



Short communication

Sleep complaints and fatigue of airline pilots

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ABSTRACT

This work aimed to determine daytime sleepiness and sleep complaints prevalence and the corresponding influence on perceived fatigue and to evaluate the influence of sociodemographic parameters and labour variables on sleep complaints, sleepiness and fatigue.

A questionnaire was developed including socio-economic and labour issues and instruments, focused in sleep and fatigue. The response rate was 32% and the final sample had 435 pilots.

The prevalence of sleep complaints was 34.9%, daytime sleepiness 59.3% and fatigue 90.6%.

The high prevalence of sleep complaints, sleepiness and fatigue was disclosed in pilots, with those who fly short/medium having an added risk of fatigue.

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1. Introduction

Pilot's fatigue is a concern in airline operations, with long and unpredictable working hours, circadian disruptions and insufficient sleep [1]. These non-"nine to five" shifts may disrupt the opportunity for eight hours sleep at night in suitable conditions. The disruption or restriction of sleep can lead to high levels of subjective fatigue and/or impaired performance [2]. Brown defines fatigue as the decreased capability to perform mental or physical work, or the subjective state in which one can no longer perform a task, resulting from inadequate sleep, circadian rhythm disruption, or excessive task duration, complexity or effort [3]. Shift work, like the one done by airline pilots (which comprises the night period, including the window of circadian low (02:00-05-59)), presents pronounced negative effects on sleep, performance and accident risk [4]. The disruption or restriction of sleep can lead to heightened levels of subjective fatigue and/or impaired performance [2]. The two most common types of flight in regular air transport are Long-Haul (L-H) and Short-Medium-Haul (SM-H). L-H pilots attribute their fatigue to sleep deprivation and circadian disturbances associated with time-zone crossing [5]. According to Caldwell [1], SM-H pilots attribute their fatigue to sleep deprivation and high workload. Both pilot groups associate their

fatigue with night flights, jet lag, early morning wakeups, crossing time zone, multiple flight sectors, and consecutive duty periods without adequate recovery breaks [6]. As a consequence of the nature of their work, SM-H pilots conduct more take-offs and landings per duty period, the most workload intensive stages of a flight [5]. SM-H pilots can experience relatively high levels of fatigue, and its major causes are long duty periods and early starts [7]. Something that characterizes fatigue, namely in airline pilots, are the increasing number of lapses or even errors that may jeopardize flight safety [8]. A study with Brazilian airline pilots where the relationship between errors and time of day was established, showing that the early morning period represented a greater risk of attention problems and fatigue comparing to the morning, afternoon and night periods [8].

In a large sample of Portuguese airline pilots, they self-reported high levels of fatigue (89.3%), the highest levels being in pilots that flew SM-H flights [9]. The present objective is to measure the prevalence of daytime sleepiness and sleep complaints, and evaluate their influence on perceived fatigue. As well as to identify which are the variables (sociodemographic and labour) associated to sleep complaints, sleepiness and fatigue in a large sample of airline pilots.

2. Methods

2.1. Participants

The inclusion criteria were: being an airline pilot on active duty, aged between 20 and 65 years old, and having flown during the

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last six months.

Questionnaires were placed in the personal locker of all pilots of commercial Portuguese airlines, involving a total of 1500 pilots. 435 valid responses were obtained during a period of one month.

CHLN-Santa Maria Hospital Ethics Committee approved this study as well as the Portuguese Airline Pilot's Associations and the National Commission for Data Protection.

2.2. Questionnaire

The questionnaire consisted of socio-demographic data (age, gender, living with children < 3 years old), labour variables (professional category, type of flight, number of hours flown, number of duty hours, number of early starts (05:00–06:59 am), number of night periods (11:00 pm to 06:29 am), number of sectors flown); all values took into account the preceding 28 days. The type of flight was also one of the analysed variables. For the purposes of this study, SM-H were considered to be multi-sector operations lasting less than 6 h. L-H pilots undertake flights longer than 6 h, the majority of which are single/dual sector operations.

Alcohol and sleep medication were also analysed ("How often do you take sleep medication?") ("How often do you use alcohol for sleep?"); evaluation used a 5 point Likert scale: "1-never; 2-rarely (1–10 times/year); 3-Sometimes (1–2 times/month); 4-Often (3–4 times/week); 5-Very often (5–7 times/week). We considered unusual consumption < 3 times/month and frequent consumption > 3 times/week. The instruments used were the *Fatigue Severity Scale* (FSS) for fatigue [10], the *Jenkins Sleep Scale* (JSS) for sleep complaints [11] and the *Epworth Sleepiness Scale* (ESS) for daytime sleepiness [12].

The *Fatigue Severity Scale* is a self-response questionnaire composed by 9 items, referring to the previous week, rated on a 7 point Likert scale, ranging between "1: strongly disagree" and "7: strongly agree". The total score is obtained by adding all items and dividing the sum by 9. The scale assesses the level of perceived fatigue in daily situations. Results at or above 4 indicate a clinically significant level of fatigue [10].

The *Jenkins Sleep Scale* is a self-reported questionnaire that assesses the sleep quality and the difficulty falling asleep in the previous month. The scale is composed by 4 items rated on a 6 point Likert scale, ranging between "0 - never" and "5 - every day - 21 to 31". Sleep disturbances are considered whenever mean score is 4 or greater, corresponding to at least 15 troubled nights per month. Higher scores indicate more severe sleep difficulties [11].

The *Epworth Sleepiness Scale* is a self reported questionnaire composed by 8 items, which assess the level of sleepiness in daily situations, rated on a 4 point Likert scale, ranging between "0 - no probability of falling asleep" and "3 - high probability of falling asleep". The total score is obtained by adding all items, ranging between 0 and 24. Results at or above 10 indicate abnormal or pathological sleepiness and results at or above 17 indicate severe sleepiness [12].

2.3. Procedure

A random number was assigned to each inquiry, to ensure that the investigating team distributed them all, thus preventing duplication. Anonymised questionnaires were placed in the personal locker of each pilot from all regular airline companies (private and national companies) operating in Portugal. The Pilots Associations made an announcement of the study to all pilots, and explained the importance and the aim of the study. Also, the questionnaire had brief instructions explaining how to answer it and clarifying the objectives of the study. Informed consent was not required because no interaction occurred between participants and researchers to jeopardize individual privacy.

When completed, the forms were deposited in a locked deposit

box and collected by one element from the investigating team. Of the 1498 inquiries distributed, 435 were correctly answered, 44 were invalidated and 1019 were not returned (response rate 32%).

2.4. Statistical analysis

Quantitative variables were expressed as mean and standard deviation and categorical variables as frequencies. According to their distribution, quantitative variables were evaluated with a *t* test or Mann-Whitney test. Categorical variables were compared with a Chi-square test (χ^2). The association between the tested variables and the dependent variable was also tested by a binomial logistic regression analysis (backward method); the cut-off value established to enter in the model was $p < 0.1$. Regarding the variables assessed with psychological evaluation scales (fatigue, sleep and sleepiness), the cut-off points were established as suggested by the scales author's.

The odds ratio for labour variables was calculated in an exploratory basis, bearing in mind that there are maximum values for flight and duty hours established by aeronautical authorities [13]. The cut-off point for the labour variables was established with the percentile 75. A significance level of 5% was considered appropriate in all the statistical analyses undertaken. Statistical analyses were carried out with IBM, SPSS v.22.

3. Results

3.1. Study population characteristics

The mean age for the study population was 39.05 ± 8.14 . Of the valid questionnaires, 12 (2.8%) corresponded to female and 423 (97.2%) to males. This sample corresponded approximately the female/male and SM-H/L-H ratios of the Portuguese Airline Pilots. Regarding the type of flight, 313 (71.95%) were SM-H and 122 (28.05%) were L-H pilots. The prevalence values for sleep complaints were 152 (34.9%), and daytime sleepiness was signalled by 258 (59.3%); of these, 57 (13.1%) presented severe sleepiness ($ESS \geq 17$). Fatigue ($FSS \geq 4$) was reported by 394 (90.6%). Considering their consumption habits (sleep medication and the use of alcohol for sleep), both conditions present 6 individuals (1.4%) who affirm to use it more than 3 times per week; 2 individuals (0.5%) assume to take sleep medication on a daily basis and 1 (0.2%) to ingest alcohol for sleep at the same conditions.

3.2. Exploratory analysis for labour variables

An odds ratio for labour variables (duty and flight hours, flown sectors, early starts and night shifts) was calculated in an exploratory basis with a cut-off based on the percentile 75 value (Table 1), considering that there are maximum values established for duty and flight hours by aeronautical authorities [13].

Having sleep complaints (JSS) as dependent variable, the variables that were statistically significant were early mornings, with an odds ratio of 1.612 CI [1.042; 2.493] ($p = 0.031$), and flight hours OR=2.155; CI [1.401; 3.313] ($p < 0.001$). Analysing the same variables for daytime sleepiness (ESS), none of the independent variables obtained a statistically significant value. However, when looking towards fatigue (FSS), flight hours obtained once more a statistically significant added risk of OR=3.004; CI [1.150; 7.848] ($p = 0.019$) as well as night work OR=2.139; CI [0.993; 4.607] ($p = 0.048$).

3.3. Associations and binomial logistic regression analysis for fatigue

A statistically significant association was found between fatigue

Table 1.
Sociodemographic and labour characteristics of the study population.

Variable	Category	N (%)		
n (%)		435		
Type of flight (%)	SM-H	313 (72%)		
	L-H	122 (28%)		
Age (mean ± SD)		39.05 ± 8.14		
Sex (%)	Male	423 (97.2%)		
	Female	12 (2.8%)		
Professional category (%)	Captains	225 (51.7%)		
	First officers	210 (48.3%)		
Sleep medication (%)	Unusual consumption < 3 times/month	429 (98.6%)		
	Frequent consumption > 3 times/week	6 (1.4%)		
Alcohol consumption (%)	Unusual consumption < 3 times/month	429 (98.6%)		
	Frequent consumption > 3 times/week	6 (1.4%)		
Jenkins Sleep Scale (%)	Without sleep disturbances ≤ 3	283 (65.1%)		
	With sleep disturbances ≥ 4	152 (34.9%)		
Epworth Sleepiness Scale (%)	Without sleep deficit ≤ 9	177 (40.7%)		
	Pathological sleepiness ≥ 10	201 (46.2%)		
	Severe sleepiness ≥ 17	57 (13.1%)		
Fatigue Severity Scale (%)	Without fatigue ≤ 3	41 (9.4%)		
	With fatigue ≥ 4	394 (90.6%)		
Labour variables/28 days		Mean ± SD	Percentile 75	
	Duty hours	101.24 ± 29.87	120	
	Flown hours	61.68 ± 16.78	73	
	Flown sectors	22.80 ± 12.66	31	
	Early starts	4.03 ± 3.43	6	
	Night periods	3.96 ± 2.68	6	

(FSS ≥ 4) and type of flight ($p=0.006$), duty hours ($p=0.002$), flown sectors ($p=0.016$), flight hours ($p < 0.001$), early mornings ($p=0.002$), night shifts ($p=0.005$) and both sleep variables, daytime sleepiness ($p < 0.001$) and sleep complaints ($p=0.001$). Considering the sociodemographic data (age, sex, having children below 3 years of age) and professional category, no statistically significant association was found (Table 2).

A binary logistic regression model was built but, since the smallest group from our dependent variable (fatigue) only had 41 individuals (without fatigue), it was only possible to enter with four (10%) independent variables in the model. Variables that had a statistically significant predictive value for fatigue and an added risk were type of flight, namely SM-H (OR=2.945), night periods (OR=1.272), sleepiness (OR=2.656) and sleep complaints (OR=3.612), for an $R^2=0.180$ (Table 2).

3.4. Associations and binomial logistic regression analysis for sleep complaints

In the bivariate analysis the variables with statistically significant associations with sleep complaints (JSS) were flight hours

($p=0.003$), early starts ($p=0.035$), fatigue ($p=0.001$), sleepiness ($p < 0.001$), use of alcohol for sleep ($p=0.021$) and the consumption of sleep medication ($p=0.021$). Age, sex, professional category, living with children > 3 age, type of flight, duty hours, flown sectors and night shifts had no statistically significant association with sleep complaints. For the logistic regression, using the backward method, the variables that had statistically significant predictive value for sleep complaints were sleepiness (OR=2.760), flight hours (OR=1.014) and early mornings (OR=1.063) for an $R^2=0.155$ (Table 2).

3.5. Associations and binomial logistic regression analysis for daytime sleepiness

Analysing daytime sleepiness (ESS), variables that had a statistically significant association value were early starts ($p=0.011$), sleep complaints ($p < 0.001$) and fatigue ($p < 0.001$). In the binary logistic regression model, variables that entered in the model were the ones referred previously and also type of flight, and flown sectors. For the backward method, variables that had a predictive value for daytime sleepiness were sleep complaints (OR=2.795) and fatigue (OR=2.875), $R^2=0.108$ (Table 2).

4. Discussion

In this study, a prevalence value for daytime sleepiness and sleep complaints in airline pilots was established. Regarding fatigue, a high prevalence for this professional group was also observed. The variable 'type of flight' had a statistically significant predictive value for fatigue, with the group flying SM-H presenting an added risk of 2.945. This study confirms previous results [9], with the highest values of subjective fatigue for Portuguese airline pilots found in SM-H pilots.

For the sample of airline pilots, the work pattern variables associated with higher levels of subjective fatigue (FSS), besides type of flight, were duty hours, hours flown, flown sectors, early starts and night shifts. Although, in the logistic model the only variable that had a statistically significant added risk (OR=1.272) was 'night shifts', this result was due to the hour that these flights occur (11:00 pm to 06:29 am) corresponding to the circadian cycle low point (lower temperatures), this was also found in Brazilian airline pilots [8].

Sleepiness (ESS) (OR=2.656) and sleep complaints (JSS) (OR=3.612) were also predictors for fatigue in airline pilots, and this is in accordance with other data [14]. This has been reported in the majority of studies performed with this professional group, and it is due to their work specificities, working long duty periods, crossing time zones and performing irregular schedules [7]. Sleep complaints normally increase with age [15,16]. Nevertheless, in this study that was not observed, and sleep complaints were predictors for fatigue while age was not. Also regarding age, it was expected that younger pilots would have higher levels of fatigue because normally they have small children (age < 3 years) living with them, limiting their opportunities to rest. Higher levels of fatigue were expected in First Officers, who are often younger than Commanders; however, these results were not found, and differ from other data [17]. The female gender is usually associated with higher levels of fatigue [17], but in the present study this was not observed, probably owing to the reduced sample of women (2.8%). The percentage of individuals taking sleep medication or using alcohol as a sleep aid is very low; there is however a positive significance with sleep complaint, but not with fatigue or daytime sleepiness. Considering that in Portugal Fatigue Risk Management Systems (FRMS) are not yet implemented in the majority of airline companies, we wanted to evaluate the level of awareness of

Table 2. Association between sleep and fatigue and all the tested variables; one-way analysis and binary logistic regression, reflecting (OR) and 95% confidence intervals (95% CI).

Dependent variable		Fatigue (FSS ≥ 4)		Sleep complaints (JSS ≥ 4)		Diurnal sleepiness (ESS ≥ 10)	
Independent variable		Bivariate analysis test (p value)	Logistic regression R ² (0.180) OR (CI)	Bivariate analysis test (p value)	Logistic regression R ² (0.155) OR (CI)	Bivariate analysis test (p value)	Logistic regression R ² (0.108) OR (CI)
Age		U=8044 (0.966)		U=23002 (0.232)		U=24103 (0.324)	
Live with children < 3 age	No						
	Yes	$\chi^2=0.478$ (0.489)		$\chi^2=0.277$ (0.599)		$\chi^2=0.443$ (0.506)	
Sex	Female						
	Male	$\chi^2=1.284$ (0.615) ^a		$\chi^2=0.245$ (0.620) ^a		$\chi^2=1.259$ (0.262) ^a	
Professional Category	Captain						
	First Officer	$\chi^2=1.109$ (0.292)		$\chi^2=2.843$ (0.092)		$\chi^2=1.638$ (0.201)	
Type of flight	L-H						
	SM-H	$\chi^2=7.508$ (0.006) ^{**}		2.945 (1.450;5.980) ^{**}		$\chi^2=0.281$ (0.596)	
Fatigue	FSS ≤ 3						
	FSS ≥ 4	n.a.	n.a.	$\chi^2=10.304$ (0.001) ^{**}		2.50 (0.923;6.766)	
Sleep complaints	JSS ≤ 3						
	JSS ≥ 4	$\chi^2=10.304$ (0.001) ^{**}		3.612 (1.336;9.766) [*]		n.a.	
Diurnal sleepiness	ESS ≤ 9						
	ESS ≥ 10	$\chi^2=14.291$ (< 0.001) ^{**}		2.656 (1.297;5.441) ^{**}		$\chi^2=25.872$ (< 0.001) ^{**}	
Alcohol consumption	< 3x/week						
	> 3x/week	$\chi^2=0.633$ (0.426) ^a		$\chi^2=6.267$ (0.021) ^a		5.964 (0.585;60.810)	
Sleep medication	< 3x/week						
	> 3x/week	$\chi^2=0.633$ (0.426) ^a		$\chi^2=6.267$ (0.021) ^a		8.531 (0.839;86.697)	
Duty Hours		U=10401 (0.002) ^{**}		U=22912 (0.261)		U=23974 (0.375)	
Flown Hours		U=11031 (< 0.001) ^{**}		U=25238 (0.003) ^{**}		1.014 (1.00;1.028) [*]	
Flown Sectors	U=9916 (0.016) [*]			U=22043 (0.669)		U=25315 (0.054)	
	U=10412 (0.002) ^{**}			U=24122 (0.035) [*]		1.063 (1.00;1.130)	
Early Starts		U=10208 (0.005) ^{**}		1.272 (1.081;1.497) ^{**}		U=22845 (0.281)	
Night Periods						U=23706 (0.495)	

n.a.: non applicable.

^a Fisher's Exact Test.

^{*} p < 0.05.

^{**} p < 0.01.

airline pilots regarding this subject. Daytime sleepiness (ESS) (OR=2.760), number of early mornings (OR=1.063) and number of hours flown (OR=1.014) in the last 28 days were the ones with a predictive value for sleep complaints. More hours flown represent more work [18] and consequently reduced opportunity for sleep and higher circadian misalignment.

When analysing daytime sleepiness, where the main cause is usually irregular work hours influencing the biological clock and the homeostatic regulation of sleep and wakefulness [19], variables that were associated were early starts, fatigue and sleep complaints, although only the last two had a predictive value for sleepiness. Once again, the role of sleepiness and fatigue were highlighted.

When looking through the exploratory analysis established with the percentile 75 cut-off point, we may observe an added risk of 2.139 of having fatigue for pilots who flew more than 6 night periods in 28 days, and an added risk for fatigue of 3.004 for more than 73 h flown in 28 days. These results should be considered in

the light of the statutory limit for the number of hours over a period of 28 days, which is 100 h [13]. Thus, it seems that the number of hours flown can be suggested as an indicator of a contributor to fatigue to airline pilots. Fatigue is a multi factorial phenomenon, a fact that was well demonstrated in this study. Nevertheless, being a self-reported questionnaire, it is understandable that the individuals who answered it are the most affected, which may result in some overemphasis within the results obtained, making this, in our opinion, a potential limitation of this study.

Although these values were self-reported subjective values of sleep, they are important tools to quantify and understand fatigue in airline pilots. As in all cross-sectional studies, it is not possible to identify causality, only associations, implying that further investigation is needed in this area.

This study could be an important tool in FRMS [20] implementation, with its multi-layered defensive strategies to manage fatigue, enhancing the importance of crew monitoring in

facilitating a higher control in the observed variables. Sleep hygiene techniques/education and fatigue countermeasures are currently contemplated in FRMS [20]. However, these are not yet mandatory policies, resulting in insufficient or lacking implementation in many companies. This study demonstrates the importance of these educational plans to manage sleep and fatigue, considering the high prevalence values obtained for sleep and fatigue.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at <http://dx.doi.org/10.1016/j.slsci.2016.05.003>.

References

- [1] Caldwell JA, Mallis M, Caldwell JL, Paul M, Miller J, Neri D. Fatigue countermeasures in aviation. *Aviat Space Environ Med* 2009;80:29–59.
- [2] Petrilli R, Roach G, Dawson D, Lamond N. The sleep, subjective fatigue, and sustained attention of commercial airline pilots during an international pattern. *Chronobiol Int* 2006;23:1357–62.
- [3] Brown I. Driver fatigue. *Hum Factors* 1994;36(2):298–314.
- [4] Akerstedt T, Wright KP, Kecklund G, Gillberg M. Sleep loss and fatigue in shift work and shift work disorder. *Sleep Med Clin* 2009;4(2):257–71.
- [5] Roach G, Petrilli R, Dawson D, Lamond N. Impact of layover length on sleep, subjective fatigue levels, and sustained attention of long-haul airline pilots. *Chronobiol Int* 2012;29:580–6.
- [6] Caldwell J. Fatigue in aviation. *Travel Med Infect Dis* 2005;3:85–96.
- [7] Bourgeois-Bougrine S, Carbon P, Gounelle C, Mollard R, Coblentz A. Perceived fatigue for short- and long-haul flights: a survey of 739 airline pilots. *Aviat Space Environ Med* 2003;74:1072–7.
- [8] Mello MT, Esteves AM, Pires MLN, Santos DC, Bittencourt LRA, Silva RS, Tufic S. Relationship between Brazilian airline pilot errors and time of the day. *Braz J Med Biol Res* 2008;41:1129–31.
- [9] Reis C, Mestre C, Canhão H. Prevalence of fatigue in a group of airline pilots. *Aviat Space Environ Med* 2013;84:828–33.
- [10] Laranjeira C. Translation and adaptation of the fatigue severity scale for use in Portugal. *Appl Nurs Res* 2012;25:212–7.
- [11] Reis C, Mestre C, Tecedeiro M, Paiva T. Translation, cross-cultural adaptation and psychometric properties of the Jenkins Sleep Scale in a sample of shift workers. *Lab Psicol* 2014;12:89–98.
- [12] Santos C, Ferreira P, Santos M. Escala De sonolência De Epworth (ESS). (Retrieved from) (<http://www.uc.pt/org/ceisuc/RIMAS/Lista/Instrumentos/ESS>); 2001.
- [13] Commission Regulation (CE) No. 859/2008 - SubPart Q - Flight and Duty Time Limitations and Rest Requirements. (Retrieved 01.04.15 from) (<http://eurlex.europa.eu/LexUriServ/LexUriServ.do?uri=L:2008:254:0001:0238:EN:PDF>).
- [14] Dawson D, MacCulloch K. Managing fatigue: it's about sleep. *Sleep Med Rev* 2005;9:365–80.
- [15] Akerstedt T, Knutsson A, Westerholm P, Theorell T, Alfredsson L, Kecklund G. Sleep disturbances, work stress and work hours: a cross-sectional study. *J Psychosom Res* 2002;53(3):741–8.
- [16] Gander PH, Nguyen D, Rosekind MR, Connell LJ. Age, circadian rhythms, and sleep loss in flight crews. *Aviat Space Environ Med* 1993;64(3) (section 1).
- [17] Akerstedt T, Knutsson A, Westerholm P, Theorell T, Alfredsson L, Kecklund G. Mental fatigue, work and sleep. *J Psychosom Res* 2004;57:427–33.
- [18] Roach GD, Fletcher A, Dawson D. A model to predict work-related fatigue based on hours of work. *Aviat Space Environ Med* 2004;75(3):61–9.
- [19] Akerstedt T. Work hours, sleepiness and the underlying mechanisms. *J Sleep Res* 1995;4(2):15–22.
- [20] International Civil Organization. Fatigue risk management systems manual for regulators. ICAO Doc 9966, Montreal. (Retrieved 25.05.14 from) (<http://www.icao.int/safety/fatiguemanagement/frms%20tools/doc%209966%20-%20frms%20manual%20for%20regulators.pdf>); 2011.