Sleep Disturbance in Female Flight Attendants and Teachers

Barbara Grajewski; Elizabeth A. Whelan; Mimi M. Nguyen; Lorna Kwan; Roger J. Cole

BACKGROUND: Flight attendants (FAs) may experience circadian disruption due to travel during normal sleep hours and through multiple time zones. This study investigated whether FAs are at higher risk for sleep disturbance compared to teachers, as assessed by questionnaire, diary, and activity monitors.

METHODS: Sleep/wake cycles of 45 FAs and 25 teachers were studied. For one menstrual cycle, participants wore an activity monitor and kept a daily diary. Sleep metrics included total sleep in the main sleep period (MSP), sleep efficiency (proportion of MSP spent sleeping), and nocturnal sleep fraction (proportion of sleep between 10 p.m. to 8 a.m. home time). Relationships between sleep metrics and occupation were analyzed with mixed and generalized linear models.

RESULTS: Both actigraph and diary data suggest that FAs sleep longer than teachers. However, several actigraph indices of sleep disturbance indicated that FAs incurred significant impairment of sleep compared to teachers. FAs were more likely than teachers to have poor sleep efficiency [adjusted odds ratio (OR) for lowest quartile of sleep efficiency = 1.9, 95% Confidence Interval (CI) 1.2 – 3.0] and to have a smaller proportion of their sleep between 10 p.m. and 8 a.m. home time (adjusted OR for lowest quartile of nocturnal sleep fraction = 3.1, CI 1.1 -9.0).

DISCUSSION: Study FAs experienced increased sleep disturbance compared to teachers, which may indicate circadian disruption.

KEYWORDS: jet lag, circadian rhythm sleep disorders, sleep monitoring, aircrew, work schedule tolerance.

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The cabin air environment is the workplace of over 168,000 United States aircrew, including 93,100 flight attendants,[1] of whom 84% are female.[3] For these workers, sleep disturbance is both a cause and an effect of the circadian disruption caused by irregular work schedules and travel through multiple time zones.[26] In female flight attendants, rapid time zone changes have been associated with extended sleep disturbance[12] and resynchronization of circadian rhythms.[27] Fatigue is an occupational hazard for aircrew and countermeasures, including an alertness management program, have been proposed and developed to maintain alertness and safe operating conditions for flight attendants.[13]

Despite interest and research in fatigue countermeasures for aircrew, however, there is relatively little research on chronic effects of sleep disturbance in flight attendants. Sleep disturbance as a component of circadian disruption is of interest in studies of longer-term health outcomes; chronic sleep disturbance may contribute to adverse reproductive health outcomes[11,18] and cancer.[14]

This report describes sleep disturbance in flight attendants based on approximately one month of monitoring. Our goal was to investigate whether flight attendants are at higher risk for sleep disturbance compared to workers from an occupation with more regular work hours (teachers), as assessed by questionnaire, diary, and actigraphy. The analysis was part of a reproductive biomonitoring feasibility study of flight attendants and teachers to assist the creation of exposure metrics for subsequent records-based flight attendant studies.[29] Separate analyses of data from the biomonitoring feasibility study

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examined melatonin production as a marker of circadian disruption and the interrelationships between multiple indicators of circadian disruption, including melatonin, sleep, activity, and flight history.[9]

METHODS

Study Population and Data Collection

The study protocol was approved in advance by the NIOSH Human Subjects Review Board. Each subject provided written informed consent before participating. Study methods for the NIOSH reproductive biomonitoring feasibility study of flight attendants and teachers have been described previously[29] and are summarized here. Two major airline companies were selected for this study: one with a domicile (home base) in Miami and the other with a domicile in Seattle. Flight attendants and teachers were enrolled from company and union rosters in the two cities. Teachers were selected as a comparison group for this study because this predominantly female occupation has more regular work hours, minimal air travel, few reproductive hazards, and comparability to flight attendants on several key demographic characteristics (e.g., age, race, education, parity). Eligibility criteria were: 1) current full-time employment as a flight attendant or teacher, as determined by the employer; 2) age 18-45 yr; 3) not currently pregnant; 4) had not yet reached menopause; 5) not using an intrauterine device (IUD); 6) not using oral contraceptives or other exogenous hormones; and 7) not planning to use an IUD or exogenous hormones in the next 3 mo. Of the eligible women contacted, 45 (40.2%) of the flight attendants and 26 (31.7%) of the teachers enrolled in the study. Of those enrolled in the study, 93% of flight attendants and 96% of teachers completed the biomonitoring study period (approximately one menstrual cycle). During the biomonitoring study period, study participants filled out a daily diary, collected daily urine and saliva samples, and wore a wrist activity monitor. An interviewer-administered baseline questionnaire included questions on demographics, medical history, lifestyle factors, reproductive history, and occupational factors.

Work (Flight) History Records

Work history records of individual flights were obtained for each flight attendant from the study airlines. These records contained the origin city, destination city, date, and departure and arrival times of each flight segment for the 4-mo study period (September - December 1995). Less detailed recreational travel records were obtained from the airlines and commuter travel questionnaire data were also collected. For teachers, flight data were estimated from questionnaire information describing air travel in the preceding 6 mo.

Diary

Study participants were asked to complete a daily diary for their biomonitoring study period and two subsequent months. The diary included questions about urine collection, acute illnesses and medications used, active and passive smoking, alcohol consumption, caffeine consumption, exercise, ergonomic stressors (workplace tasks which may increase the risk of musculoskeletal disorders), psychosocial stress, and dieting. For each sleep period, the following information was recorded based on modifications of previous survey instruments of Monk et al.[20] and Rosa et al.:[24] bedtime, latency, sleep-inducing medications or alcohol, number of wake after sleep onset (WASO) episodes, total WASO minutes, wakeup time, and four five-point responses regarding depth of sleep, sleep quality, mood on awakening, and alertness on awakening. **Table I** defines the diary-derived sleep metrics (as well as actigraph metrics and related modeling outcome categories described in detail below).

Activity Monitoring

Sleep and wakefulness were estimated from wrist activity data collected with the Mini Motionlogger Actigraph System (Ambulatory Monitoring, Inc. (AMI), Ardsley, NY). Each study participant was asked to wear the activity monitor 24 h/d during the biomonitoring period, removing it for bathing or swimming only. Participants were instructed to push an event marker button to electronically mark events including sleep, naps, activity monitor removal, and to confirm daily that the activity monitor was working based on the event marker's audible signals. Artifact removal, sleep estimation, and cosinor (circadian fitting) analysis were performed with AMI's ACT (Version 5.07) and ACTION3 (Version 3.16) software. Sleep and wakefulness were estimated according to the EEG-validated algorithm of Cole et al.,[5] modified for 3-min epochs. Six metrics of disturbance of activity rhythms and estimated sleep were derived from daily actigraph data for each woman. The metrics are defined in Table I and a subset is illustrated in **Fig. 1**.

Activity monitoring quality indices calculated included number of activity monitors used per woman; percent compliance days, defined as [(total days activity monitor worn – total days activity monitor removed for 3 h or more) / total days activity monitor worn] × 100; and percent analyzable days, defined as [(total days activity monitor worn – total days for which activity monitor recorded unusable data or activity monitor was removed for 6 h or more) / total days activity monitor worn] × 100. Also, because aircraft vibration can be recorded by the activity monitor as artifactual wake in the 2-3 Hertz range, 50% of self-reported in-flight naptime minutes were manually scored as sleep where actigraphy supported self-report. Actigraph recordings varied between sleep and wake during these naps for the 15 flight attendants who reported them. Sensitivity analyses of preliminary data suggested 2–8% changes toward the null for several daily sleep metrics if all self-reported plane naps were scored as sleep (compared to scoring all in-flight self-reported naps as wake).

Records-Based Metrics

To assess work-related disruption of flight attendants' Standard Sleep Interval (SSI), cumulative and per-flight-segment SSI travel (flight segment time flown between 10 p.m. and 8 a.m. home base time) were calculated from work (flight) history

Table I. Sleep Disturbance Metrics.

				OUTCOME CATEGORY*	
		DIARY	ACTIVITY MONITOR	HIGHEST 25% = 1	LOWEST 25% = 1
Total Sleep MSP†	Total sleep in the main sleep period (h or min)	X	X	.	X
MSP midpoint‡	Time midpoint of the MSP (minutes from midnight)	X	X	.	.
MSP variance‡	Within-woman angular variance of the MSP midpoint	X	X	.	.
WASO minutes	Wake after sleep onset (min) in the MSP	X	X	X	.
Total Sleep 24h	Total sleep in 24 h (h or min)	.	X	X	.
Sleep efficiency	Proportion of sleep inside MSP	.	X	.	X
Nocturnal Sleep Fraction	Proportion of sleep within 10 p.m. – 8 a.m.	.	X	.	X
Latency	Time to fall asleep after "lights out" (min)	X	.	.	.
Deep sleep	"How deeply did you sleep?" 1 = very lightly, 5 = very deeply	X	.	.	.
Sleep quality	"What was your sleep quality?" 1 = very poor, 5 = very good	X	.	.	.
Mood	Mood on awakening; 1 = very tense, 5 = very calm	X	.	.	.
Feelings at wakeup	1 = tired and drowsy, 5 = awake and alert	X	.	.	.
SSI § travel	Flight record-based time spent flying within the SSI	.	.	.	.

* Quartile of outcome distribution modeled as 1 (highest risk) for regression analysis.
† MSP = Main Sleep Period. The MSP can occur any time during each 24 h period. It is usually the day's first sleep period.
‡ The daily midpoint of the main sleep period is consistent and has little day-to-day variability within an undisrupted person.
§ Standard Sleep Interval (SSI) = Time between 10 p.m. and 8 a.m. home base/domicile time, or the city in which a teacher lived.

records. These records were also used to estimate number of flight days during each flight attendant's study biomonitoring period, and, in conjunction with recreational and commuter travel data, cumulative block time (airborne plus taxi time). Cumulative block time was also estimated for teachers, who were assumed to have minimal SSI travel.

Data Analysis

One teacher withdrew and was excluded from the study. In addition, data from five flight attendants with nonphysiological (abnormally high) urinary 6-sulfatoxymelatonin levels were excluded from all analyses except those for activity monitor performance and compliance. Two of these five flight attendants reported taking melatonin supplements during the biomonitoring period. Data from the remaining 40 flight attendants and 25 teachers were available for analyses of sleep disturbance. Women with less than 3 full days of actigraph data for a specific metric of sleep or activity disturbance were excluded from the analysis of that metric. With the exception of the actigraph ACT and ACTION3 software mentioned previously, SAS Version 9.2 (SAS Institute, Cary, NC) was used for all statistical procedures. For descriptive statistics, medians and ranges were reported for nonnormally distributed data. A subset of sleep disturbance metrics (Table I) was further examined in multivariable repeated measures regression analyses (SAS Proc Mixed/Proc Genmod). Both diary and actigraph data were analyzed for total sleep in the MSP. All other sleep outcomes analyzed with regression analysis were based on actigraph data. Screening for interaction with flight attendant status was limited to age and Body Mass Index (BMI), based upon previous analyses and literature. For models in which there was interaction with BMI, adjusted means and odds ratios were calculated with a mean BMI value of 23.8 – 24.0 $kg \cdot m^{-2}$.

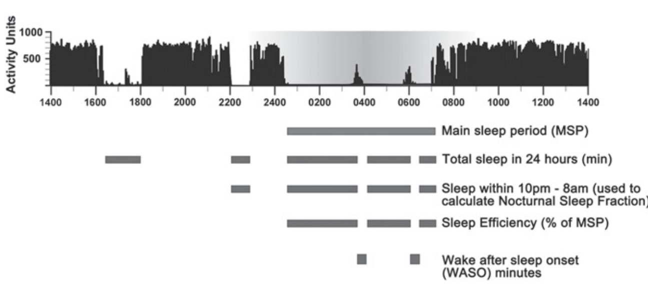

Fig. 1. Example of 24 h activity recorded by activity monitor. Horizontal axis shows military time for a 24 h period. Vertical axis shows relative wrist activity, which is related to sleep status. Bars indicate scoring for four indices of sleep. See Table I for definitions.

The following demographic, medical, and lifestyle variables were evaluated among the flight attendants and teachers at combined domiciles as potential confounders: 1) demographic information, including age, race, Hispanic origin, education, income; 2) daily and weekly diary information, including use of sleep medications, alcohol and caffeine consumption, minutes of exercise outside work, heavy lifting, chance to relax during the week, attempt to diet during the week; 3) daily urinary cotinine concentrations to reflect passive and/or active smoke exposure;[23] 4) medical/physical factors, including BMI, and report of a current cold; and 5) work environment, decision latitude,[15] job strain,[16] acute and chronic stressors, sharing of household duties, presence of a hostile living environment, caregiver status, body image, and stress events during the study period and six months prior.

Frequency distributions and stratified analyses were used to initially characterize the relationship between sleep metrics and flight attendant/teacher status, and to assess evidence of confounding and effect modification. Main sleep period midpoint time data were normalized with circular transformation[4] and reported as means and angular variances since time data are angular rather than linear. Proportions or nonnormal distributions (sleep efficiency, nocturnal sleep fraction, WASO minutes) were reported as medians and interquartile ranges. Adjusted means, standard errors, and 95% confidence intervals (CI) were derived from a linear mixed-effects regression model with flight attendant/teacher status as a fixed effect, subject as a random effect, and a compound symmetric covariance structure. Categorical generalized estimating equations were used to assess the relationship between flight attendant work and the highest or lowest quartiles of the sleep disturbance metrics corresponding to the lowest or highest 25% of study values in the direction of estimated sleep disturbance (Table I). The relative odds of falling into the highest or lowest quartile and the 95% confidence interval for the odds ratio were calculated. Initial models contained potential confounders with a *P*-value less than or equal to 0.2 and a 10% or greater change in the exposure coefficient. Regression analyses were conducted with modified backward selection of covariates causing 15% or greater change in the exposure coefficient.

To examine diary and actigraph data, three diary sleep outcome metrics (total sleep in the MSP, WASO minutes, and MSP midpoint and variance) were compared to corresponding actigraph data. A paired analysis was performed using SAS Proc Genmod, which accounted for multiple observations per woman. One of the metrics in both diary and actigraph data, total sleep in the MSP, was compared with regression analysis.

RESULTS

Table II describes activity monitor performance and compliance. Study participants wore their activity monitors for a median of 35 biomonitoring days (range 11–50 d). Frequent mechanical failure in the initial weeks of the study was the major reason for a 60% activity monitor failure rate and a median of 76% analyzable data among Seattle flight attendants. Although instruments were replaced as failure was reported by participants, monitoring time was lost as instruments were exchanged as many as four times per participant. Despite these problems, study participants had a median of 94% of biomonitoring period days in compliance with activity monitor wear, and the overall median analyzable data from the activity monitors was 92%.

Several differences in demographic characteristics were observed between flight attendants and teachers, although age was similar in both groups (mean ± SD for flight attendants, 36.0 ± 4.7 yr; data not shown).[29] Teachers were more likely than flight attendants to be nonwhite (34.6% vs. 9.1%, respectively) and to have a higher body mass index (BMI; 28.8 $kg \cdot m^{-2}$ vs. 21.0 $kg \cdot m^{-2}$, respectively). Flight attendants were more likely than teachers to drink alcohol four or more times per week and to consume 300 mg or more of caffeine (equivalent to 3 cups of caffeinated coffee) per day (42.2% vs. 3.9%). Teachers were more likely than flight attendants to have three or more live births (23.1% vs. 11.1%, respectively). Flight attendants had lower decision latitude (57 vs. 79) and higher strain (0.61 vs. 0.45) than teachers in this study.

We assessed records-based air travel and work during the standard sleep interval (SSI; 10 p.m. – 8 a.m., home base time). Flight attendants traveled 54.7 ± 19.9 block hours/month (mean ± SD), including unofficial (commuter and recreational) travel; teachers reported a median of 6 (range 0 – 50) total hours of block time in the preceding 6 mo. Flight attendants worked on flights 9.45 ± 5.0 d (mean ± SD), or a median of 33% (range 4 – 76%), during study biomonitoring periods (range 21 – 44 d). For flight attendants, 25% of single flight segments crossed 1 – 5 time zones (median = 0, range 0 – 5). The median annual number of time zones crossed was 93 (range 0 – 465); the median travel within SSI for a single flight segment was 17 min (range 4 – 425 min), and median annual travel within SSI was 82.3 h (range 6.7 – 616.8 h). Flight segments averaging 2.3 h or more were flown by 50% of the flight attendants; 10% of the flight attendants had a mean flight segment length of 8.3 h or more (range 1.7 – 8.8 h).

Table III compares diary and activity monitor results. While data from the daily diary were less precise than those from actigraphy, the results were consistent between these data sources.

Diary values differed from actigraph values for mean total sleep in the MSP, mean wake after sleep onset (WASO) minutes, and the midpoint and variance of the MSP. The first two differences appear to reflect self-reported overestimation of undisturbed sleep; on average, the diary total sleep in the MSP was greater than the corresponding actigraph value by approximately 41 min, and the mean actigraph WASO minutes were 59 min greater than the diary value. The MSP differences suggested increased sleep disturbance in flight attendants, since variability of the MSP in flight attendants was consistently greater than in the teachers.

Table II. Activity Monitor Performance and Compliance Among Flight Attendants and Teachers in Two Cities.

	SEATTLE		MIAMI		
CHARACTERISTIC	Flight attendants ($N = 24$)	Teachers ($N = 13$)	Flight attendants ($N = 21$)	Teachers ($N = 12$)	TOTAL ($N = 70$)
Number of activity monitors used*	40	15	27	14	96
Number (%) of activity monitor failures†	24 (60)	4 (27)	8 (30)	4 (29)	40 (42)
Median % compliance days‡ (range)	96 (0-100)	97 (60-100)	91 (66-100)	90 (6-100)	94 (0-100)
Median % analyzable data§ (range)	76 (0-95)	94 (44-96)	92 (0-95)	92 (0-95)	92 (0-96)

* Multiple (2-4) activity monitors were used by 16 (23%) of the study participants due to activity monitor failure.
† Six (15%) activity monitors failed due to field team error. Mechanical failure occurred in the remaining 34 (85%) activity monitors.
‡ ((Total days activity monitor worn – total days activity monitor removed for 3 h or more) / Total days worn) × 100.
§ ((Total days activity monitor worn – total days for which activity monitor recorded unusable data or activity monitor removed for 6 h or more) / Total days worn) × 100.

Table III. Actigraphy and Diary-Derived Sleep Metrics.

UNADJUSTED MEAN ± SD FOR THE BIOMONITORING STUDY PERIOD*							
	ACTIVITY MONITOR			DIARY			
Metric	FA[†]	T	$P_{\text{FA vs. T}}$	FA	T	$P_{\text{FA vs. T}}$	$P_{\text{activity monitor vs. diary}}$
Total sleep in the Main Sleep Period (MSP), h	7.3 ± 0.7	6.6 ± 0.7	0.0002	8.2 ± 0.8	7.4 ± 0.8	0.002	<0.0001
WASO (Wake After Sleep Onset) minutes	61.5 (52, 69.5)	51.5 (43.5, 58.0)	0.009	3 (0,5)	2 (0,10)	0.9	<0.0001
MSP midpoint (minutes from midnight)	216 ± 62	180 ± 15	0.02, 0.0006[‡]	215 ± 52	175 ± 14	0.005, 0.001	0.03, 0.02

Activity Monitor Only			
Metric	FA	T	$P_{\text{FA vs. T}}$
Total sleep in 24 h (h)	8.4 ± 0.6	7.8 ± 0.9	0.005
Sleep efficiency (proportion of sleep inside MSP)	0.87 ± 0.03	0.87 ± 0.03	0.1
Nocturnal sleep fraction (proportion of sleep within 10 p.m. – 8 a.m.)	0.87 ± 0.14	0.92 ± 0.06	0.1

Diary Only			
Metric	FA	T	$P_{\text{FA vs. T}}$
Latency (min to fall asleep after "lights out")	11.6 ± 6.9	12.4 ± 8.4	0.9
Deep sleep ("How deeply did you sleep?" 1 = very lightly, 5 = very deeply)	3.6 ± 0.7	3.9 ± 0.5	0.1
Sleep quality ("What was your sleep quality?" 1 = very poor, 5 = very good)	3.5 ± 0.6	3.8 ± 0.5	0.07
Mood on awakening (1 = very tense, 5 = very calm)	3.6 ± 0.6	3.7 ± 0.6	0.6
Feelings at wakeup (1 = tired and drowsy, 5 = awake and alert)	3.2 ± 0.7	3.3 ± 0.6	0.5

* *N* varies from 724 to 1302 daily data values from 32 to 39 flight attendants and 524 to 899 daily values from 21 to 24 teachers, based on specific missing or excluded data.
† FA = flight attendants, T = teachers (comparison group).
‡ Separate tests for midpoint and variance of the midpoint for FA vs. T and activity monitor vs. diary.

Actigraph total sleep in 24 h was greater for flight attendants than teachers, which was consistent with results for total sleep in the MSP. The additional sleep may be due to naps or to sleep adjacent to the MSP, but not scored within it. Sleep efficiency and nocturnal sleep fractions were similar for flight attendants and teachers. Diary questions were suggestive of deeper and better quality sleep for teachers, but did not distinguish between these groups for latency, mood on awakening, or feelings at wakeup.

Table IV reports crude and adjusted means and odds ratios for sleep outcomes among flight attendants and teachers. Flight attendants appeared to sleep longer than teachers. Analysis of both diary and actigraph data indicated that flight attendants had more minutes of total sleep time in the main sleep period than teachers. There was a larger flight attendant-teacher difference in the diaries' adjusted means for total sleep time (503 vs. 414 min) than in the activity monitors' (410 vs. 396 min). Both analyses' adjusted odds ratios were consistent with the adjusted means, and indicated that teacher values for total sleep in the MSP were 2 – 3 times more likely than flight attendants' to fall into the lowest 25% of the study data.

Although flight attendants had slightly more unadjusted wake after sleep onset (WASO) minutes and more unadjusted total sleep in 24 h than teachers, the total sleep differences were smaller after adjusting for BMI, hostile home environment, and BMI interaction with flight attendant status and were no longer associated with occupation.

For two indices of sleep disturbance, adjustment increased flight attendants' odds of being in the lowest quartile, suggesting poor sleep quality. Flight attendants were 1.9 times as likely (95% CI: 1.2 – 3.0) to be in the lowest quartile of sleep efficiency (i.e., to have the least amount of time spent sleeping in the MSP), and 3.1 times as likely (95% CI: 1.1 – 9.0) to be in the lowest quartile for nocturnal sleep fraction (i.e., to have the lowest amount of sleep time within 10 p.m. – 8 a.m. home time) compared to teachers.

DISCUSSION

In this study, activity monitors in conjunction with diary data indicated that flight attendants, on average, sleep longer than comparison workers from an occupation with more regular work hours (teachers). However, for two activity monitor indices of sleep disturbance, sleep efficiency and nocturnal sleep fraction, flight attendants incurred significant impairment of sleep compared to teachers.

Overall, the findings of this study were reflected in both diary and actigraph data. Results were generally consistent but not identical, and for some metrics, such as wake after sleep onset, differences were large. Although poor correspondence between actigraphy and self-report has been reported for sleep-wake transition states such as sleep latency, number and duration of night awakenings, and daytime naps, agreement has been reported for measuring changes in sleep patterns over time.[19] Also, actigraphy circumvents bias from self-reported information, which may be a critical consideration for study of occupational groups with perceived sleep problems.[2]

An additional question is whether actigraphy can or should be used to report sleep metrics of individual air crewmembers. Signal et al.[25] found consistency between actigraphy and polysomnography for sleep duration, but weaker correlations for

Table IV. Mixed-Effects Model of Crude and Adjusted Means and Odds Ratios (ORs) with 95% Confidence Intervals (CIs) for Metrics of Sleep Disturbance in Flight Attendants and Teachers.

SLEEP OUTCOME*	WOMAN-DAYS	CRUDE MEAN (95% CI)	ADJUSTED MEAN (95% CI)	CRUDE OR (95% CI)	ADJUSTED OR (95% CI)
Diary Decreased† TS MSP (min)					
FA	1022	484 (468-500)	503‡ (480-526)	0.48 (0.30-0.79)	0.16§ (0.06-0.46)
T	761	439 (420-458)	414‡ (384-443)	1.00	1.00
Decreased† TS MSP (min)					
FA	879	439 (426-452)	410¶ (386-434)	0.49 (0.29-0.82)	0.27** (0.08-0.87)
T	623	400 (384-415)	396¶ (378-414)	1.00	1.00
Increased†† WASO (min)					
FA	879	72‡‡ (67-77)	.	1.27‡‡ (0.81-2.03)	.
T	623	64‡‡ (57-70)	.	1.00	.
Increased†† TS 24h (min)					
FA	810	507 (491-523)	478§§ (453-503)	1.79 (1.21-2.64)	1.11¶¶ (0.55-2.27)
T	587	470 (450-490)	484§§ (462-507)	1.00	1.00
Decreased† Sleep Efficiency					
FA	879	.	.	0.98 (0.60-1.60)	1.92*** (1.22-3.02)
T	623	.	.	1.00	1.00
Decreased† Nocturnal Sleep Fraction					
FA	724	.	.	2.46 (1.45-4.18)	3.07††† (1.05-8.97)
T	524	.	.	1.00	1.00

* Outcomes are actigraph-based except Diary TS MSP. FA = flight attendants, T = teachers, TS MSP = total sleep in the main sleep period, WASO = wake after sleep onset, TS 24h = total sleep in 24 h. See Table I for definitions.
† For odds ratios, the odds of a flight attendant being in the lowest quartile of the outcome compared to teachers.
‡ Adjusted for body mass index (BMI) and decision latitude.
§ Adjusted for BMI, shared home responsibilities, decision latitude, time to take it easy at work, and body image.
¶ Adjusted for BMI and BMI – FA status interaction (mean BMI = 24.0 $kg \cdot m^{-2}$).
** Adjusted for BMI, hostile home environment, race, body image, decision latitude, and BMI –FA status interaction (mean BMI = 24.0 $kg \cdot m^{-2}$).
†† For odds ratios, the odds of a flight attendant being in the highest quartile of the outcome compared to teachers.
‡‡ No confounders or effect modifiers changed the crude outcome means and odds ratios.
§§ Adjusted for BMI, hostile home environment, and BMI – FA status interaction (mean BMI = 23.8 $kg \cdot m^{-2}$).
¶¶ Adjusted for BMI and BMI – FA status interaction (BMI = 23.8 $kg \cdot m^{-2}$).
*** Adjusted for BMI.
††† Adjusted for decision latitude.

other sleep metrics among the 21 flight crew studied. Although they concluded that actigraphy is not reliable for estimating sleep for individual flight crew, our study suggests that actigraphy is useful in an epidemiologic or population-based context.

We hypothesized that flight attendants would sleep less than teachers, but observed the opposite. Longer total sleep time[8] or longer sleep on days off[22] have been observed in studies of shift-workers, and has also been observed in sleep pathologies such as sleep apnea, for which longer sleep was a result of multiple disturbances of the main sleep period.[31] Despite longer total sleep times and possibly more opportunities to sleep on days off, the flight attendants in this study had reduced sleep efficiency and more wakefulness during the main sleep period compared to teachers. These findings suggest that flight attendants may spend more time in bed attempting to sleep than teachers do in an effort to compensate for their chronic occupationally related sleep disturbance.

Confounders and interaction in our models were largely of two categories: body mass index (BMI) and job stressors. Average BMI values were higher for teachers than for flight attendants in our study, and associations between sleep disturbance and BMI have been reported.[17] Decision latitude and job strain, interrelated job stressors which have been associated with sleep disturbance,[7,21] were more extreme for flight attendants in our study (lower decision latitude, higher strain).

SSI travel is the work history records-based exposure metric we have validated to assess the sleep disturbance component of circadian disruption in air crew studies based on records of individual flight segments.[9] The SSI travel among this group of flight attendants was consistent with our findings in our study of 83 U.S. commercial airline pilots.[10] In that study, we also observed that our records-based metrics of circadian disruption (time zones crossed and SSI travel) rose markedly from the 1990s to 2003. Circadian disruption as assessed by these metrics appeared to be increasing for U.S. airline pilots and is likely to be increasing for other U.S. aircrew as well. Although our study was conducted in 1995, it is likely that working conditions which would contribute to chronic sleep disturbance have not been adequately addressed. For female flight attendants, rest requirements[28] may begin to address fatigue and alertness issues. However, for all aircrew, the chronic health effects of sleep debt and circadian disruption still need to be determined.

Interpretation of our results is limited by the small number of women included in this feasibility study, the age limit imposed on study participants, the nonseparation of duty and nonduty days, and several technical aspects of sleep monitoring at the time the study was conducted. First, activity monitors tend to overestimate sleep when people lie awake but motionless in bed or elsewhere.[5] It is possible that the degree of sleep disruption induced by flight attendants' schedules was underestimated, or overestimated due to limitations of event marking, although diary data can help to reduce this artifact. Second, at the time of the study, practical field methods were not available to assess concurrent light exposures. This would have been desirable, since the light-dark cycle is the most important synchronizer of the human circadian system.[6] Third, in order to monitor activity, sleep, and wake for an entire menstrual cycle, the AMI activity monitor was modified to collect data at 3-min intervals. In this tradeoff, the fine discrimination possible with shorter sampling intervals was lost. Finally, we did not assess fatigue and alertness, and did not separate duty- and nonduty-day sleep. These limitations, however, did not impair our study findings, which suggested sleep disturbance among flight attendants and informed our exposure assessment of circadian disruption in air crew.

Sleep disturbance in flight attendants is supported by these study findings, and circadian disruption was supported in our earlier analyses of overnight melatonin variability among the same group of flight attendants.[9] Misalignment of the sleep-wake cycle and circadian rhythms due to flight attendants' unique form of shiftwork may be a chronic occupational condition. Circadian misalignment may not be fully readjusted for flight attendants by rest after duty periods and may have additional implications for their reproductive health. In our subsequent records-based study of miscarriage in flight attendants, we reported an increased risk of miscarriage for flight attendants with 15 h or more of SSI travel during early pregnancy.[11] Similarly, night work schedules during nurses' pregnancies have been shown to increase the risk of adverse reproductive outcomes such as spontaneous abortion and early preterm birth.[18,30] Sleep disturbance may also contribute to cancer as a component of shiftwork. An International Agency for Research on Cancer working group classified shiftwork that involves circadian disruption as Group IIA (probably carcinogenic to humans) based, in part, on studies of female flight attendants.[14] The long-term potential health effects of sleep disturbance and circadian disruption need to be considered in educating and scheduling air crew and other shift workers.

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