Sleep Health xxx (2018) xxx–xxx

Contents lists available at ScienceDirect

Sleep Health

Journal of the National Sleep Foundation

journal homepage: sleephealthjournal.org

Sleep and neurobehavioral performance vary by work start time during non-traditional day shifts

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ARTICLE INFO

Article history:
Received 21 January 2018
Received in revised form 24 May 2018
Accepted 1 August 2018
Available online xxxx

Keywords:
Daytime work
Circadian phase
Sleep
Performance
Alertness
Transportation

ABSTRACT

Introduction: It is established that shiftwork causes sleep loss and circadian misalignment. Individuals who work non-traditional day shifts that encroach into typical sleep times, such as those in the service and transportation sectors, may also experience sleep and circadian disruption. We aimed to determine how neurobehavioral performance and sleep would be affected by work start time among individuals working a non-traditional daytime shift pattern.
Methods: We collected sleep diaries, wrist-worn actigraphy (CamNtech, Cambridge UK), and the psychomotor vigilance task (PVT) from 44 pilots (4F) who worked a shift rotation consisting of a five-day baseline block starting in the mid-morning (baseline), five early shifts (early), five high workload midday shifts (midday), and five days of late shifts (late), each separated by 3–4 days off.
Results: Mixed-model analysis revealed that individuals obtained less sleep when working the early shifts (5.70 ± 0.73 h) relative to baseline (6.78 ± 0.86 h; $P < .01$). Sleep duration declined significantly from the beginning to the end of late shifts ($P = .003$). All shifts were associated with decreased reaction time on the PVT relative to baseline (236 ± 48; early, 257 ± 70 ms; midday 261 ± 62 ms; late 266 ± 64 ms; $P < .01$ for all).
Conclusions: We found that non-traditional day shifts encroach on an individual's sleep opportunity and such shifts could be a contributing factor to the high prevalence of sleep deficiency observed in modern society. Our findings suggest that it would be prudent for industries requiring such shifts to expand fatigue risk management training to individuals classified as day shift workers.

Introduction

Sleep loss and circadian misalignment experienced by shiftworkers have been implicated in numerous incidents and accidents.[1,2] Much of the research effort to date has focused on understanding and mitigating the negative effects of sleep loss and circadian misalignment during rotating shift work, night work, extended duty work shifts, and jet lag.[3,4] However, many occupations, such as those in the service and transportation industries, require that workers engage in non-traditional daytime work, with variable daily start and end times, often requiring high workload. Early starts and late finishes may not be classified as night work in these occupations, due to the majority of work hours occurring during the day (e.g. a 5:00 AM to 2:00 PM shift or a 2:00 PM to 11:00 PM shift), but such shifts have the capacity to cause circadian disruption and may be a factor in the high prevalence of sleep deficiency among the general population.[5,6]

Performance impairment due to sleep loss and circadian misalignment among airline pilots is of particular concern, due to the safety implications to passengers and crew alike. There are many factors in daytime short-haul aviation operations that have the potential to cause sleep deprivation and disruption of the circadian rhythm, including irregular schedules, early report times,[7,8] and late finishes.[9] In addition, short haul operations typically involve higher workload in the form of frequent takeoffs and landings, which exposes the crew to an increased opportunity for error relative to long-haul operations.[10,11] Sleep loss and circadian desynchrony of this nature is associated with degradation in alertness and performance.[12]

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https://doi.org/10.1016/j.sleh.2018.08.002
2352-7218/© 2018 Published by Elsevier Inc. on behalf of National Sleep Foundation.

These concerns have been addressed by regulating agencies in the United States and Europe through limitations on the number of hours that a crewmember can work based on the work start time and the number of flight segments scheduled (FAA 14 CFR 117; Commission Regulation (EU) 83/2014), however, it is unclear how schedule design within the legal limits impacts sleep and alertness in an operational environment, particularly when work shifts are scheduled during the day. To this end, we conducted a study of short-haul commercial airline operations using a controlled shift design in an effort to better understand how work start time and workload affect sleep duration and timing, alertness, cognitive performance, and circadian phase.

Participants and methods

Participants

All pilots working for a single airline, at one of the airline's largest hubs, were eligible for participation. There were no other exclusion criteria, as we wanted to characterize sleep, performance, and circadian phase under real world conditions. Study participants were invited to participate in the study via an e-mail distributed through the Fatigue Risk Management group at the airline. Participation in the study was voluntary and all study participants provided written informed consent prior to engaging in any study procedures. The

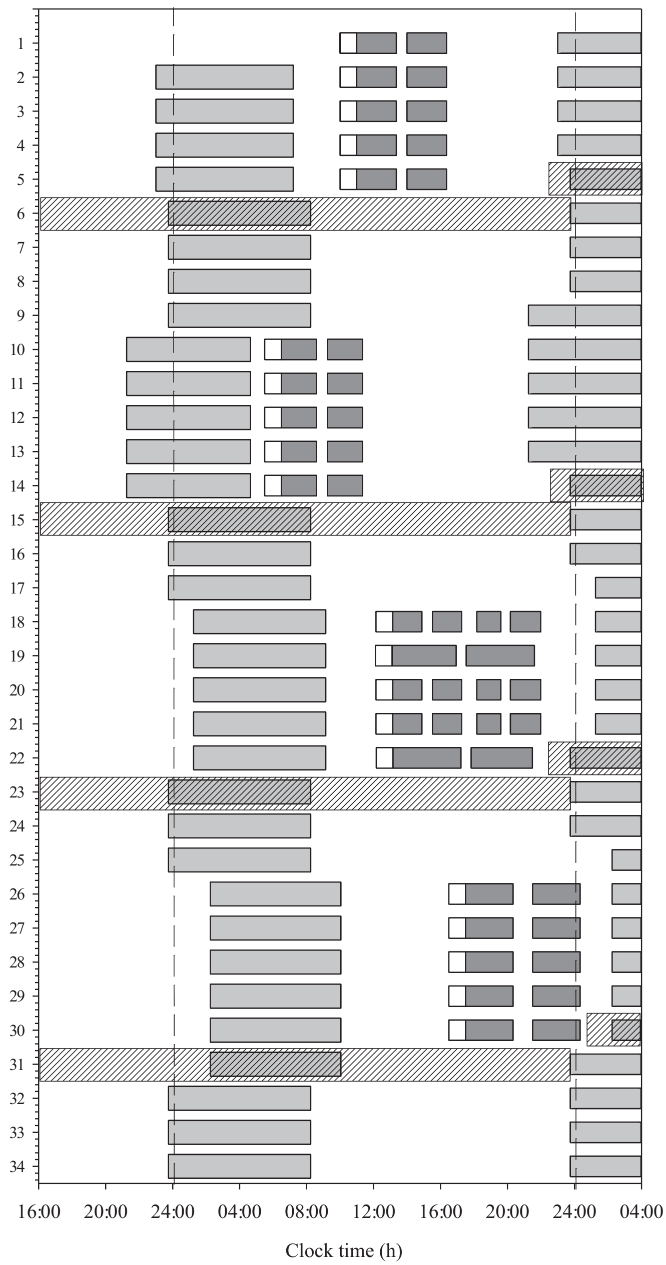

Fig. 1. Study protocol raster plot. Each row represents one day of the study. The x-axis is plotted over 36 hours to show work schedule and available time for sleep on the same line. Flight duty schedule (dark gray) and sleep periods (light gray bars) are shown including the pre-flight report time (open bar) with breaks between flights. Baseline duties are on days 1–5, early report duties on days 10–14, midday duties on days 18–22 and late reports on days 26–30. Shaded hatched bars indicate the scheduled time of the post-block urine collection.

Please cite this article as: Flynn-Evans EE, et al, Sleep and neurobehavioral performance vary by work start time during non-traditional day shifts, Sleep Health (2018), https://doi.org/10.1016/j.sleh.2018.08.002