Obesity and Its Relation to Excessive Daytime Sleepiness in Civilian Pilots

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INTRODUCTION: Excessive daytime sleepiness (EDS) is often associated with decreased work performance and fatigue in civil pilots. However, aeromedical recommendations for the evaluation of EDS are associated with suspicion of obstructive sleep apnea (OSA). Currently, many studies have found an association between obesity and EDS, regardless of OSA. This study aims to determine whether there is a relationship between obesity and EDS in Indonesian civilian pilots, as well as its risks for developing OSA.

METHODS: This study used a cross-sectional design and was carried out at the Directorate General Civil Aviation Medical. Subjects were asked to fill out questionnaires, including the Epworth Sleepiness Scale to measure EDS and STOP-Bang to assess OSA risk, followed by anthropometric measurements for body mass index (BMI) and waist circumference as obesity indicators.

RESULTS: A total of 156 subjects were obtained, with an EDS prevalence of 16.7%. There was no significant relationship between obesity and EDS, but the prevalence of EDS was higher in obese subjects based on waist circumference than based on BMI (17.8% vs. 15.6%). Most obese pilots with EDS had a low risk of OSA (83.3% and 80%).

CONCLUSION: The prevalence of EDS was found to be higher in pilots with central obesity compared to BMI-categorized obesity. The incidence of EDS was not correlated with the risk of OSA.

KEYWORDS: obesity, excessive daytime sleepiness.

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Daytime sleepiness is the inability to stay awake and alert during the major waking episode of the day, resulting in the person falling asleep at inappropriate times and occurring almost every day for at least 3 mo.[1] It is referred to as excessive daytime sleepiness (EDS) if it causes complaints and interferes with daily activities or functions. EDS can decrease work performance by affecting cognitive function, the information-receiving process, response time, level of alertness, and short-term memory. In the civilian pilot population, Marqueze et al. found 41.9% of Brazilian pilots have EDS and Reis et al. found 59.3% of Portuguese pilots have daytime sleepiness. EDS in the civilian pilot population is associated with sleep insufficiency due to work characteristics, excess body weight, medical history, lifestyle, and obstructive sleep apnea (OSA).[9,15]

The evaluation for EDS in civilian pilots is usually carried out when there is a suspicion of OSA. In International Civil Aviation Organization Doc 8984, Manual of Civil Aviation Medicine, if a pilot complains of snoring or a tendency to fall asleep at inappropriate times or has a body mass index (BMI) of more than $30\,kg \cdot m^{-2}$ and a neck circumference of more than 43 cm, an evaluation for EDS is carried out using the Epworth Sleepiness Scale (ESS). In Indonesia, based on the Ministry of Transportation Circular Number 16 Year 2018 concerning aeromedical recommendations for obesity in flight personnel with a Class 1 medical certificate, it is recommended to assess the possibility of OSA in pilots who have a BMI of more than

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35 kg · m^{-2}, along with an evaluation of sleep patterns, ESS questionnaire for EDS evaluation, and examination of abdominal and neck circumference (note if >90 cm and >43 cm, respectively).

EDS is commonly associated with obesity due to the presence of OSA. There is a sixfold increase in the risk of OSA in individuals who gain weight by 10%.[13] However, EDS can occur in obese individuals regardless of OSA, which is presumably due to a disturbance in the regulation of orexin neurons that have a role in wakefulness due to the imbalance of peripheral metabolic hormones, namely leptin and ghrelin.[12]

Obesity itself is a global health problem. In 2016, the World Health Organization noted that around 650 million people were obese. In a study conducted at Directorate General Civil Aviation Medical Indonesia in 2020, it was found that the prevalence of overweight and obese civilian pilots was 20.1% and 62.4%, respectively.[17] Given the high prevalence of obesity in civil aviation pilots, it is possible that the prevalence of EDS is also high.

A person's history of diseases such as Type 2 diabetes mellitus was also found to have a significant relationship with the incidence of EDS due to insulin resistance. In addition, EDS is also caused by decreased sleep duration influenced by a pilot's unique work characteristics, including various work schedules and flight routes that cross multiple time zones, causing circadian rhythm disturbances. Certain lifestyle choices are also associated with the incidence of EDS, such as alcohol consumption habits and physical activity.[4,5]

Based on the above, the evaluation for the presence of EDS in civilian pilots should be conducted when there is a concern about other factors besides OSA that may contribute to the incidence of EDS, especially obesity. This study aims to examine the relationship between obesity and EDS, as well as to see whether obesity influences the incidence of EDS more than other factors like work characteristics, lifestyle, and medical history.

METHODS

Subjects

This study used a cross-sectional design and was conducted at the Directorate General Civil Aviation Medical Center Indonesia from July 5–11, 2022. The study's target population was civilian pilots carrying out routine medical examinations, with inclusion criteria of being Indonesian citizens, male, ages 23–65 yr, fixed-wing aircraft pilots, and having a body mass index (BMI) of more than 18.5 kg · m^{-2}. The exclusion criteria were not filling out the questionnaire completely and medical records stating a diagnosis of obstructive sleep apnea that was confirmed through polysomnography. This study passed the ethical review of the Medical Research Ethics Committee, Faculty of Medicine, the University of Indonesia with certificate number: KET.642/UN2.F1/ETIK/PPM.00.02/2022. The subjects provided written informed consent before research participation.

Materials and Procedure

Subjects were asked to fill out a questionnaire asking about the following: age; work characteristics from the last 6 mo, including work position (captain, first officer, and single-seat pilots), amount of flight hours, frequency of night flights (occurring from 22:00–05:00), most frequent flight duration (short haul, medium haul, or long haul), and length of sleep during working days and off days; and lifestyle, including alcohol consumption and duration of exercise in the last 6 mo. To measure EDS, the Epworth Sleepiness Scale was used, which is an eight-item questionnaire that asks the subjects to determine the possibility of them dozing off in certain everyday life situations using a scale from 0–3, the highest score being the highest possibility. A score of more than 10 was considered as having EDS. As for measuring the risk of OSA, which was considered a confounding factor in this study, the STOP-Bang questionnaire was used. This is also an eight-item questionnaire, where the first four items are yes/no questions to determine whether the subjects are snoring, feeling tired, have observed apnea, or have high blood pressure. These are followed by four items that record their BMI, age, neck size, and gender. Each item is scored 1 if the subject answered yes or had a BMI of >35 kg · m^{-2}, was >50 yr of age, had a neck size >40 cm, and was male. A total score of 0–2 is determined as low risk, 3–4 as intermediate risk, and 5–8 as high risk. After filling in questionnaires, anthropometric measurements were performed for neck and waist circumference. The data for height and weight (which were measured by the health workers on duty during the medical check-up) and medical history of Type 2 diabetes mellitus (T2DM) were obtained from medical records. We classified the BMI and waist circumference based on World Health Organization—Asia-Pacific criteria, which is as follows: BMI (in kg · m^{-2}) is underweight at <18.5, normal at 18.5–22.9, overweight at 23–24.9, and obese at ≥25; central obesity for males is defined with a waist circumference of ≥90 cm.

Statistical Analysis

Statistical analysis was performed using IBM Statistical Package for the Social Sciences (SPSS) version 22 software. Descriptive statistics of each variable were performed to assess the prevalence. Since all the variables were categorical, proportion analysis with Chi-squared or Fisher test was carried out to assess the association between the dependent and independent variables. We determined a P-value of <0.05 to be statistically significant. Multivariate analysis with logistic regression was then carried out to analyze the variables with a P-value of <0.2.

RESULTS

A total of 166 subjects participated in the study, 10 of whom were excluded because they met the exclusion criteria, hence the total sample obtained was 156 subjects. Based on age range, 71.1% of the subjects were between 23–40 yr old, with the remaining 28.3% in the age range of 40–65 yr. The prevalence of

EDS among the subjects was 16.7%. Based on BMI classification, 61.5% subjects were obese and 23.75% were overweight; based on waist circumference, 64.7% of the subjects had central obesity.

As for work characteristics in the last 6 mo, 50.6% of the subjects were first officers and the remaining were captains and single-seat pilots. The subjects' flight hours were categorized based on the median value of 200 h, where 52.6% of them had more than 200 flight hours. The subjects who had a frequency of night flights less than 10 times were 77.6%, while 10.9% had a frequency between 11–20 times and 11.5% had a frequency of more than 20 times. We found that 53.8% of subjects flew short-haul flights, followed by medium-haul, long-haul, and ultra-long-haul flights (35.9%, 9%, and 1.3%, respectively). During working and off days, the percentage of subjects who slept for more than 7 h was 55.8% and 76.9%, respectively.

As for lifestyle characteristics in the last 6 mo, 71.8% of the subjects did not consume alcohol, 23.7% consumed fewer than 5 times a month, and 4.5% consumed more than 5 times a month. The percentage of subjects who exercised for less than 150 min · wk^{-1} was 59.6%, while 35.9% exercised more than 150 min · wk^{-1} and the remaining 4.5% did not exercise at all. Many subjects had no medical history and around 8% were found to have T2DM.

For the OSA risk, 89.1% of the subjects had low risk, 10.3% of the subjects had moderate risk, and 1 subject was found with high risk.

Bivariate analysis in **Table I** showed no significant relationship between obesity and EDS, either based on BMI or waist circumference ($P > 0.05$). There was also no significant relationship between work characteristics, lifestyle, and medical history with EDS (all $P > 0.05$). Age and risk of OSA were also not found to have a significant relationship with EDS ($P > 0.05$).

Although there was no significant relationship, EDS was more commonly found in subjects with central obesity (17.8%). Meanwhile, based on BMI, the prevalence of EDS was found to be higher in subjects who were overweight (18.9%) and normal (17.4%) than in those who were obese (15.6%). However, as shown in **Table II** and **Table III**, based on the group of subjects with EDS, most of them were obese, either based on BMI (57.7%) or waist circumference (69.2%), and most had a low risk of OSA (80% and 83.3%, respectively).

When compared to the work characteristics of the subjects as shown in Table I, the prevalence of EDS is higher in single-seat pilots (25%), pilots with more than 200 h of flight (18.3%), pilots who have had night flight frequency of more than 20 times (27.8%), pilots who traveled medium-haul flights (21.4%), and pilots who slept less than 7 h on working days and off days (18.8% and 25%), all in the past 6 mo. For lifestyle, it was found that the prevalence of EDS was higher in subjects who had alcohol consumption levels less than 5 times a month (18.9%) and in subjects who did not do physical exercise (28.6%) during the last 6 mo. As for medical history, it was found that the prevalence of EDS was higher in subjects who did not have a history of illness compared to the ones with T2DM (17% and 11.1%, respectively).

Multivariate analysis was performed on the variables of night flight frequency of more than 20 times in the last 6 mo ($P = 0187$) and duration of sleep on off days for less than 7 h in the last 6 mo ($P = 0.165$), with the result that none of the variables had statistically significant values ($P > 0.05$) and inconsistent confidence intervals. The analysis also showed the Nagelkerke R^2 had a value of 0.047, indicating that the independent variables in the study had an influence of 4.7% on the prevalence of EDS.

DISCUSSION

This study found that the prevalence of EDS in Indonesian civilian pilots was 16.7%, with the highest prevalence of EDS found in the age group between 23–40 yr old. The presence of EDS can have an impact on the implementation of flying tasks as it reduces work performance by affecting cognitive function, the process of receiving information, and the level of alertness.[11] Furthermore, EDS can cause the pilot to fall asleep unintentionally, thereby increasing the likelihood of an airplane incident or accident.[9]

Although there was no significant relationship between obesity and EDS, when viewed from the group of subjects who had EDS, about 27% were overweight and almost 60% of subjects were obese. The latter findings are consistent with a study by Hayley et al.,[7] which found a significant relationship between higher BMI and EDS in the male population. Also, de Souza Palmeira et al.[4] found that sleepiness was associated with pilots who were obese. Pilots with a waist circumference of more than 90 cm in this study had a slightly higher prevalence of EDS (17.8%) than normal (14.5%), whereas in the group of subjects with EDS, almost 70% had central obesity. This is in accordance with previous studies which found an increase in the prevalence of EDS and an increase in waist circumference in the male population. There was also a significant relationship between waist circumference/central obesity and the incidence of EDS compared to BMI. The difference in the prevalence of EDS between obese subjects based on BMI and waist circumference might be because central obesity represents the distribution of abdominal visceral and subcutaneous adipose tissue. Meanwhile, BMI can be influenced by muscle mass.[6,7,10]

We did not find any significant relationship between the other factors such as age, OSA risk, work characteristics, and lifestyle which we initially thought might affect the relationship with EDS in this study. This led us to consider that it might be due to the use of a questionnaire to measure EDS, which is subjective in nature and therefore the subjects might have scored themselves higher or lower than is actually accurate. We also must consider that there could be other factors not studied in this research that are related significantly with EDS in civilian pilots.

In this study we carried out a risk assessment for OSA to see whether the incidence of EDS in obese civilian pilots was influenced by the risk of OSA. As stated previously, we did not find a significant relationship between OSA risk and EDS in this

Table I. Statistical Analysis for Obesity and Other Factors with Excessive Daytime Sleepiness.

VARIABLES	EXCESSIVE DAYTIME SLEEPINESS			
	YES *N* (%)	NO *N* (%)	*P*-VALUE	OR (CI 95%)
Body Mass Index				
Obese	15 (15.6%)	81 (84.4%)	0.761†	0.88 (0.26–2.95)
Overweight	7 (18.9%)	30 (81.1%)	1.0 †	1.1 (0.29–4.3)
Normal	4 (17.4%)	19 (82.6%)	Reference	
Waist Circumference				
≥90 cm	18 (17.8%)	83 (82.8%)	0.6*	1.27 (0.52–3.15)
<90 cm	8 (14.5%)	47 (85.5%)	Reference	
OSA Risk				
High	1 (100%)	0 (0%)	0.171†	-
Intermediate	2 (12.5%)	14 (87.5%)	1.0†	0.72 (0.15–3.39)
Low	23 (16.5%)	116 (83.5%)	Reference	
Age				
23–30 yr	12 (17.9%)	55 (82.1%)	1.0†	-
31–40 yr	8 (17.8%)	37 (82.2%)	1.0†	-
41–50 yr	5 (16.7%)	25 (83.3%)	1.0†	-
51–60 yr	1 (10%)	9 (90%)	1.0†	-
61–65 yr	0 (0%)	4 (100%)	Reference	
Professional Position				
Single Pilot	1 (25%)	3 (75%)	0.53†	1.69 (0.16–17.7)
First Officer	13 (16.5%)	66 (83.5%)	0.998*	1.00 (0.42–2.36)
Captain	12 (16.4%)	61 (83.6%)	Reference	
Amount of Flight Hours				
≥200 h	15 (18.3%)	67 (81.7%)	0.566*	1.28 (0.55–3.0)
<200 h	11 (14.9%)	63 (85.1%)	Reference	
Night Flight Frequency				
>20 times	5 (27.8%)	13 (72.2%)	0.164†	2.35 (0.74–7.44)
11–20 times	4 (23.5%)	13 (76.5%)	0.294†	1.88 (0.55–6.45)
0–10 times	17 (14%)	104 (86%)	Reference	
Flight Duration				
Short haul (<3 h)	12 (14.3%)	72 (85.7%)	1.0†	-
Medium haul (3–6 h)	12 (21.4%)	44 (78.6%)	1.0†	-
Long haul (6–12 h)	2 (14.3%)	12 (85.7%)	1.0†	-
Ultra-long haul (>12 h)	0 (0%)	2 (100%)	Reference	
Sleep Duration – Workday				
<7 h	13 (18.8%)	56 (81.2%)	0.516*	1.32 (0.56–3.0)
≥7 h	13 (14.9%)	74 (85.1%)	Reference	
Sleep Duration – Day Off				
<7 h	9 (25%)	27 (75%)	0.126*	2.02 (0.81–5.02)
≥7 h	17 (14.2%)	103 (85.8%)	Reference	
Alcohol Consumption				
≥5 times/month	1 (14.3%)	6 (85.7%)	1.0†	0.87 (0.1–7,6)
<5 times/month	7 (18.9%)	30 (81.1%)	0.688*	1.21 (0.46–3.2)
Does not consume	18 (16.1%)	94 (83.9%)	Reference	
Exercise Duration				
Does not exercise	2 (28.6%)	5 (71.4%)	0.26†	2.8 (0.45–17.3)
<150 min/wk	17 (18.3%)	76 (81.7%)	0.353*	1.56 (0.6–4.0)
≥150 min/wk	7 (12.5%)	49 (87.5%)	Reference	
Medical History				
Type 2 diabetes mellitus	1 (11.1%)	8 (88.9%)	1.0f	0.61 (0.07–5.09)
No medical history	25 (17%)	122 (83%)	Reference	

*Chi-Squared; †Fisher.

population; however, it was found that the obese subjects with EDS, either based on BMI or waist circumference, mostly had a low risk of OSA (80% and 83.3%, respectively). This suggests that the incidence of EDS in obese subjects was not influenced by the high risk of OSA. Previous studies state that the pathophysiology of EDS in obese individuals is caused by an increase in leptin secretion due to increased adipose tissue in the body. When leptin receptors in the hypothalamus detect this increase, transcription of anorexigenic neuropeptides decreases, resulting in excessive sleepiness and promoting sleep fragmentation. Increased leptin is also detected by orexin receptors, which then increases inhibitory GABA neurotransmission to orexin neurons, resulting in decreased orexin signaling along with decreased physical activity and alertness. Subsequent leptin resistance decreases prepro-orexin transcription as well. In addition, in individuals with increased adipose tissue/obesity, it was

Table II. Comparison of Body Mass Index and Waist Circumference with Excessive Daytime Sleepiness.

VARIABLES	EXCESSIVE DAYTIME SLEEPINESS	
	YES *N* (%)	NO *N* (%)
Body Mass Index		
Obese	15 (57.7%)	81 (62.3%)
Overweight	7 (26.9%)	30 (23.1%)
Normal	4 (15.4%)	19 (14.6%)
Waist Circumference		
≥90 cm	18 (69.2%)	83 (63.8%)
<90 cm	8 (30.8%)	47 (36.2%)

found that there was an increase in the secretion of inflammatory cytokines such as TNF-α and IL-6, which then led to changes in the basal forebrain and anterior hypothalamus that regulate the sleep/wake cycle, increasing the intensity of non-rapid eye movement (NREM) sleep and decreasing the activity of neurons that are active in wakefulness.[2,12]

As for work characteristics, the prevalence of EDS is the highest in single-seat pilots (25%) compared to the other two professional categories. Single-seat pilots perform more tasks on short-duration flights, making them vulnerable to fatigue that can manifest as EDS.[16] The prevalence of EDS is higher in pilots who have had 200 flight hours for the past 6 mo (18.3%). Flight hours are a known contributor to fatigue in civilian pilots, where each increase in the score on the ESS questionnaire that assesses EDS has a significant relationship with the incidence of fatigue.[9,15,19] The prevalence of EDS is also found to increase in parallel with the frequency of night flying (from 14% to 27.8%). This may be due to the dysregulation of circadian rhythms influenced by night schedules. To mitigate this, a pilot is given 9 consecutive hours of rest (including sleep) within 24 h before commencing a flight duty of 9 h or less. However, various factors can affect the quality of the recommended rest time, such as sleeping environments or commuting time, hence affecting sleep duration.[9] For the flight duration frequently traveled within the past 6 mo, medium-haul flights had the highest percentage of EDS occurrences (21.4%). Fatigue occurs more often in pilots who fly short/medium-haul flights than in long-haul flights due to higher number of flight sectors, which can manifest as EDS.[14,15,19] The prevalence of EDS was highest in pilots who slept for less than 7 h on working days and off days (18.8% and 25%, respectively). Sleep restriction is one of the main causes of EDS. The American Academy of Sleep Medicine recommends a minimum of 7 h of sleep to maintain optimal health, and sleeping less than 7 h regularly is associated with decreased work performance, increased errors, and an increased likelihood of accidents.[3]

Table III. Comparison of Body Mass Index and Waist Circumference with EDS Stratified with OSA Risk.

VARIABLES	OBSTRUCTIVE SLEEP APNEA RISK	EXCESSIVE DAYTIME SLEEPINESS	
		YES *N* (%)	NO *N* (%)
Body Mass Index			
Obese	High	1 (6.7%)	0 (0%)
	Intermediate	2 (13.3)	12 (14.8%)
	Low	12 (80%)	69 (85.2%)
Overweight	Intermediate	0 (0%)	2 (6.7%)
	Low	7 (100%)	28 (93.3%)
Normal	Low	4 (100%)	19 (100%)
Waist Circumference			
≥90 cm	High	1 (5.6%)	0 (0%)
	Intermediate	2 (11.1%)	13 (15.7%)
	Low	15 (83.3%)	70 (84.3%)
<90 cm	Intermediate	0 (0%)	1 (2.1%)
	Low	8 (100%)	46 (97.9%)

Then for lifestyle, the highest prevalence of EDS was found in pilots who consumed alcohol less than 5 times a month. Alcohol consumption was found to have a significant relationship with EDS.[8] There was an increase in the prevalence rate of EDS in parallel with decreased duration of physical exercise (12.5% to 28.6%). Regular physical exercise has a significant relationship with shorter sleep initiation time, shorter waking time from sleep, and longer sleep time. EEG examination also revealed a longer period of NREM stages 3 and 4 and shorter rapid eye movement sleep (REM).[18] There was also a lower prevalence of EDS in pilots with T2DM (11.1%) compared to those without a history of illness (17%). However, it is still a concern considering T2DM has been proven from other studies to be a strong independent risk factor for the incidence of EDS.[5,12] Based on multivariate analysis, work characteristics such as night flight frequency of more than 20 times and duration of sleep on off days for less than 7 h, both in the last 6 mo, were the dominant variables in this study compared to obesity.

One of the limitations of this study was the use of questionnaires, which are subjective in nature, to measure EDS. Also, based on multivariate analysis, the variables studied had a small effect on the incidence of EDS, indicating that other external factors not studied in this research contributed more than 90% to EDS in Indonesian civilian pilots. This also might explain why there were not any significant relationships between the studied variables and EDS in this study.

In conclusion, the pilots who had EDS were mostly obese and had a low risk of OSA. This highlights the importance of excess body weight management in pilots to minimize its effects on performance. However, the variables that most influenced EDS occurrence in civilian pilots are related to sleep restriction due to work characteristics rather than obesity. Therefore, besides educating the pilots regarding the incidence of EDS related to excess body weight and the impact on work performance, we also recommend for pilots to have adequate balance between working hours and resting time. Further research is recommended regarding the relation of other work characteristics outside of this study with EDS, such as length of work as a pilot, the average duration of flight duty, commuting time and vice versa, the comfort of the accommodation provided during layover, and other factors outside of work that can affect the duration of sleep, such as the home environment and social or family activities.

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