Sleep and Fatigue Differences in the Two Most Common Types of Commercial Flight Operations

Cátia Reis; Catarina Mestre; Helena Canhão; David Gradwell; Teresa Paiva

BACKGROUND: Sleep and fatigue management is one of the main challenges in airline operations scheduling. Our aim was to compare the differences regarding fatigue, sleep, and labor specificities between the two most common types of flight, short/medium haul (SM-H) and long haul (L-H), in a large sample of airline pilots.

METHODS: A self-report questionnaire was developed, composed of socio-economic and labor questions, and psychological assessment scales for fatigue and sleep. Associations of these variables and type of flight were tested.

RESULTS: Of the total sample of Portuguese airline pilots ($N = 435$), 313 (72%) were from SM-H and 122 (28%) were from L-H. For SM-H, the values obtained for sleep complaints were 34.2%, daytime sleepiness 61.6%, and fatigue 93.0%. For L-H, 36.9%, 53.3%, and 84.4%, respectively. Looking at labor variables, the differences between the two types of flights were evident, with SM-H pilots' having statistically significant higher mean values of duty and flight hours, numbers of sectors, and early mornings. Only the mean number of night periods was higher in L-H pilots. All values were reported for 28 consecutive scheduling days.

CONCLUSION: Night periods and time-zone crossing may explain higher prevalence levels of sleep disturbances in L-H pilots. However, the values for daytime sleepiness were higher in SM-H pilots, which may be attributed to diminished sleep caused by a combination of frequent early starts and long duty periods. Taking into account the large differences between the two types of flights, different regulatory limits should be considered by aviation authorities.

KEYWORDS: short/medium haul, long haul, airline pilots, prevalence values.

Reis C, Mestre C, Canhão H, Gradwell D, Paiva T. *Sleep and fatigue differences in the two most common types of commercial flight operations*. Aerosp Med Hum Perform. 2016; 87(9):811–815.

Pilots' fatigue has been identified as a significant hazard in modern aviation operations, mostly because of unpredictable working patterns, long duty periods, circadian disruptions, and insufficient sleep, issues that are common in both civilian and military flight operations.[3] Fatigue is defined by the International Civil Aviation Organization, the responsible entity for supervising civil aviation, as "a physiological state of reduced mental or physical performance capability resulting from sleep loss or extended wakefulness, circadian phase, or workload (mental and/or physical activity) that can impair a crewmember's alertness and ability to safely operate an aircraft or perform safety related duties."[6]

There are two types of commercial flights, short/medium-haul (SM-H), characterized by flights of less than 6 h with multiple sectors in one duty period, and long haul (L-H) flights, which are flights with 6 or more hours, usually with one or two sectors maximum. In L-H flights, pilots frequently attribute their fatigue to sleep deprivation and circadian disturbances associated with multiple crossings of time-zones (jetlag). According to Caldwell,[2] SM-H pilots blame their fatigue mainly on sleep deprivation and high workload. Both L-H and SM-H pilots commonly associate their fatigue with night flights (23:00–06:29), jet lag, early morning wakeups (early starts, between 05:00 and 06:59), time zone crossings, multiple flight sectors, and consecutive duty periods without adequate recovery

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This manuscript was received for review in March 2016. It was accepted for publication in June 2016.

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DOI: 10.3357/AMHP.4629.2016

breaks.[2] There are additional differences between these two types of flights. SM-H flights are always crewed by only two pilots (minimum crew), while in the longer L-H flights (>11 h), there must be additional crewmembers (augmented crew). This provides the possibility of in-flight rest (resting stations outside the flight deck). These planned in-flight breaks are one of the most common fatigue countermeasures in aviation.[3] SM-H pilots have a limited capability to rest. They may only do it in their flight stations, because it is mandatory for two pilots to be always on the flight deck. SM-H pilots conduct more takeoffs and landings per duty period than long-haul pilots, and these are the riskier stages of flight, involving a greater workload.[11] Previous studies of SM-H operations indicate that these pilots may experience relatively higher levels of fatigue and that the major causes of fatigue are early starts and long duty periods.[1,8] The objective of this study was to compare SM-H and L-H flight specificities in a large sample of airline pilots, measuring the prevalence of fatigue, daytime sleepiness, and sleep disturbances.

METHODS

A total of 1498 questionnaires were distributed during a period of 1 mo to most of the population of Portuguese airline pilots (≈1500). Of these, 435 were considered valid and constituted the study population. The inclusion criteria were: being an airline pilot on active duty, ages between 20 and 65 yr, and having flown during the last 6 mo.

The questionnaire consisted of sociodemographic data (age, gender, professional category, living with children with age <3), labor variables (duty hours, number of sectors flown, hours flown, early starts, and night periods, with all values referring to 28 scheduling days), and validated psychological instruments: the Fatigue Severity Scale (FSS),[7] the Jenkins Sleep Scale (JSS),[10] and the Epworth Sleepiness Scale (ESS).[12] The cutoff values established for all instruments were in accordance with those established by the authors.

A random number was assigned to each inquiry. To ensure that the investigating team distributed them all, thus preventing duplication, anonymized questionnaires were placed in the personal locker of each pilot. When completed, the forms were deposited in a locked deposit box and afterwards collected by one element from the investigating team. Of the 1498 inquiries distributed, 435 were correctly answered, 44 were invalid, and 1019 were not returned (response rate 32%).

Quantitative variables were expressed as mean and standard deviation, and categorical variables in frequencies. Associations between all variables and type of flight were assessed using the Mann-Whitney non-parametric (U) test for continuous variables (taking into account data distribution) and by a Chi-square test (χ^2) for categorical variables. A significance level of 5% was considered in all statistical analysis undertaken. Statistical analyses were carried out with IBM SPSS v.22. The Portuguese Airline Pilots' Association and the CHLN-Santa Maria Hospital Ethics Committee approved this study. Informed consent was not required because it was completely anonymous, with no interaction between the participants and the investigation team.

RESULTS

The mean age for the study population was 39.05 ± 8.14. Of the valid questionnaires, 12 (2.8%) were from female pilots and 423 (97.2%) were from male pilots. Regarding the type of flight, 313 (71.95%) were SM-H and 122 (28.05%) were L-H pilots. This corresponds approximately to the female/male and SM-H/L-H ratios of the Portuguese airline pilot's population (**Table I**).

The subjective prevalence values for sleep complaints (JSS) in SM-H were 107 (34.2%) and 45 (36.9%) in L-H. Self-reported daytime sleepiness (ESS) was indicated by 193 (61.66%) SM-H pilots and by 65 (53.3%) L-H pilots. Regarding subjective fatigue (FSS), it was reported by 291 (93%) SM-H pilots and 103 (84.4%) L-H pilots (Table I).

For SM-H, the mean values for duty hours, sectors flown, number of flight hours, and early starts were higher then in L-H. Only the mean value for night periods was higher for L-H (**Table II**). All values were referent to 28 scheduling days. When comparing these variables, all had statistically significantly different values for SM-H and L-H, with a P-value < 0.001, except for night periods, which had a $P = 0.049$ (**Fig. 1**).

The mean age of pilots was statistically different between SM-H and L-H pilots ($U = 12581$, $P < 0.001$), with the L-H having the higher mean age. When asked about living with children under the age of 3, and since there were significant differences between age for the SM-H and L-H groups, values were corrected for age in order to prevent bias. We observed a positive association with L-H, but age was a confounder and the association was really because of the younger pilots from the L-H who had children less than 3 yr of age. Regarding gender, there were no differences between groups ($\chi^2 = 0.172$, $P = 0.679$) or professional category ($\chi^2 = 0.768$, $P = 0.381$) (Table II).

Associations between the two types of flights and sleep complaints (JSS), daytime sleepiness (ESS), and fatigue (FSS) were performed. Statistically significant differences were only found between the groups for fatigue ($\chi^2 = 7.580$, $P = 0.006$), with SM-H being the group who presented an added risk of fatigue [OR = 2.440, CI (1.269; 4.691)] (Table II).

Table I. Sample Characteristics by Type of Flight.

VARIABLE	SHORT-MEDIUM HAUL	LONG HAUL
N (%)	313 (72%)	122 (28%)
Age (mean ± SD)	37.63 ± 7.62	42.70 ± 8.31
Sex (%)		
Male	305 (97.4%)	118 (96.7%)
Female	8 (2.6%)	4 (3.3%)
Children <3 yr of age		
No	86 (27.5%)	22 (18%)
Yes	227 (72.5%)	100 (82%)
Professional Category (%)		
Captains	166 (53%)	59 (48.4%)
First Officers	147 (47%)	63 (51.6%)

Table II. Associations Among Types of Flight, Labor Variables, Sleep, and Fatigue.

VARIABLES	SHORT/MEDIUM HAUL	LONG HAUL	TEST (*P*-VALUE)	OR (95% CI)
Age	37.63 ± 7.62	42.70 ± 8.31	U = 12581 (< 0.001)	
Sex				
Male	305 (97.4%)	118 (96.7%)	χ^2 = 0.172 (0.679)	1.292 (0.382; 4.373)
Female	8 (2.6%)	4 (3.3%)		
Children <3 yr of age				
Yes	227 (72.5%)	100 (82%)	χ^2 = 4.194 (0.320)*	1.319 (0.765; 2.274)*
No	86 (27.5%)	22 (18%)		
Fatigue Severity Scale				
FSS ≥ 4	291 (93%)	103 (84.4%)	χ^2 = 7.508 (0.006)	2.440 (1.269; 4.691)
FSS ≤ 3	22 (7%)	19 (15.6%)		
Jenkins Sleep Scale (JSS)				
JSS ≥ 4	107 (34.2%)	45 (36.9%)	χ^2 = 0.281 (0.596)	0.889 (0.575; 1.374)
JSS ≤ 3	206 (65.8%)	77 (63.1%)		
Epworth Sleepiness Scale (ESS)				
ESS ≥ 10	193 (61.7%)	65 (53.3%)	χ^2 = 2.556 (0.110)	1.410 (0.924; 2.152)
ESS ≤ 9	120 (38.3%)	57 (46.7%)		
Professional Category				
Commanders	166 (53%)	59 (48.4%)	χ^2 = 0.768 (0.381)	0.829 (0.546; 1.261)
First Officers	147 (47%)	63 (51.6%)		
Labor Variables/28 days				
Duty Hours	112.11 ± 25.03	73.38±22.29	U = 34125 (< 0.001)	
Flown Hours	63.03 ± 14.89	55.67±19.70	U = 23601 (< 0.001)	
Flown Sectors	28.89 ± 9.33	7.15 ± 2.70	U = 37897 (< 0.001)	
Early starts	5.33 ± 3.12	0.72 ± 1.34	U = 35935 (< 0.001)	
Night Periods	0.91 ± 1.10	3.45 ± 1.88	U = 16790 (< 0.049)	

One-way analysis reflecting OR and 95% CI for the Chi-square (χ^2) test; mean ± SD are given for continuous variables. *Indicates value corrected for age.

DISCUSSION

The prevalence values for reported fatigue were high, especially in pilots who flew SM-H. This study confirms previous results,[9] with the highest values of subjective fatigue for Portuguese airline pilots found in the group flying SM-H flights. Furthermore, daytime sleepiness was also higher in the SM-H group (61.6%) in comparison with the sample of L-H pilots (53.3%), which is commonly attributed to diminished sleep caused by the combination of frequent early starts and long duty periods, as observed in another study.[1] These numbers were very explicit on the values obtained in this study for the two different types of flights. The prevalence of sleep complaints was higher in L-H pilots, probably due to the very nature of these flights, often characterized by night flights with multiple time-zone crossings.[1]

Unexpectedly, we obtained a positive association between having children under the age of 3 with L-H pilots. Usually L-H pilots have a higher mean age and we have confirmed that, but it is a mean age of only 42.70, which means that they could still have children under the age of 3 living with them. This was expected to be a factor associated with fatigue, but in this sample fatigue was associated with SM-H, not L-H. Regarding gender, and despite the low frequency of female pilots in this sample, the number of individuals from SM-H and L-H was quite similar.

In this study, differences between the two types of flight (SM-H and L-H) were demonstrated, with all the labor variables presenting statistically significant differences. SM-H pilots were the ones with a higher mean value of duty hours, sectors, flight hours, and early mornings. Only night flights were higher in the L-H pilots' group. These results should be taken into account when discussing regulatory limits, because flight hours and duty hours have an approximate value for L-H pilots. The equivalence between flight hours and workload may be related to the closer association between flying a single sector per duty period. When looking at SM-H pilots, their duty hours do not reflect their effective workload, given that they require more duty time for the same amount of flight time.

In European legislation, the only variable that has maximum regulatory limits established is the duty time, which is the same in 28 consecutive days for both types of flights (100 h). With the mean values for duty time achieved in this study, we have already observed high levels of reported fatigue and sleep complaints, and the maximum limits established by law were not even reached. As such, in our opinion, these results should be taken into account if the regulatory limits will for any reason be revised.[4] Considering the differences between flights presented in this study, there should be different limits for the two types of flights. Alternatively, the European aviation authorities (EASA) could follow the example of the American aviation authorities (Federal Aviation Administration or FAA), who opted for establishing maximum values for duty time and time at the controls (flight time). Flight time is limited to 8 or 9 h, depending on the time of day that the flight duty period commences.[5]

Nevertheless, being a self-reported questionnaire, a certain bias is expected, since it is understandable that the individuals who answered it are the most affected, potentially resulting in

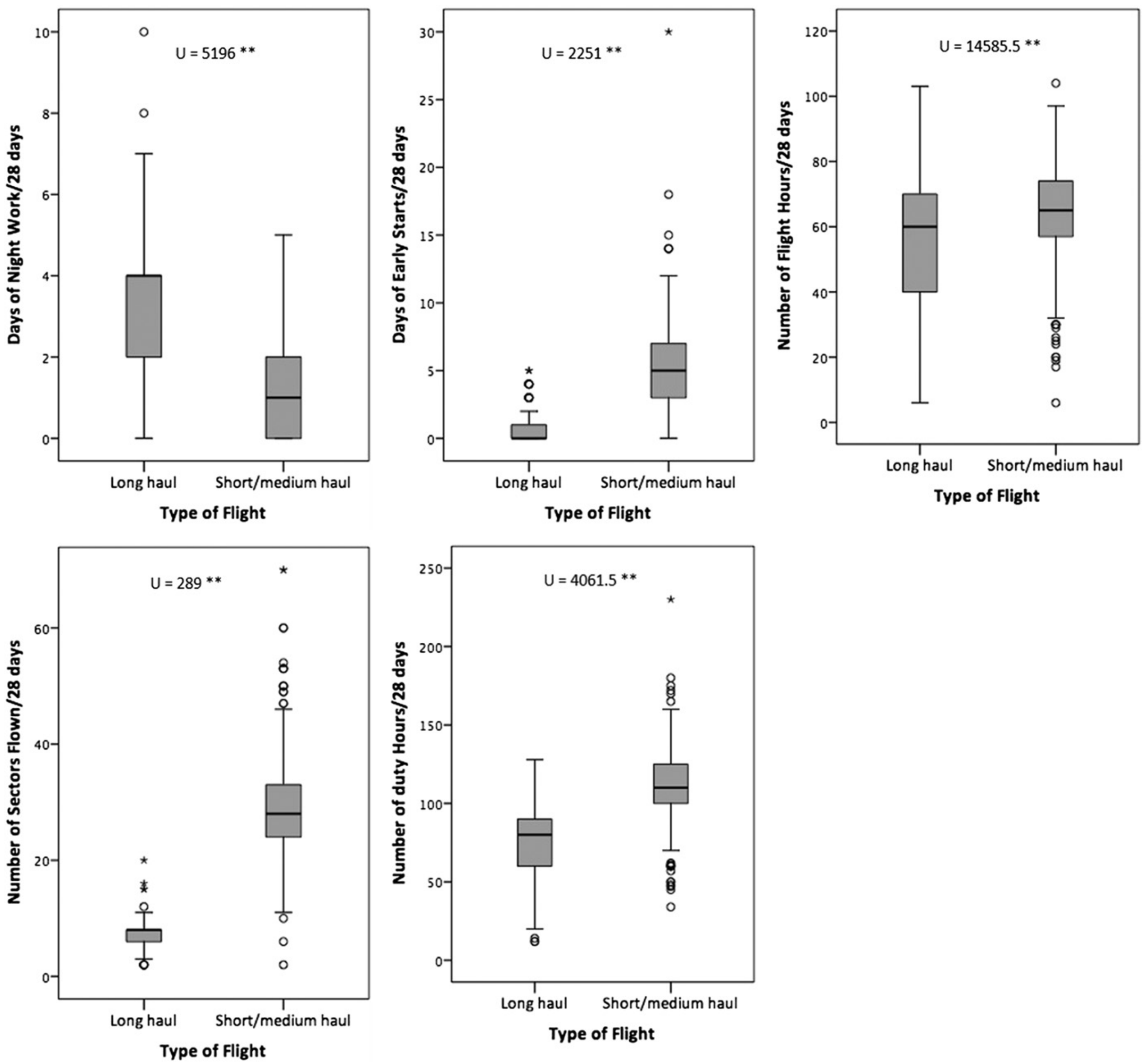

Fig. 1. Differences in labor variables for both types of flights (U – Mann Whitney test). *Indicates $P < 0.05$, **$P < 0.01$.

some overemphasis within the results obtained. Although these values were self-reported subjective values of sleep, they are important tools to quantify and understand fatigue in airline pilots. While this study could be considered to have a large sample, the response ratio of 32% is not representative of all the Portuguese airline pilots. As such, it was not possible to extend the analysis to modelling and causality, but only to identify significant associations, which is common in cross-sectional studies. This reinforces the need of further investigation in this area.

This study can be an important implementation tool in Fatigue Risk Management Systems (FRMS),[6] which have multi-layered defensive strategies to manage fatigue. The study enhances the importance of crew reporting and monitoring, allowing a greater control in the observed variables, especially for SM-H pilots. This study heightens the importance of defining different strategies to mitigate fatigue, taking into account all the differences between flights. Sleep hygiene techniques and fatigue countermeasures are currently contemplated in FRMS.[6] However, these are not yet mandatory policies, resulting in insufficient or simply a lack of implementation in many companies. This study demonstrates the importance of these educational plans in the managing of sleep and fatigue, considering the high prevalence values obtained for sleep and fatigue, for both types of flights. Aircraft manufacturers also have an important say in the matter. Great efforts have been made in the last 30 yr to improve the man-machine interface through improvements in flight deck design and ergonomics, as well as in the improvement of in-flight rest facilities. But there are still many "stones to turn" that may enable fatigue reduction and improve vigilance in the cockpit environment. General examples might include pilot seat design, enabling pilots to perform some exercise when seated, and "intelligent" cockpit lighting that may smooth the day/night light transition between departure and destination airports. Future research should include more biological and physiological variables. Exercise, dietary profiles, snoring, and the Body Mass Index are important variables to evaluate the risk of sleep apnea. This is an important issue for airline pilots considering its impact on fatigue, daytime sleepiness, cardiovascular risk, and cognitive decrement, which altogether imply active screening.

ACKNOWLEDGMENTS

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