was not ($F_{2,26}$=0.2). Thus sleepiness was higher for the 8-hour shift, and there was a reduction in sleepiness across the 3 night shifts. The same type of analysis for the 3 days of day work showed a significant effect for schedule ($F_{1,13}$=7.0, P<0.05), but no significant effect for day ($F_{2,26}$=0.03) or interaction ($F_{2,26}$=1.6). The 12-hour schedule involved less sleepiness. The mean values for the free day in figure 1 did not show any differences between the 8-hour and 12-hour shifts (t-test).

In an attempt to obtain a total measure of (diary-based) sleepiness for the entire shift cycle, the ratings were first averaged across the waking span of each day. The ratings for the unmeasured days were estimated by

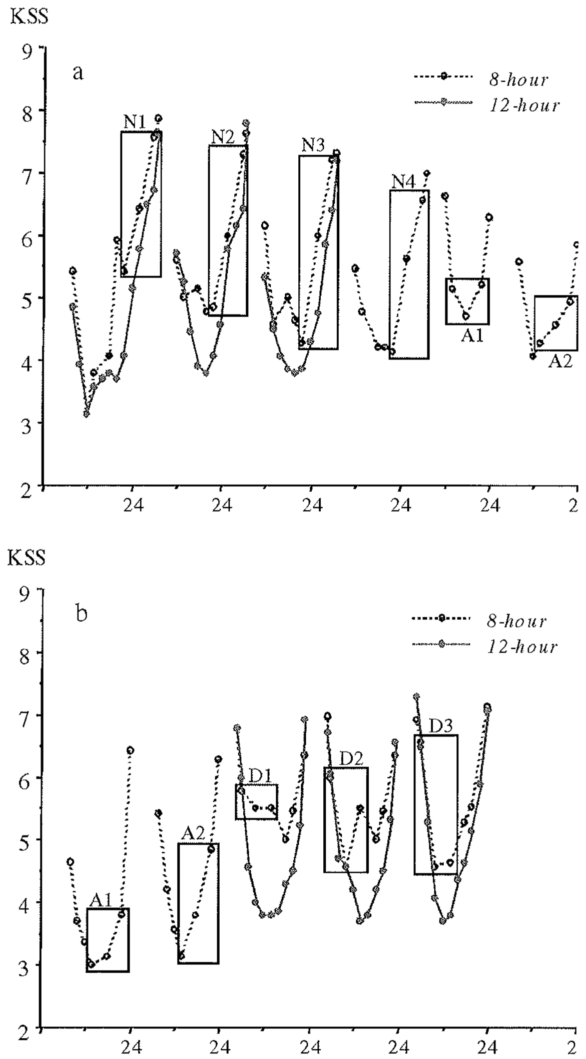

Figure 1. Ratings of sleepiness on the Karolinska sleepiness scale (KSS), in figure a for night (N) shifts and afternoon (A) shifts (8-hour shift=N1-N4+A1-A2; 12-hour shift=N1-N3) and in figure b for afternoon (A) shifts and day (D) shifts (8-h=A1-A2+D1-D3, 12-h=D1-D3), given at the time of rising and every 2—4 hours until bedtime (KSS; 1=very alert, 9=very sleepy, fighting sleep). (Bars = the 8-hour shiftwork period)

taking the mean values of corresponding measured days. The 35 days were then averaged across the shift cycle. In addition, averages were computed for workdays and days off. The results showed that the mean sleepiness for the entire shift cycle changed from 5.0 (SE 0.2) to 4.6 (SE 0.2) for the shift workers and from 3.8 (SE 0.2) to 3.2 (SE 0.2) for the day workers. The ANOVA showed a significant effect for group ($F_{1,21}$=15, P<0.001) and time (F_1=11, P<0.01), but no significant interaction ($F_{1,21}$=1.7, not significant). The same analysis for work days yielded 5.4 (SE 0.3) to 5.0 (SE 0.2) for shift workers and 4.1 (SE 0.2) to 3.3 (SE 0.3) for day workers. The ANOVA showed a significant effect for group ($F_{1,21}$=19, P<0.001), and time (F_1=11, P<0.01), but no significant interaction ($F_{1,21}$=2.7). For days off the values were 4.4 (SE 0.2) to 4.4 (SE 0.2) for the shift workers and 3.4 (SE 0.3) to 3.2 (SE 0.2) for the day workers. Again, the ANOVA showed a significant group effect ($F_{1,21}$=15, P<0.001), but no effect for time (F_1=0.2) or interaction ($F_{1,21}$=0.3).

Discussion

The overall impression of the results is that the change to the 12-hour schedule was positive. The strongest effect was seen in the questionnaire data, in which the 12-hour schedule received strong support in the before-after measurements, particularly with respect to attitude towards workhours, increased time for family and friends, and improvement in sleep. Subjective health and mental fatigue were not significantly affected, however.

The retrospective comparison also yielded strong support for the new schedule with strong improvement for social aspects, health and many aspects of sleep, as well as reduced fatigue after work and during days off. In addition, the 12-hour shift did not seem to have caused more physical and mental strain, or an increase in accident risk. An increase in the possibility to organize food intake was also reported; this finding seems to suggest an increase in influence on work organization.

The lack of negative effects on sleep, alertness, and performance is also shown by activity monitoring and diary ratings. If anything, the effects were positive — improved sleep and alertness. Lack of effects also holds for the integration of sleepiness across the entire shift cycle.

Even if the results suggest that the 12-hour shifts were superior, there are alternative interpretations that need to be considered. One may be a concomitant change in worktasks. Such a change can safely be ruled out, however, since the tasks remained the same. In addition, any changes in company atmosphere should have been controlled through the use of the reference group. A more likely confounder may have been an initial negative attitude towards the 8-hour shift. Such negativity may have been operating to some extent, but the before-after design with 10 months of experience with the new schedule should have reduced such effects.

To some extent the effects may have been due to a rather poor 8-hour shift system rather than to a very good 12-hour shift. In particular, the 8-hour shift contained 4 problematic quick changes causing sleep reductions and disturbances. Furthermore, the schedule had a backward rotation with many workdays in a row, including 4 night shifts (NNNNAA). Usually, backwards rotation (20) and slow shift rotation have negative effects on sleep and wakefulness (21). Finally, the number of free days in the 8-hour schedule was fewer, and only 1 of the weekends during the 35-day cycle was completely free. It seems obvious that the more free days inherent in the 12-hour schedule would lead to greater ease of recuperation and more prime weekend time for social activities.

A further confounding factor in the interpretation of the results may have been the selection of the reference group. It had, for obvious reasons, different workhours, but it worked in the same section of the plant as the shift workers. Thus it should suffice as a reference for changes in the social climate of the company. The higher frequency of women (among the day workers) did not seem to be a problem, as the women gave the same ratings as the men on questions of whether or not they had enough time for family and domestic work. Having (paid) extra work (elsewhere) was more common for the shift workers (43% versus 12%), but it was not controlled for in the analysis.

Even if some external influences may have affected the results, the fact remains that the change to the 12-hour shift was very positive (apart from the reduction in sick-leave benefits due to loss because of a longer shift and less contact between shift teams due to the 12-hour shift workers meeting with the same team at all shift changes). The reason can probably be found in the fewer successive shifts worked providing frequent recuperation between shifts. The fewer shifts also meant fewer days disturbed by having to work and fewer days of being exposed to disturbed sleep-wakefulness. It might also be argued that it is probably easier to handle switching between only 2 types of shifts rather than between 3. This possibility needs to be tested empirically however.

Earlier studies of 12-hour schedules have emphasized the particular risk of elevated sleepiness, primarily caused by sleep deficits (11, 21). In the present study strong sleepiness symptoms were rare on the 12-hour shifts, even on the night shifts. As has already been mentioned, 1 reason is probably the decrease in consecutive night shifts and the increase in free time between shifts. The times for change-over between shifts were also well chosen with respect to sleepiness, since the extension of the shifts was added to the start of the shifts (N=1800—2200, D=1400—1800). This was not the case in an earlier study where the authors (22) found negative effects on performance 10 months after the introduction of a 12-hour shift, particularly at night. No such decreases were found in the present study, but both studies show a parallel between performance and circadian variation. Another important difference was that sleep in the study of Rosa & Bonnet (22) was much shorter on some days towards the end of the week and that the work was physically demanding. A 50% increase in work length during the work shift in such a work setting would probably produce negative effects on performance. This question of work load is probably a key to determining the feasibility of implementing 12-hour shifts. Very little empirical data are available, however. Another study of performance in the introduction of a 12-hour schedule for computer operators (23) did not show any deterioration of operator lapses per hour, not even at night.

Finally the attempt to integrate sleepiness across the whole shift cycle indicated that shift workers were sleepier, not only on the average or during workdays, but also during days off. This observation will have to be tested in future studies, but it clearly suggests that shift workers' allotted recovery days may not be sufficient. The suggested technique at integrating "load" across shift cycle may be a tool for estimating the need for improving the shift schedules towards the lighter "load" of day workers.

In summary, it is concluded that the change from 8-hour to 12-hour shifts was positive in most respects, possibly due to the shorter sequences of the workdays, the longer sequences of consecutive days off, the fewer types of shifts (easier planning), and the elimination of quick changes. The results may differ in groups with a higher work load.

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