FAA-AM-77-5

SLEEP IN AIR TRAFFIC CONTROLLERS

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February 1977

Document is available to the public through the National Technical Information Service, Springfield, Virginia 22151

Prepared for
U.S. DEPARTMENT OF TRANSPORTATION
Federal Aviation Administration
Office of Aviation Medicine
Washington, D.C. 20591

NOTICE

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
FAA-AM-77-5		

4. Title and Subtitle

SLEEP IN AIR TRAFFIC CONTROLLERS

5. Report Date

Feb[redacted]977

6. Performing Organization Code

7. Author(s)

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8. Performing Organization Report No.

9. Performing Organization Name and Address

FAA Civil Aeromedical Institute
P. O. Box 25082
Oklahoma City, Oklahoma 73125

10. Work Unit No. (TRAIS)

11. Contract or Grant No.

13. Type of Report and Period Covered

12. Sponsoring Agency Name and Address

Office of Aviation Medicine
Federal Aviation Administration
800 Independence Avenue, S.W.
Washington, D.C. 20591

14. Sponsoring Agency Code

FAA

15. Supplementary Notes

Work was performed under Tasks AM-C-75-PHY-71 and AM-C-76-PHY-71.

16. Abstract

Data obtained from sleep logs maintained for a period of 5 weeks by 185 air traffic controllers indicate that on a weekly basis there is no significant difference in the amount of sleep obtained by controllers working the 2-2-1 rotation pattern and that obtained by those on the 5-day rotation pattern. Controllers working the 2-2-1 rotation pattern slept significantly less prior to the midshift than they did before the evening and day shifts. On both the 2-2-1 and 5-day rotation patterns, the most sleep obtained was on the evening shift followed by the day shift and midshift respectively. Approximately half the controllers indicated satisfaction with their present shift rotations; however, preferences indicate that they would prefer to work a shift rotation that excluded the midshift.

Age and experience do not appear to be related to pattern of sleep or amount of sleep obtained. "Fatigue," "weakness," and "somnolence" were complaints most often expressed on the midshift on both rotation patterns. Reasons most often given for not sleeping were "work related" and "illness" by controllers on the 2-2-1 rotation pattern and "work related" and "nonspecific" by those on the 5-day rotation pattern.

17. Key Words	18. Distribution Statement
Air Traffic Controllers Sleep Patterns Stress Shift Rotation	Document is available to the public through the National Technical Information Service, Springfield, Virginia 22151.

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	15	

A 264 320

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SLEEP IN AIR TRAFFIC CONTROLLERS

I. Introduction.

Since World War II, there has been a steady increase in the number of operations handled by the U.S. air traffic control (ATC) system. Advances in systems tend to make the controller's task somewhat easier from an operational point of view; however, the same cannot be said about the work schedules at most ATC facilities.

At air route traffic control centers (ARTCC), separation of aircraft is a 24-hour operation requiring continuous monitoring by air traffic personnel. To make the necessary coverage equitable, personnel are required to work rotating shift schedules. It then becomes imperative from management's viewpoint to determine what impact these rotating schedules might have on air safety and the health of controllers. Such determinations cannot be made simply and directly because the physiological, psychological, and social variables are numerous, complex, and interacting. Shift work demands adaptability; the ability of controllers to function optimally in their jobs is dependent, in part, on how well they adapt to their work schedules.

The two most common shift rotation schedules in effect at ATC facilities are the 2-2-1 rotation schedule (two evening shifts, two day shifts, and one midshift followed by 2 days off) and the the 5-day rotation schedule (usually five evening shifts, 2 days off, five day shifts, 2 days off, five midshifts, 2 days off, and then the cycle begins again). In studies conducted at Houston Intercontinental Tower during 1970-71, Melton *et al.* (1) compared the physiological, biochemical, and psychological responses of controllers working these two rotation schedules. In those studies, it was found that the level of biochemical and physiological stress was significantly lower in several respects when controllers worked the 2-2-1 rotation schedule than it was when they worked the 5-day rotation schedule. In addition, the amount of sleep was not greatly different on the two rotation schedules except that controllers slept significantly less prior to working the midshift on the 2-2-1 rotation schedule than at any other time.

While controllers generally maintain that they experience no adverse physiological or psychological effects from working the 2-2-1 rotation schedule, this opinion is not generally shared by management. The managerial position is perhaps justified in view of the large number of publications (2) relating to effects on job performance by various work-rest schedules. An investigation into the matter was indicated, not only to determine problem areas that might affect job performance and hence compromise air safety, but also to contribute to a data base from which short- and long-term effects of shift rotation work on the health of the controller can be determined.

II. Method.

Data were collected by means of a survey conducted with the cooperation of the Professional Air Traffic Controllers Organization (PATCO). Letters requesting controller volunteers to participate for 5 weeks in the study were forwarded through PATCO's Director of Labor Relations to each of 35 PATCO representatives in ARTCC's in the contiguous United States. Sleep logs (Fig. 1) were distributed by PATCO to controller volunteers. Completed sleep logs were returned to PATCO for forwarding to the Stress Physiology Research Unit, FAA Civil Aeromedical Institute, for processing and analysis; thus, complete anonymity of controller volunteers was insured.

One hundred and eighty-five completed questionnaires were returned. Thirty-two of the respondent controllers (average age 33 years, 9.4 years experience) worked the 2-2-1 rotation schedule, and 132 (average age 34 years, 9.7 years experience) worked the 5-day rotation schedule. Differences in age and experience between controllers on the two rotation schedules were not statistically significant. Twenty-one controllers worked rotation schedules different from the 2-2-1 and 5-day rotation schedules; data from this group are not reported.

From each of the 185 questionnaires, 534 entries were made into the Hewlett-Packard 2100 Executive Computer System for data processing and analysis. This total of 98,790 entries related to age, number of years of experience, rotation schedule and shift worked, quantity and quality of sleep, on- and off-duty complaints, and reasons for not sleeping. Entries were arranged into subsets of information for ease of handling.

III. Results.

Quantity of Sleep. On the basis of a 7-day week (including 2 days off), the average amount of sleep obtained by controllers on the 2-2-1 rotation schedule did not differ significantly from that obtained by controllers working the 5-day rotation schedule (Table 1). However, when the 5-day workweek (not including 2 days off) was considered, the amount of sleep obtained on the two rotation schedules was significantly different. On the average, controllers working the 5-day rotation schedule obtained 18 minutes more sleep per 24-hour period ($p < .01$) than did controllers working the 2-2-1 rotation schedule. The difference was clearly caused by the small amount of sleep obtained by controllers on the 2-2-1 rotation schedule prior to the midshift. On both rotation schedules, the greatest amount of sleep was obtained in association with the evening shift, while the least amount of sleep was associated with the midshift.

Age ______________________ Male _____ Female _____

How long a controller including military and training time? ______________

How long a controller at this facility? ______________________________

Journeyman? ______________________

Trainee? ________________________

Supervisor? ______________________

What shift rotation pattern do you prefer? ___________________________

What shift rotation pattern do you presently work? ____________________

Bedtime ________ Arising time ________ Date of arising ________

Begin ATC work (Date and Time) ________ End ATC work (Date and Time) _______

Overtime (if any) from _____ to _____ Leave (if any) from _____ to ________

Type of leave __________ Regular days off (yes or no) ________________

Remarks ____

Physical complaints On duty ____

Off duty ____

Sleep quality: Good ___ Average ___ Poor ___ Estimated hours of sleep ____

Trouble going to sleep. None ___ Slight ___ Moderate ___ Considerable ____

How do you feel? Well rested ___ Moderately rested ___ Slightly rested ____

Not at all rested ___. Reasons for inadequate sleep. Be specific.

____

____

Figure 1. Sample of sleep log kept by controllers for 5 weeks. The biographical data are not repeated on subsequent pages of the log.

TABLE 1. Comparison of Average Number of Hours Slept in Connection With the Various Shifts (and Days Off) on the Two Rotation Schedules

Shift	Rotation Schedule	
	5-Day	2-2-1
Day	6.0	5.8 *
Evening	7.4	7.6
Mid	5.2	3.5 **
Days Off	7.7	7.9
Average, 5-day workweek	6.4	6.1 **
Average, 7-day week	7.1	7.0

* $p < .05$

** $p < .01$

Quality of Sleep. There was no significant difference in the reported quality of sleep obtained by controllers on the two schedules in terms of percentage of responses of "good," "fair," and "poor" (Table 2). However, the percentage of responses of "poor" quality of sleep was greater on the 5-day rotation schedule than on the 2-2-1 rotation schedule. This difference is most apparent when a comparison is made of the percentage of "poor" responses from controllers on the midshift of the 2-2-1 rotation schedule with that from controllers on the 5-day rotation schedule.

The quality of sleep obtained by controllers on the 2-2-1 rotation schedule on their days off was significantly better than that obtained by controllers on the 5-day rotation schedule, as evidenced by a greater number of responses of "good" sleep ($p < .01$) and fewer responses of "poor" sleep ($p < .01$).

Age, Quantity, and Quality of Sleep. A within-age-group comparison of the amount of sleep obtained by controllers on the two rotation schedules shows that significant differences occurred with greater frequency in the 31- to 35-year age group (Table 3). Within this age group the number of responses from controllers on the 2-2-1 rotation schedule indicating sleep of less than 4 hours ($p < .01$) was greater than that from controllers on the 5-day rotation schedule. In the 31- to 35-year age group, controllers on the 5-day rotation schedule reported sleeping 6-8 hours a percentage of time greater ($p < .01$) than that reported by controllers on the 2-2-1 rotation schedule. It is noteworthy that there were no significant differences with regard to quantity of sleep in the over-41 age group on either shift rotation schedule.

Insofar as quality of sleep is concerned (Table 4), controllers who were over 41 years of age seemed to fare better on the 2-2-1 rotation schedule than did their counterparts on the 5-day rotation schedule. This is evidenced by the fact that they reported a significantly greater ($p \leq .01$) number of "good" responses for quality of sleep than did controllers on the 5-day rotation schedule.

Complaints. "Fatigue," "weakness," and "somnolence" were the most frequent on-duty complaints given by controllers on the midshift, followed by those same complaints in decreasing order of frequency on day and evening shifts. The high incidence of upper respiratory complaints might be related to the winter weather (Table 5). Postduty complaints (Table 6) followed the same response pattern as shown in Table 5 for on-duty complaints.

Reasons for Unsatisfactory Rest. The reasons given most frequently for unsatisfactory rest following the day shift were "nonspecific" on the 5-day rotation schedule and "work related" on the 2-2-1 rotation schedule (Table 7). On both rotation schedules, "illness" ranked first as the reason given for unsatisfactory rest following the evening shift and "work related" and "noise" were indicated most often in connection with the midshift (day sleep).

TABLE 2. Comparison of Sleep Quality in Connection With Various Shifts on the Two Rotation Schedules

Sleep Quality	Day		Evening		Mid		Days Off	
	5-Day † (1,440)	2-2-1 (341)	5-Day (1,370)	2-2-1 (283)	5-Day (341)	2-2-1 (56)	5-Day (1,237)	2-2-1 (278)
Good	36	35	48	52	24	29	57	66*
Fair	49	54	43	40	45	50	36	30
Poor	15	11	9	8	31	21	7	4**

† N = total number of responses made relative to quality on a particular shift within a rotation schedule. The numbers in the columns represent the percentages of N applicable to each category of quality.

* $p < .01$

** $p < .05$

TABLE 3. Within-Age-Group Comparisons of Hours Slept

in Connection With the Two Rotation Schedules

Hours Slept	Age Groups (Years)							
	≤30		31-35		36-40		≥41	
	5-Day †(1,541)	2-2-1 (319)	5-Day (1,185)	2-2-1 (312)	5-Day (930)	2-2-1 (134)	5-Day (459)	2-2-1 (126)
4	4	6	3	6*	3	0*	3	3
4-6	21	21	18	26**	21	23	22	20
6-8	42	35*	45	37***	45	38	44	39
8	33	38	34	31	31	39	31	38

† N = total number of responses made within a rotation schedule by each age group. The numbers in the columns represent the percentages of N applicable to each sleep period.

* $p < .05$

** $p < .01$

TABLE 4. Within-Age-Group Comparisons of Sleep Quality in Connection With the Two Rotation Schedules

Sleep Quality	Age Groups (Years) ≤30		31-35		36-40		>41	
	5-Day † (1,618)	2-2-1 (340)	5-Day (1,280)	2-2-1 (343)	5-Day (1,000)	2-2-1 (139)	5-Day (516)	2-2-1 (140
Good	44	51*	46	44	43	47	42	55**
Fair	44	40	43	46	44	47	42	36
Poor	12	9	11	10	13	6*	16	9*

† N = total number of responses made relative to quality by the various age groups within a rotation schedule. The numbers in the columns represent the percentages of N applicable to each category of quality.

* $p < .05$

** $p < .01$

TABLE 5. Comparison of On-Duty Physical Complaints

for Each Shift on the Two Rotation Schedules

Complaint	Day		Evening		Mid	
	5-Day † (397)	2-2-1 (40)	5-Day (225)	2-2-1 (20)	5-Day (141)	2-2-1 (19)
Eye	2.8	0	1.3	0	0	0
Chest	0.5	0	3.1	0	0	0
Gastrointestinal	7.6	12.5	17.4	15.0	7.8	0
Headache and Nervousness	7.8	15.0	20.9	25.0	2.8	0
Musculoskeletal Pain	6.0	5.0	6.7	25.0	3.5	0
Upper Respiratory Infection	11.5	5.0	16.9	10.0	9.3	5.3
Dental	0	0	0	10.0	0	0
Fatigue, Weakness, and Somnolence	60.0	60.0	30.2	15.0	75.2	94.7
"Flu"	2.0	0	0.4	0	0	0
Hangover	0	0	0.9	0	0	0
Minor Injuries	0	2.5	0	0	0	0
Malaise	1.5	0	2.2	0	1.4	0
Dizziness	0.3	0	0	0	0	0

† N = total number of complaints for shift on the indicated rotation schedule. The numbers in the columns represent percentages of N.

TABLE 6. *Comparison of Postduty Physical Complaints for Each Shift (and Days Off) on the Two Rotation Schedules*

Complaint	Postday		Postevening		Postmid		Days Off	
	5-Day † (373)	2-2-1 (40)	5-Day (213)	2-2-1 (17)	5-Day (119)	2-2-1 (8)	5-Day (189)	2-2-1 (24)
Eye	0.5	0	0	0	0	0	0.5	0
Chest	0.5	0	2.8	0	0	0	2.6	0
Gastrointestinal	9.1	20.0	10.8	17.6	7.6	0	12.7	0
Headache and Nervousness	11.8	15.0	16.5	17.6	2.5	0	9.0	12.5
Musculoskeletal Pain	8.8	5.0	14.6	29.4	2.5	0	14.3	25.0
Upper Respiratory Infection	15.8	15.0	23.0	29.4	16.0	12.5	25.9	20.8
Dental	0	2.5	0	0	0	0	0	0
Fatigue, Weakness and Somnolence	50.0	37.5	30.0	0	68.1	75.0	28.6	29.2
"Flu"	2.4	2.5	0.9	0	0	0	2.1	4.2
Hangover	0	0	0.5	6.0	0	0	2.1	0
Minor Injuries	0	2.5	0	0	0	0	0	0
Malaise	0.3	0	0.9	0	3.3	12.5	1.7	8.3
Dizziness	0.8	0	0	0	0	0	0.5	0

† N = total number of complaints for each shift on the indicated rotation schedule. The numbers in the columns represent percentages of N.

TABLE 7. Comparison of Reasons for Unsatisfactory Rest for Each Shift (and Days Off) on the Two Rotation Schedules

Reason	Postday		Postevening		Postmid		Days Off	
	5-Day (443)†	2-2-1 (84)	5-Day (244)	2-2-1 (33)	5-Day (158)	2-2-1 (14)	5-Day (220)	2-2-1 (34)
Illness, Aches, and Pains	15.8	11.9	20.9	30.3	3.2	0	18.2	23.5
Noise	3.8	2.4	6.1	12.1	20.9	21.4	10.9	5.9
Work Related	21.9	25.0	8.6	3.0	49.4	42.9	5.9	2.9
Family Problems	0.5	0	2.0	3.0	1.3	0	0.9	2.9
Entertainment	12.6	16.7	13.9	12.1	2.5	7.1	20.5	14.7
Fatigue	2.7	4.8	1.2	0	2.5	0	0.5	2.9
Environment	2.7	0	3.3	0	0.6	0	4.5	8.8
Dreams	2.7	0	4.1	6.1	0.6	0	1.8	2.9
Restless, Nervous	7.7	17.7	10.2	12.1	0	14.4	6.4	2.9
Nonspecific	26.1	16.7	20.4	9.1	14.6	7.1	17.6	20.9
Weather	0.2	1.2	0.8	0	0	0	0.5	0
Travel	0.9	1.2	2.0	0	1.9	0	3.6	0
Family Illness	0.5	2.4	4.5	9.1	0	0	4.1	8.8
Education	0.9	0	0.4	3.1	0.6	0	0.9	0
Death in Family	0.5	0	0.8	0	0	7.1	0.5	2.9
Outside Business	0.5	0	0.8	0	1.9	0	3.2	0

† N = total number of complaints for each shift on the indicated rotation schedule. The numbers in the columns represent percentages of N.

Miscellaneous Observations.

1. Controllers tended to report a better quality of sleep as the number of hours of sleep increased, indicating an interaction of quality and quantity.

2. Approximately half the controllers on each rotation schedule were satisfied with their work schedules. Controllers on both rotation patterns who indicated a preference for a schedule other than the one being worked tended to prefer a schedule with few or no midshifts.

3. The difference between the number of hours of annual leave taken during the 5-week period by controllers working the 5-day rotation schedule (4.9 hours) and the number taken by controllers working the 2-2-1 rotation schedule (4.5 hours) was not statistically significant. The amount of annual leave taken during the 5-week period on the evening shift was slightly, but not significantly, greater than the amount taken on the day shift or midshift of both rotation schedules.

4. Controllers working the 5-day rotation schedule averaged 7.5 hours of sick leave during the 5-week period and controllers working the 2-2-1 rotation schedule averaged 7.3 hours. The difference was not statistically significant.

IV. Discussion.

The purpose of this study was to compare the sleep patterns of air traffic controllers working the 2-2-1 rotation schedule and those working the 5-day rotation schedule and, from the comparison, draw conclusions that would be helpful in determining problem areas that might possibly arise from working those schedules. Initially, FAA management's concern related to the question of whether controllers working the 2-2-1 rotation schedule had sufficient time between shifts to obtain adequate rest before reporting to work. Of particular concern was the short time (9-10 hours) between some shifts on the 2-2-1 rotation schedule. Previous studies conducted by this laboratory (1,3) showed that statistically significant biochemical differences between the 2-2-1 and the 5-day rotation schedules indicated the 2-2-1 rotation schedule was the less stressfull of the two rotations. The results of the present study generally support the conclusions reached in those earlier studies.

Controllers working the 2-2-1 rotation schedule averaged significantly less sleep during the workweek than did controllers on the 5-day rotation schedule, and it is clear that this is due to the little time the 2-2-1 controllers spent sleeping just prior to the midshift. The amount of sleep differed only slightly when the first 4 days of the workweek were considered (12 minutes more sleep per night by 5-day controllers in connection with the day shift). However, the average amount of sleep reported for the workweek by controllers on either rotation schedule is not out of line with values reported by other investigators for shift workers. Bjerner (4), in his study, indicated that shift workers as a group average about 6.5 hours of sleep per 24 hours while rotating shift workers averaged somewhat less when on the night shift (about 5.5 hours). Wyatt and Marriott (5) concluded that 37 percent of the nightworkers in their study reported less than 6 hours of sleep per 24 hours.

It is generally true that the midshift has the least traffic, hence the least workload. Characteristically, air traffic volume is low early in the midshift and becomes higher during the last hours of the shift. Usually, the first 1 or 2 hours of the day shift overlap the last 1 or 2 hours of the midshift. As on other shifts, controllers rarely engage in a full 8 hours of controlling traffic. It is common for a controller to be relieved after the first half of the shift and reassigned to a noncontrol function. During peak traffic density late in the midshift, the newly arrived day-shift controllers provide relief.

For the above reasons, excessive workload and prolonged hours at a control position cannot be considered the primary stressful factors on the midshift. An assessment of the complaints made by the controllers indicates that work underload causing boredom, fatigue, and sleepiness is the principal stressor. From the physiological point of view, these are valid complaints. A change from daywork to nightwork is contrary to a number of cyclic biological functions, some of which are body temperature, appetite, elimination, and sleepiness (6). In the case of controllers on the 2-2-1 rotation schedule, a disruption of circadian periodicity is not considered a serious problem because they are effectively doing daywork and sleeping at night. The data suggest that the controllers do not always take full advantage of the time available to them for rest. They relate that the amount of sleep they get is adequate for them to perform at an acceptable level of competence and that a short rest following the midshift allows them to continue their day-wakefulness, night-sleep routine with minimum disruption of their sleep pattern (1). Their contention is supported by studies (7) that have shown performance can be kept at an acceptable level by subjects on a rigorous schedule of 4-hour work periods and 2-hour rest periods maintained for 15 consecutive days.

The 5-day rotation schedule presents a problem of a more serious nature than does the quick turnaround of the 2-2-1 rotation schedule, particularly insofar as midshift work is concerned. The workweek is sufficient in length to allow some controllers to undergo some degree of circadian rephasal. Once this has occurred, the time necessary for them to readjust to a routine of daywork and night sleep consumes most of their 2 days off. Consequently, they report returning to work tired.

It seems reasonably clear from the data presented in this report that the midshift of either rotation schedule is the shift that presents the most problems insofar as quantity and quality of sleep are concerned. Considering only the midshift on both rotation schedules, it is noteworthy that even though the 2-2-1 controllers reported less sleep in connection with the midshift than did the 5-day controllers, the former reported a higher percentage of "good" and a lower percentage of "poor" day sleep. In addition, the 2-2-1 controllers reported more and better sleep on their days off than did the 5-day controllers, a further indication that the 5-day controllers have more trouble readjusting to a day-work, night-sleep routine.

Comparisons of sick and annual leave usage on the two rotation schedules showed that there were no significant differences in amount of leave taken. However, in another study, Dille (8) found that sick leave usage among ARTCC controllers on a 5-day rotation schedule was slightly less (60 hours per person per year) than that for 2-2-1 controllers (73 hours per person per year).

The data reported here indicate that the 2-2-1 rotation schedule is not a more disruptive routine than is the 5-day rotation schedule as far as quantity and quality of sleep are concerned.

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