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Duration of Sleep Depending on the Type of Shift Work*

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Summary. Time budget studies were performed in eight groups of shift workers. The 9,480 diary records of altogether 1,230 shift workers were analyzed and related to corresponding shift types. The shortest night sleep was found before the morning shift (mean 7.0 h). There were large differences in the duration of day sleep when classifying this sleep into specific types, as day sleep before 1st night shift (mean 2.1 h), between two night shifts (mean 6.1 h), or after last night shift (mean 4.2 h). Average sleep durations of five kinds of day sleep and 12 kinds of night sleep are presented together with 14 frequency distributions of durations of sleep.

It is concluded that there should not be many night shifts in succession and that morning shifts should not begin too early to avoid an accumulation of sleep deficits.

Key words: Sleep duration – Shift work – Day sleep – Night sleep

Sleep is a major concern in the life of shift workers. Complaints of sleeping difficulties reported in the literature occurred especially in connection with night shift (about 10 to more than 90%) but rarely in shift work without night shifts or in day work (about 5–20%; Knauth et al. 1980). Variations of complaints of shift workers working permanently or rotatingly in night shifts may be caused by differences in their housing conditions, kinds of work, or shift systems.

Complaints about sleeping difficulties refer both to the duration of sleep and to the quality of sleep. Problems of the quality of sleep were discussed in a previous paper mainly based on experimental shift work studies (Knauth et al. 1980). This article, however, will be centered on the *duration of sleep.*

In Figs. 1 and 2 average hours of sleep depending on the type of shift as reported in the literature are presented. These data are based on interviews, questionnaires, or diaries of about 5,000 shift workers. Some groups occur several times in the figures. In these cases the data of sleep duration of the same groups

* Dedicated to Dr. H. Loskant on the occasion of his 65th birthday

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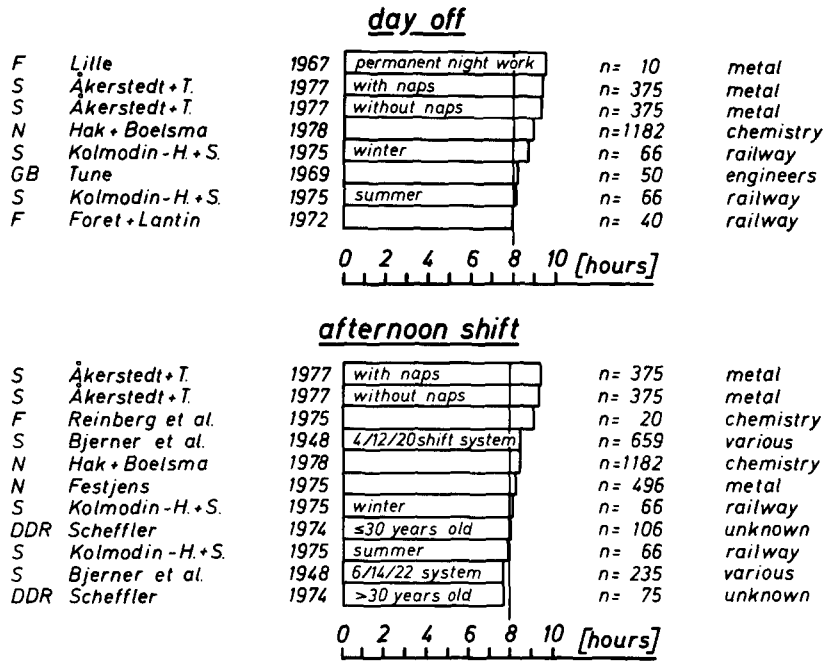

Fig. 1. Duration of sleep at day off and in connection with afternoon shift

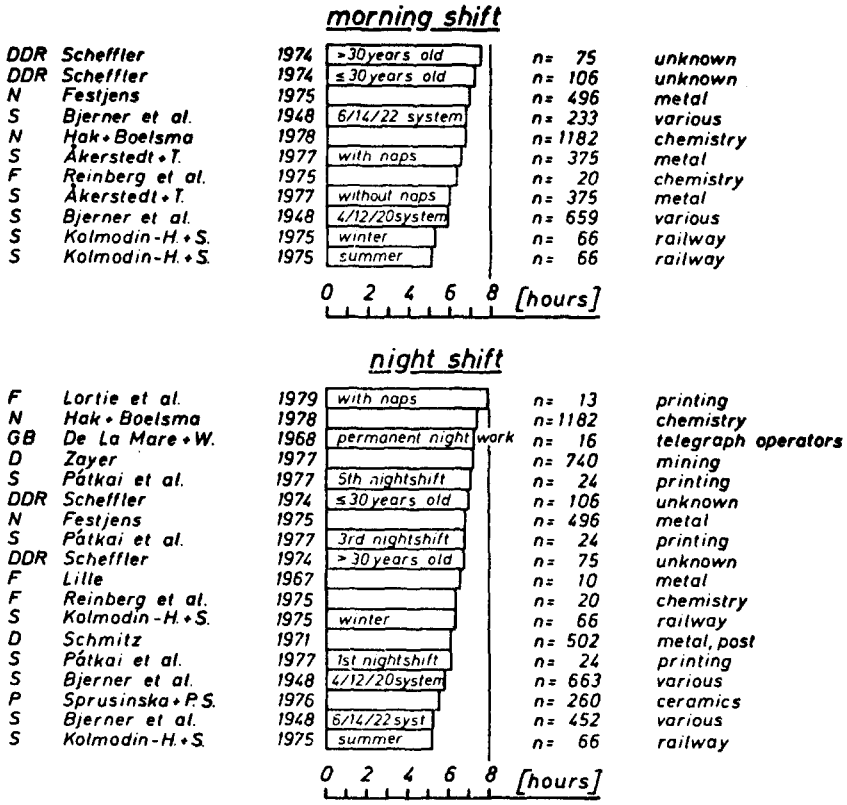

Fig. 2. Duration of sleep in connection with morning shift and night shift

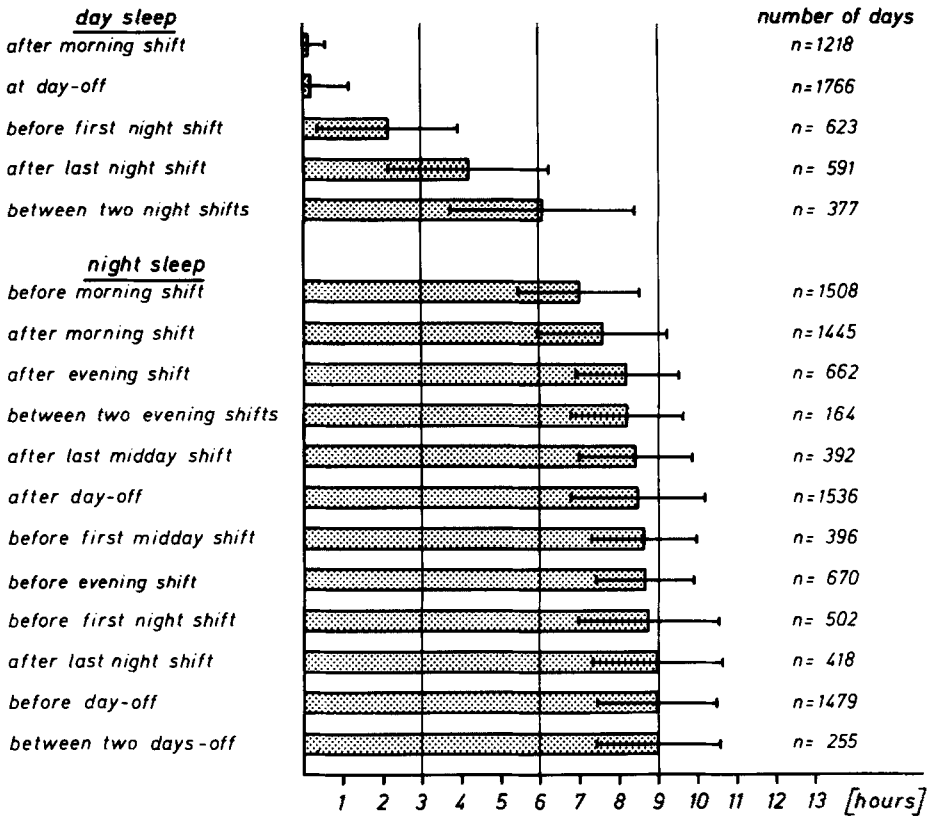

Fig. 3. Duration of sleep by shift type (diary records of 1,230 shift workers)

are classified according to the type of shift or divided within one shift into two conditions, e.g., winter/summer or including naps/without naps. These figures are not only based on different methods of investigation but also on different types of work, shift systems, age groups, housing and other environmental conditions and reflect the large intra- and interindividual variance of sleep data. However, some tendencies may be recognized. The average duration of sleep during days off was 8.0 to 9.5 h and varied between 7.6 and 9.3 h in connection with afternoon shifts. The sleep length before morning or after night shifts, however, was shorter than 7 h in most cases.

We thought that it would be easier to draw further conclusions from results based on the same method of investigation and classified into more specific types of sleep, e.g., night sleep before 1st night shift, night sleep after last night shift or day sleep between two night shifts, day sleep after last night shift. Therefore we performed time budget studies in eight groups of shift workers.

Method

Shift workers were asked to fill out a printed diary-form each day over a period of 8 consecutive days, writing down the times of working, travelling to and from work, leisure time as well as

Table 1. Results of α-adjusted multiple t-tests for differences between all durations of sleep presented in Fig. 3

type of sleep and shift			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
day sleep	after morning shift	1	—																
	at day-off	2	n.s.	—															
	before 1st night shift	3			—														
	after last night shift	4				—													
	between 2 night shifts	5					—												
night sleep	before morning shift	6						—											
	after morning shift	7							—										
	after evening shift	8								—									
	between 2 evening shifts	9								n.s.	—								
	after last midday shift	10								n.s.	n.s.	—							
	after day-off	11									n.s.	n.s.	—						
	before 1st midday shift	12										n.s.	n.s.	—					
	before evening shift	13										n.s.	n.s.	n.s.	—				
	before 1st night shift	14										n.s.	n.s.	n.s.	n.s.	—			
	after last night shift	15														n.s.	—		
	before day-off	16														n.s.	n.s.	—	
	between 2 days - off	17														n.s.	n.s.	n.s.	—

n.s. = not significant
$p < 0.05$
$p < 0.002$

sleeping during night- and daytime. We used this method in several studies between 1972 (Knauth and Rutenfranz 1972a) and 1978 (Landau et al. 1978).

The following groups of shift workers contributed to the study:

Group 1: 466 air traffic controllers

Groups 2 and 3: 296 shift workers in the chemical industry (8-h shift system: $n = 78$; 12-h shift system: $n = 218$)

Groups 4 and 5: 193 employees of two radio and television broadcasting companies

Group 6: 112 computer operators

Group 7: 111 workers at an airport transporting and loading freight

Group 8: 52 workers producing plastic articles.

Groups 1–7 worked in rotating, continuous shift work, Group 8 in a rotating but discontinuous shift system (days off on Saturdays and Sundays). There were no permanent shifts, e.g., permanent night shifts. Group 4 in general did not work between 01.00 h and 05.00 h. About half of the shift workers had regular shift changing times (e.g., 06.00 h, 14.00 h, 22.00 h) whereas according to the time budget studies of the other shift workers there were more than 400 different cases of starting and stopping times of the shifts within 24 h. We therefore arbitrarily classified the shifts between the earliest and latest shift: we called the shifts beginning between 05.00 h and 09.59 h "morning shift", beginning between 10.00 h and 13.59 h "midday shift", beginning between 14.00 h and 18.00 h "evening shift" and beginning 22.00 h and 03.30 h "night shift".

To test the differences between the durations of all kinds of sleep an *α-adjusted* multiple t-test was used (Weber 1972): If the null hypothesis $H_0: \mu_1 = \mu_2 = \ldots = \mu_r$ is erroneously accepted on an α% level the probability that at least one single null hypothesis $H_0: \mu_i = \mu_j$ $(i \neq j)$ is erroneously accepted is

(*) $p = 1 - (1 - \alpha)^{r-1}$,

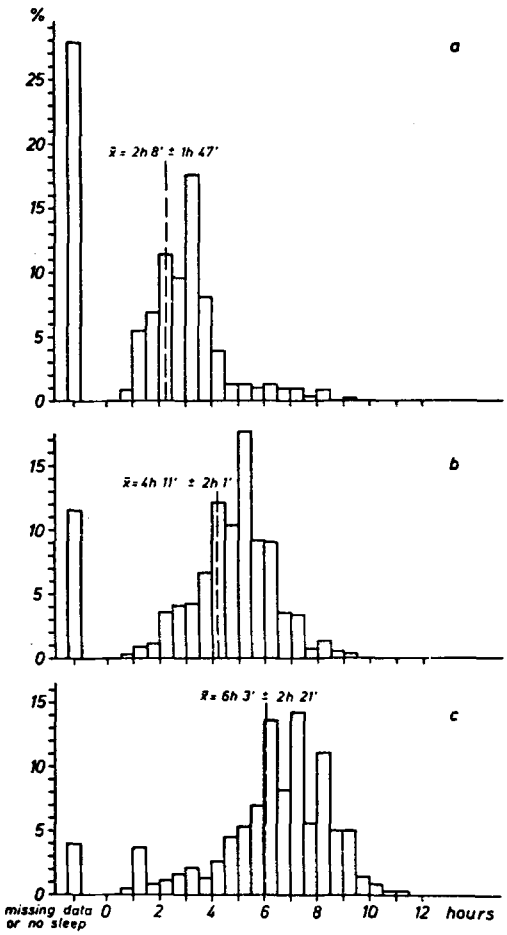

Fig. 4a–c. Frequencies of durations of day sleep; **a** before the first night shift (623 days); **b** after the last night shift (591 days); **c** between two night shifts (377 days)

i.e., all mean values differ from each other with a significance p. Based on this formula (*) the significance α with a level of, e.g., $p = 0.05$ and $r = 16$ (number of comparisons) is:

$$\alpha = 1 - (1 - p)^{\frac{1}{r-1}} = 0.003.$$

Results

In Fig. 3 the average durations of day and night sleep dependent on the type of shift are presented. When the time budget protocol began or ended with a sleeping time this sleep was only analyzed once. Sleep between two shifts, however, was analyzed twice: first in relation to the preceding and then in relation to the following shift. Therefore, the results in Fig. 3 are based on the analysis of 9,480 days but on 14,002 sleep periods. The results of the α-adjusted multiple t-tests are presented in Table 1. For example there is a significant difference ($p < 0.002$) between the duration of day sleep after the last night shift (line 4, Table 1) and of the duration of day sleep before the 1st night shift (column 3, Table 1).

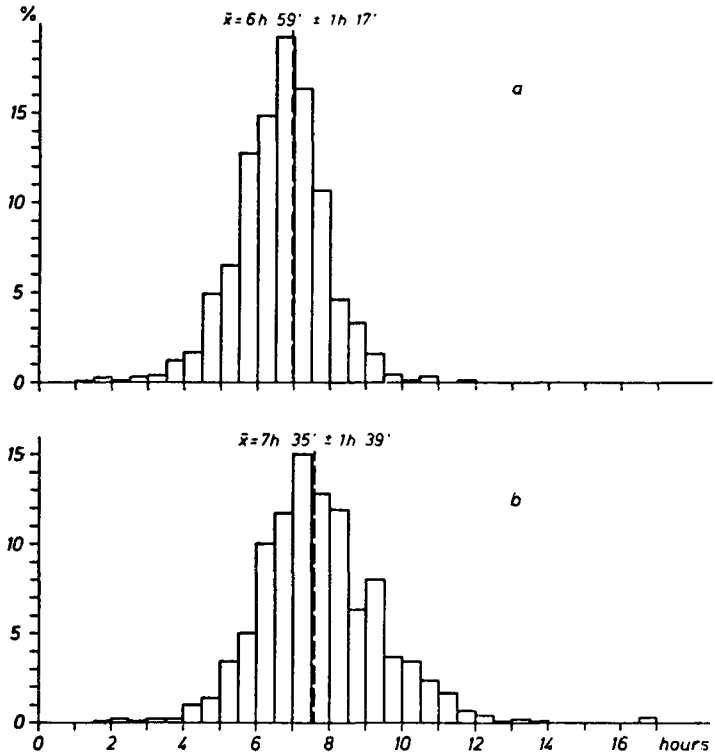

Fig. 5a and b. Frequencies of durations of night sleep; **a** before the morning shift (1,508 days); **b** after the morning shift (1,445 days)

Day Sleep

The upper part of Fig. 3 shows the mean durations of day sleep. The mean values are calculated on the basis of *all* corresponding days, including the days without a reported day sleep. On 91.8% of the days off and after 90.4% of the morning shifts no day sleep was noted by the shift workers. Before the first night shift (Fig. 4), however, in more than $^2/_3$ of the cases the shift workers slept during day time. The percentage of shift workers not sleeping during day time before the first night shift varied between 15.0% (Group 1) and 48.6% (Group 8). The behavior of Group 1 seems to be very special because they had to work 12-h shifts. The longest average duration of day sleep was found between two night shifts (Fig. 4). The distribution of sleep durations with half-hour classes has three peaks. The groups contributing most of all to these peaks were Groups 3, 7, and 8 (6.0–6.5h), Groups 2, 7, and 8 (7.0–7.5 h) and Group 8 (8.0–8.5 h).

Night Sleep

The data of the night sleep did not vary as much as the ones of the day sleep (Fig. 3). Only in connection with morning shift mean sleep durations shorter than 8 h were observed (Fig. 5). As many shift workers are not very flexible in regard to the time they go to bed (Knauth and Rutenfranz 1972a; Wedderburn 1972)

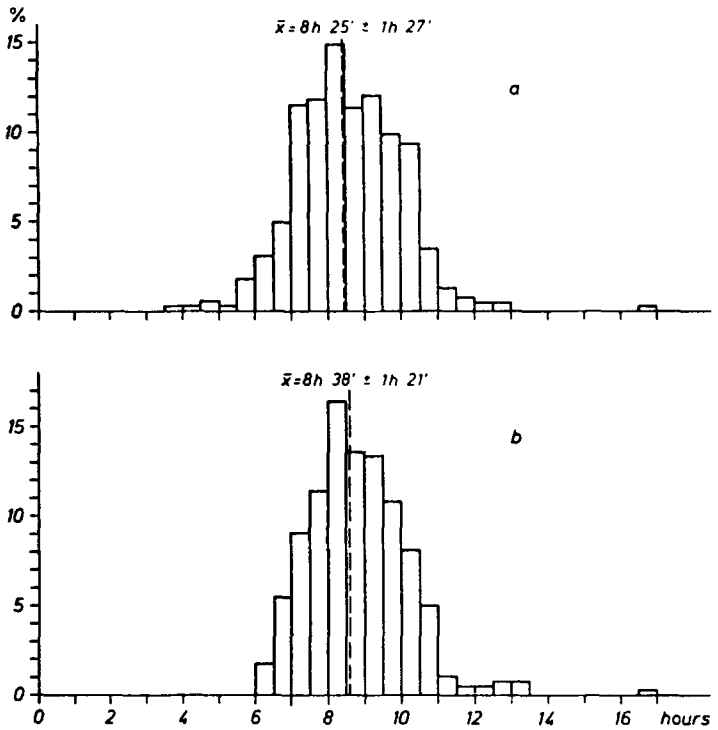

Fig. 6 a and b. Frequencies of durations of night sleep; **a** after the midday shift (392 days); **b** before the midday shift (396 days)

reduction of sleep has to be expected especially when the morning shift begins early.

Though the shift begin varied in our data from 05.00 to 09.59 h the average duration of sleep before morning shifts was about 7 h. Figures 6 and 7 show the distribution of sleep lengths in connection with midday and evening shifts. In Fig. 8, the corresponding sleep data of the night sleep before and after night shift periods are presented. The distribution of sleep durations before the first night shift has a large variance and several peaks. The peaks in the classes with a longer sleep duration than 10 h have to be attributed to Group 1 with 12 h night shifts. The distribution of the sleep data after the last night shift has a negative skewness. The sleep after days off (Fig. 9) in some cases was limited by the following morning shifts whereas the longest durations of night sleep were observed between 2 days off. Though the differences between the mean durations of night sleep dependent on the type of shift were not very large, most of them were statistically significant (Table 1).

Discussion

The results of the present study confirm the findings of most other authors that shift workers slept shortest during the day time and that the mean night sleep in

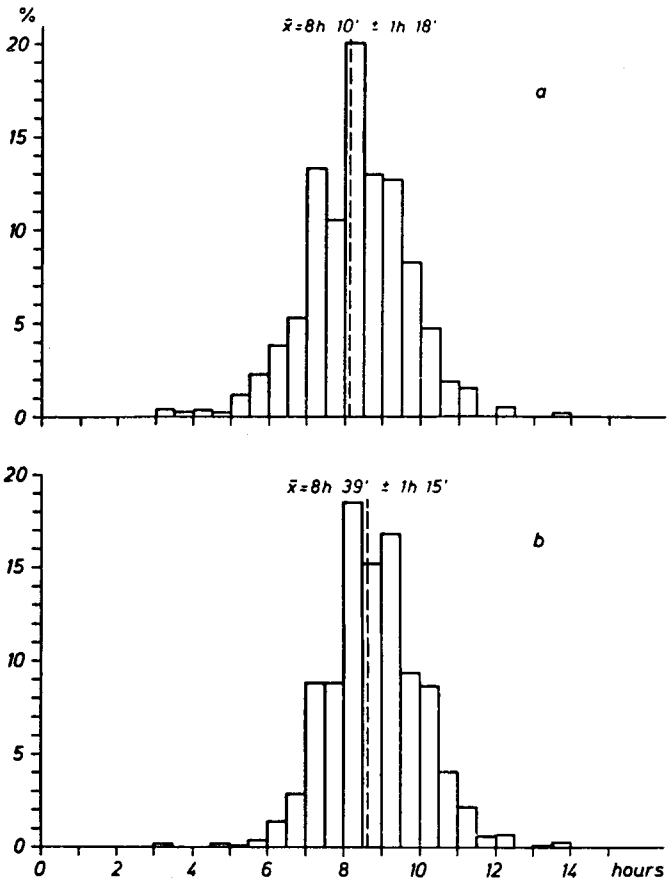

Fig. 7 a and b. Frequencies of durations of night sleep; **a** after the evening shift (662 days); **b** before the evening shift (670 days)

connection with morning shifts was shorter than 8 h. However, we found large differences of duration of sleep when classifying the sleep into more specific types, e.g., day sleep before 1st night shift (mean 2.1 h), between two night shifts (mean 6.1 h), or after last night shift (mean 4.2 h). The short day sleep of 2.1 h before the 1st night shift is plausible in connection with the long preceding night sleep of 8.75 h. Furthermore, the night sleep before a morning shift (mean 7.0 h) and after a morning shift (mean 7.6 h) differed from each other. The sleep reduction before morning shifts depends on the begin of the shift and on the time for travelling to work. As Reinberg et al. (1975) found, starting work at 05.00 h clearly reduces the duration of sleep (mean = 6.3 h).

The reports of a longer mean sleep in connection with the other types of shift and with days off show that there was a need for compensation. Tune (1969) even found a longer mean sleep for shift workers than for day workers. However, he studied sleep logs of engineers who form a special group of shift workers. Perhaps they had better housing conditions than other shift workers usually have. Besides the housing conditions (Aanonsen 1964) there are many other factors influencing

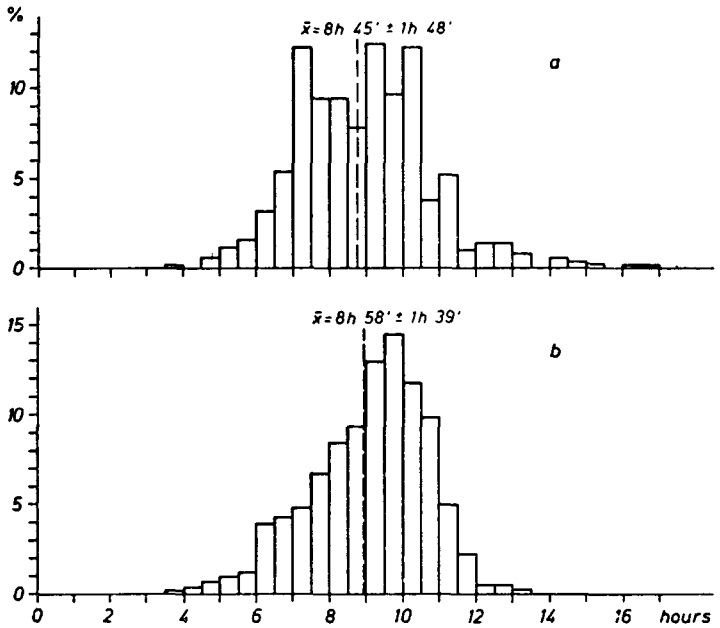

Fig. 8a and b. Frequencies of durations of night sleep; **a** before the first night shift (502 days); **b** after the last night shift (418 days)

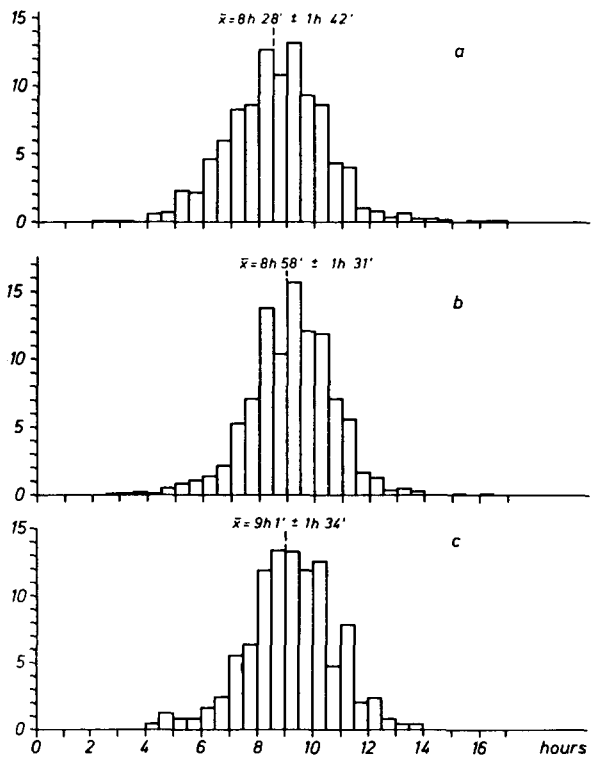

Fig. 9a–c. Frequencies of durations of night sleep; **a** after day off (1,536 days); **b** before day off (1,479 days); **c** between two days off (255 days)

the duration of sleep: time of going to bed (Åkerstedt and Gillberg 1979), noise (Knauth and Rutenfranz 1972b; Griefahn et al. 1976; Williams 1973), age (Scheffler 1974; Knauth and Rutenfranz 1972a), marital status and age of the children (Knauth and Rutenfranz 1972a), season, especially in the northern countries (Kolmodin-Hedman and Swensson 1975), and regularity of the shift system (Rutenfranz et al. 1974).

However, despite the large intra- and interindividual variations of sleep duration it may be concluded from our results that there should be few night shifts in succession and that morning shifts should not begin too early to avoid an accumulation of sleep deficits.

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