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Correlation between body mass index and apnea-hypopnea index, and the Epworth sleepiness scale: An epidemiological study on sleep

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Abstract. Obstructive sleep apnea (OSA) is a common sleep disorder leading to the disruption of breathing and sleeping. Body mass index (BMI) and the apnea-hypopnea index (AHI) are frequent measures used to evaluate the severity of OSA. The present study investigated the correlation between body mass and apnea-hypopnea indices using the Epworth sleepiness scale (ESS). The present study included 150 participants who had undergone a sleep assessment. The collected data included age, BMI, ESS scores and AHI. The ESS ranged from 0 to 24, with a score >10 indicating abnormal levels of daytime sleepiness. A BMI >25 kg/m^2 was regarded as overweight. The sex distribution was equal and the age ranged from 18 to 79 years in males, and 31 to 82 years in females. A statistical variation was observed between the age (P=0.001) and BMI (P<0.001) of males and females, whereas the ESS was found to be comparable in both groups. No association was found between ESS and AHI in females (P=0.834); however, a correlation was found in males (P=0.001). When the information of both sexes was assessed collectively (P=0.003), a significant association was discovered between BMI and AHI in both sexes and also in the combined data of both sexes (P=0.016). The data of the present study demonstrated that there was a significant correlation between BMI and AHI, indicating that the severity of sleep apnea worsens with higher BMI levels.

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Introduction

Obstructive sleep apnea (OSA) is a common sleep disorder characterized by repetitive partial or complete obstruction of the upper airway during sleep, leading to the disruption of breathing and sleeping. Body mass index (BMI) and the apnea-hypopnea index (AHI) are frequent measures used to evaluate the severity of OSA (1). The Epworth sleepiness scale (ESS) is a commonly used questionnaire to assess subjective daytime sleepiness in patients with sleep disorders. This questionnaire asks individuals to rate their likelihood of falling asleep during eight different daily situations on a scale of 0 to 3 for each question. The scoring range of the ESS is from 0 to 24, and a higher score implies a more pronounced tendency for daytime sleepiness (2). BMI is a measure of body mass based on height and weight, while AHI measures the number of apneas and hypopneas per hour of sleep (3). As defined, apnea is when the flow of air is ceased for a minimum of 10 sec, while hypopnea denotes a decrease in airflow below the threshold outlined in the definition of apnea (4). Obesity is a chronic disease that is complex and multifactorial in nature, and it is the most prevalent condition of fat metabolism among humans. This condition arises due to a combination of genetic and environmental factors (5). Insufficient sleep, poor sleep quality and delayed bedtime are linked with the overconsumption of food, inferior dietary habits and the development of obesity (6).

The aim of the present epidemiological study on sleep was to determine the possible correlation between BMI and the AHI index, and the ESS in an Iraqi population.

Subjects and methods

Study design. The present study was a cross-sectional study conducted between February, 2019 and March, 2021. The study was written in line with the STROCSS 2019 Guideline (7).

Study setting. The data for the present study were obtained by evaluating the records of 150 consecutive participants who underwent sleep assessments at a community-based healthcare facility (Faruq Medical City, Sulaimani, Iraq) from 2019 to 2021.

The collected data included various parameters, such as the age, BMI and ESS scores of the participants, as well as the presence or absence of excessive daytime sleepiness and AHI. BMI was computed by dividing the body weight in kilograms by the height in meters squared. The ESS scores ranged from 0 to 24, with scores >10 indicating abnormal levels of daytime sleepiness. A BMI >25 kg/m^2 was regarded as overweight for both males and females. AHI was assessed through the utilization of an ambulatory sleep study known as ApneaLink Plus (ALP) Polygraphy (ResMed UK Ltd.). Sleep apnea refers to the temporary and often recurring cessation of breath or significant reduction in airflow for ≥10 sec during sleep. This type of apnea occurs when the upper airway is partially or completely blocked, which is known as OSA. Hypopnea represents a partial loss or reduction in airflow of breath for ≥10 sec during sleep, typically associated with slow breathing, which is common in sleep apnea, particularly in OSA (with a noticeable reduction of at least 50%). To calculate AHI, the total count of apneas and hypopneas was measured and then divided this sum by the total duration of sleep (in hours).

Eligibility criteria. The inclusion criteria included individuals who experienced sleep-related breathing issues (snoring with or without apneic attacks) and/or excessive daytime sleepiness (hypersomnolence). The ESS score was used as an objective measure of daytime sleepiness, and participants with a score >10 or <10 who still reported sleep-related breathing problems and excessive daytime sleepiness were also included.

Statistical analysis. Statistical analysis was performed using SPSS software version 26 (IBM Corp.), and the outcomes are presented as the mean ± standard deviation. Continuous variables were analyzed using one-way ANOVA and numerical data were analyzed using the Chi-squared test. Pearson's and Spearman's correlation analyses were utilized to measure the degree of correlation between the variables (presenting as R or Rho values, respectively). A value of P<0.05 was considered to indicate a statistically significant difference. A regression estimation graph was utilized to illustrate the association between ESS and AHI.

Results

The present study included a total of 150 cases with an equal sex distribution. The age of the participants ranged from 18 to 79 years in males, and it was between 31 and 82 years in females. A statistical variation was observed between the age (P=0.001) and BMI (P=0.001) of the males and females, whereas the ESS was found to be comparable in both groups. Furthermore, no statistically significant difference was observed between sex and AHI (P=0.180; Table I). No correlation was found between ESS and AHI in females (Rho=0.025, P=0.834); however, a correlation was found in males (Rho=0.468, P=0.001) and when the information of both sexes was assessed collectively (Rho=0.244, P=0.003; Table II and Fig. 1).

A significant correlation was discovered between BMI and AHI in both sexes (males: R=0.294, P=0.011; females: R=0.254, P=0.028), as well as in the combined data of both sexes (R=0.197, P=0.016) (Table II).

Of note, no correlation was found between ESS and BMI in males (Rho=0.077, P=0.510), females (Rho=0.132, P=0.260). However, a significant correlation was found when the data of both sexes was assessed collectively (Rho=0.170, P=0.037) (Table II).

Discussion

The correlation between BMI, AHI and ESS is a key topic in the field of sleep medicine. The ESS is a self-report questionnaire that is widely used to assess daytime sleepiness, while BMI is a measure of body weight relative to height and AHI is a measure of the severity of sleep-disordered breathing (3,8). Individuals who are overweight or obese have a higher prevalence of obstructive sleep apnea, which occurs when the upper airway of an individual becomes narrowed or blocked during sleep due to the accumulation of fat in the neck region, known as pharyngeal fat. This can cause snoring as air has to squeeze through the restricted airway, and dietary habits play a crucial role in OSA; some authors have demonstrated a negative association between fiber-rich nutrients and OSA severity, while a positive association with high-fat food consumption has been demonstrated (3,9).

The present study found a significant positive correlation between ESS and AHI, indicating that a higher AHI severity is associated with higher ESS scores. This association was noted in males when data from both sexes were analyzed separately. It was previously observed that in females, correlations between ESS and AHI were only observed in severe sleep-disordered breathing; however, this correlation was notably weaker compared to males (10). However, as one of the limitations of the present study, sleep-disordered breathing was not concluded in the participants examined herein. The finding of the present study is in accordance with that of a cross-sectional study conducted by Lipford *et al* (10). Sleep deprivation has been linked to increases in the levels of ghrelin, a hormone that stimulates appetite. As a result, individuals may experience an increase in cravings for high-calorie foods (7,11). Further evidence indicates that not getting a sufficient amount of sleep can result in excessive eating and obesity and a decrease in the amount of fat that is lost during calorie restriction (12).

The present study did not find any association between ESS and BMI, which is in line with the findings of the study by Roure *et al* (8). However, when the data for both sexes were collectively analyzed, a statistically significant correlation was found between ESS and BMI. This finding aligns with the hypothesis presented in the study by Basta and Vgontzas (11), which indicated that metabolic factors may not have a significant influence on ESS. Furthermore, excess body fat around the abdomen can lead to the compression of the chest wall, resulting in a decrease in lung volume. This reduction in airflow can cause the upper airway to collapse during sleep, increasing the likelihood of OSA. The risk of developing this condition increases as BMI increases. Even a 10% increase in weight can elevate the risk of OSA by up to 6-fold. Ciavarella *et al* (3) found no correlation between BMI and

Table I. Distribution of the demographic data of the study subjects.

Characteristic	Males (n=75)	Females (n=75)	Total (n=150)	P-value
Mean age (years)	49.04±13.743	60.9±11.581	54.97±13.995	**0.001**[a]
Mean BMI (kg/m^2)	34.99±8.216	43.32±10.166	39.15±10.116	**<0.001**[a]
Mean ESS	12.07±7.136	13.85±6.772	12.96±6.991	P=0.424[b]
Mean AHI	37.99±17.011	32.37±12.288	35.18±15.058	P=0.180[a]

Data were analyzed using [a]one-way ANOVA or [b]the Chi-squared test. Values in bold font indicate statistically significant differences (P<0.05). BMI, body mass index; ESS, Epworth sleepiness scale.

Table II. Results of the correlation analyses between BMI, ESS and AHI.

Correlations examined	Males (n=75)	Females (n=75)	Total (n=150)
ESS and AHI	Rho=0.468	Rho=0.025	Rho=0.244
	P=0.001[a]	P=0.834	P=0.003[a]
BMI and AHI	R=0.294	R=0.254	R=0.197
	P=0.011[a]	P=0.028[a]	P=0.016[a]
ESS and BMI	Rho=0.077	Rho=0.132	Rho=0.170
	P=0.510	P=0.260	P=0.037

[a]Indicates a significant correlation (P<0.05). R, Pearson's correlation coefficient; Rho, Spearman's correlation coefficient; P, P-value.

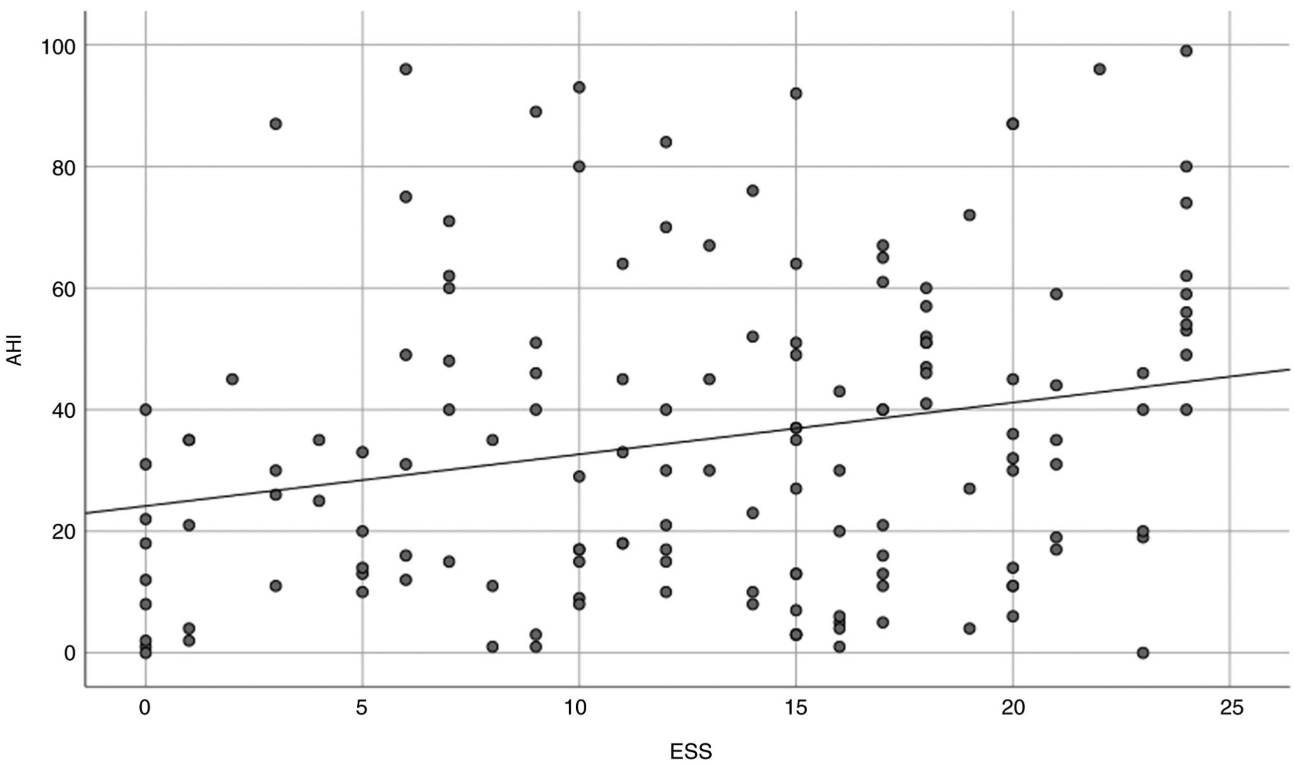

Figure 1. Regression estimation curve of elevated ESS plotted against AHI. ESS, Epworth sleepiness scale; AHI, apnea-hypopnea index.

AHI, and Basta and Vgontzas (11) claimed that obesity-related objective daytime sleepiness was less associated with OSA and these findings are in contrast with those of the present study; herein, a correlation was found between these two factors. However, this finding is consistent with the findings of the study by Soylu *et al* (13); their study demonstrated that an increase in BMI, waist circumference and neck circumference was associated with a greater severity of OSA (13). It is important to note that the present study study was limited first by its sample size, which may limit the generalizability of the findings to larger populations. Second, the present study did not include data regarding the comorbidities of the participants in the questionnaire.

In conclusion, the present study found a clear correlation between being overweight or obese and AHI; the majority of the study subjects with AHI had a BMI >25 kg/m^2. The correlation analysis revealed a significant correlation between BMI and AHI, indicating that the severity of sleep apnea worsens with higher BMI values. This correlation was observed in both males and females.

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Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Authors' contributions

HMWA and HMA were major contributors to the conception of the study, as well as in the literature search for related studies. HOA, SMA and FHK were involved in the literature review, in the writing of the manuscript and in the design of the study. SFA, FHF, BAA and KAOK were involved in the literature review, in the design of the study, in the critical revision of the manuscript and in the processing of the figure. FHK and HMWA confirm the authenticity of all the raw data. SJH, SOK and SHM were involved in data collection and analysis. All authors have read and approved the final manuscript.

Ethics approval and consent to participate

Written informed consent was obtained from all the study subjects for their participation in the present study. Ethical approval was obtained from the Ethics Committee of the University of Sulaimani (Sulaimani, Iraq; reference no. 88).

Patient consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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