Sleep and Vigilance (2024) 8:193–200
https://doi.org/10.1007/s41782-024-00270-x

ORIGINAL ARTICLE

Sleep Quality of Heavy Vehicles' Professional Drivers: An Analysis Based on Self-Perceived Feedback

Brigida Monica Faria[1,2] · Tatiana Lopes[1] · Alexandra Oliveira[1,2,3] · Rui Pimenta[1,4] · Joaquim Gonçalves[5,6] · Victor Carvalho[7] · Marta Gonçalves[8] · Luis Paulo Reis[2,9]

Received: 24 May 2023 / Revised: 20 February 2024 / Accepted: 20 May 2024 / Published online: 4 June 2024

Abstract

Introduction Sleep is a crucial biological need for all individuals, being reparative on a physical and mental level. Driving heavy vehicles is a task that requires constant attention and vigilance, and sleep deprivation leads to behavioral and physiological changes that can develop sleep disorders which can put lives at risk.

Objectives The main objectives of this study are to describe and evaluate sleep quality, excessive daytime sleepiness, circadian preference, and risk of suffering from obstructive sleep apnea in a population of Portuguese professional drivers.

Methods To fulfill the objectives, 43 Portuguese professional drivers, between 23 and 63 years old, answered validated questionnaires: Epworth Sleepiness Scale, Morningness–Eveningness, Stop-Bang Questionnaire, and Pittsburgh Sleep Quality Index.

Results Results indicated that older drivers tend to experience higher daytime sleepiness (11 ± 3.4; $p = 0.002$) and obstructive sleep apnea risk (4.5 ± 1.5; $p = 0.03$). Regarding sleep quality, the majority of drivers were classified with poor sleep quality (74.4%). It was possible to infer statistical differences between groups based on body mass index ($p = 0.037$), the type of route ($p = 0.01$), and physical activity ($p = 0.005$).

Conclusion Drivers have an indifferent circadian preference and small-course drivers have a worse sleep health perception. Therefore, it is essential to implement prevention programs, promoting the basic rules for better sleep quality as well as identifying sleep disorders to minimize possible road accidents.

Keywords Self-perceived sleep · Drivers' sleep · Sleep quality · Professional drivers

1 Introduction

Car accidents are one of the major causes of death in modern society, and sleepiness and drowsiness are identified as risk factors [1]. Long-haul drivers tend to suffer higher injury rates when compared to the rest of the population [2]. Driver fatigue has been recognized as a probable cause and corresponding risk factor of crashes involving heavy trucks [3]. In a situation of tight schedules, truck drivers may not feel adequately empowered to stop and rest when the onset of fatigue occurs. Sleep deprivation is related to various aspects of cognitive performance, namely tasks that require vigilant attention [4]. Various studies have shown that with the increase in sleep restrictions, behavioral lapses also increase during the performance [5]. Other studies have also indicated a reduction in the efficacy of cognitive processing, reaction time, and attentive responsiveness when sleep deprivation is present [6, 7]. A serious consequence

✉ Brigida Monica Faria
monica.faria@ess.ipp.pt

1 ESS, Polytechnic of Porto, Rua Dr. António Bernardino de Almeida, 400, 4200-072 Porto, Portugal

2 Artificial Intelligence and Computer Science Laboratory—LIACC (Member of LASI-LA), Porto, Portugal

3 Retail Consult, Porto, Portugal

4 Centre for Health Studies and Research, University of Coimbra—CEISUC, Coimbra, Portugal

5 Polytechnic Institute of Cávado and Ave, Barcelos, Portugal

6 Applied Artificial Intelligence Laboratory, Barcelos, Portugal

7 Innovation and Knowledge Engineering Lab—Optimizer, Porto, Portugal

8 Sleep Medicine Center—CUF, Porto, Portugal

9 Faculty of Engineering, University of Porto, Porto, Portugal

of sleep deprivation is the decrease of the driving capacity. A study developed by Stutts et al. [8] concluded that, for the subjects who slept less than 7 h per night, the accidents related to sleep had increased. Other than sleep deprivation, various variables contribute to the increase in road accidents, such as poor sleep quality, dissatisfaction with sleep duration, drowsiness during the day, drowsiness when driving, and the amount of time that is spent driving during the night. Moreover, the driving performance decreases with the increase of drowsiness, and when the sleep is restricted to 4 and 6 h per night [8, 9]. Several factors, including sleep restrictions and sleep fragmentation, can interfere with truck drivers' ability to obtain the requisite quantity and quality of sleep. Sleep quality can be restricted by work demands, medication, family responsibilities, and personal and lifestyle factors [10]. Sleep fragmentation can affect both the quantity and quality of sleep, as can other common occurrences, including excessive noise and concerns about personal safety while resting in the sleeper berth of a heavy truck [11] or other inadequate on-site rest areas [12]. Portugal has been classified as the fourth European country with the highest frequency of falling asleep while driving [13]. The most frequently perceived reasons for falling asleep at the wheel were the previous night's poor sleep quality and poor sleeping habits in general. The main individual determinants of falling asleep were younger age, male gender, higher daytime sleepiness, and risk of sleep apnea syndrome [13]. Sleep quality includes quantitative aspects of sleep, such as sleep duration and sleep latency, and subjective features such as depth or restfulness of sleep as mentioned in [14]. Quantity and quality of sleep by each individual have great relevance in executing daily tasks. If they are ignored, it can lead to fatigue, degrading multiple aspects of safe driving [15]. Although quantitative measures of sleep are easily calculated, it is more challenging to measure subjective aspects of sleep reliably.

There is a reasonable body of research that is concerned with the relationship between objective sleep measures and perceived sleep quality. However, comparisons between the various studies are not always feasible as they use different measuring instruments [16]. The objective sleep parameters are either assessed with actigraphy or polysomnography measures and the perceived sleep quality is often evaluated by means of questionnaires, as described above. Moreover, the term sleep quality is used interchangeably for objective sleep quality as well as for reported sleep quality. Finally, the study populations differ across studies and a limited number of studies investigated the relationship in normal sleepers. Most studies that investigated the relationship between objective sleep measures and perceived sleep quality are cross-sectional studies. Studies have found associations between perceived sleep quality and the following objective sleep parameters: wake time after sleep onset [17–19], sleep latency [20, 21], and total sleep time [21, 22]. In addition, associations have been deduced between sleep architecture measurements and perceived sleep quality. For example, a high amount of light sleep was associated with a decline in perceived sleep quality [23]. Also, the number of minutes in deep sleep was associated with perceived sleep quality [17, 18, 24].

The high prevalence of road accidents in Portugal and the important role of perceived sleep quality in causing crashes merit comprehensive research to determine the quality of sleep of professional drivers. Professional drivers, especially long-haul drivers, often face extended periods of driving, increasing the likelihood of fatigue and drowsiness. By evaluating their self-perceived sleep quality, it is possible to identify drivers who may be at a higher risk of experiencing sleep-related impairments while on the road. Based on this, several specific objectives were established, such as: describing and evaluating sleep quality, circadian preference, risk of obstructive sleep apnea, and excessive daytime sleepiness of long-haul drivers based on self-perceived feedback. Therefore, by describing and evaluating these factors among professional drivers based on self-perceived feedback and appropriate questionnaires, it is possible in the future to implement targeted interventions and preventive measures to enhance driver safety, reduce the incidence of accidents, and ultimately save lives on the road.

2 Materials and Methods

This study adopts a cross-sectional design, collecting data at a single time point on an individual basis. It is characterized as both descriptive and exploratory, with a comparative aspect involving the analysis of differences between groups to infer characteristics of the driver population. The study also incorporates elements of a quasi-experimental design justified by the nature of the intervention or exposure, which, while not manipulated by the researcher, allows for the examination of naturally occurring conditions and their impact on the observed outcomes. Furthermore, it is a quantitative study, as it involves the collection and analysis of numerical data to make conclusions.

2.1 Target Population and Sampling

Concerning the problem behind the sleep quality of heavy vehicle drivers, the target population was Portuguese professional heavy vehicle drivers. A group of 43 male drivers replied to the combined questionnaires by a non-probabilistic sampling technique and collected them during the year 2021. The inclusion criterion was being a Portuguese professional driver currently active, while the exclusion criterion was having missing values in the questionnaire responses.

2.2 Procedures

This study is integrated into the Sono ao Volante project [25, 26] authorized by the Center for Sleep Medicine and Psychiatry Service (at CUF hospital) ethics commission in July 2020. A first contact was made with the professional drivers associations which provide the necessary support to contact a total of 60 drivers. All participants agreed to participate in the study, with proper signed informed consent, and the confidentiality of all data was guaranteed. This study complied with the assumptions contained in the Declaration of Helsinki.

Data collection was materialized through the application of four translated and validated questionnaires for the Portuguese population as detailed in Sect. 2.3. These inquiries are self-reported and were assembled using Google Forms (Online Form Creator) making the questionnaires more practical and accessible. It was necessary 40 min approximately to answer all the questions. A proper description of the used questionnaires is presented in the next section.

2.3 Questionnaires

A sociodemographic questionnaire was included for sample characterization. Other self-reportable questionnaires were: the Epworth Scale of Sleepiness (ESS) [27], Morningness–Eveningness Questionnaire (MEQ) [28], Stop-Bang Questionnaire (SBQ) [29], and Pittsburgh Sleep Quality Index (PSQI) [30]. Table 1 presents a review of the validated questionnaires for the Portuguese population and respective measures for internal consistency (Cronbach's alpha or Kuder–Richardson 20 for dichotomous items).

2.3.1 Socio-Demographic Questionnaire

Several quantitative and qualitative questions related to gender (male; female), age (young adults; adults, end of professional life), education level (middle school; high school; college degree; master's degree), weight and height, physical activity (yes; no), health problems or diseases (present; absent), and work practices, such as route distance (long; short), type of transportation (freight transport; passenger), belonging or not to a drivers association (yes; no), and being or not in the lay-off status during 2020 and 2021 (yes; no) were organized for sample characterization. The Body Mass Index (BMI), categorized as underweight, normal weight, pre-obesity, obesity grade I, obesity grade II, and obesity grade III, was calculated from self-reported weight and height, and the grouping was done according to the World Health Organization (WHO) [35]. Age classification was defined based on related references [36, 37].

Table 1 Validated questionnaires for the Portuguese population and internal consistency

Questionnaire	Validated by	Internal consistency	Internal consistency in this study
ESS	Sargento et al. [31]	0.77	0.77
MEQ	Silva et al. [32]	0.75	0.78
SBQ	Reis et al. [33]	0.71	0.52*
PSQI	Del Rio João et al. [34]	0.70	0.81

Internal consistency measured with Cronbach's alpha

*Kuder–Richardson 20

2.3.2 Epworth Sleepiness Scale

Epworth Sleepiness Scale questionnaire intends to measure daytime sleepiness, with a particular interest in respiratory sleep disorders [38]. This scale was created to assess the "daytime sleepiness" of patients [27]. ESS evaluates the probability of falling asleep on a scale of increasing probability, on a 4-point scale, from 0 to 3, for eight situations that people engage in daily lives [39]. The scores for the eight questions are added together to obtain a single number which is a measure of the subjects' average sleep propensity in those eight situations. The total ESS score provides an estimate of the general characteristics of each person and their average level of sleepiness [27]. For the classification of excessive daytime sleepiness (EDS) was used a total score of the ESS construct was equal to or higher than 13 points [40].

2.3.3 Morningness–Eveningness Questionnaire

Morningness–Eveningness Questionnaire (MEQ) is a self-assessment questionnaire used to evaluate the diurnal type. The main purpose of this questionnaire is to measure whether a subject circadian rhythm creates peak alertness in the morning, in the evening, or in between [28]. MEQ consists of 19 multiple-choice questions scored from 1 to 5 points [41]. Circadian preference was assigned according to the total score from the MEQ questionnaire: definitely evening from 16 to 30 points; moderate evening from 31 to 40 points; intermediate from 42 to 58 points; moderate morning and definitely morning from 70 to 86 points [42].

2.3.4 STOP-BANG Questionnaire

The STOP-BANG acronym stands for Snoring history, Tired during the day, Observed, Blood Pressure, BMI, Age, Neck circumference, and Gender. The questionnaire was developed in response to the need for a concise, user-friendly obstructive sleep apnea screening tool in the preoperative clinic [43]. A total score equal to or higher than three points

in the SBQ questionnaire resulted in a prediction of Obstructive Sleep Apnea (OSA) risk [44].

2.3.5 Pittsburgh Sleep Quality Index

Pittsburgh Sleep Quality Index was developed to create a standardized measure designed to gather consistent information about the subjective nature of sleep habits and provide a clear index that both clinicians and patients can use [30]. PSQI is a self-report questionnaire that assesses sleep quality over a 1-month time interval. This questionnaire is constructed with nineteen individual items that generate seven different components of sleep: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleep medication, and daytime dysfunction over the last month. A total score equal to or higher than five points in the PSQI construct indicates that the subject has poor sleep quality.

2.4 Statistical Analysis

Data pre-processing was performed to avoid possible errors, such as data out of the possible range and missing data. Descriptive analyses were used to characterize the sample, and qualitative variables are presented as absolute (*n*) and relative (%) frequency, while quantitative variables are expressed as (mean ± standard deviation) or *median* and *interquartile deviation*.

Shapiro–Wilk normality test was applied, and if the variables presented non-normal distribution, a proper non-parametric test was used. Mann–Whitney test or *t* Student's tests were applied to compare two independent groups. One-way ANOVA or Kruskal–Wallis tests were used to compare three or more independent groups. It was considered statistically significant the effects whose p values were equal to or less than 0.05. "Statistical Package for the Social Science", 28 version (SPSS) was used for data analysis and G*Power 3.1.9.4 for tests' power analysis.

3 Results

3.1 Sample Characterization

The sample was represented by 43 adult males from the Portuguese drivers' community, with ages ranging from 23 and 63 years (44.3 ± 9.75). Three categories were considered: 14 young adults (23 until 40 years old), 17 adults (41 until 50 years old), and 12 at the end of professional life (equal to or greater than 51 years old). Subjects with middle school level are predominant (23 have middle school level, 15 high school level, 3 have a college degree, and 2 subjects had a master´s degree).

Regarding BMI, it was verified that 11 drivers (25.6%) have normal weight, 16 subjects (37.2%) have pre-obesity, 11 drivers (25.6%) have obesity grade I, and 5 participants (11.6%) have obesity grade II. The mean weight was 88.11 ± 16.90 kg and the mean height was 175.02 ± 6.29 cm; therefore, the BMI mean was 28.65 ± 4.73 kg/m^2.

Concerning health problems or diseases, 22 (51.2%) drivers did not report any disease and 21 (48.8%) subjects declared to have a health condition. In particular, three of the drivers reveal suffering from OSA, and nine were diagnosed with hypertension. Eighteen drivers (41.9%) do physical activity, while 25 participants (58.1%) referred not adopt any physical activity.

During 2020 and 2021, 29 subjects were not on lay-off and 14 stopped working during the COVID-19 pandemic. No statistical differences were found between these two groups in the four different constructs. It was possible to verify that 18 drivers (41.9%) usually do short routes and 25 participants (58.1%), usually do long routes. About belonging to a drivers association, 14 (32.6%) are affiliated with an association or workers union. Finally, regarding the type of transportation, 35 drivers (81.4%) transport goods, and from this group, one of the drivers said to transport dangerous matter and the remaining 8 participants (18.6%) transport passengers.

3.2 Self-Perceived Sleep Results

The self-perceived sleep results were examined through the application of the Excessive Daytime Sleepiness, the Circadian Preference, the Obstructive Sleep Apnea Risk, and the Sleep Quality questionnaires. These assessments provided insights into various aspects of sleep health, including daytime alertness, circadian rhythms, risk of sleep apnea, and overall sleep quality. By analyzing the responses gathered from these questionnaires, a description and understanding of individuals' self-perceived sleep patterns and potential sleep-related issues were attained, with a focus on professional drivers. Table 2 shows all results based on drivers' responses and divided into different possible groups by age, BMI, presence of health conditions, usual route, and physical activity.

Regarding the daytime sleepiness and having into consideration the global score of the ESS, it was verified that 27 subjects revealed having EDS with score values between 7 and 18 points; 16 drivers did not present excessive daytime sleepiness with score values between 1 and 6. It was verified that the older group presented a higher mean (11 ± 3.4), in comparison with the remaining groups, which indicates a higher score in the ESS, and excessive daytime sleepiness. Differences between groups were not found in other criteria; nevertheless, subjects that do short-type routes have a higher

Table 2 Drivers' sleep characterization results

Variables	Description	Excessive daytime sleepiness (ESS)		Circadian preference (MEQ)		Obstructive Sleep Apnea Risk (SBQ)		Sleep quality (PSQI)	
	(*n*)	Mean (sd) or *Md* (*id*)		Mean (sd) or *Md* (*id*)		*Md* (*id*)		Mean (sd) or *Md* (*id*)	
Age	1—Young adults (14)	8 (4.1)	$p=0.002$* (ANOVA§)	55.6 (8.74)	$p=0.87$ (ANOVA§);	3 (1)	$p=0.03$* (K–W)	7.57 (4.99)	$p=0.47$ (ANOVA§);
	2—Adults (17)	5.8 (3.11)		57.1 (8.54)		3 (1)		6 (3.43)	
	3—End of professional life (12)	11 (3.4)		56.8 (6.76)		4.5 (1.5)		6.17 (2.08)	
BMI	2—Normal weight (11)	7.6 (3.98)	$p=0.69$ (ANOVA$^{\&}$)	57.7 (11.92)	$p=0.76$ (ANOVA$^{\&}$)	2 (1)	$p=0.01$* (K–W)	5 (3.26)	$p=0.037$* (ANOVA$^{\&}$)
	3—Pre-obesity (16)	8.1 (3.71)		55.9 (5.62)		3 (0.5)		6.75 (3.32)	
	4—Obesity grade I (11)	8.8 (5.23)		55.0 (6.56)		4 (1.5)		6 (1.95)	
	5—Obesity grade II (5)	6.20 (2.28)		59.0 (8.34)		5 (1.5)		10.6 (6.31)	
Diseases/health conditions	1—Presence (22)	7.9 (3.68)	$p=0.91$ (t-S§)	*55.0 (3.13)*	$p=0.37$ (M-W)	3 (1)	$p=0.81$ (M-W)	*6 (1.5)*	$p=0.767$ (M-W)
	2—Absence (21)	8 (4.47)		*57.0 (4.39)*		3 (2)		*6 (2.5)*	
Route	1—Long (18)	7.2 (3.39)	$p=0.335$ (t-S$^{\&}$)	57.3 (8.14)	$p=0.56$ (t-S$^{\&}$)	3 (0.5)	$p=0.55$ (M-W)	4.61 (1.98)	$p=0.002$* (t-S$^{\&}$)
	2—Short (25)	8.4 (4.44)		55.9 (7.99)		3 (1.5)		7.96 (4.10)	
Physical activity	1—Yes (18)	*8.5 (2)*	$p=0.647$ (M-W)	58.56 (8.73)	$p=0.15$ (t-S$^{\&}$)	3 (0.5)	$p=0.16$ (M-W)	*5 (2)*	$p=0.027$* (M-W)
	2—No (25)	*7 (3.75)*		55.0 (7.23)		4 (1.5)		*6 (2.5)*	

Median (Md) and interquartile deviation (ID) are in italics to differentiate them from the mean and standard deviation (SD). These are the proper measures to include in the table for the non-parametric tests

$p=p$ value; *$p<0.05$; sd standard deviation; *Md* median; *id* interquartile deviation; *K–W* Kruskal–Wallis test;

ANOVA§ – One-Way ANOVA (effect size = 0.4; power = 0.6)

ANOVA$^{\&}$ – One-Way ANOVA (effect size = 0.4; power = 0.53); M–W – Mann–Whitney test (effect size = 0.6; power = 0.50)

t-S§ *t* Student test for independent samples (effect size = 0.6; power = 0.48)

t-S$^{\&}$ *t* Student test for independent samples (effect size = 0.6; power = 0.53)

mean in the ESS (8.4 ± 4.44), in comparison with the drivers that do long routes (7.2 ± 3.38).

For the MEQ construct (56.5 ± 7.99), 3 drivers had a score that classified them as definitely morning, 10 subjects moderate morning, 29 intermediate, and only 1 moderate evening. In fact, concerning the circadian preference of the drivers, a mean score of 56.5 points reveals that the studied sample has an intermediate circadian type. For this construct, no statistically significant differences were found between the circadian preferences within the categories of the sociodemographic variables.

Referent to the probability of OSA risk, having into consideration the global score of the SBQ (3.4 ± 1.59), 15 subjects had a score lower than 3 points classified them as having a low risk of OSA, and 28 drivers had a score equal to or higher than 3 points, resulting in a high risk for OSA. Regarding the risk of obstructive sleep apnea, 65% of the drivers were classified as at risk for OSA. It was also possible to verify that subjects with obesity grade II tend to have a higher risk of OSA.

Having into consideration the global score of the PSQI instrument (6.56 ± 3.72), 11 subjects (25.6%) had a score lower than 5 points, therefore, considered good sleep quality, and 32 drivers (74.4%) had a score higher or equal to 5 points, thus considered to have poor sleep quality. Statistical differences between groups based on BMI, the type of route, and physical activity were detected.

4 Discussion

Having into consideration the sociodemographic data and the ESS, it is possible to infer that older subjects tend to suffer from EDS in their daily life. Several studies point to changes in sleep properties with age [41, 45, 46]. There is a decrease in total sleep time, from deep slow sleep (delta sleep), and the restorative properties of sleep. Some studies found that the sleep of older individuals is shorter, more easily interrupted and fragmented [47]. The remaining variables did not show to influence the EDS. The mean score from this questionnaire was slightly higher than what was found in the literature [48, 49]. It is relevant to emphasise that excessive daytime sleepiness is an important problem for clinical and public health. EDS can lead to a significant reduction in quality of life, an increased risk of road accidents, and may affect the performance of daily life tasks.

A study evolving long-haul drivers has shown that episodes of stage 1 sleep occurred, while the subjects were driving between 11 p.m. and 5 a.m., suggesting a circadian influence [50]. Within the length of the night, there was an increase in drowsiness, which was consistent with the expected effects of the circadian influences.

The PSQI also suggests that most of the drivers presented bad sleep quality. These results are slightly higher than those found in the literature, where approximately 59% of the 150 adult drivers have sleep-related problems [51]. A mean score higher than 5 points on the PSQI indicates poor sleep quality. Regarding the obtained results, it was possible to conclude that poor sleep quality is related to the type of route that the drivers do, the practice of physical activity and BMI. The practice of physical activity can be beneficial for the improvement of the drivers' sleep quality and can contribute to better sleep regulation. Moreover, better sleep quality can contribute to a better self-perception of sleep health [52]. Physical activity promotes an increase in the total sleep time [53, 54], and promotes the production of melatonin, which contributes to thermoregulation and provides a better sleep quality [55]. In addition, the energy expenditure used during physical activity increases the need for sleep to restore this loss [54].

The high prevalence of sleep-associated problems found in the present study can be explained by the reduction of sleep to a minimum of possible hours, which leads to sleep deprivation associated with the demands of life [56]. In fact, the maintenance of sleep deprivation causes physiological and behavioral changes, contributing to poor sleep quality and sleep disturbances [57].

5 Conclusions and Future Work

This work identified various characteristics associated with excessive daytime sleepiness and sleep disorders, that when associated with driving, can lead to poorer sleep and quality of life. Therefore, this can lead to dangerous consequences such as road accidents. This research is crucial for gaining a deeper understanding of the self-perceived sleep quality among Portuguese professional drivers, marking it as a pioneering study.

Drivers have an intermediate circadian preference and small-course drivers have a worse sleep health perception. The implementation of these studies is essential for understanding the sleep quality and perception of the driver population, which can lead to minimizing sleep-related disorders and road accidents.

For future work, it will be important to implement complementary diagnostic tests, such as polysomnography (PSG), which can provide an objective evaluation of sleep disorders. This will facilitate the comparison between subjective and objective measures of sleep. Additionally, variables that impact sleep quality, such as the consumption of sleeping pills, anxiolytics, caffeine, sugar, and psychotropic substances, should also be included and analyzed for their impact on sleep quality. It is also important to

increase the sample size and have broader types of drivers essential for the validation of sleep perception.

Funding Open access funding provided by FCT|FCCN (b-on). This work was supported by the Base Funding—UIDB/00027/2020 of the Artificial Intelligence and Computer Science Laboratory—LIACC (member of LASI-LA)—funded by national funds through the FCT/MCTES (PIDDAC); and Sono ao Volante 2.0—Information system for predicting sleeping while driving and detecting disorders or chronic sleep deprivation (NORTE-01–0247-FEDER-039720) supported by Norte Portugal Regional Operational Programme (NORTE 2020), under the PORTUGAL 2020 Partnership Agreement.

Data Availability The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Conflict of Interest No.

References

1. Chattu VK, Manzar MD, Kumary S, Burman D, Spence DW, Pandi-Perumal SR. The global problem of insufficient sleep and its serious public health implications. Healthcare. 2019;7(1):1–16.
2. Stoohs RA, Bingham L, Itoi A, Guilleminault C, Dement WC. Sleep and sleep-disordered breathing, in commercial long-haul truck drivers. Chest. 1995;107(5):1275–82.
3. DeLisi J. National transportation safety board. In: 63rd Annu Bus Aviat Saf Summit, BASS 2018. 2018;161–79.
4. Drummond SPA, Brown GG. The effects of total sleep deprivation on cerebral responses to cognitive performance. Neuropsychopharmacology. 2001;25(1):S68-73.
5. Bonnet MH, Arand DL. Clinical effects of sleep fragmentation versus sleep deprivation. Sleep Med Rev. 2003;7(4):297–310.
6. Pilcher JJ, Walters AS. How sleep deprivation affects psychological variables related to college students' cognitive performance. J Am Coll Health. 1997;46(3):121–6.
7. Batéjat DM, Lagarde DP. Naps and modafinil as countermeasures for the effects of sleep deprivation on cognitive performance. Aviat Sp Environ Med. 1999;70(5):493–8.
8. Stutts JC, Wilkins JW, Scott Osberg J, Vaughn BV. Driver risk factors for sleep-related crashes. Accid Anal Prev. 2003;35(3):321–31.
9. Smolensky MH, Di Milia L, Ohayon MM, Philip P. Sleep disorders, medical conditions, and road accident risk. Accid Anal Prev. 2011;43(2):533–48.
10. Lyznicki JM, Doege TC, Davis RM, Williams MA. Sleepiness, driving, and motor vehicle crashes. Council on Scientific Affairs American Medical Association. JAMA. 1998;279(23):1908–13.
11. Filiatrault DD, Vavrik J, Kuzeljevic B, Cooper PJ. The effect of rest-schedule orientation on sleep quality of commercial drivers. Traffic Inj Prev. 2002;3(1):13–8.
12. Rocha FP, Marqueze EC, Kecklund G, de Castro Moreno CR. Evaluation of truck driver rest locations and sleep quality. Sleep Sci. 2022;15(1):55–61.
13. Gonçalves M, Amici R, Lucas R, Åkerstedt T, Cirignotta F, Horne J, et al. Sleepiness at the wheel across Europe: a survey of 19 countries. J Sleep Res. 2015;24(3):242–53.
14. Buysse DJ, Reynolds III CF, Monk TH, Berman SR, Kupfer DJ. The Pittsburgh Sleep QUality Index: a new instrument for psychiatric practice and research. 1988.
15. Jay SM, Dawson D, Lamond N. Train drivers' sleep quality and quantity during extended relay operations. Chronobiol Int. 2006;23(6):1241–52.
16. Hughes JM, Song Y, Fung CH, Dzierzewski JM, Mitchell MN, Jouldjian S, et al. Measuring sleep in vulnerable older adults: a comparison of subjective and objective sleep measures. Clin Gerontol. 2018;41(2):145–57.
17. Westerlund A, Lagerros YT, Kecklund G, Axelsson J, Åkerstedt T. Relationships between questionnaire ratings of sleep quality and polysomnography in healthy adults. Behav Sleep Med. 2016;14(2):185–99.
18. Keklund G, Akerstedt T. Objective components of individual differences in subjective sleep quality. J Sleep Res. 1997;6(4):217–20.
19. Lewandowski A, Rosipal R, Dorffner G. On the individuality of sleep EEG spectra. J Psychophysiol. 2013;27:105–12.
20. Petersen H, Kecklund G, D'Onofrio P, Nilsson J, Åkerstedt T. Stress vulnerability and the effects of moderate daily stress on sleep polysomnography and subjective sleepiness. J Sleep Res. 2013;22(1):50–7.
21. Riedel BW, Lichstein KL. Objective sleep measures and subjective sleep satisfaction: how do older adults with insomnia define a good night's sleep? Psychol Aging. 1998;13(1):159–63.
22. Lemola S, Ledermann T, Friedman EM. Variability of sleep duration is related to subjective sleep quality and subjective well-being: an actigraphy study. PLoS ONE. 2013;8(8): e71292.
23. O'Donnell D, Silva EJ, Münch M, Ronda JM, Wang W, Duffy JF. Comparison of subjective and objective assessments of sleep in healthy older subjects without sleep complaints. J Sleep Res. 2009;18(2):254–63.
24. Armitage R, Trivedi M, Hoffmann R, Rush AJ. Relationship between objective and subjective sleep measures in depressed patients and healthy controls. Depress Anxiety. 1997;5(2):97–102.
25. Optimizer. Sonoao Volante—Information systems for predicting sleep while driving and detecting chronic sleep deprivation or disorder [Internet]. 2022. http://sonoaovolante.com/
26. Rodrigues C, Faria BM, Reis LP. Detecting, predicting, and preventing driver drowsiness with wrist-wearable devices BT—progress in artificial intelligence. In: Marreiros G, Melo FS, Lau N, Lopes Cardoso H, Reis LP, editors. Cham: Springer International Publishing; 2021. pp. 109–20.
27. Johns MW. Daytime sleepiness, snoring, and obstructive sleep apnea: the Epworth Sleepiness Scale. Chest. 1993;103(1):30–6.
28. Randler C. Morningness–Eveningness and satisfaction with life. Soc Indic Res. 2008;86(2):297–302.
29. Chung F, Subramanyam R, Liao P, Sasaki E, Shapiro C, Sun Y. High STOP-Bang score indicates a high probability of obstructive sleep apnoea. Br J Anaesth. 2012;108(5):768–75.

30. Carpenter JS, Andrykowski MA. Psychometric evaluation of the Pittsburgh Sleep Quality Index. J Psychosom Res. 1998;45(1):5–13.
31. Sargento P, Perea MV, Ladera V, Ferreira Lopes P, Oliveira J. The Epworth Sleepiness Scale in Portuguese adults: from classical measurement theory to Rasch model analysis. Sleep Breath. 2014;19:693–701.
32. Silva C, Silvério J, Rodrigues P, Pandeirada J, Fernandes S, Macedo FB, et al. The Portuguese version of the Horne and Östberg morningness–eveningness Questionnaire: its role in education and psychology. Rev Psicol e Educ. 2002;1:39–50.
33. Reis R, Teixeira F, Martins V, Sousa L, Batata L, Santos C, et al. Validation of a Portuguese version of the STOP-Bang questionnaire as a screening tool for obstructive sleep apnea: analysis in a sleep clinic. Rev Port Pneumol. 2015;21(2):61–8.
34. Del Rio-João KA, Becker NB, de Neves-Jesus S, Isabel-Santos-Martins R. Validation of the Portuguese version of the Pittsburgh Sleep Quality Index (PSQI-PT). Psychiatry Res. 2017;247:225–9.
35. WHO. Obesity: preventing and managing the global epidemic. Report of a WHO consultation. Vol. 894, World Health Organization technical report series. Switzerland; 2000.
36. Chen T, Sze NN, Bai L. Safety of professional drivers in an ageing society—a driving simulator study. Transp Res Part F Traffic Psychol Behav. 2019;67:101–12.
37. McDonough A. The experiences and concerns of young adults (18–40 years) living with an implanted cardioverter defibrillator (ICD). Eur J Cardiovasc Nurs. 2009;8(4):274–80.
38. Furuta H, Kaneda R, Kosaka K, Arai H, Sano J, Koshino Y. Epworth Sleepiness Scale and sleep studies in patients with obstructive sleep apnea syndrome. Psychiatry Clin Neurosci. 1999;53(2):301–2.
39. Johns MW. Sleepiness in different situations measured by the Epworth Sleepiness Scale. Sleep. 1994;17(8):703–10.
40. Aurora RN, Caffo B, Crainiceanu C, Punjabi NM. Correlating subjective and objective sleepiness: revisiting the association using survival analysis. Sleep. 2011;34(12):1707–14.
41. Mecacci L, Zani A, Rocchetti G, Lucioli R. The relationships between morningness–eveningness, ageing and personality. Pers Individ Dif. 1986;7(6):911–3.
42. Horne JA, Ostberg O. A self-assessment questionnaire to determine morningness–eveningness in human circadian rhythms. Int J Chronobiol. 1976;4(2):97–110.
43. Chung F, Abdullah HR, Liao P. STOP-Bang Questionnaire: a practical approach to screen for obstructive sleep apnea. Chest. 2016;149(3):631–8.
44. Rebelo-Marques A, Vicente C, Valentim B, Agostinho M, Pereira R, Teixeira MF, et al. STOP-Bang questionnaire: the validation of a Portuguese version as a screening tool for obstructive sleep apnea (OSA) in primary care. Sleep Breath. 2018;22(3):757–65.
45. Thomas ES, Mathew G, Prajnashree GSM, Nandakumar UP, Subramanya C. Assessment of factors affecting sleep quality in geriatric patients: a cross-sectional single centre study. Sleep Vigil. 2024. https://doi.org/10.1007/s41782-023-00260-5.
46. Gander PH, Nguyen D, Rosekind MR, Connell LJ. Age, circadian rhythms, and sleep loss in flight crews. Aviat Space Environ Med. 1993;64(3 Pt 1):189–95.
47. Natvik S, Bjorvatn B, Moen BE, Magerøy N, Sivertsen B, Pallesen S. Personality factors related to shift work tolerance in two- and three-shift workers. Appl Ergon. 2011;42(5):719–24.
48. Valente F, Batista C, Simões V, Tomé I, Carrilho A. Quality of sleep among Portuguese anaesthesiologists: a cross-sectional study. Acta Med Port. 2019;32(10):641–6.
49. Souza JC, Paiva T, Reimão R. Sleep habits, sleepiness and accidents among truck drivers. Arq Neuropsiquiatr. 2005;63(4):925–30.
50. Sleep THE, Truck OFL. The sleep of long-haul truck drivers. 1997;755–61.
51. Malek M, Halvani G, Fallah H, JaefariNadooshan| R. The study of relationship between Pittsburgh Sleep Quality Index and road accidents of truck drivers. J Occup Med. 2011;3(1):14–20.
52. Back FA, Hino AAF, Bojarski WG, Santos EHR, dos Afonso LS, Borges LJ, et al. Worse sleep quality predicts early drop out from physical exercise programs. Sleep Sci. 2022;15(4):453–8.
53. Lim CL, Byrne C, Lee JKW. Human thermoregulation and measurement of body temperature in exercise and clinical settings. Ann Acad Med Sing. 2008;37(4):347–53.
54. Driver HS, Taylor SR. Exercise and sleep. Sleep Med Rev. 2000;4(4):387–402.
55. McLellan TM, Gannon GA, Zamecnik J, Gil V, Brown GM. Low doses of melatonin and diurnal effects on thermoregulation and tolerance to uncompensable heat stress. J Appl Physiol. 1999;87(1):308–16.
56. Ferrara M, De Gennaro L. How much sleep do we need? Sleep Med Rev. 2001;5(2):155–79.
57. Paiva P. Bom Sono, Boa Vida. Lisbon: Oficina do Livro; 2008.