Quality of Life, Health, and Sleep of Air Traffic Controllers with Different Shift Systems

Jaqueline Sonati; Milva De Martino; Roberto Vilarta; Érika Maciel; Edméia Moreira; Fernando Sanchez; Gustavo De Martino; Renato Sonati

BACKGROUND: Air traffic controllers (ATC) work shifts and their work schedules vary according to the characteristics of each airport. The human body adapts to shiftwork differently. These adjustments affect the health-disease process, predisposing ATC to risk conditions associated with sleep deprivation and lack of night sleep, which can lead to conditions such as cardiovascular diseases, mood disorders, anxiety, and obesity. This study investigated the characteristics of health, sleep, and quality of life of ATC exposed to 8-h alternate work shifts and 6-h rotational work shifts.

METHODS: The study was cross-sectional with convenience samples consisting of 84 ATC from two international airports in Brazil. We applied questionnaires to collect data about socioeconomic conditions, quality of life, sleep, and physical activity levels. We also collected health data regarding nutritional status, body composition, and blood pressure. We analyzed the differences between ATC from the two airports considering the variables of sleep, quality of life, and health.

RESULTS: Differences were found between the groups in terms of body fat percentage (30.7% and 27.8%), scores of overall quality of life (56.2 and 68), concentration (3.37 and 3.96), energy (3.12 and 3.62), and sleep time on working days (5:20 h and 6:15 h).

CONCLUSION: ATC under 8-h alternate shifts showed lower scores for quality of life, higher body fat, and less sleep time on working days, which characterizes inadequate shiftwork for this population.

KEYWORDS: human factors, alternate shiftwork, rotating shiftwork, nutritional status.

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In Brazil, air navigation services cover an extensive area of approximately 77,000 nmi (142,604 km) of lower airways up to 24,500 ft (7468 m) and 30,000 nmi (55,560 km) of higher airways above 24,500 ft, all supported by a network of equipment for en route flight operations.[10] Air traffic controllers (ATC) are responsible for controlling aircraft in their various flight phases, encompassing the entire Brazilian airspace, airport control towers, approach controls for terminal areas, and area control centers. Their activities involve air traffic control, flight information, and alert operations, with or without the aid of the radar. ATC are required to have quick and logical thinking, knowledge of technical phraseology, good knowledge of the English language and the rules and instructions that regulate air traffic control issued by the Department for Airspace Control, as well as emotional balance and spatial vision. These professionals receive intense training for the proposed activities and undergo periodic medical examinations that confirm adequacy of health for their position.[10]

ATC work in shifts and their schedules vary according to the characteristics of each airport. The model of rapidly rotating shifts (6 h) has been used more frequently;[21] however, regardless of the shiftwork model adopted, the night shift is always mandatory. The night shift is a requirement of contemporary society and a challenge to ensuring workers' health. The human body adapts to shiftwork by various endogenous (age, sex, personality, chronotype) and exogenous paths (financial, shiftwork system, work environment).[17] These adjustments affect

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the health-disease process, exposing ATC to risk conditions associated with sleep deprivation and lack of night sleep, such as cardiovascular diseases, mood disorders, anxiety, obesity, diabetes mellitus, and decrease of work motivation, as well as family and social life issues.[13]

Sleep is responsible for the energy replenishment for daily life activities, metabolic balance, and physical and mental development. Sleep deprivation, in turn, causes irritability and memory and concentration problems. Sleep deprivation caused by shiftwork leads to mental and physical fatigue, apathy, negligence, and inconsideration of individual attitudes. For prolonged periods, sleep deprivation often compromises workers' efficiency and performance.[5]

This study was conducted on ATC who work in two control towers of two Brazilian international airports under different shiftwork models. One is the clockwise shift schedule, alternating three shifts of 8 h/d with 3 workdays and 2 d off. The other is the counterclockwise rapidly rotating shift schedule with quick rotation of four shifts of 6 h/d with 4 workdays and 2 d off. This research aimed to analyze the characteristics of health, sleep, and quality of life of ATC subject to these two different shiftwork models, and discuss strategies to promote health in the workplace of ATC.

METHODS

Subjects

ATC from the two large international airports in Brazil comprised the subjects of this study. Airport 1 (AIR 1), located 95 km from the city of São Paulo, is the second most important cargo terminal of Brazil and registered 9.2 million passengers transported and 127,259 takeoffs and landings in 2013. Airport 2 (AIR 2) is located 26 km from the city of São Paulo and is the main cargo and passenger terminal in Brazil and recorded 36 million passengers transported and 284,000 takeoffs and landings in 2013.

There were 51 subjects who participated voluntarily and signed a free consent document. Of the subjects, 21 ATC worked at AIR 1 (62% of the sample) and 30 at AIR 2 (58% of the sample). There was some variability between the numbers of participants since not all of them participated in all stages of data collection during the years 2013/2014 in the respective airport control towers. The research project was approved by the Research Ethics Committee of the Universidade Estadual de Campinas under the number CAAE: 050,048,212.3.0000.5404 and was sponsored by the Foundation for Research Support of the State of São Paulo and authorized by the Brazilian Company of Airport Infrastructure. The schedules of the ATC were developed using alternate (AIR 1) and rotating (AIR 2) shiftwork, both with counterclockwise shifts (**Fig. 1** and **Fig. 2**).

Materials

Socioeconomic data were collected through an auto-respond questionnaire for sample characterization. In this research, we considered the variables sex, age, education, marital status, income, and working conditions, such as workshift model (alternate or rotating), hours worked per day, hours worked in the night shift per month, and time on the job. Sleep data were collected through the Munich ChronoType Questionnaire for Shift-Workers ($MCTQ^{shift}$)[11] and used the average time in sleep hours for night sleep per shift worked and between 2 d off. Thus, the average was obtained between the three work shifts and 2 d off after each shift. The perception of quality of life (QOL) was assessed using the WHOQOL-BREF questionnaire[25] and considered the domains physical, psychological, social relationships, environment, and general QOL.

Facets pertaining to concentration (Q7: How well are you able to concentrate?), energy (Q10: Do you have enough energy for everyday life?), and sleep satisfaction (Q16: How satisfied are you with your sleep?) were analyzed separately to check the association between the variables concentration, energy, and sleep with the perception of the overall QOL. Facets 7, 10, and 16 were assessed with a Likert scale with variation from 1 to 5, where 1 meant "nothing or unsatisfied" and 5 meant "extremely or very satisfied." The facets and domain scores were calculated using SPSS (IBM, Armonk, NY) and scores transformed to a 0-100 scale.[16]

Level of physical activity was assessed through the International Physical Activity Questionnaire,[8] version 8, short-form and normal week. This questionnaire was developed by the World Health Organization (WHO), and validated in Brazil and in other countries.[16] The sample was classified by level of physical activity (sedentary, insufficiently active, active, and very active).

Nutritional status was verified by the Body Mass Index (BMI), which divides body mass (kg) by height (m^2). The BMI classification adopted was proposed by WHO, where the individual is classified as underweight ($BMI < 18.5$), normal ($18.5 < BMI < 24.9$), or overweight ($BMI > 24.9$). Body mass was verified according to international standards[7] using a digital scale (Healthmeter brand), calibrated, with a capacity of up to 150 kg, and height with a wall stadiometer with 0.1-cm precision (Sanny, São Paulo, Brazil).

Body composition was assessed by tetrapolar bioelectrical impedance (model BIA 310e, Biodynamics Body Composition, Seattle, WA). Surface electrodes were placed at four anatomical points: back, right wrist, chest, and right ankle[7]. Subjects were asked not to eat or drink for 4 h before the test, to refrain from physical activity in the previous 12 h, to have an empty bladder, to refrain from alcohol consumption for 48 h before, and to not drink diuretics in the 7 d preceding the test.[7] The classification used to assess the body fat rate was suggested by Lohman.[7]

The measurement of systolic blood pressure and diastolic blood pressure was carried out in the morning (07:00 to 11:59); therefore, the workers were evaluated at the end of the night shift and during the morning shift. We used an automatic device (Omron, Hoofddorp, The Netherlands) previously calibrated. Data were analyzed according to classification standards of the Brazilian Guidelines of Hypertension.[20]

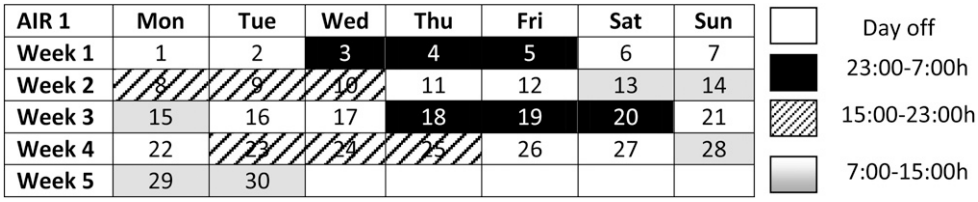

Fig. 1. Characteristics of 30-d shiftwork of and alternate shiftwork of ATC from AIR 1, Brazil, 2013/2014. Exposure to night shift (23:00 to 07:00) = 48 h/mo.

Statistical Analysis

The study was cross-sectional with a convenience sample representing 62% of participation of ATC from AIR 1 and 58% of ATC from AIR 2. The data analysis verified the sample distribution in terms of socioeconomic variables, physical activity level, sleep, and time on the job and measurements of mean and SD for the variables of health and quality of life. The Shapiro-Wilk test was used to verify the adherence or not of data to the Gauss curve. To verify the differences between the groups, we used the *t*-test and Mann-Whitney test, considering $P \leq 0.05$ to be significant. The Spearman and Pearson correlation tests were performed to verify the associations between "scores for QOL and facets: sleep, concentration, and energy with overall QOL." The software used was Bioestat 5.0 (Mamirauá Institute, Tefé, Amazonas, Brazil).

RESULTS

Socioeconomic characteristics showed that AIR 2 had a higher number of male subjects, on the job for a longer time, with better education, and a higher number of married subjects (**Table I**). Most subjects reported an income greater than US$2364 per month (AIR 1 = 81.5%, AIR 2 = 74%).

With regard to hours of night work, ATC from AIR 1 reported a longer time (48 h) per month. The average sleep hours on workdays and days off were 5:20 h and 9:06 h ($P = 0.0039$), respectively, for ATC from AIR 1, and 6:15 h and 8:04 h ($P < 0.0001$), respectively, for ATC from AIR 2 (Table I).

The highest physical activity level was found for ATC from AIR 1, where 81% were classified as active and very active, and sedentary individuals were not reported. The comparison of groups of men and women showed the presence of overweight for men and eutrophy for women in both airports. The body fat rate remained above the normal range for men and women, but women showed higher percentages. A statistically significant difference was also identified between male workers from both airports in terms of body fat rate, and male workers from AIR 1 showed higher values.

In the analyses of perception of overall life quality, ATC from AIR 1 (alternate shift) reported higher scores (63.28) for the environmental domain and lower values (55.20) for the domain of social relationships. ATC from AIR 2 (rotating shift) expressed higher scores for the domain of overall QOL and lower scores for the domain of physical activity level. Comparing data between the shifts, only the facet of sleep satisfaction did not show a statistically significant difference (**Table II**) and showed lower scores for both groups.

The analysis of blood pressure levels remained within the normal range, with higher values for men in both airports (**Table III**); however, a frequency of 20% and 30% was observed for individuals with blood pressure values above 120/80 in AIR 1 and AIR 2, respectively.[20] QOL of ATC from AIR 1 showed a positive association with the physical domain, social relationships domain, sleep, and energy. Data for ATC from AIR 2 showed that QOL was associated with the environment domain, sleep, and energy (**Table IV**).

DISCUSSION

Both groups were homogeneous in terms of schooling, income, time on the job, and age. According to data from the Brazilian Institute of Geography and Statistics,[9] in 2013 and 2014, the average monthly income of Brazilians was US$1087 and US$1105, respectively, and the education level was 8 yr of schooling. The study showed an average monthly income of US$2364 and education more than 10 yr of schooling, indicating a good socio-economic context of the subjects studied when compared with data of the Brazilian population in general. ATC from the two airports showed significant differences between the average sleep time on workdays and days off ($P_{AIR1} = 0.0039$ and $P_{AIR2} = 0.0001$), characterizing sleep deprivation. The average sleep time on workdays was also different between groups ($P = 0.0459$) and was lower for ATC from AIR 1 (5:20 h). The average sleep time on days off did not show a statistically significant difference between the groups.

Signal and Gander[21] studied ATC in rotating shifts and observed that sleep deprivation is a reality of shiftwork. However, the same authors highlighted the

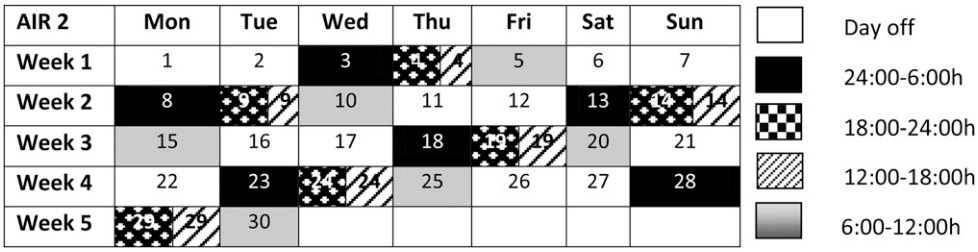

Fig. 2. Characteristics of 30-d shiftwork and rotating shiftwork of ATC from AIR 2, Brazil, 2013/2014. Exposure to night shift (23:00 to 07:00) = 42 h/mo.

Table I. Socioeconomic Characteristics, Sleep, and Physical Activity Level of ATC from AIR 1 and 2, São Paulo, Brazil, 2013-2014.

VARIABLES	AIR 1 ALTERNATE SHIFT	*N*	AIR 2 ROTATING SHIFT	*N*
Gender				
Men	50%	8	67%	20
Women	50%	8	33%	10
Age	40 yr	16	42.1 yr	30
Schooling				
≥15 yr	50%	16	57%	30
11-14 yr	50%	16	13%	30
10-12 yr	0	16	20%	30
Marital Status				
Single	44%	16	37%	30
Married	37%	16	47%	30
Divorced	19%	16	16%	30
Physical Activity Level				
Insufficiently active	19%	21	30%	30
Active	38%	21	30%	30
Very active	43%	21	13%	30
Sedentary	0%	21	27%	30
Work (h/d)	8.18	16	6.27	30
Hours of night work/month	48	16	42	30
Hours of sleep on workdays	5:20	6	6:15	19
Hours of sleep on days off	9:06	6	8:04	19
Average time on the job	11.7 ± 7.91 yr	16	17 ± 7.46 yr	30

importance of sleep hours before the night shifts, and warned that if workers sleep less than 6 h before the night shifts, their concentration and performance may be compromised, causing fatigue to workers.

Fatigue stems from several factors, some related to shiftwork, models and schedules, workload, time spent at the workplace, and others related to unhealthy lifestyles such as physical inactivity, poor dieting, sleep negligence, and alcohol, cigarettes, and drug use.[15] The work characteristics found in this study seem to be more stressful for ATC from AIR 1 regarding sleep deprivation, hours of night shift per month, and alternate shiftwork model. Sleep is a restorer of body functions and its deprivation is associated with greater perception of fatigue in workers in shifts,[1] causing damage to health such as increased bodyweight and body fat.[12]

Table II. Anthropometric Characteristics, Nutritional Status, Blood Pressure, and Quality of Life Scores of ATC from AIR 1 and AIR 2, São Paulo, Brazil, 2013-2014.

	AIR 1	AIR 2	*P*
Age (yr)	39.92 ± 11.18	42.1 ± 9.46	0.5071*
Weight (kg)	74.18 ± 13.78	77.41 ± 13.23	0.4611*
Height (cm)	168.07 ± 7.5	170.92 ± 7.64	0.2529*
BMI (kg/m^2)	26.24 ± 4.41	26.37 ± 3.53	0.7816†
BF (%)	30.72 ± 5.59	27.83 ± 5.76	0.0494†
FFM (kg)	51.29 ± 9.83	55.86 ± 10.3	0.1658†
SBP (mmHg)	121.71 ± 27.22	123.26 ± 17.77	0.4347†
DBP (mmHg)	78.64 ± 8.66	82.5 ± 11.48	0.2713*
N	13	30	
Physical Domain	60.49 ± 11.55	55.28 ± 10.45	0.1368*
Psychological Domain	60.93 ± 14.89	64.66 ± 7.78	0.5382†
Social Relationships Domain	55.20 ± 16.90	60.49 ± 16.11	0.2800†
Environment Domain	63.28 ± 11.55	63.42 ± 10.74	0.9671*
Overall	56.25 ± 19.36	68.05 ± 17.44	0.0471†
Sleep	3.12 ± 0.80	3.25 ± 1.09	0.5465
Concentration	3.37 ± 0.71	3.96 ± 0.58	0.0253†
Energy	3.12 ± 0.88	3.62 ± 0.74	0.0359†
N	16	27	

* *t*-test; †Mann Whitney; BMI = body mass index; BF = body fat; FFM = free fat mass; SBP = systolic blood pressure; DBP = diastolic blood pressure.

Analysis of nutritional status showed that both groups were overweight with a high body fat rate with a significant difference among male subjects. Higher rates were observed in men from AIR 1. Body composition changes with the aging process, tending to increase body fat and decreasing fat-free mass over the years,[22] but behavioral factors such as dietary excesses and sedentary lifestyle may influence the metabolic processes, resulting in a higher incidence of population obesity.[12] In AIR 2, 57% of inactive and 70% of overweight individuals were identified, corroborating the abovementioned data.

Shiftwork and exposure to light at night disrupt the circadian rhythmicity, melatonin production, and affect food and physical activity routines, triggering metabolic disorders like insulin resistance, dyslipidemias, metabolic syndrome, and obesity. These changes occur because the circadian clock and metabolism are inextricably related and they depend on the quality of sleep to ensure good balance.[4]

Opportunities for physical activity practices and nutritional advice could be strategies to cope with the consequences of shiftwork. Physical activity combined with healthy dieting contributes to overall health and a better perception of work capacity, as well as social relationships.[8] Eating habits, often five to six meals a day, are considered a marker of social rhythm and can help reduce the deleterious effects caused to health by disruption of the sleep/wake cycle.

This study showed the importance of knowing the shift models and the consequences of night work to health aimed at the adequacy of shiftwork and listed specific strategies to prevent and control diseases related to work shift. For Signal and Gander,[21] rotating and rapid shifts minimize chronic desynchronization when compared with slow rotating shifts because the biological clock becomes less disoriented.

The European Organization for the Safety of Air Navigation[6] explains that there are two models of rotating rapid shifts: clockwise and counterclockwise rotations. The clockwise rotation starts the week with the day shift, goes through the afternoon shift, then the night shift, and ends with a rest period. The counterclockwise rotation initiates with the afternoon shift, passes through the day shift, then the night shift, and ends with the rest period.

Researchers have argued that rotating shift models are best suited for the circadian rhythm. For Nesthus et al.,[18] the rotating counterclockwise shift has been associated with minor disruption of the circadian rhythm. However, Boquet et al.[2] analyzed the effects of both shift models on cortisol, melatonin, and body temperature, and concluded that there are no significant differences between the two models for these variables. The authors reported that the counterclockwise rotating shift causes less damage to the circadian rhythmicity, which originated from an extrapolation of a quasi-experimental study on

Table III. Comparison Between Sexes Regarding Anthropometric Measurements, Nutritional Status, and Blood Pressure of ATC from AIR 1 and 2, São Paulo, Brazil, 2013-2014.

	WOMEN			MEN		
	AIR 1	AIR 2	*P*	AIR 1	AIR 2	*P*
Age (yr)	37.5 ± 11.58	38.1 ± 6.26	0.8899	43.16 ± 10.72	44.1 ± 10.27	0.8483*
Weight (kg)	65.05 ± 10.13	66.74 ± 15.43	0.7934	86.36 ± 6.2	82.75 ± 8.03	0.3222*
Height (cm)	164.68 ± 5.59	163.56 ± 6.25	0.696	172.58 ± 7.74	174.6 ± 5.27	0.467*
BMI	24.09 ± 4.26	24.8 ± 4.65	0.7435	29.11 ± 2.83	27.16 ± 2.61	0.1441†
BF (%)	31.68 ± 5.99	33.32 ± 4.97	0.5362	29.45 ± 5.25	25.08 ± 3.9	0.036*
FFM (kg)	44.17 ± 5.72	43.93 ± 7.35	0.9394	60.78 ± 4.08	61.83 ± 4.89	0.6379
SBP (mmHg)	109.25 ± 14.29	111 ± 11.09	0.7898	138.33 ± 32.57	129.4 ± 17.47	0.8077†
DBP (mmHg)	76.12 ± 9.71	77.5 ± 10.8	0.7828	82 ± 6.26	85 ± 11.23	0.5413*
N	8	10		6	20	

* *t*-test; †Mann Whitney; BMI = body mass index; BF = body fat; FFM = free fat mass; SBP = systolic blood pressure; DBP = diastolic blood pressure.

jet lag, where it was concluded that travels westward resulted in a minor disruption of circadian rhythm. These statements show that the jet lag study considers a sporadic situation of changing hours, which is different from the reality of the workers studied here with frequent counterclockwise slow (AIR 1) and rapid (AIR 2) work shifts. Thus, there is no significant scientific difference between clockwise and counterclockwise rotating shift schedules, and each location needs to adopt a particular shift model, which involves airport operations and includes individual preferences of prioritizing the bio-psycho-social wellbeing of workers and work security.

Working night shifts in and of itself, regardless of the work shift model, affects family life, social life, and leisure time with partners, children, and friends.[23] These characteristics may partly explain our findings that identify smaller scores for the domain of social relationships in AIR 1 (55.2) and physical domain in AIR 2 (55.28). The significant differences between the groups were found for variables for overall QOL, concentration, and energy, with lower scores for ATC who worked alternate shifts and greater exposure to night shifts. Studies on QOL of ATC are scarce in the literature, especially those that investigate different shift models. However, some studies relate QOL with shiftwork. Palhares et al.[19] conducted a study on 250 nurses from a school hospital in Brazil who worked rotating shifts and found lower scores in the environment domain (57.6) associated with the night shift. In our study, this domain did not show the lowest score; however, for the AIR 2 group, it had positive association with the domain of overall QOL ($r = 0.3994$), considered an important domain for this group.

Table IV. Correlation Between Variables for Quality of Life and Overall Quality of Life of ATC, São Paulo, Brazil, 2013/2014

	AIR 1 ALTERNATE SHIFT (8 h/d)		AIR 2 ROTATING SHIFT (6 h/d)	
VARIABLES X OVERALL	*P*	*r*	*P*	*r*
Physical Domain	0.0365	0.5255†	0.1298	0.2989*
Psychological Domain	0.0935	0.4333†	0.0821	0.3406*
Social Relations Domain	0.0112	0.6151†	0.5226	0.1286*
Environment Domain	0.0546	0.4889†	0.0389	0.3994*
Sleep	0.0409	0.5156*	0.0037	0.539*
Concentration	0.6568	0.1205†	0.841	–0.0405*
Energy	0.0031	0.689*	0.0001	0.6714*
N	16 (46% of sample)		27 (52% of sample)	

* Spearman; †Pearson.

The Association analysis also showed positive values for physical and social relationship domains with the domain of overall quality of life of ATC from AIR 1. These results corroborate Maciel et al.,[14] who studied the QOL of a university community and found an association between more active individuals and better perception of QOL.

The studies considering the facets of sleep, energy, and overall QOL showed associations for both groups, indicating that regardless of the shift model studied here, the night shift is inherently stressful.[24] For Cippola,[3] humans who are totally sleep deprived recover a good part of the deep sleep lost on the first night after sleep deprivation and recover the out-of-sync sleep on the second night after sleep deprivation. If individuals attempt to sleep during the day, they are not able to recover deep sleep and sleep synchronization is lost. This may explain the lower scores in our study for the facets of sleep, energy, and concentration in ATC working alternate shifts, which exposes ATC to 3 straight days of night shift without recovery after deprivation. Thus, the results highlight the research dimension about the effects of work shift on health and QOL of ATC despite limitations regarding regionalization and sample number. We observed that the participation of ATC in the choice for the shiftwork model is important, especially after studying these variables, as they may help in the group's priorities and a better choice of work shift model.

The study was cross-sectional and, therefore, evaluated a temporal moment and cannot infer cause and effect. Sleep satisfaction, concentration, and energy were evaluated through the workers' perception. We believe that the use of the actigraph to measure the sleep-wake cycle and the collection of biochemical variables such as melatonin and cortisol will contribute to and complement this research.

This research concluded that ATC under alternate shiftwork have a higher body fat rate, worse overall perception of QOL, and worse perception of concentration and energy. The adoption of healthy habits such as physical activity and dietary routine maintenance could collaborate to improve health parameters; however, strategies for sleep hygiene and adoption of a rotating shift model could be further discussed, tested, and defined for this group of professionals.

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