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Research Suggests That Some Rotating Work Shift Schedules Do Not Harm Air Traffic Controllers' Sleep Patterns

A so-called "advancing" or "counterclockwise" rotation, beginning earlier with each change, may actually benefit workers' ability to obtain adequate sleep.

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Aviation Writer

Groups of air traffic control (ATC) specialists who worked two rapidly rotating work shift schedules reported getting as much or more total sleep time over the course of their work week than their counterparts on a consistent (straight-day) work shift schedule, according to a study by the U.S. Federal Aviation Administration's (FAA's) Civil Aeromedical Institute (CAMI).

Despite the drawbacks of such rotating schedules, the Oklahoma City, Oklahoma, U.S.-based researchers suggested that one rotating schedule, called the "2-1-2" schedule, "may improve in some ways on a [straight-day] schedule of [early-morning] start times."

The 2-1-2 rotating schedule features two days of afternoon shifts (starting at 1330 or 1430 hours), followed by a single midday shift (starting at 1030), followed by two early-morning shifts (starting at 0700). (Because of variations within the group, start times are approximations.)

[In this article, *shift* means the part of the day during which working hours fall, e.g., midday or night. Shifts can be consistent or can rotate. For the CAMI study, the approximate start time for the group on a consistent shift schedule was between 0630 and 0730.

[*Rotation* of shifts includes several variables. A "delaying" rotation changes in a clockwise fashion, so that work-start times are progressively later during the work week. An "advancing rotation" (such as the 2-1-2 rotation in the CAMI study) works in a counterclockwise fashion, so that work-start times are progressively earlier during the work week. In general, delaying rotations lengthen the work week, while advancing rotations compress the work week.

[Rapid rotation involves working no more than two or three consecutive days on the same shift, compared with less frequent changes in a slow rotation. Various shift progressions are possible in a rotation, e.g., morning-midday-afternoon or afternoon-midday-morning. In addition, the number of days on each shift can vary, e.g., 2-1-2 or 2-2-1.

[*Schedule*, the most comprehensive term, represents a work-week pattern including the type of shift and the type of rotation. Although the variables can combine to produce numerous possible schedules, the Miami study restricted itself to three schedules (Table 1, page 2) — technically, schedules for three groups whose work patterns approximately coincided.]

In a study of two dozen ATC specialists in Miami, Florida, U.S., CAMI researchers Crystal E. Cruz and Pamela S. Della Rocco found that workers on the 2-1-2 (afternoon-midday–early morning) schedule — which has the effect of compressing the work week — experienced no less sleep time and no poorer sleep quality than those working a straight-day schedule. In addition, the employees on the 2-1-2 schedule reported fewer instances of sleepiness during the drive home from work.

Table 1
Group Work Schedules of Air Traffic Control Specialists in CAMI Study

	Day 1	Day 2	Day 3	Day 4	Day 5
Straight-day Schedule					
Shift type	E*	E	E	E	E
Approximate start time	0730	0700	0700	0630	0630
Range of start times	0630–1000	0630–0900	0630–1000	0630–0700	0630–0645
Approximate hours off between Shifts	16 hours	16 hours	16 hours	16 hours	
2-2-1 Schedule					
Shift type	A*	A	E	E	N*
Approximate start time	1430	1330	0700	0630	2230
Range of start times	1330–1600	1000–1600	0600–0800	0600–0620	2200–2400
Approximate hours off between shift	16 hours	8 hours	16 hours	8 hours	
2-1-2 Schedule					
Shift type	A	A	M*	E	E
Approximate start time	1430	1330	1030	0700	0700
Range of start times	1330–1500	1250–1400	0955–1100	0630–0700	0600–0745
Approximate hours off between shifts	16 hours	12 hours	12 hours	16 hours	

* E = early morning, M = midday, A = afternoon, N = night

Source: U.S. Federal Aviation Administration, Civil Aeromedical Institute/Crystal E. Cruz/Pamela S. Della Rocco
Note: Based on a study of 24 volunteers for a two-week period.

The 2-1-2 schedule studied by the two researchers provided 12 hours off between shifts and did not include a night shift. The schedule compressed the work week, providing about eight more hours between work weeks than a straight-day schedule did.

While cautioning that more sleep research is needed to validate the preliminary conclusions, the researchers reported that "the benefits of this schedule may indicate that [counterclockwise], rapid rotations, *per se*, should not be dismissed as less desirable than clockwise rotations."

ATC Specialists Must Rotate Shifts

The CAMI sleep study was conducted as part of a wider research program into the problem of schedule-induced fatigue among ATC specialists, most of whom contend with rotating work shifts. The Miami Air Route Traffic Control Center (ARTCC) had asked experts to investigate reported problems of sleepiness on the night shift.

Because some of the Miami specialists worked counterclockwise rotations, the researchers had the opportunity to compare the effects of different work schedules on sleep and fatigue.

They analyzed the sleep patterns of 24 volunteers from the Miami ARTCC. The participants' average age was 32.9 years. Eighteen of the volunteers were men and six were women. All but one of the two dozen volunteers were ATC specialists; the other worked at Miami's Airway Facilities department.

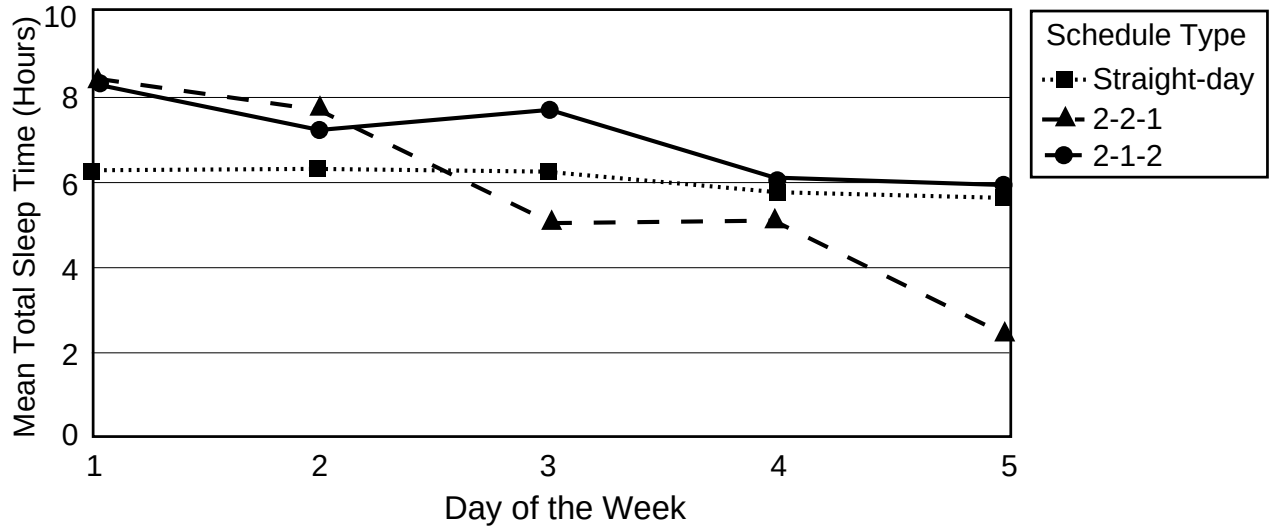
The research focused on three different schedules: a straight-day shift schedule; the 2-1-2 (afternoon-midday–early morning) schedule; and the 2-2-1 schedule. The 2-2-1 schedule consists of two afternoon shifts (beginning at 1330 or 1430), followed by two early-morning shifts (beginning at 0630 or 0700) followed by a night shift (beginning at 2230).

The 2-1-2 and the 2-2-1 schedule are examples of what researchers call "counterclockwise, rapidly-rotating shift schedules," used in some ATC centers. The volunteers kept daily logbooks of their sleep schedules, and were asked to distinguish between "in-bed" and "asleep" times, and between "awake" and "arise" times.

The study participants also logged subjective ratings of the quality of their sleep, ranging from "not deep" (1) to "deep" (5), and ranking their waking up from "not difficult" (1) to "difficult" (5).

The subjects also recorded how sleepy they were when awake. For the sleepiness ratings, participants used the Stanford Sleepiness Scale, which instructed participants to rate their fatigue by selecting one of seven descriptions, ranging from

Mean Total Sleep Time by Day of the Week for Straight-day, 2-2-1 and 2-1-2 Schedules of Air Traffic Control Specialists in CAMI Study



Source: U.S. Federal Aviation Administration, Civil Aeromedical Institute/Crystal E. Cruz/Pamela S. Della Rocco
Note: Based on a study of 24 volunteers for a two-week period.

Figure 1

"feeling active and vital; wide awake" (1) to "almost in reverie; sleep onset soon; losing struggle to remain awake" (7).

When they analyzed the logbook records to draw conclusions, the researchers found that:

- Total sleep time on the straight-day schedule (Figure 1) was approximately six hours every day (ranging from 5.6 to 6.3 hours). That is less sleep than some other studies have found for straight-day schedule workers.

- Total sleep time on the 2-1-2 (afternoon-midday–early morning) schedule (Figure 1) was between 7.5 and eight hours before the two afternoon shifts and the one midday shift, but decreased to about six hours before the two early morning shifts.

The results "indicated that only the second quick-turnaround, from the [midday] to the early-morning shift, resulted in a decline in sleep duration."

- Total sleep time on the 2-2-1 (afternoon–early morning–night) schedule (Figure 1) averaged about eight hours before the two afternoon shifts, but decreased to only five hours before the two early-morning shifts and to a mere 2.4 hours before the night shift.

"Within all three schedules," the researchers reported, "the average amount of sleep obtained before an early-morning shift was only about [six] hours, whether the early mornings were part of a straight schedule or a rapidly rotating one. Thus the least amount of sleep was obtained before early-morning shifts and before the night shift."

Noting that "disruptions in the timing of sleep may be as important to [work] performance as sleep duration," the two researchers had hypothesized that the sleep disruptions in the 2-2-1 schedule (with its quick, eight-hour turnarounds) would be greater than for the other rotating schedule.

"This hypothesis was only partially supported," the researchers said. Although sleep times were relatively stable for workers on both schedules, awake times changed significantly in only one instance: by 2.5 hours in the 2-2-1 (afternoon–early morning–night) schedule, and by two hours in the 2-1-2 (afternoon-midday–early morning) schedule. "Both of these alterations in Awake Time corresponded with a quick turnaround to an early-morning shift," the researchers observed.

The subjective measures of sleep quality are combined in Figure 2 (page 4). Assessments of sleepiness are shown in Figure 3 (page 5).

"Volunteers on all schedules rated themselves as more sleepy at the end of the day than at the beginning of the day," the researchers said, "and more sleepy on the last day of the work week than the first three days of the work week."

But a close examination of the ATC specialists' logbooks did show that "more ratings of extreme sleepiness were given by volunteers on the 2-2-1 (afternoon–early morning–night)

schedule for the drive home after the night shift than on any other day or any other schedule," the researchers said.

Of the eight volunteers in that 2-2-1 group, three reported a "6" sleepiness rating ("sleepy; woozy; prefer to be lying down; fighting sleep") and three others reported a "5" rating ("foggy; slowed down; beginning to lose interest in remaining awake").

The 2-2-1 (afternoon–early morning–night) schedule, the researchers concluded, resulted in no less sleep and no poorer sleep quality than the straight-day shift.

"Both quick turnarounds in this schedule involved only [eight] hours off between shifts, but only the sleep before the night shift and the number of ratings of extreme sleepiness on the drive home from the night shift were worse than the straight-day schedule," the researchers said.

Study Augmented Earlier Research

The CAMI research was performed in the context of previous studies on the influence of work shifts on fatigue among air traffic controllers, who must keep highly alert to be able to perform their jobs well.[1–4]

In designing schedules, ATC managers consider the pros and cons of different approaches. "Each kind of … schedule … has it own set of benefits and problems," the researchers said. The different approaches include:

Consistent vs. rotating schedules. Some experts believe that consistent work schedules tend to be best for employees. But rotating schedules are unavoidable in many workplaces, such as busy airports, which require around-the-clock operations.

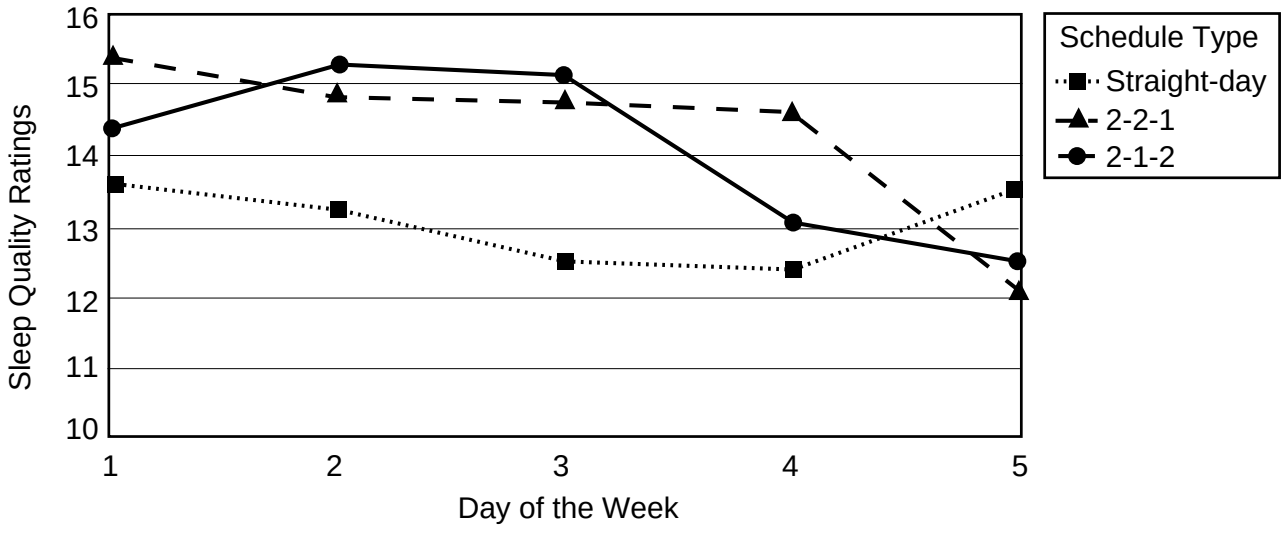
Akerstedt[5] reported that disturbed sleep is perhaps the most dramatic effect of rotating shifts on any schedule. And, in workers on rotating schedules, sleep duration for people on the night and morning shifts tends to be reduced by one to four hours.

Delaying (clockwise) vs. advancing (counterclockwise) rotations. Three different research studies[6–8] have argued that, in rapidly rotating schedules, delaying rotations are preferable to advancing rotations.

The major objection to advancing rotations is that they require "quick turnarounds," sometimes calling for employees to return to work after only eight hours off. Folkard[9,10] suggested that such quick turnarounds tend to result in greater fatigue and shortened sleep times. Another study[11] argued that delaying rotations are better because they are more compatible with the body's normal sleep cycles (the "endogenous body clock").

But other experts[5,12] found little empirical evidence that delaying rotations allow more sleep time and deeper sleep. Turek's research[13] suggested that there is not much difference in sleep disruptions between delaying and advancing rotations.

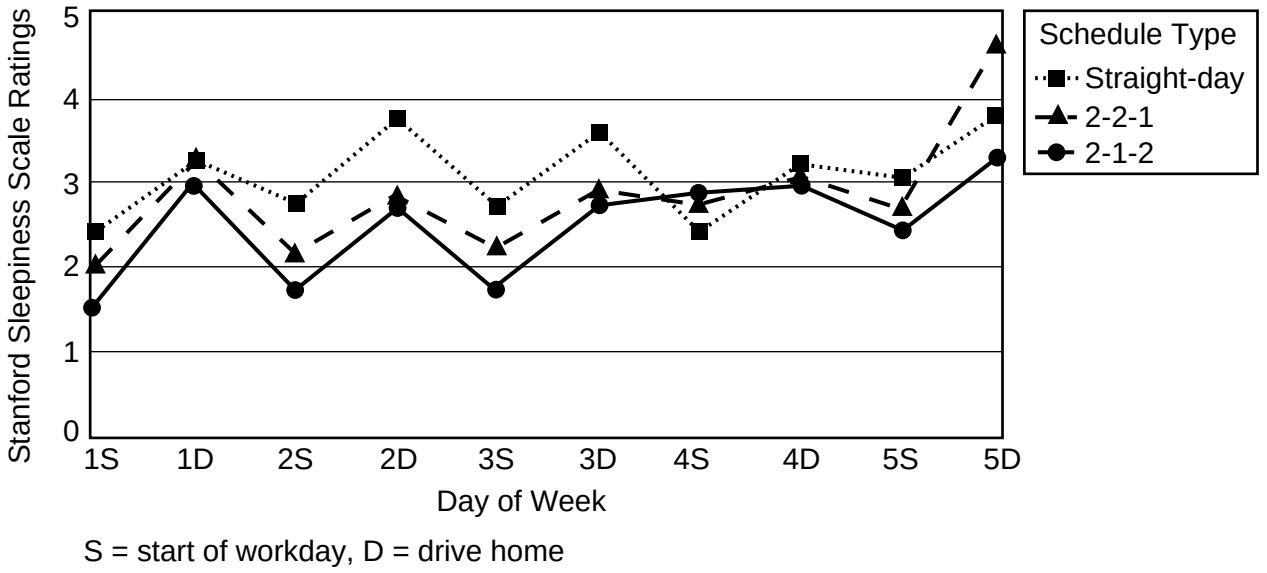
Combined Sleep Quality Ratings by Day of the Week for the Straight-day, 2-2-1 and 2-1-2 Schedules of Air Traffic Control Specialists in CAMI Study



Source: U.S. Federal Aviation Administration, Civil Aeromedical Institute/Crystal E. Cruz/Pamela S. Della Rocco
Note: Based on a study of 24 volunteers for a two-week period.

Figure 2

Stanford Sleepiness Scale Ratings by the Day of the Week for the Straight-day, 2-2-1 and 2-1-2 Schedules of Air Traffic Control Specialists in CAMI Study



S = start of workday, D = drive home

Source: U.S. Federal Aviation Administration, Civil Aeromedical Institute/Crystal E. Cruz/Pamela S. Della Rocco
Note: Based on a study of 24 volunteers for a two-week period.

Figure 3

In their analysis of Miami ATC specialists, the researchers reported: "The results of this study may indicate that the problems associated with counterclockwise, rapid rotations have more to do with working the night shift and early-morning work-start times than with quick turnarounds."

The researchers suggested that their study adds "empirical data to the largely theoretical body of literature regarding counterclockwise, rapidly rotating shift schedules."

Applicability May Be Limited

The researchers cautioned that several factors may limit the applicability of their findings to other situations. For example:

- The control group for the straight-day schedule had a lower amount of sleep time than expected, probably because of early-morning start times. The researchers wrote that their data supported Folkard's suggestion that "early start times for the morning shift could result in similar sleep debt to that seen for the night shift."

- The study excluded employees who traded shifts, took annual leave or sick leave, or otherwise altered their schedules. For that reason, the researchers cautioned, the study "may have focused on participants with particularly stable sleep patterns and potentially excluded individuals who do not cope well with either rotating [shift] schedules or early morning shifts."

- The sample size (24) in the research study was relatively small, the researchers said. "Further empirical study of counterclockwise, rapidly rotating shift schedules should be done before generalizing these findings to other populations or advocating their use," the researchers warned.

To shed more light on the affects of counterclockwise, rapidly rotating schedules, the researchers are analyzing other data from a shift-work questionnaire that asked about the health, sleep patterns, work schedules, eating habits and lifestyles of ATC specialists.♦

Editorial Note: This article was adapted from *Sleep Patterns in Air Traffic Controllers Working Rapidly Rotating Shifts: A Field Study*. Report No. DOT/FAA/AM-95/12. A special report prepared for the U.S. Federal Aviation Administration (FAA) Civil Aeromedical Institute. April 1995. The report is available through the National Technical Information Service, Springfield, VA 22161 U.S. The 15-page report includes charts and references.

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