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16. Abstract

Stress in 23 air traffic controllers (ATCS) at Atlanta Air Route Traffic Control Center (ATL) on the straight 5-day shift rotation schedule was compared with stress in 23 ATCS's on the 2-2-1 shift rotation schedule at Fort Worth Air Route Traffic Control Center (FTW). Stress in six other FTW ATCS's on the 5-day schedule was compared to stress in their 23 cohorts on the 2-2-1 schedule. Stress estimates were made from urinary levels of 17-ketogenic steroids (st), epinephrine (e), and norepinephrine (ne). There were no statistically significant between-group differences in e excretion. Levels of st and ne were significantly higher for ATL ATCS's under all conditions. Ranking by composite stress index ($C_s$) of ATC facilities showed that ATL ranked third and FTW, ninth. When $C_s$ was calculated for shifts, FTW ranked last in stressfulness on all shifts. ATL ranked fifth on the day shift and second on the evening shift. There were no significant differences in excretion of st, e, and ne between the FTW ATCS's on the 2-2-1 schedule and those on the straight 5-day schedule. Mean scores for neither anxiety trait (A-trait) nor anxiety state (A-state) were significantly different at FTW and ATL and the scores of controllers at both facilities were low compared to those of other normative groups. It is concluded that physiological stress at ATL is significantly greater than at FTW. The difference probably cannot be accounted for by the shift schedules, since stress in the group at FTW on the 5-day schedule does not differ significantly from stress in their cohorts on the 2-2-1 schedule.

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# STRESS IN AIR TRAFFIC CONTROLLERS: COMPARISON OF TWO AIR ROUTE TRAFFIC CONTROL CENTERS ON DIFFERENT SHIFT ROTATION PATTERNS

## I. Introduction.

On the straight 5-day shift rotation schedule, the controller works 5 days on the same shift, has 2 days off, then works 5 days on a different shift; 104 hours are required to accomplish a week's work. The pattern is repeated until rotation has occurred through all shifts; one rotation cycle requires 5 to 6 weeks. The main feature of the 5-day shift pattern is a 16-hour off-duty period between 8-hour work periods.

On the standard 2–2–1 rotation pattern (2 evenings, 2 days, 1 midshift), the controller works a different shift every day and, by so doing, compresses his 5-day workweek into 88 hours. For example, a controller on the 2–2–1 schedule works 1600–2400 on day 1, 1400–2200 on day 2, 0800–1600 on day 3, 0700–1500 on day 4, and 2400–0800 on day 5. He is then off duty from 0800 on his fifth day until 1600 on the first day of his next workweek. Thus, a controller on the 2–2–1 schedule has 80 hours off duty between workweeks as compared to 72 hours that a controller on the straight 5-day schedule has off-duty. The extended off-duty period is obtained by shift compression, which, in turn, occurs by reduction of off-duty time between work periods—the so-called "quick turnaround." On the schedule outlined above, a controller is off duty for 14 hours between his first and second days, 10 hours between his second and third days, 11 hours between his third and fourth days, and 9 hours between his fourth and fifth days. On the 2–2–1 schedule the lone midshift is always the last work period in the week and is always followed by scheduled days off. Normally, controllers are scheduled to work 8 hours with the meal break being included in the 8 hours.

FAA management usually looks with disfavor on the 2–2–1 rotation pattern because controllers usually cannot take 8 hours of rest between shifts when the turnaround time is only 9 to 14 hours. Management feels that fatigue brought on by the 2–2–1 schedule contributes to excessive use of sick leave and possibly to compensable claims.

Dille[1] compared medical records from two air route traffic control centers (ARTCC), one on the 2–2–1 shift rotation schedule and the other on the straight 5-day schedule. Because of multiple factors in the data, he could not conclusively relate incidence of disease at the facilities to shift schedule; however, the disability retirement rate was four times as high and pending disability claims were twice as numerous at the 5-day facility.

A study carried out at Houston Intercontinental Tower (IAH) showed that there was little difference between the two shift rotation patterns as far as physiological or psychological stress was concerned, and such difference as existed indicated that the 2–2–1 pattern was less stressful than the 5-day schedule.[2]

Because the results of the IAH study did not confirm that the 5-day schedule was physiologically less stressful than the 2–2–1 pattern, further study was strongly indicated. Two ARTCC's were chosen as project sites because centers have a larger number of controllers than do towers and therefore could be expected to yield a larger number of volunteer subjects.

The Atlanta ARTCC (ATL) was selected to represent the 5-day rotation pattern and the Fort Worth ARTCC (FTW), to represent the 2–2–1 pattern. These two centers have several common characteristics, such as size, climate, and relationship to nearby cities.

## II. Methods.

Twenty-three male controllers at ATL (average age: 37 years) and 29 at FTW (average

TABLE 1. Between-Group Comparisons of Resting and Working Values for Urinary Metabolites From ATL and FTW Controllers

Resting Values

| | st | | | e | | | ne | | |
|---|---|---|---|---|---|---|---|---|---|
| | DS* | NS** | NS*** | DS | NS | NS | DS | NS | NS |
| ATL | 987.3 | 533.2 | 831.8 | 0.52 | 0.35 | 0.38 | 4.47 | 2.56 | 3.55 |
| FTW | 429.7 | 284.2 | 362.8 | 0.73 | 0.52 | 0.53 | 1.28 | 1.15 | 1.16 |
| P | ≤ 0.05 | ≤ 0.01 | ≤ 0.01 | N.S. | N.S. | N.S. | ≤ 0.01 | ≤ 0.01 | ≤ 0.01 |

Working Values

| | Shift | | | Shift | | | Shift | | |
|---|---|---|---|---|---|---|---|---|---|
| | Mid | Day | Evening | Mid | Day | Evening | Mid | Day | Evening |
| ATL | 469.1 | 1193.1 | 877.3 | 0.84 | 1.17 | 1.11 | 3.88 | 4.45 | 5.44 |
| FTW | 332.3 | 700.9 | 499.9 | 0.78 | 1.55 | 1.25 | 1.28 | 2.19 | 2.08 |
| P | N.S. | ≤ 0.01 | ≤ 0.01 | N.S. | N.S. | N.S. | ≤ 0.01 | ≤ 0.01 | ≤ 0.01 |

*DS = Day sleep, midshift work
**NS = Night sleep, day shift work
***NS = Night sleep, evening shift work

age: 35 years) volunteered to serve as subjects. Twenty-three of the FTW controllers were on the 2–2–1 rotation schedule and six were on the 5-day pattern. Data on the 23 FTW controllers on the standard 2–2–1 pattern are compared with that of ATL controllers on the 5-day rotation pattern. Data on the six FTW controllers on the 5-day shift patterns are presented separately.

Pooled urine collections were made by every subject throughout each 8-hour work period for one 5-day workweek. Controllers at ATL made urine collections on the same shift for 5 days. Seven ATL subjects were on the midshift, seven were on the day shift, and nine were on the evening shift.

At FTW, because of the daily change of work periods, urine collections were made on more than one shift by each of the 23 subjects on the 2–2–1 pattern. Ten FTW controllers worked all three shifts (day, midshift, and evening) and 13 worked days and evenings only.

Subjects at both facilities collected urine on arising from their sleep periods. For those on the day and evening shifts, these specimens were composed of urine formed during night sleep; for those on the midshift, the specimens were composed of urine formed during day sleep. The night sleep specimen was used as the baseline specimen in all estimates of stress.

Urine was analyzed, as previously reported,[3] for 17-ketogenic steroids (st), epinephrine (e), and norepinephrine (ne). These urinary metabolites are reported as micrograms per 100 mg of urinary creatinine ($\mu$g/100 mg cr). The three metabolites are referenced to creatinine because of uncertainties about urine volumes and times of collection inherent in specimens collected outside controlled laboratory conditions.

The State-Trait Anxiety Inventory (STAI)[5] was used to assess psychological aspects of controller stress. Each controller completed the A-State Scale (a measure of moment-to-moment levels of anxiety) of the STAI immediately before and after each work period. In addition, the A-Trait Scale (a measure of anxiety proneness or general anxiety level) was answered by each controller once at the beginning and again at the end of the study. The first administration of the A-Trait Scale occurred before a controller's initial shift and the second, at the completion of the final shift considered for each controller.

Center workload was recorded at each facility as total radio transmission time on seven sectors identified by line supervisors as fairly representing total traffic. Workload was normalized by expressing transmission time as percentage of total recording (shift) time.

## III. Results.

Table 1 shows the comparison of resting and working values for st, e, and ne at ATL and FTW. There were no significant differences in e excretion during sleep between the two facilities. At each of the facilities, however, st, e, and ne excretion was greatest during day sleep following midshift work. Excretion of st and ne by ATL controllers during sleep (day or night) was significantly greater than the output of those stress indicators by FTW controllers.

Table 1 shows that e excretion during work was not significantly different on any shift at ATL and FTW. Excretion of ne was significantly higher at ATL than at FTW on all three shifts. However, st excretion on the day and evening shifts was significantly higher at ATL than at FTW; the difference in st excretion during the midshift work was insignificant.

TABLE 2. Within-Group Comparisons of Urinary Metabolites at ATL and FTW (Avg. $\mu$g/100 mg creatinine)

| | ATL | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Midshift | | | Day Shift | | | Evening Shift | | |
| | R* | W** | P | R | W | P | R | W | P |
| st | 987.3 | 469.1 | N.S. | 533.2 | 1193.1 | ≤ 0.01 | 831.8 | 877.3 | N.S. |
| e | 0.5 | 0.8 | N.S. | 0.4 | 1.2 | ≤ 0.01 | 0.4 | 1.1 | ≤ 0.05 |
| ne | 4.5 | 3.9 | N.S. | 2.6 | 4.5 | ≤ 0.01 | 3.6 | 5.4 | ≤ 0.05 |
| | FTW | | | | | | | | |
| st | 429.7 | 332.3 | N.S. | 284.2 | 700.9 | ≤ 0.01 | 362.8 | 499.9 | ≤ 0.01 |
| e | 0.7 | 0.8 | N.S. | 0.5 | 1.6 | ≤ 0.01 | 0.5 | 1.3 | ≤ 0.01 |
| ne | 1.3 | 1.3 | N.S. | 1.2 | 2.2 | ≤ 0.01 | 1.2 | 5.4 | ≤ 0.01 |

* Resting values
** Working values

In Table 2, the data in Table 1 have been reorganized to show differences in resting and working values at ATL and FTW. At neither facility were the differences significant for st, e, or ne on the midshift. In fact, st and ne excretion declined slightly during midshift work from the day sleep level. The differences between resting and working values for all three urinary constituents were statistically significant and greatest in magnitude on the day shift, with the exception that the increment in excretion of ne was greatest at FTW on the evening shift. Steroid excretion at ATL was not significantly increased during the evening shift over the baseline level; all other values increased on the evening shift at both facilities and the increases were statistically significant.

An earlier publication from this laboratory presented a biochemical stress index ($C_s$) computed from the average of the products of normalized baseline and working values of st, e, and ne ($c_{st}$, $c_e$, and $c_{ne}$).[4] Table 3 shows ATC facilities studied from 1968 to the present time ranked according to $C_s$ computed for all work shifts. ATL ranks third in the list and FTW ranks ninth.

TABLE 3. Ranking of ATC Facilities by Stress Index ($C_s$) Computed for All Work Conditions

| | $C_s$ |
|---|---|
| O'Hare Tower | 1.05 |
| Opa Locka Tower | 0.84 |
| Atlanta ARTCC | 0.82 |
| Miami ARTCC | 0.76 |
| Houston Intercontinental Tower (1970, 5-day shift) | 0.74 |
| Houston Intercontinental Tower (1971, 2-2-1 shift) | 0.68 |
| Oakland TRACON (pre-ARTS-III) | 0.60 |
| Los Angeles TRACON (pre-ARTS-III) | 0.60 |
| Fort Worth ARTCC | 0.34 |

*All $C_s$ values calculated by using night sleep as baseline.

Table 4 shows the ranking of $C_s$ computed for the day shift, evening shift, and midshift at various ATC facilities. ATL and FTW rank fifth and ninth respectively in total stress ($C_s$) on the day shift. ATL ranks second and FTW ranks fourth on the evening shift. FTW ranks fourth on the midshift; $C_s$ could not be calculated for the midshift at ATL because data representing night sleep (baseline) were not collected from the seven controllers who worked the midshift. No midshift work data were collected at Miami ARTCC, Opa Locka Tower, Oakland TRACON, or Los Angeles TRACON. No day shift data were collected at O'Hare Tower. No evening shift data were collected at IAH Tower (1970), Miami ARTCC, Opa Locka Tower, Oakland TRACON, or Los Angeles TRACON. The stress index, which was formulated after these studies were completed, could not be calculated for the shifts listed above.

Table 5 shows the values for $c_{st}$, $c_e$, and $c_{ne}$ at ATL and FTW for the three shifts. It is apparent that the catecholamines contribute mainly to the magnitude of $C_s$. It is interesting that $c_{ne}$ is the prime determinant of $C_s$ on the day and evening shifts at ATL whereas $c_e$ is the prime determinant of $C_s$ on all three shifts at FTW.

The relationships of $C_s$, $c_{st}$, $c_e$, and $c_{ne}$ at the ATC facilities studied to date are shown on Streng triangles in Figure 1.[6 7] This triangle is useful in showing the relationship between three variables and is based on the theorem that the sum of the perpendicular distances of any interior point from the sides of an equilateral triangle is equal to the altitude of the triangle. The values of $c_{st}$, $c_e$, and $c_{ne}$ are represented by

TABLE 4. Ranking of ATC Facilities by Stress Index ($C_s$) Calculated for Different Shifts

| Day Shift | | Evening Shift | | Midshift | |
|---|---|---|---|---|---|
| Facility | $C_s$ | Facility | $C_s$ | Facility | $C_s$ |
| Houston Intercontinental Tower (1970, 5-day shift) | 0.92 | O'Hare Tower | 1.09 | O'Hare Tower | 1.01 |
| Opa Locka Tower | 0.84 | Atlanta ARTCC | 0.96 | Houston Intercontinental Tower (1971, 2-2-1 shift) | 0.57 |
| Houston Intercontinental Tower (1971, 2-2-1 shift) | 0.79 | Houston Intercontinental Tower (1971, 2-2-1 shift) | 0.65 | Houston Intercontinental Tower (1970, 5-day shift) | 0.55 |
| Miami ARTCC | 0.76 | Fort Worth ARTCC | 0.34 | Fort Worth ARTCC | 0.21 |
| Atlanta ARTCC | 0.64 | | | | |
| Oakland TRACON (pre-ARTS-III) | 0.60 | | | | |
| Los Angeles TRACON (pre-ARTS-III) | 0.60 | | | | |
| Fort Worth ARTCC | 0.41 | | | | |

TABLE 5. $c_{st}$, $c_e$, and $c_{ne}$ for Each Shift at ATL and FTW

| | Day Shift | | | Evening Shift | | | Midshift | | |
|---|---|---|---|---|---|---|---|---|---|
| | $c_{st}$ | $c_e$ | $c_{ne}$ | $c_{st}$ | $c_e$ | $c_{ne}$ | $c_{st}$ | $c_e$ | $c_{ne}$ |
| ATL | 0.70 | 0.33 | 0.91 | 0.81 | 0.34 | 1.72 | -- | -- | -- |
| FTW | 0.29 | 0.72 | 0.22 | 0.22 | 0.57 | 0.22 | 0.12 | 0.27 | 0.13 |

the lengths of lines (see ORD, Fig. 1) originating at a common point and diverging at angles of 120°. Lines perpendicular to the ends of the vectors form an equilateral triangle, the altitude of which is equal to the sum of the lengths of the diverging lines. One-third of the altitude of the triangle is equal to $C_s$; thus, the area (or size) of the triangle, while not equal to, is proportional to $C_s$. It is apparent from these triangles that total stress ($C_s$) at ATL exceeds total stress at FTW and that $c_{ne}$ is the largest individual value at ATL while $c_e$ is the largest value at FTW.

At FTW a comparison by means of the stress index showed that the six controllers on the 5-day rotation did not differ significantly from the 23 controllers on the 2–2–1 rotation (Table 6).

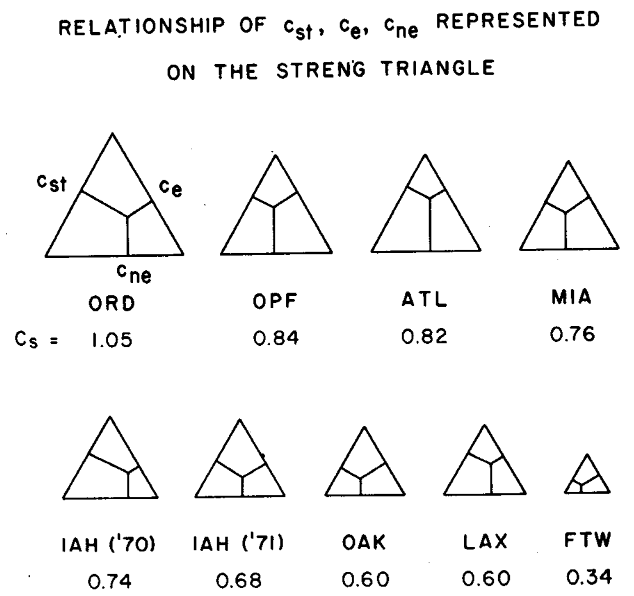


FIGURE 1. Relationship between $c_{st}$, $c_e$, and $c_{ne}$ represented on the Streng triangle. The size of the triangle is proportional to $C_s$.

TABLE 6. Internal Comparison of 5-Day and 2–2–1 Rotations at FTW—Day Shift Only

| | Resting Values | | | |
|---|---|---|---|---|
| | st | e | ne | |
| 5-day | 323.7 | 0.59 | 0.97 | |
| 2-2-1 | 284.2 | 0.50 | 1.20 | |
| P | N.S. | N.S. | N.S. | |
| | Working Values | | | |
| | st | e | ne | |
| 5-day | 525.6 | 1.29 | 1.34 | |
| 2-2-1 | 700.9 | 1.60 | 2.20 | |
| P | N.S. | N.S. | N.S. | |
| | $c_{st}$ | $c_e$ | $c_{ne}$ | $C_s$ |
| 5-day | 0.21 | 0.61 | 0.11 | 0.31 |
| 2-2-1 | 0.23 | 0.62 | 0.23 | 0.36 |
| P | N.S. | N.S. | N.S. | N.S. |

The findings from the STAI indicate that anxiety levels were essentially equal for controllers on both rotation schedules (Table 7). There

TABLE 7. Mean A-Trait and A-State Raw Scores for Air Traffic Controllers Under Two Shift Rotation Schedules

| | | | Rotation Schedule | |
|---|---|---|---|---|
| Scale | Shift | Time | 5-day | 2-2-1 |
| A-Trait | ---- | ---- | 32.1 | 28.9 |
| A-State | Day | Before | 26.1 | 32.2 |
| | | After | 31.5 | 36.6 |
| | Evening | Before | 32.5 | 35.2 |
| | | After | 37.5 | 36.6 |
| | Midshift | Before | 30.4 | 28.9 |
| | | After | 33.4 | 34.0 |
| | Overall | | 31.9 | 32.9 |

TABLE 8. Average Workload (Transmission Time) at ATL and FTW

| | ATL | FTW |
|---|---|---|
| Day Shift | 32.9 | 38.1 |
| Evening Shift | 30.5 | 28.4 |
| Midshift | 4.9 | 9.0 |

were no significant overall differences between groups on either the A-trait or A-state measures. There was some slight (although statistically insignificant) variance in anxiety levels according to shifts. The evening shifts had the highest scores for both groups; however, the day shifts were lowest for the 5-day sequence and the midshifts were lowest for the 2–2–1 schedule.

As in previous studies,[3] it was consistently found in this study that significant differences existed between the A-State Scale scores obtained before and those obtained after each work shift. In each case, anxiety levels were reported to increase as a function of work.

In comparison to other normative groups for the STAI, the air traffic controllers scored relatively low on both the A-trait and A-state measures. In comparison with the norms for college students (of the various normative groups including hospital patients, college freshmen, high school students, psychiatric patients, college undergraduates had the lowest overall anxiety level), it was found that the average A-trait score for both shift groups considered together is equivalent to the 27th percentile; that is, it

TABLE 9. Average Amount of Reported Sleep (hr) Prior to Each Shift at ATL and FTW

ATL

| Number of Subjects | Shift | Day Number 1 | 2 | 3 | 4 | 5 | Weekly Average |
|---|---|---|---|---|---|---|---|
| 7 | Day | 6.97 | 7.27 | 6.78 | 6.83 | 6.56 | 6.88 |
| 7 | Evening | 9.19 | 7.42 | 7.84 | 8.49 | 7.67 | 8.12 |
| 9 | Mid | 5.93 | 7.11 | 6.68 | 6.04 | 7.04 | 6.56 |

FTW

| Number of Observations | Shift | Day Number 1 | 2 | 3 | 4 | 5 | Weekly Average |
|---|---|---|---|---|---|---|---|
| 11 | * | 8.38 | 7.75 | 7.23 | 6.31 | 2.98 | 6.53 |
| 12 | ** | 8.89 | 7.58 | 6.55 | 6.31 | 5.71 | 7.01 |
| 6 | *** | 8.13 | 6.25 | 7.13 | 6.78 | 7.42 | 7.14 |

*Midshift on 5th work day
**Day shift on 5th work day
***Day shifts only

TABLE 10. Average Bedtime/Arising Time at ATL and FTW

| ATL | | | | | |
|---|---|---|---|---|---|
| Work Day No. | 1 | 2 | 3 | 4 | 5 |
| Shift | | | | | |
| Day | 2339/0630 | 2330/0646 | 2334/0621 | 2339/0629 | 2353/0626 |
| Evening | 2400/0915 | 0210/0935 | 0130/0921 | 0054/0923 | 0212/0952 |
| Mid | 2000/2235 | 0900/1606 | 1017/1658 | 0930/1532 | 1035/1759 |
| FTW | | | | | |
| Midshift 5th day | 0010/0832 | 0053/0838 | 2341/0655 | 2310/0529 | 1817/2153 |
| Day shift 5th day | 2335/0829 | 0123/0858 | 2354/0627 | 2325/0543 | 2348/0531 |
| Day shift only | 0005/0812 | 0008/0623 | 0038/0745 | 0018/0714 | 2305/0630 |

essentially would fall in the lowest quarter of the college student scores. The overall A-state score obtained before work, 30.9, is at the 33rd percentile while the corresponding score after work, 34.9, falls at the 99th percentile on these norms. These levels are closely comparable to those obtained at the IAH Tower.[3]

Workload on the three shifts at the two centers is shown in Table 8. No correlation of workload with stress in any individuals could be made because of the way that workload was recorded. There is a generally positive correlation of facility workload with facility $C_s$ at FTW while the correlation is negative at ATL. Workloads at the two centers are similar except that the correlation for the midshift workload is somewhat higher at FTW than at ATL.

Data were obtained by questionnaire on the amount of sleep obtained prior to each of the five work periods. Table 9 shows the average amount of sleep obtained prior to each day's work by controllers at ATL and FTW. At both facilities controllers slept most in connection with the evening shift and least prior to the midshift. Overall, ATL controllers slept 18 minutes more per sleep period than did FTW controllers. However, when the single midshift is not considered, FTW controllers slept an average of 32 minutes more per sleep period than did ATL controllers on the day shift, 42 minutes less than ATL controllers on the evening shift, and 51 minutes more than ATL controllers on the midshift. When the midshift is considered in the workweek at FTW, ATL controllers on five straight midshifts slept an average of only 2 minutes more per sleep period than did their FTW counterparts.

Bedtimes and arising times are shown in Table 10, and it is apparent that the longer sleep period associated with the evening shift occurred because of late morning sleep. Average bedtime for ATL controllers on the day shift was 2339 while their average bedtime on the evening shift was 0121. The average arising times, however, were 0630 at ATL on the day shift and 0929 on the evening shift. Thus, ATL controllers went to bed 1 hour 42 minutes earlier when working the day shift than they did when working the evening shift, but they slept 2 hours 59 minutes later the morning after the evening shift than they did the morning after the day shift.

Figure 2 is a line graph of the average amount of sleep day-by-day at ATL and FTW. It is

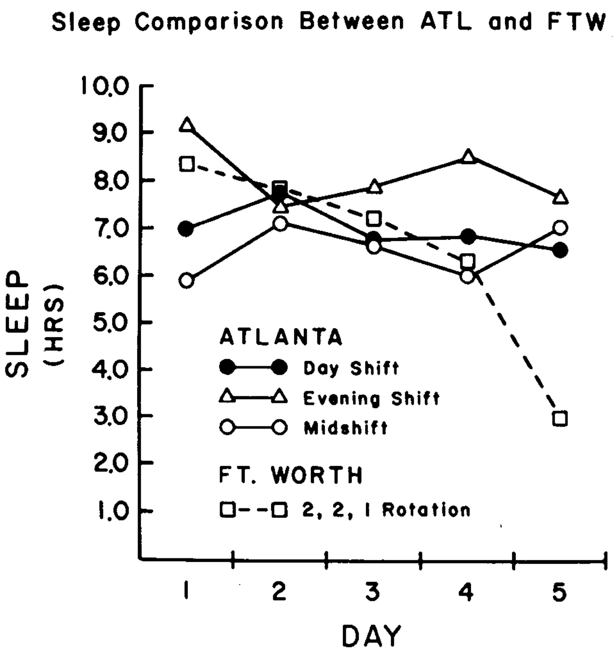


FIGURE 2. Line graph on the average amounts of sleep taken by controllers on the 2–2–1 and 5-day shift rotation patterns.

clear from inspection that the amount of daily sleep by controllers was more consistent throughout the workweek at ATL than at FTW. At FTW there was a definite decline in the amount of daily sleep throughout the workweek. The six controllers at FTW on the 5-day schedule show a sleep pattern resembling the patterns at ATL.

## IV. Discussion.

Physiological stress among FTW controllers is measurably less than among ATL controllers. Since the FTW ARTCC was on the 2–2–1 rotation schedule, it is clear that, in and of itself, there is no physiological support for the conviction that the 2–2–1 schedule is more taxing than the 5-day schedule to the individual controller. However, it would be equally unjustifiable to consider the 2–2–1 schedule necessarily—or always—superior to the 5-day schedule. The differences probably are minimal, as suggested by the comparisons between the six controllers on the 5-day pattern and the 23 controllers on the 2–2–1 schedule at FTW; no significant differences were shown on the variables considered.

Apparently, the managerial set against the 2–2–1 rotation is largely rooted in the belief that controllers on such a schedule get insufficient rest between shifts. When the entire workweek is considered, ATL controllers averaged about a half hour more sleep per night than did FTW controllers. The difference in favor of ATL is entirely accounted for, however, by FTW controllers' practice of taking only a short nap before their single midshift. When only the first 4 days of the week are considered (i.e., the midshift is not considered), FTW controllers slept about a half hour longer than did ATL controllers. It is doubtful that the difference in stress is explainable in terms of the relative amounts of sleep taken by controllers at the two facilities.

It would be misleading to consider the midshift as a very-low-stress shift, primarily because the stress of midshift work is inseparable from the stress of day sleep. The data show that excretion of st, e, and ne is greatest at both facilities during day sleep. The elevated excretion of catecholamines during day sleep may be partially explained by circadian effects, though elevated steroid excretion runs counter to the early morning circadian maximum.

Steroid and norepinephrine excretion by ATL controllers during day sleep was greater than the excretion of those substances by FTW controllers during day sleep. Epinephrine excretion during day sleep was not significantly different for the two groups of controllers. It was shown in another study that e excretion was more closely related to workload than was the excretion of st and ne.[4] Since workload is at a minimum during the rest period, it is not surprising to find no difference in e excretion between the facilities.

Norepinephrine represents sympathetic nervous system activity. The elevation of ne in the urine of ATL controllers may be interpreted to mean that ATL controllers did not relax as well during day sleep as did FTW controllers. Significantly elevated st excretion in ATL controllers during day sleep indicates that they were experiencing some sort of continuous physiological stress, perhaps related to the five straight midshifts.

It seems reasonably clear that the two shift schedules are essentially equal in the degree to which anxiety is aroused. It does appear that controllers experience somewhat more anxiety while engaged in work (A-state) than they do on the average in other settings (as estimated by the A-Trait Scale); however, the extent to which their anxiety increases as a function of their work seems well within normal limits. It must therefore be concluded that (1) controllers as a group, at least at these two installations, are not under undue psychological stress, as measured by the STAI, and (2) the alternating shift schedules do not have an appreciable effect on such stress levels.

It is probable that the differences in the stress-arousing properties of the 2–2–1 and 5-day schedules, in both a physiological and a psychological sense, are relatively minimal. The differences in physiological stress favoring FTW were probably due to relatively low levels of stress at this facility rather than to excessively high levels of stress at ATL, since the indices were also low at that location. Certainly, any negative effect of working under the 2–2–1 schedule was not sufficient to unduly arouse FTW personnel. It therefore seems appropriate to conclude that there is little justification, in the sense of physiological or psychological stress arousal, for the necessity of choosing one schedule over the other, although if these data are decisive in such decision making, the choice would be in the direction of the 2–2–1 schedule.

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