International Cooperative Study of Air Crew Layover Sleep: Operational Summary

R.C. Graeber, W.C. Dement, A.N. Nicholson,
M. Sasaki, and H.M. Wegmann

The major goals of this research were to examine the changes in sleep associated with flights across multiple time zones and, if necessary, to suggest recommendations for improving such sleep. Flight crews were studied during the first layover after long flights crossing seven to nine time zones. The basic findings can be best described in terms of flight direction and discussed with respect to strategies used by crew members to obtain sufficient sleep before operating the return flight home.

Westward Flights

There was clear evidence that crew members experienced less sleep difficulties during layovers following westward flights (LHR-SFO, FRA-SFO, SFO-NRT) than after eastward flights. Following the westward flights almost all subjects went to bed soon after arrival (Fig. 1). During the first night, sleep appeared to be of generally good quality and not unduly disturbed except for increased wakefulness during the second half of the night. In comparison with baseline, subjects generally fell asleep faster and slept essentially the same amount as at homebase. Some even reported better sleep quality.

During the next day, the increase in alertness usually seen during the late afternoon in local individuals was not observed. Instead, drowsiness continued to increase during the remainder of the wake span. By the second night, there was already some adaptation of sleep to the new time zone as indicated by even less awakenings occurring during the early morning hours.

Nevertheless, on the following day, the previous day's pattern of increasing drowsiness was seen in crews who were available for testing. Most crew members successfully attempted to take a pre-flight nap in preparation for duty that afternoon. The same findings held for the one group of subjects whose layover lasted approximately 25h instead of the usual 48h. The only major difference was that their pre-flight nap occurred during the first afternoon after arrival.

The strategy of taking a nap before departure after a westward layover appears important in view of the coming night flight with its prolonged period of wakefulness. Recent research suggests that such a nap will help reduce in-flight drowsiness and avoid potential performance deficits (3). A second aspect of planning strategies to cope with this flight schedule emphasizes the potential importance of time of the latter part of flight in relation to the crew members' circadian rhythms. Additional results obtained from some crews during the eastward return flight suggest that alertness improves as the circadian rhythms in body temperature and heart rate begin to rise. Therefore, certain schedules may be more desireable if they facilitate a nap before flight and take advantage of the circadian rise in alertness during the latter part of the flight.

Eastward Flights

Sleep patterns were much more variable and fragmented after eastward night flights (NRT-SFO, SFO-LHR, SFO-FRA) than after westward flights across an equivalent number of time zones (Fig. 2). There appears to have been a powerful influence which fractionated sleep, probably dependent on the difficulty which individuals experienced in shortening their day. Furthermore, the consequences of sleep pattern fragmentation were reflected in subsequent measures of daytime drowsiness.

Many crew members went to bed as soon as possible after arrival and fell asleep more quickly than observed during baseline but slept a relatively short amount of time even after a long overnight flight. Subjects tended to awake spontaneously at a time corresponding to the late morning of their home time. Overall, this strategy can be beneficial; however, the onset of the next major sleep varied considerably among individuals, with some crew members from each airline delaying sleep until it coincided with their usual bedtime at home. Similar wide-ranging differences were seen in the second night's sleep and intervening sleeps. In spite of a high degree of variability, sleep duration was usually shorter than baseline and subjectively worse.

Given the usual importance attributed by flight crews to obtaining "good" sleep immediately before a flight, these data suggest that their chance of doing so could be substantially improved by adhering to a more structured sleep schedule. In order to optimize sleep during an eastward layover of 24h or multiples thereof, it would be important to limit sleep immediately after arrival and prolong the subsequent wakeful period to end around the normal local time for sleep. This process would increase the likelihood that the sleep immediately preceding the next duty period would be of adequate duration for these operations. It appears that proper sleep scheduling during the first 24h is most critical and that crew members should develop the discipline to terminate sleep even though they could sleep longer.

Several subjects attempted the strategy of trying to maintain a sleep schedule based on home time. For the schedules under study this practice would appear to be less desirable since it would produce a substantially shorter sleep span immediately before departure; however, this approach could not be adequately evaluated due to the relatively small number of subjects who used it.

Unless layover sleep is arranged in a satisfactory manner by an appropriate sleep-wake strategy, increased drowsiness is likely to occur during the subsequent long-haul flight. Other research (1,2) suggests that under acceptable operational circumstances, limited duration naps can be a helpful strategy to provide refreshment and improve alertness for a useful period of time. Although we do not have the appropriate data to address this issue directly, flight deck napping could be an important strategy if operationally feasible.

Individual Factors

While the subjects as a whole did not exhibit serious sleep problems, certain individual crew members did experience some difficulty. Further investigation of these data is required before any clarifying statement can be made regarding the factors responsible for this situation. Such work is currently underway.

Age is one individual factor which appears to have been important in this study. Older persons tend to experience more difficulties obtaining undisturbed sleep, and this was seen in the aircrew during baseline and layover recordings. Less restful sleep is a feature of growing older and begins to affect individuals in middle age. Surprisingly little is known about the nature and prevalence of less restful sleep over this important span of life, but the data obtained from these flight crews has highlighted the need for normative data in a similar age group of individuals who are usually involved in highly skilled and responsible occupations. These data are now being collected and may be helpful in understanding why some individuals in this age group have difficulty in adapting to unusual hours of work and rest. This issue may be relevant to the practice of occupational medicine.

Finally, in one group of pilots, preliminary analyses suggest that other individual factors may contribute to the crew member's response to layover sleep requirements. Although this evidence is currently limited to differences in daytime sleepiness in morning vs. evening-type individuals, it underscores the potential usefulness of factors related to personality and lifestyle as predictors of individual reactions to multiple time zone flights.

Study Limitations

Although these results have direct implications for air carrier operations, they must be viewed within the context of several limitations inherent in the study design. Most important is the fact that we studied relatively uncomplicated trip patterns. All but one of these trips involved an immediate return to the home time zone after the layover. The primary data were obtained from crew members during the first layover stay following an initial outbound flight. One group of subjects provided additional data upon return to homebase.

At present, such trips are not typical of most international flight crew duty schedules which usually involve multiple flight segments and layovers in different time zones before return home; nevertheless, the trips under examination represent an important type of schedule which is becoming more prevalent.

Although the alterations in sleep were not considered to be of operational significance in the present schedules, it is nevertheless possible that the pattern of disturbed sleep would lead to cumulative sleep loss if the schedule were longer or if complete recovery of sleep were not attained before the next trip. The latter possibility is supported, at least in part, by the observation that baseline sleep was reduced in some subjects, though this may have also been due to other factors such as early rising. Furthermore, all flights occurred during late summer or early fall, which did not permit us to examine seasonal influences, particularly the length of daylight vs. darkness, which may also be an important operational factor.

Secondly, the relatively limited sample sizes may not be representative of the flight crew population as a whole. In this regard, it is clear that the groups differed considerably in age and possibly may have differed along other dimensions related to the voluntary nature of their participation. Third, spending a layover at a sleep laboratory may not be equated with staying at a crew hotel. However, sleep log results from two participating groups of crew members suggest that sleep-wake patterns differ little under these two conditions.

Finally, a potentially more serious problem stems from the difficulty we experienced in obtaining baseline data immediately preceding the trip. Except for one airline, baseline data could only be obtained whenever the volunteers were available following at least three non-flying days. Consequently, these measurements often preceded or followed the trip by a week or more. Thus, any conclusions relating to baseline sleep must be tempered by the realization that the actual sleep obtained during the nights immediately prior to flight might have differed from that measured in the homebase laboratory and may have been confounded by the residual effect of the previous flight schedule, particularly if the preceding trip involved an eastward flight direction.

Regardless of these interpretative issues, the data revealed a high degree of similarity and consistency among the different flight crew samples despite significant differences in culture, age, and airline operational practices. Consequently, it is likely that the overall results apply to a wide spectrum of long-haul crew members and carriers.

REFERENCES

1. Mullaney DJ, Kripke, DF, Fleck PA, Johnson LC. Sleep loss and nap effects on sustained continuous performance. Psychophysiol. 1983; 20:643-51.

2. Naitoh P. Circadian cycles and restorative power of naps. In: Johnson LC, Tepas DI, Colquhoun WP, Colligan MJ (eds.) Biological rhythms, sleep and shiftwork. New York: Spectrum Publications, 1981:553-80.

3. Nicholson AN, Pascoe PA, Roehrs T, Roth T, Spencer MB, Stone BM, Zorick F. Sustained performance with short evening and morning sleeps. Aviat. Space Environ. Med. 1985; 56:105-14.

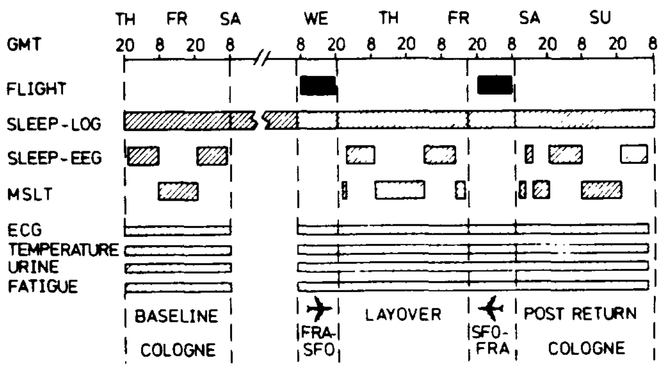

Figure 1.- Overview of time lines for the data collection of the flight schedule Frankfurt-San Francisco.

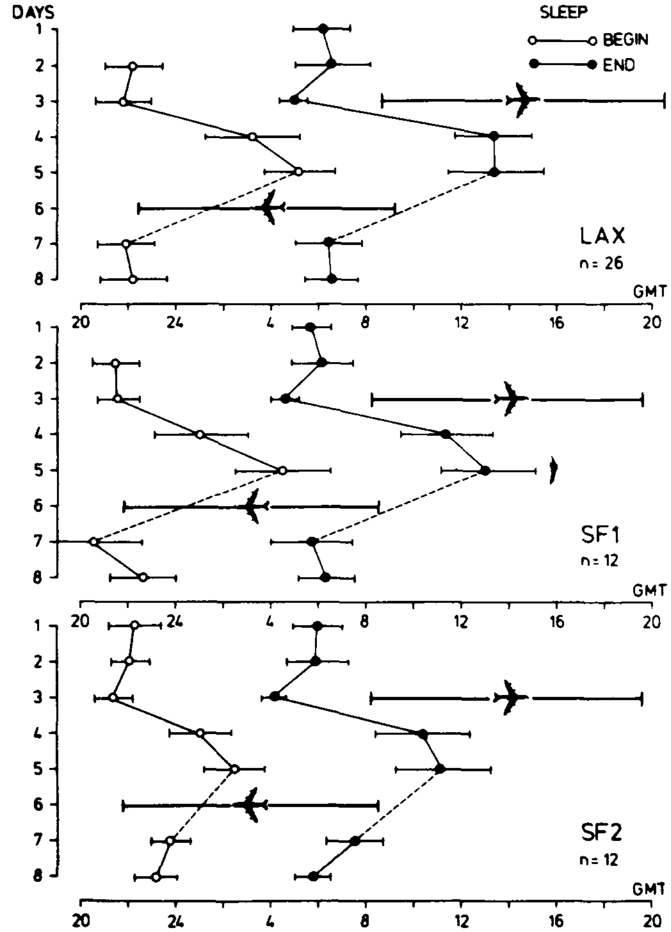

Figure 2. Subjective ratings of beginning and end of sleep during control, layover and post-return nights. Presented are means (±S.D.) of the three different groups. (Numbers of days at the vertical axis refer to days beginning at 2400 GMT.)

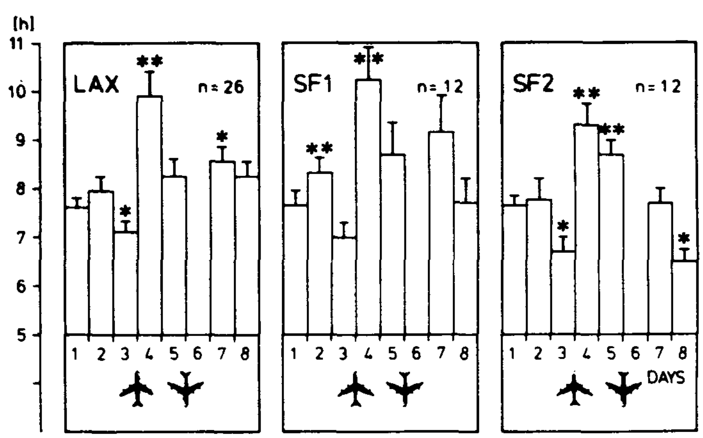

Figure 3. Subjective ratings of sleep duration during control, layover, and post-return nights (means +/- S.E.). * p<=0.05; ** p<=0.01 for differences from sleep period of day 1.