

Research Article

Electrophysiological Evaluation of the Relation between Body Mass Index and Apnea Hypopnea Index

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Submitted: 01 March 2018

Accepted: 27 March 2018

Published: 28 March 2018

ISSN: 2379-0822

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OPEN ACCESS**Keywords**

- Body mass index
- Apnea hypopnea index
- Sleep electrophysiology

Abstract

Study objective: The aim of our study is to investigate the electrophysiological features of the relationship between 'body mass index' (BMI) and 'apnea-hypopnea index' (AHI) and to underline the importance of this connection for sleep health.

Methods: For this goal, 120 adult subjects, aged between 20 and 65 years, were classified to 4 groups as regards to their BMI and existence of sleep disordered breathing (SDB): (1) BMI=18,5-24,9 kg/m², healthy (n=30), (2) BMI=25-29,9 kg/m², overweight, SDB (n=30), (3) BMI=30-39,9 kg/m², obese, SDB (n=30), (4) BMI ≥ 40 kg/m², morbidly obese, SDB (n=30). Polysomnography of the subjects were recorded in Sleep and Electrophysiology Laboratory. We analyzed the effect of BMI levels on the electrophysiological recordings by OneWay ANOVA test, Duncan's multiple comparison procedures and Pearson Correlation Test.

Results: We found that BMI levels were significantly and positively correlated with AHI values ($r=0,470^{**}$). However, we detected significant negative correlations between BMI and sleep efficiency ($r=-0,235^{*}$) and between BMI and REM duration ($r=-0,281^{**}$).

Conclusion: We revealed that BMI levels had some effects on sleep electrophysiology. We showed that subjects having higher BMI could have higher levels of AHI. Again, in our study, it was shown that changes in sleep efficiency and quality resulting from increased AHI could disturb sleep health.

ABBREVIATIONS

AASM: American Academy of Sleep Medicine; AHI: Apnea-Hypopnea Index; SpO₂: Arterial Oxyhemoglobin Saturation; BMI: Body Mass Index; EEG: Electroencephalography; EMG: Electromyography; EOG: Electrooculography; OSA: Obstructive Sleep Apnea; PSG: Polysomnography; REM: Rapid Eye Movement; SDB: Sleep Disordered Breathing; NREM: non-REM

INTRODUCTION

Timing and duration of sleep and electrophysiological processes during sleep are determined by biological factors like day light, temperature, nutrition, health conditions and social factors of individual. Indeed, body weight control of modern human being is directly affected by these factors.

Most people take care of keeping their weight under control. The level of body mass index (body weight (kg)/square of height (m²)) is an important indicator of health according to body systems and metabolism. In fact, it is a helpful parameter in regulating life style and physiological needs of human beings.

Sleep and sleep health which may be accepted as important functions of central nervous system may be affected by alterations of body mass index (BMI) [1]. In present study, sleep quality of individuals having different BMI levels has been evaluated by electrophysiological methods.

Sleep quality directly affects life style of people. Obese patients who complain sleep problems explain that they could not sleep efficiently and accomplish daily activities. Snoring, obesity, obstructive sleep apnea (OSA) become three main problems seen in modern societies [2,3]. Obstructive Sleep Apnea Syndrome (OSAS) is a common airways disease recognized as an independent cardiovascular risk factor. It is often associated with obesity, diabetes and dyslipidemia. It is a syndrome characterized by recurrent sleep arrest or decrease during sleep, interrupted sleep, increased blood pressure, impaired glucose tolerance and daytime sleepiness [4-7].

It is known that the connection between BMI which gives information about general health, and apnea hypopnea index (AHI) which points to how respiratory system works exist. Our

hypothesis is towards to that alteration of electrophysiological processes in sleep may be different among individuals having different BMI values and may affect sleep quality and daily life style. We think that there is positive correlation between BMI and AHI, which are most important parameters of our hypothesis.

METHODS

Study design, participants, and ethics

We included the subjects who had sleep disorders, and applied to sleep laboratory between 2013 and 2014 and had polysomnographic recordings. We evaluated the data retrospectively. All subjects included in the study have been evaluated clinically in detail before polysomnography (PSG). We chose the subjects without additional comorbid diseases (e.g., obstructive or restrictive pulmonary disease, cardiovascular disease) and having only sleep disordered breathing. The study was carried out in Sleep Disorder Center, Electrophysiology Laboratory in Erzurum Regional Training and Research Hospital. Local ethics committee of the hospital approved this study with an approval number of 2014/ 7-3. In accordance with the declaration of Helsinki, 120 volunteers participated to this study.

For this goal, 120 subjects, between 20 and 65 years of age, were divided to four groups according to BMI and existence of sleep disordered breathing: (1) BMI=18,5-24,9 kg/m², healthy (n=30), (2) BMI=25-29,9 kg/m², overweight, sleep disordered breathing (n=30), (3) BMI=30-39,9 kg/m², obese, sleep disordered breathing (n=30), (4) BMI ≥ 40 kg/m², morbidly obese, sleep disordered breathing (n=30) (Table 1).

PSG recordings of the subjects were received in 'Sleep and Electrophysiology Laboratory in Erzurum Training and Research Hospital', Turkey. The electrophysiological properties achieved at night-time polysomnography which was done by Grass Technologies Twin Recording & Analysis Software System. The electrophysiological properties achieved were AHI, sleep efficiency (%) and duration (in minutes) of total sleep, and of stage 1, stage 2, stage 3 of Rapid Eye Movement (REM) and of non-REM periods.

PSG consists of four channel electroencephalography (EEG), two channel electrooculography (EOG), one channel submental muscle electromyography (EMG), two channel EMG on both anterior tibial muscles, one channel nasal cannula for oronasal airflow measurement, one channel oronasal thermal sensor, two channel inductive pletysmography to show respiratory effort on thorax and abdomen, one channel "body position" sensor to determine body position, one channel pulse oximeter measuring arterial oxyhemoglobin saturation (SpO₂) and simultaneous video recording.

We evaluated sleep stages and respiratory actions during sleep according to guideline published by "American Academy of Sleep Medicine (AASM)" in 2007. Apnea was defined as cessation of oronasal airflow by ten seconds. Hypopnea was defined as cessation of oronasal airflow by 50% together with 3% decrease in oxygen saturation or existence of arousal. Arousal could be defined as to be awake during sleep or to turn to more superficial stage during sleep.

Data analysis

A descriptive overview of the baseline characteristics of the study population is presented. We analyzed the effect of BMI levels on the electrophysiological recordings by One Way ANOVA test. The differences between groups were analyzed with Duncan's multiple comparison procedures. We performed Pearson Correlation Test to determine the degree of relationship between the parameters of the subjects.

We used multivariate linear regression model to analyze the effects of age and BMI on AHI. Regression model explained AHI change with a rate of 42% ($R^2 = 0,42$). This model was found as statistically significant [$F=36,918$, $p<0,05$, confidence intervals(CIs): 95% CIs_{age} = 1,353-2,090, 95% CIs_{BMI} = 1,816-3,275] (Figure).

RESULTS

We found that BMI levels were significantly and positively correlated with AHI values ($r= 0,470^{**}$). However, we detected significant negative correlations between BMI and sleep efficiency ($r= -0,235^*$) and between BMI and REM duration ($r= -0,281^{**}$).

AHI belonging to group 1 and 2 were significantly lower than those of group 3 and 4 ($p=0,000$). The level of sleep efficiency was lower in group 4 in comparison to the other groups ($p=0,027$). The duration of stage 2 was significantly higher in group 2 and group 3 ($p=0,092$). The duration of stage 3 and REM period were significantly shorter in group 4 comparing with group 1 (respectively; $p=0,009$; $p=0,000$) (Table 2).

DISCUSSION

We revealed that BMI levels had some effects on sleep electrophysiology. We showed that subjects having higher BMI could have higher levels of AHI. Again, in our study, it was shown that changes in sleep efficiency and quality resulting from increased AHI could disturb sleep health.

Sleep is an important action establishing homeostatic balance. During night, REM and NREM periods repeat again and again. There is reciprocal relationship between NREM and REM sleep, while the effect of one of them becomes wane, the other becomes stronger [8,9]. In our study, this relationship was determined in group 1. However, the reciprocal relationship between REM and NREM was disturbed in other groups in which BMI and AHI increased.

Sleep starts with NREM period; and NREM and REM periods follow each other throughout night. The cycle of NREM-REM takes about 90-120 minutes. Slow wave sleep (NREM-III) lasts shorter in second part of night, NREM-II dominates in the last cycle [9,10]. In our study, it was shown that the duration of NREM-III became least in the group having highest BMI and AHI levels. As BMI and AHI levels of groups has become lower, duration of slow wave sleep (NREM-III) increased.

NREM sleep comprises a part of 75-80 % of whole sleep time. Of that, 2-5 % is composed of NREM-I, 45-55 % NREM-II, 15-20 % NREM-III [10,11]. In our study, duration of NREM-II has increased with increasing values of BMI and AHI levels. Similarly,

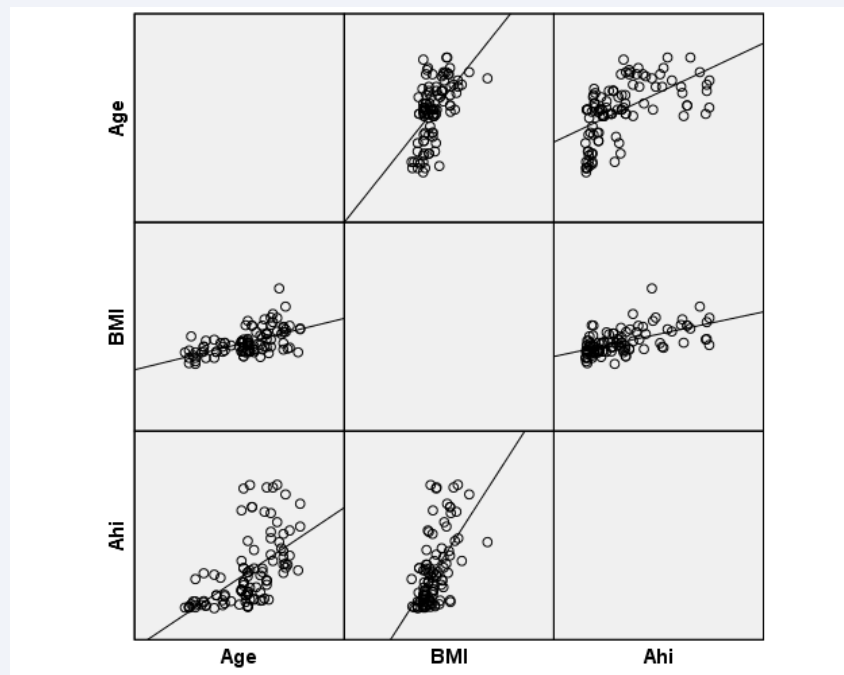


Figure 1 Multivariate linear regression model to analyze the effects of age and BMI on AHI.
Abbreviations: BMI: Body Mass Index; AHI (Ahi): Apne Hypopnea Index.

Table 1: Distribution of the subjects according to demographic features.

Group 1 (n=30)	Group 2 (n=30)	Group 3(n=30)	Group 4 (n=30)
BMI 22.37 ± 1.88	BMI 28.2 ± 1.49	BMI 33.56 ± 2.68	BMI 43.84 ± 5.14
Normal	Overweigh	Obese	MorbidlyObes
Healthy	SDB	SDB	SDB
Age 36.83 ± 8.03	Age 43.87 ± 18.75	Age 48.97 ± 10.96	Age 51.27 ± 8.73
ComorbidDisease Absent	ComorbidDisease Absent	ComorbidDisease Absent	ComorbidDisease Absent

Abbreviations: BMI: Body Mass Index; SDB: Sleep Disordered Breathing

Table 2: Electrophysiological properties of the subjects according to BMI values.

	Group 1 (n=30)	Group 2 (n=30)	Group 3(n=30)	Group 4 (n=30)
BMI (kg/ m ²)	22.37 ± 1.88	28.2 ± 1.49	33.56 ± 2.68	43.84 ± 5.14
AHI	9.60 ± 12.02	16.64 ± 14.11	45.55 ± 34.93	44.03 ± 30.45
Age	36.83 ± 8.03	43.87 ± 18.75	48.97 ± 10.96	51.27 ± 8.73
SE (%)	84.73 ± 10.06	87.48 ± 11.56	86.31 ± 9.61	78.267 ± 10.04
TST (min)	357.67 ± 50.95	336.29 ± 79.83	354.07 ± 60.54	340.15 ± 56.54
NREM 1	36.30 ± 24.29	50.99 ± 42.02	47.99 ± 31.43	54.08 ± 26.29
NREM 2	183.34 ± 48.40	187.62 ± 64.50	219.21 ± 75.80	207.15 ± 61.83
NREM 3	81.33 ± 50.68	77.11 ± 68.40	60.12 ± 49.76	53.07 ± 35.49
REM	49.50 ± 25.20	32.31 ± 22.58	23.31 ± 23.72	25.85 ± 19.75

Abbreviations: BMI: Body Mass Index; AHI: ApneHipopne Index; SE: Sleep Efficiency; TST: Total Sleep Time; REM: Rapid Eye Movement; NREM: non-REM

as BMI and AHI levels of groups increased, duration of NREM-I has increased. Probably, decreasing duration of slow wave sleep has shifted towards more superficial sleep NREM-II and NREM-I.

Generally, as deep sleep NREM-III dominates in first third of night in adults, in last third of sleep REM sleep dominates. Short awakening periods emerges during late parts of night and REM sleep transitions. Physiologically, REM sleep has become longer during late night [12]. In our study, as BMI and AHI levels increased, sleep quality was disturbed and REM duration became shorter.

In our study investigating the connection between AHI which gives information about the action of respiratory system during sleep and BMI which points to general health; sleep efficiency was lower in group 1 (AHI:9,60) consisting of subjects having normal BMI than in group 2 and group 3. In group 1, stay in NREM-I and NREM-II was lowest, stay in NREM-III and REM was highest in comparison to the other groups. Even if subjects having normal BMI had lower AHI levels, deep wave sleep and stay in REM have not been affected negatively.

In REM period, brain tissue has been restored, moreover motor connections has been integrated. REM period is an important electrophysiological process in regard to protection and strengthening of memory [13]. REM periods of subjects in group 3 (obese) and group 4 (morbidly obese) have been shortened.

The balance of BMI has an important meaning in continuing sleep health and general health. As individuals having lower BMI have problems according to sleep transition, those having higher BMI experience sleep-disordered breathing. Obesity could lead to deterioration of sleep quality [2,14].

STUDY LIMITATIONS

The main limitation of observational studies is the potential imbalance with regard to baseline characteristics between the four groups compared. A multivariate regression analysis should be included in order to evaluate the role of confounding factors on final results. One way to address this limitation is to adjust for baselines characteristics in a regression analysis model, which we performed in this study.

Due to the difficulty we encountered in recruiting patients, the sample size was smaller than we originally planned, which limited our analysis of prevalence. Lastly our study groups contain only patients with SDB patients without comorbidity. Therefore we used multivariate linear regression model to analyze the effects of age and BMI on AHI. This model was found as statistically significant (Figure).

CONCLUSION

As the subjects have not fed correctly, did not attend regular

exercise programs and thus had increasing BMI levels, they encountered more problems about sleep and thus day time sleep quality has been deteriorated and general health became worse. Electrophysiological alterations in REM sleep and especially NREM-III (slow deep sleep) have been affected by all factors influencing BMI and AHI.

As a result, BMI and AHI are closely related to each other. These parameters directly affect general health and sleep health according to physical and mental aspects. Not only children, but also continuity of sleep duration and harmony of adult subjects have importance in keeping general health.

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Cite this article

Kayabekir M, Topaloğlu Ö (2018) Electrophysiological Evaluation of the Relation between Body Mass Index and Apnea Hypopnea Index. *J Sleep Med Disord* 5(1): 1090.