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Tenth International Conference on Managing Fatigue: Abstract for Review

Sleep Patterns in Early Morning Out-and-Back Cargo Flight Operations

Suresh Rangan, FedEx Express Corporation, suresh.rangan@fedex.com
Samantha M. Riedy, Washington State University, samantha.riedy@wsu.edu
Ying Zhang, FedEx Express Corporation, yingzhang2@fedex.com
Patrick Hagerty, FedEx Express Corporation, pat.hagerty@fedex.com
Hans P. A. Van Dongen, Washington State University, hvd@wsu.edu

Corresponding author: Suresh Rangan

Problem: US cargo flight operations include night and early morning flight patterns in which pilots fly out from their base to diverse cargo delivery locations, from which they then turn back to base with new cargo. These so-called AM out-and-backs require pilots to be awake at night and obtain sleep during the day, although there may also be brief opportunities for sleep at the turn location. In the context of a naturalistic data collection program to study the sleep patterns of pilots in cargo flight operations, we measured sleep in pilots flying AM out-and-backs for multiple days in a row.

Method: Twenty-six pilots flying AM out-and-backs out of Memphis (MEM) were measured for up to three consecutive duty days. During each duty day, pilots flew at night to one of 23 turn locations, where they had a layover between 0.92 and 3.10 hours in duration, and then returned to MEM in the early morning. Sleep was measured by means of wrist actigraphs worn 24 hours per day starting the day before the first duty period. We investigated the accumulation of sleep obtained, in 1-hour bins, across the 24 hours preceding each duty period. The cumulative sleep patterns were analyzed using mixed-effects analysis of variance (ANOVA) with fixed effects for duty days, hours prior to take-off from MEM, and their interaction. A random intercept over subjects was included to account for systematic individual differences. The analysis was repeated by clock time to also investigate the accumulation of sleep obtained across the 24 hours of the day.

Results: The average time of day for take-off from MEM was 3:59 AM (standard deviation: 46 minutes). Overall sleep duration in the 24 hours before take-off from MEM was 6.0 hours for the first duty day, 5.7 hours for the second duty day, and 5.9 hours for the third duty day. In the analysis of cumulative sleep obtained by hours prior to take-off from MEM, there were significant effects of duty day ($F_{2,1447}$=117.3, $p<0.001$), hour prior to take-off ($F_{22,1447}$=254.3, $p<0.001$), and their interaction ($F_{44,1447}$=6.8, $p<0.001$) – see Figure 1 (top left). Likewise, in the analysis of cumulative sleep obtained by hours of the day, there were significant effects of duty day ($F_{2,1511}$=195.9, $p<0.001$), hour of the day ($F_{23,1511}$=171.2, $p<0.001$), and their interaction ($F_{46,1511}$=7.1, $p<0.001$) – see Figure 1 (top right).

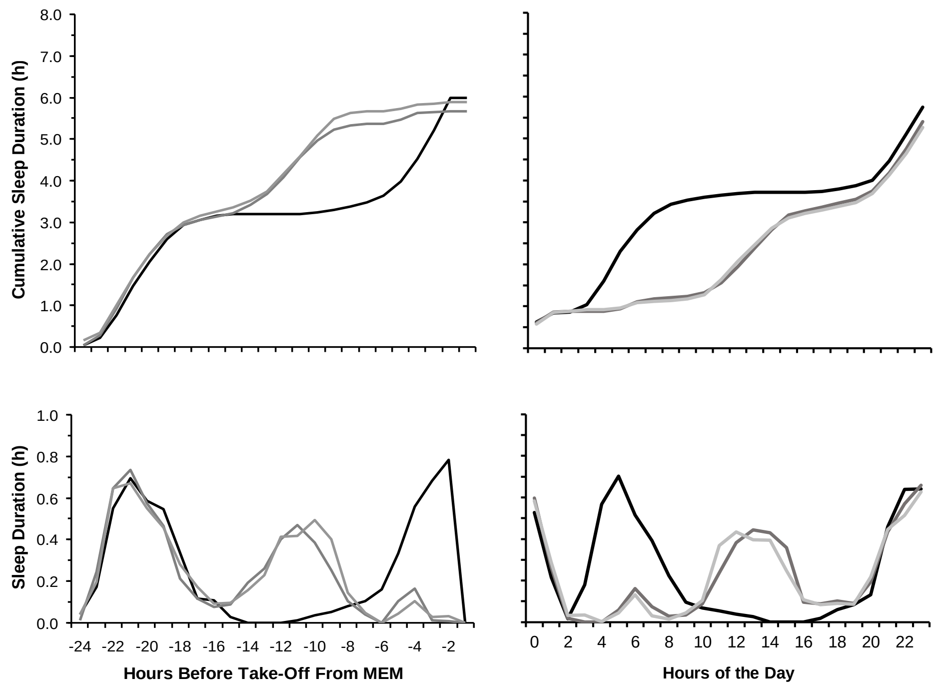

Figure 1: Mean sleep durations in pilots flying AM out-and-backs. *Top left:* cumulative sleep duration by hour through the 24 hours preceding take-off from MEM. *Top right:* cumulative sleep duration by hour through the 24 hours of the day. *Bottom left:* hourly sleep duration through the 24 hours preceding take-off from MEM. *Bottom right:* hourly sleep duration through the 24 hours of the day. **Black:** first duty day; **dark gray:** second duty day; **light gray:** third duty day.

Discussion: The cumulative sleep duration graphs in Figure 1 show that there were considerable differences between sleep patterns in the 24 hours preceding the first duty day and the 24 hours preceding the second and third duty days. To aid in data interpretation, Figure 1 also displays the data as incremental change for each hour prior to take-off from MEM (bottom left) and each hour of the day (bottom right). These graphs show that sleep prior to the first duty day was primarily obtained during the nighttime hours. Due to the nighttime and early morning flights, however, nighttime sleep was curtailed during the second and third duty days, and pilots added a sleep period during the late morning / early afternoon. Additionally, when the layover periods were sufficiently long, pilots took naps at the turn location. Other studies in the laboratory and in the field have shown the effectiveness of split sleep schedules when duty schedules do not permit consolidated nighttime sleep. Figure 1 further reveals that almost no sleep was obtained in the early evening hours, during the so-called “wake maintenance zone,” when the biological clock exerts a high pressure for wakefulness. Naturalistic studies of sleep in other populations in around-the-clock operations, such as truck drivers, have also shown little to no sleep in the wake-maintenance zone, even in the near-absence of nighttime sleep.

Summary: We investigated objective sleep patterns in 26 cargo pilots flying AM out-and-backs for up to three consecutive duty periods. Sleep obtained prior to the first duty day was primarily obtained during the night. During the second and third duty days, nighttime sleep was curtailed, but pilots took a nap at the turn location when the layover period was long enough. Pilots also added a substantial daytime sleep period, although there was little sleep in the early evening during the wake-maintenance zone. Pilots tended not to obtain any daytime sleep before the first duty day. Whether adding a daytime nap before the first duty day would provide an additional opportunity to mitigate fatigue remains to be investigated. Furthermore, promoting sleep at the turn locations could be explored, for example by having crew members take advantage of sleep-friendly hub rooms combined with a wake-up call program to maximize the sleep opportunity.