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Sleep quality, sleepiness level and their connection with obesity indicators in Brazilian military pilots

Calidad del sueño, grado de somnolencia y su relación con indicadores de obesidad en pilotos militares brasileños

Abstract: This article aimed at evaluating sleep quality and sleepiness levels in order to connect them to obesity indicators in Brazilian military pilots. In total, 40 men answered validated questionnaires to evaluate sleep quality and daytime sleepiness, as well as an assessing form. We measured their body mass, height, perimeters (waist and hip), and body composition. We also calculated their Waist-to-height ratio (WTHR), waist-to-hip ratio (WHR), and body mass index (BMI). Visceral adipose tissue was measured by magnetic resonance imaging. We used Stata 14.0 ($p < 0.05$) for statistical analysis. We observed that 47.5% of the pilots presented low sleep quality, 25% slept less than six hours a day, and that there are positive correlations of low magnitude between poor sleep quality with WTHR ($r = 0.3364$; $p = 0.0338$) and fat percentage ($r = 0.3451$; $p = 0.0292$). We concluded that approximately half of the individuals presented poor sleep quality, but almost all of them depicted normal daytime sleepiness.

Keywords: health; sleep disorder; anthropometry; aviators; Armed Forces.

Resumen: Este artículo tuvo como objetivo evaluar la calidad del sueño y el grado de somnolencia y su relación con indicadores de obesidad en pilotos militares brasileños. Los 40 participantes varones respondieron a un cuestionario validado para evaluar la calidad del sueño y somnolencia diurna, y a una anamnesis. Se obtuvieron mediciones de masa corporal, altura, perímetros (cintura y cadera) y composición corporal. Se calcularon la relación cintura/altura (RCA), la razón cintura/cadera (RCC) y el índice de masa corporal (IMC). El tejido adiposo visceral se midió mediante imágenes de resonancia magnética. Para el análisis estadístico se utilizó el programa Stata 14.0 ($p < 0,05$). El 47,5% de los pilotos tenían mala calidad del sueño, el 25% dormían menos de seis horas diarias, y se observaron correlaciones positivas de baja magnitud de mala calidad del sueño con RCA ($r = 0,3364$; $p = 0,0338$) y porcentaje de grasa ($r = 0,3451$; $p = 0,0292$). Se concluyó que cerca de la mitad de la muestra tenía mala calidad del sueño, pero casi todos los individuos presentaban un grado normal de somnolencia diurna.

Palabras clave: salud; trastorno del sueño; antropometría; aviadores; Fuerzas Armadas.

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1 INTRODUCTION

Sleep is defined as the lowering of the consciousness level characterized by reduced motor activity and decreased response to stimulation (KANDEL; SCHWARTZ; JESSELL, 2014). It is a set of synchronized behavioral and physiological changes originating from two distinct mechanisms responsible for regulating the sleep-wake cycle – a sleep promoter (homeostatic impulse) and the circadian cycle, which promotes awakening (NEVES; MACEDO; GOMES, 2017).

Sleep has restorative and protective functions, thus, alterations in its quantity or quality can negatively interfere with organic functioning, short or long-term reflexes, and various aspects of human life, including social, somatic, psychological, cognitive, and metabolic (CHATTU *et al.*, 2018).

Although the required number of sleep hours varies individually, on average, seven to nine hours of sleep per night is considered satisfactory (HIRSHKOWITZ *et al.*, 2015). However, short sleepers (those who sleep less than seven hours per night), as well as long sleepers (those who sleep more than nine hours per night), have a higher risk of disease and mortality (GALLICCHIO; KALESAN, 2009).

Among the biggest impacts on health, influenced by inadequate sleep hours, is the increase in body mass, especially regarding the fat component. Meta-analyses conducted with prospective studies have shown that short sleep is associated with elevated body mass index (BMI) and risk of developing obesity (ITANI *et al.*, 2017; WU; ZHAI; ZHANG, 2014).

The mechanisms involved in the relationship between sleep and obesity, as well as the meaning of this chain, are yet not fully elucidated. Nevertheless, changes in the circadian cycle influence appetite, satiety, and, therefore, food consumption, favoring weight gain and obesity. Interferences in the biological clock impact the length and quality of sleep, bringing negative consequences for the control of food intake, as they modify the hormonal release linked to homeostasis in the composition both of the body (CRISPIM *et al.*, 2007) and the sleep (PEYRON *et al.*, 1998).

Literature has long evidenced the close relationship between the short duration of sleep time and an increase in BMI in different populations (SEKINE *et al.*, 2002), and, in this sense, the military is not immune to the harms of this relationship. Corroborating this fact, a study conducted with 27,034 active-duty military workers, to evaluate the relationships between demographic characteristics, self-reported health behaviors, and reported medical conditions, found that, of the 17 assessed health behaviors, shorter sleep time was the practice most associated with overweight/obesity (HRUBY; LIEBERMAN; SMITH, 2018).

Military professional occupations, including pilots, regardless of the aircraft type, can be compromised when proper rest does not occur. It is an activity that requires concentration, emotional control, the ability to work under pressure, the ability to quickly adapt to operational changes, quick reasoning, and spatial orientation, among others (PALMEIRA, 2016). Therefore, the absence of restful sleep can compromise the safety conditions of the flight, whose professional failure can cause irreparable damages.

Inappropriate sleep can also lead to excessive sleepiness, defined as an increased propensity to sleep with a subjective compulsion to sleep and take involuntary naps (BITTENCOURT *et al.*, 2005). Under this condition, the pilot tends to be less careful and more prone to not identifying emergencies in a timely manner, as well as being unable to efficiently respond to adversities in due time (LYZNICKI, 1998).

In addition, poor sleep can lead to worsening physical performance, evidenced by decreased muscle strength (HALSON, 2014), and a greater likelihood of facing barriers to adopting a healthy diet and appropriate exercise behaviors (BARON *et al.*, 2017).

During work, quality sleep is key to maintaining productivity. For pilots, performing tasks sleepy can lead to errors or accidents, since they are often subjected to gravitational loads on the Z axis (+Gz load) that promote physical and mental wear and tear, including flight fatigue (CUNHA, 2007). This condition can be aggravated in pilots whose sleep quality is considered poor, especially if associated with overweight or obesity.

Thus, verifying the relationships between sleep quality, sleepiness level and obesity indicators in military pilots is important to elaborate future care protocols for these professionals, with a view to promoting physical and mental health to ensure flight safety.

Given the above, this article aimed at evaluating the quality of sleep, level of sleepiness and its connections with obesity indicators in Brazilian military pilots.

2 METHODOLOGY

This was a cross-sectional observational study, with a convenience sample, which evaluated the sleep habits of 40 active pilots of the Brazilian Air Force (FAB). The military personnel were all male and worked at the air bases in Rio de Janeiro, Brazil, in 2021.

The study was approved by the Human Research Ethics Committee (CAAE: 53174321.7.0000.5256, Opinion Nr: 5.202.697), with participation by informed consent.

2.1 Instruments and Measurements

We applied the Pittsburgh questionnaire (Pittsburgh Sleep Quality Index - PSQI*)* online, via Google Forms, in April 2021, as well as the Epworth Sleepiness Scale and an assessment form for sample characterization. After that, we performed anthropometric and body composition assessments, including an evaluation of visceral adiposity.

2.1.1 Pittsburgh Sleep Quality Index (PSQI)

The PSQI (BUYSSE *et al.*, 1989) is a self-administered questionnaire already validated in Brazil (Cronbach's alpha: 0.82; BERTOLAZI *et al.,* 2011). This instrument evaluates the subjective quality of sleep over the last month, from seven perspectives: subjective quality of sleep; sleep latency; sleep duration; sleep efficiency; sleep disorders; use of sleep medications, and daytime dysfunction. Its score ranges from zero to 21, with each component having weight distributed on a scale of zero to three points. In the final questionnaire points sum, values of up to five points indicate good sleep quality, from six to ten poor quality, and higher than ten indicate possible sleep disturbance.

2.1.2 Epworth Sleepiness Scale

The *Epworth* Sleepiness Scale (JOHNS, 1991), validated in Brazil (Cronbach's alpha of 0.83; BERTOLAZI *et al.*, 2009), evaluates sleepiness through eight questions that verify the probability of the respondent napping in different daily situations, whether active or passive. The individual answers what their chance of napping is in each of the situations presented, scoring zero, one, two, or three, respectively, for the situations: (I) never napping; (ii) small probability of napping; (iii) average probability of napping; and (iv) high probability of napping. The overall score ranges from zero to 24 points. Values lower than or equal to ten indicate normal sleepiness, between 11 and 15 indicate excessive daytime sleepiness, and higher than or equal to 16, severe excessive daytime sleepiness.

2.1.3 Anthropometric Assessment

After answering the questionnaires, the military workers underwent an anthropometric assessment, and their body mass was measured using the InBody ® bioimpedance device, model 230 (Biospace Corp. Ltd., Seoul, Korea), their height was measured using a wall-mounted tape measure and their waist and hip perimeters were also measured.

2.1.3.1 Body Mass Index

BMI was calculated using body mass in kilograms (Kg) divided by the square of height in meters (m).

2.1.3.2 Waist-to-height Ratio (WTHR) and Waist-to-hip Ratio (WHR)

The perimeters were measured with a Sanny® flexible and inelastic metallic measuring tape (American Medical do Brasil, São Paulo, Brazil), with a two-meter extension and accuracy of 0.1 centimeters (cm), three times, by a single evaluator, being considered the average of the values. The waist measurement point was the one with the smallest perimeter, between the last rib and the iliac crest, at the end of a normal exhalation. Hip circumference was measured in the largest gluteal protuberance. With the waist, height, and hip values, the waist/height ratio (WTHR) and waist/hip ratio (WHR) were calculated.

2.1.4 Body Composition

The fat percentage was the considered variable regarding the body composition, being evaluated through InBody® tetrapolar bioimpedance, model 230 (Biospace Corp. Ltd., Seoul, Korea). The pilots were evaluated only once, without carrying metallic objects, ingesting alcoholic or caffeinated beverages, and without performing intense physical activity in the 24 hours before the test. We requested that they emptied their bladder 30 minutes before evaluation.

2.1.5 Visceral Adipose Tissue

Visceral adipose tissue (VAT) was measured by magnetic resonance imaging, and images were obtained with GE Signa HDxt 1.5 T (General Electric Healthcare, Waukesha, United States). Weighted images were acquired in gradient T1 (in phase and out of phase) in the axial plane, for the measurement of VAT at the umbilical level (not including intestinal loops), and these areas were defined with the *grow region* function of Osirix, being measured in square centimeters (PARENTE *et al.*, 2018).

2.2 Data Analysis

The data analysis was developed in Stata version 14.0. Descriptive analysis was performed, and the results were presented in frequencies (%), means, and standard deviations. The normality of the data was verified by the Shapiro-Wilk test, and deviation was observed in the PSQI score. *The* Pearson correlation was used to assess the relationship between obesity indicators and Epworth questionnaire score *(*level of sleepiness), while Spearman's correlation was used to evaluate the same relationship, but with the PSQI (sleep quality) score, since this variable did not present a normal distribution. The correlation classification was made according to Margotto's analysis (2012) in 1 or -1 = perfect; $0.80 < r < 1$ or $-1 < r < -0.80$ = very high; $0.60 < r < 0.80$ or $-0.80 < r < -0.60$ = high; $0.40 < r < 0.60$ or $-0.60 < r < -0.40$ = moderate; $0.20 < r < 0.40$ or $-0.40 < R < -0.20$ = low; $0 < r < 0.20$ or $-0.20 < r < 0$ = very low and 0 = null. Values of $p < 0.05$ were considered significant.

3 RESULTS

The characteristics of the sample are presented in Table 1, and it should be noted that, on average, they are young, in addition, most belong to transport aviation and have prolonged sleep latency.

Regarding sleep characteristics, it was observed that 47.5% of the pilots had low sleep quality, distributed among poor sleep quality with a higher percentage, followed by possible sleep disturbance in a lower proportion. More than a third of the military personnel had reduced sleep efficiency. Although 25% of the military personnel slept less than six hours a day, most of the sample had normal daytime sleepiness (Table 2).

The results of the correlations can be seen in Table 3. A low magnitude positive correlation was observed between poor sleep quality and WTHR, and between poor sleep quality and fat percentage (both $p<0.05$). For the other variables, no significant relationships were observed in the correlations.

Table 1 – Characteristics of the evaluated Brazilian Air Force pilots

Variable	N	%	Mean	SD
Age (years)	-	-	29.33	3.52
Marital status				
Single	15	37.50%	-	-
Married / In a stable relationship	25	62.50%		
Aircraft (specialty)				
Rotary wings	10	25.00%		
Transport	22	55.00%	-	-
In-flight inspection	8	20.00%		
BMI	-	-	25.64	2.11
Waist circumference (cm)	-	-	83.95	6.12
Waist/height Ratio	-	-	0.48	0.04
Waist/hip Ratio	-	-	0.84	0.05
Body Fat (%)	-	-	20.90	6.15
Visceral adiposity (cm2)	-	-	60.13	45.15
Sleep latency (min)			25.04	22.54

Abbreviations: BMI= body mass index. Source: prepared by the authors, 2022

Table 2 – Sleep characteristics of the evaluated Brazilian Air Force pilots

Variable	N	%
Quality of sleep		
Good	21	52.50
Bad	17	42.50
Possible sleep disturbance	2	5.00
Sleep efficiency		
Good	26	65.00
Reduced	14	35.00
Daytime sleepiness		
Normal	33	82.50
Excessive sleepiness	06	15.00
Severe sleepiness	01	2.50
Hours of sleep		
> 7 hours	12	30.00
Between > 6 and ≤ 7 hours	18	45.00
Between > 5 and ≤ 6 hours	08	20.00
≤ 5 hours	02	05.00
Sleep latency (min)		
≤ 15 min	09	22.50
16 to 30 min	17	42.50
31 to 60 min	11	27.50
> 60 min	03	07.50

Source: prepared by the authors, 2022

Table 3 – Correlation between anthropometric and body composition variables with sleep quality and level of sleepiness.

Variable	Quality of sleep (PSQI Score)		Sleepiness Level (*Epworth* score)	
	r	p	r	p
BMI	0.2616	0.1030	0.0881	0.5888
WC	0.2803	0.0758	0.1156	0.4774
WTHR	0.3364	**0.0338***	0.0688	0.6732
WHR	0.2282	0.1568	0.1720	0.2886
Fat %	0.3451	**0.0292***	0.0558	0.7323
VAT	0.3053	0.0554	0.1525	0.3476

Abbreviations: PSQI = Pittsburgh Sleep Quality Index; BMI = body mass index.
WC = Waist Circumference; WTHR = Waist / Height Ratio WHR = Waist / Hip Ratio;
Fat % = Fat Percentage; VAT = Visceral Adipose Tissue.
* Spearman $p < 0.05$.
Source: prepared by the authors, 2022

4 DISCUSSION

This study aimed at evaluating the quality of sleep, levels of sleepiness, and connections with obesity indicators in Brazilian military pilots, since this can provide the development of more assertive care protocols for these professionals, thus ensuring the stability of flight safety. We observed that 42.5% of the pilots presented poor sleep quality, 82.5% normal daytime sleepiness level and there was a low magnitude positive correlation between poor sleep quality and WTHR, and between poor sleep quality and fat percentage.

The prevalence of poor sleep quality found in this analysis is similar to that described by Morais (2019) who probabilistically evaluated 129 military firefighters in southern Brazil. However, that study showed a high prevalence of individuals with possible sleep disorders (34.9%) when compared to ours, in which only 5% of the sample presented the outcome found by Morais.

On the other hand, Bernardo *et al.* (2018) evaluating 438 military police officers from Florianópolis, found a prevalence of 79.2% of poor sleep quality. Also, in southern Brazil, a study conducted with 22 elite military workers (PINTO *et al.*, 2018) showed that 100% of the military had at least some type of sleep-related disorder or complaint. In addition, 63.6% of the sample had poor sleep quality. It is important to note that in Pinto's study *et al.*, (2018) all military workers underwent polysomnography, clinical evaluation, and answered the Pittsburgh Sleep Quality Assessment Questionnaire and the Epworth Sleepiness Scale. A survey conducted with 68 soldiers of the Brazilian army, however, showed that 66.2% of participants had poor sleep quality (IAHNKE; MORAES, 2022).

We can attribute as a possible explanation for the difference found between the studies, the higher imminent risk faced daily by these professionals, such as military police officers and firefighters, when compared to the pilots and army personnel. We must draw attention to the fact that military police officers, especially elite ones, and firefighters work in high-risk situations, with a high load of physical and mental stress, which can negatively affect the sleep quality of these professionals.

Regarding sleep efficiency, we observed that in 65% of pilots it was classified as good, that is, when the ratio between the time the pilot remains asleep and the time, he remains in bed is taken into account, this is higher than 85%, a cutoff point to consider good efficiency (BUYSSE *et al.*, 1989). Nevertheless, 35% of military pilots show reduced sleep efficiency, indicating the need for more detailed medical monitoring. A study conducted with 156 active military workers of the US Air Force (PETERSON *et al.*, 2008) who were supporting Enduring Freedom Operation in Southwest Asia, showed that 40% of military personnel had reduced sleep efficiency (<85%). Although it is not possible to directly compare the two situations (military personnel employed in real mission vs. military personnel who were not in operation), in both studies the percentage of military personnel with reduced sleep efficiency is worrisome and needs to be further investigated.

Excessive daytime sleepiness was observed in 15% of the pilots and severe sleepiness in 2.5%. Even though these indices are low, both should not be neglected, since piloting requires concentration and constant decision-making, which can endanger flight safety. Excessive daytime sleepiness contributes to impaired cognitive function and a decrease in alertness (DE PINHO *et al.*, 2006), fundamental activities for perfect flight performance.

Akter *et al.* (2021), while evaluating 175 servicemen of the Norwegian Air Force, observed a 41% prevalence of excessive daytime sleepiness. On the other hand, Pinto *et al.* (2018) and Bernardo *et al.* (2018) found, respectively, 22.7% and 35.8% of individuals with excessive daytime sleepiness. We should note that in Pinto's study *et al.* (2018), the prevalence of excessive daytime sleepiness was associated with obstructive sleep apnea syndrome, work accidents, and worse quality of life. The results of these studies showed that investigations related to daytime sleepiness in military personnel should be carried out, as well as seeking to identify the factors that are associated with this condition so that, with this information, strategies can be developed to mitigate this occurrence.

The recommended number of sleep hours for an adult individual varies between seven to nine hours (HIRSHKOWITZ *et al.*, 2015). Most pilots reported sleeping seven hours or less (70%) with 25% of them sleeping a maximum of six hours per night. Other studies in the literature corroborate our results, as they also showed that the military routinely sleeps less than recommended (BULMER *et al.*, 2022; HARRIS *et al.*, 2015). Thus, it is necessary to expand studies related to sleep in military populations, to better understand the dynamics of this profession and, consequently, optimize the health and performance of these individuals.

It is important to highlight that, throughout the life cycle, there is a great interindividual variability in the need for sleep, and there is no ideal standard value of sleep hours for all individuals. However, it is important to promote adequate hours of sleep, according to individual characteristics, so that it does not cause, in the medium or long term, damage to the health of the military. In this context, a study conducted in 2011 in the United States showed that short sleep duration was closely related to medical problems, including overweight and obesity (HRUBY; LIEBERMAN; SMITH, 2018).

Sleep latency consists of the total time (in minutes) that the individual takes between turning off the lights and effectively starting to sleep (SHRIVASTAVA *et al.*, 2014). This measure can contribute to the evaluation of sleepiness and sleep restriction/deprivation since values below five minutes indicate severe sleep restriction/deprivation; from five to ten minutes, a problematic case; from ten to 15 minutes, a mild case and from 15 to 20 minutes, little or no sleep debt (JUNG *et al.*, 2013). Conversely, an inability to sleep within 30 minutes can mean prolonged sleep latency (KIRSCH *et al.*, 2020). In this study, the mean sleep latency was 25.02 ± 22.54 minutes, with a minimum latency of five and a maximum of 120 minutes. These data show military personnel in a situation of severe sleep restriction and with prolonged sleep latency. The study conducted by Peterson *et al.* showed a sleep latency of 32.15 ± 35.20, with 41.7 % of the military having latency > 30 minutes (PETERSON *et al.*, 2008). On the other hand, Harris *et al.*, (2015) reported a latency of 25.8 ± 15.85 minutes. Both results are close to those presented in our study, showing that there is a wide variety of sleep latency in military personnel.

In terms of the relationship between sleep variables and obesity indicators, we found a low-magnitude positive correlation between WTHR and poor sleep quality ($r = 0.3364$; $p = 0.0338$) and between fat percentage and poor sleep quality ($r = 0.3451$; $p = 0.0292$). Despite that, because this is a cross-sectional study, it is not possible to infer causality. One of the possibilities of not finding significant data with high magnitude is the fact that the sample was composed of young military personnel (aged 29 ± 4). It is well known that among military personnel, the ability to adapt to difficult situations or significant sources of stress is somewhat common (COTIAN *et al.*, 2014), including inadequate sleep during these adversities. This probably stems from the culture among military personnel, in which depriving oneself of sleep is a demonstration of physical and mental endurance. In addition, because they are pilots – the most important and representative specialty of the FAB, they must present anthropometric standards and a body composition profile compatible with the function and organic hygiene, aspects required of all military personnel. Future research will be able to more accurately elucidate the relationship between the military, obesity, sleep quality, and resilience.

Although these correlations are classified as low (MARGOTTO, 2012), we emphasize that there is evidence in the literature that sleep-related problems may lead to morbidities due to changes in energy metabolism, for example, obesity (KERVEZEE; KOSMADOPOULOS; BOIVIN, 2020). In this regard, Ferreira *et al.* (2022), in a study with 80 urban bus drivers, found a correlation between sleep quality and the variables fat percentage ($r = 0.343$, $p = 0.002$) and abdominal circumference ($r = 0.261$, $p = 0.019$).

Lentino *et al.* (2013), through questionnaires with 14,148 American military personnel, evaluated various health behaviors and habits and their relationship with poor sleep quality. Their results indicated significant associations between sleep quality and physical performance, nutritional habits, measurements of obesity, lifestyle behaviors, and of psychosocial state. The authors found that military personnel who slept poorly were significantly ($p < 0.001$)

less likely to have adequate BMI and waist circumference. In our study, the fact that we did not find relationship between poor sleep quality and waist circumference is probably due to the small sample size, when compared with the aforementioned study.

Hasler *et al.*, (2004) had already pointed out that a sleep duration of less than six hours was associated with increased BMI and obesity. A possible explanation for this is that sleep shortening alters the Ghrelin/Leptin ratio, increasing appetite and the feeling of hunger (ROMERO; ZANESCO, 2006) and causing the individual to increase their caloric intake. In addition, there may be lower caloric expenditure due to fatigue promoted by lack of sleep, which decreases the practice of physical activity (PATEL *et al.*, 2006). As the quality of sleep involves different aspects, among them the number of sleep hours, attention should be drawn to this relationship.

This study presents a limitation in the sample size, which does not allow extrapolation to the entire universe of FAB pilots. However, it was not possible to recruit a larger number of participants due to the cost of magnetic resonance imaging and the need to perform the tests with strict prevention protocols during the covid-19 pandemic. Another limitation concerns the lack of access to the equation used by the Inbody® device to calculate the percentage of fat. This made it impossible to verify possible errors in the choice of the equation, as well as its specificity for the studied sample.

As strengths, we can highlight the use of a gold standard imaging method to measure visceral adiposity; the use of validated questionnaires and scales that minimize biases and enable reliable results; and the methodological rigor of data collection, which included trained interviewers, standardized protocols and anthropometric measurements performed by a single Examiner, thus ensuring the accuracy of the results.

5 CONCLUSION

The data obtained in this article indicated that, about sleep quality, approximately half of the individuals presents poor sleep quality, but despite that, for almost all of them, the level of daytime sleepiness was normal. Regarding obesity indicators, only WTHR and fat percentage showed positive correlations, but of low magnitude, with poor sleep quality.

AUTHORSHIP AND COLLABORATIONS

All authors participated equally in elaborating the article.

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