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# The influence of the presence of sleep apnoea on cardiovascular risk in patients with hypertension

## Wpływ występowania bezdechu sennego na ryzyko sercowo-naczyniowe u pacjentów z nadciśnieniem tętniczym

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## Abstract

**Introduction.** Sleep apnoea is a disease that is difficult to diagnose early and may increase the risk of organ complications. However, its diagnostic value in assessing cardiovascular risk is uncertain.

The study aimed to demonstrate the correlation between the occurrence of sleep apnoea and increased cardiovascular risk, considering conventional and unconventional risk factors in the group of patients suffering from arterial hypertension.

**Material and methods.** Several tests have been conducted: sleep apnoea using the polygraphic method, ambulatory blood pressure monitoring, carotid-femoral pulse wave velocity (cfPWV), ankle–brachial index, body composition, and also the results of biochemical tests and data from an interview were collected from 35 patients classified into one of two groups: patients with or without hypertension. Data are reported as median values (quartiles), p values as assessed by the Mann-Whitney ANOVA test.

**Results.** In a study, 19 patients suffered from arterial hypertension (group A) and 15 patients had no hypertension (group B). There were no statistically significant differences between the groups in the anthropometric parameters, biochemical parameters, sleep apnoea diagnosis, cardiovascular risk and haemodynamic characteristics. The exception was the difference between cfPWV with statistical significance p = 0.02: 9.15 m/s (8.4–10.5), 8.1 m/s (7.4–9.7), for groups A and B respectively.

**Conclusions.** In patients suffering from hypertension, arterial stiffness expressed as cfPWV was higher than in patients without hypertension, despite the achievement of comparable results in other assessed parameters of the clinical characteristics of the studied population.

Key words: cardiovascular risk, hypertension, sleep apnoea

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## Introduction

There is a growing interest in sleep apnoea in cardiovascular diseases. Recently, cardiological scientific societies have implemented the assessment of sleep apnoea into the recommendations for the evaluation of cardiovascular risk. There seems to be an association between obstructive sleep apnoea and stroke, but its association with myocardial infarction and increased cardiovascular mortality requires further research [1]. With the growing importance of sleep apnoea syndrome in clinical practice, including the estimation of cardiovascular risk, there is a need for easily available research tools that could be used to early detect and prevent long-term effects of this syndrome.

The study aimed to demonstrate the correlation between the occurrence of sleep apnoea and increased cardiovascular risk, considering conventional (age, sex, blood pressure, smoking) and unconventional [body weight, pulse wave velocity (PWV), ankle–brachial index (ABI)] risk factors in the group of patients suffering from arterial hypertension (AH).

## Material and methods

The study was approved by an ethics committee (decision number: 336/19) and patients provided written informed consent to participate in the study.

In the period from October 2019 to March 2020, 35 patients were qualified for one of two groups:

- group A: patients diagnosed with arterial hypertension;
- group B: patients without a diagnosis of arterial hypertension.

Inclusion criteria for the study were:

- expression by patients written informed consent to participate in a study;
- age: 40–75 years;
- hypertension.

The exclusion criteria from the study were:

- unstable ischemic heart disease;
- heart failure (ejection fraction < 40%);
- coexistence of other diseases, e.g., malignant tumours, haematological diseases, cirrhosis, renal failure, inflammations, rheumatic and mental diseases;
- medical history of alcohol, drug and drug addiction.

### SCORE risk cards

Systematic COronary Risk Evaluation (SCORE) cards for countries with a high 10-year cardiovascular risk were used to assess cardiovascular risk. The following were assessed: age, sex, systolic arterial pressure, total cholesterol level and the fact of smoking by the patients. Based on the results, the patients were divided into the following groups: low (< 1%), moderate (≥ 1% and < 5%), high (≥ 5% and < 10%) and very high (≥ 10%) cardiovascular risk.

### Framingham risk cards

The Framingham scale was also used, which assessed age, gender, smoking, blood pressure, total and high-density lipoprotein (HDL) cholesterol levels, and the presence of diabetes. The level of risk was interpreted as low (< 10%), intermediate (≥ 10% and < 20%), high (≥ 20%).

### Body mass index

The body mass index (BMI), i.e., the patient's body weight/$m^2$ height was assessed and the patients were classified into one of the following weight groups: normal (< 25 kg/$m^2$), overweight (≥ 25 kg/$m^2$ and < 30 kg/$m^2$), obesity grade I (≥ 30 kg/$m^2$ and < 35 kg/$m^2$), obesity grade II (≥ 35 kg/$m^2$ and < 40 kg/$m^2$), obesity grade III (≥ 40 kg/$m^2$).

### Ankle–brachial index

The examination was performed with the boso-ABI System 100 apparatus. There was interpreted the relations between systolic arterial pressure (SBP) measured on the upper limbs (brachial arteries) and the lower limbs (dorsal and posterior tibial arteries). The ankle-brachial index was defined as the quotient of the SBP on the lower limb to the SBP on the upper limb (the higher pressure measured in the right or left brachial artery was selected). The result of the patient was the mean of ABI obtained on both sides. ABI scores < 0.9 were interpreted as chronic lower limb ischemia.

### Pulse wave velocity

Using the Bosch&Sohn PWV apparatus, arterial stiffness was assessed as the ratio of the distance travelled by the pulse wave between the recording points above the carotid and femoral arteries to the time it travelled between these points (path [m]/time [s]). The speed of the pulse wave was calculated by the apparatus automatically.

### Bodyweight composition

The composition of the body mass was assessed using the electrical bioimpedance method. The percentage of adipose tissue in the studied patients was analysed.

### 24-hour blood pressure measurement (ambulatory blood pressure monitoring)

The device was put on around noon and removed after 24 hours. The pressure was measured every 15 minutes between 6:00 and 22:00 and every 30 minutes between 22:00 and 6:00. The patients were instructed on the principles of operation and use of the apparatus. Mean values of systolic (SBP) and diastolic (DBP) pressure for the whole day were analysed.

### Sleep apnoea

In the diagnosis of sleep apnoea, the AppneaLink Air device assessed airflow, heart rate, and blood oxygenation. After

prior training, the patients put on the braces before going to bed and took them off in the morning after waking up. The software of the apparatus analysed the subjects' sleep and determined the apnoea–hypopnoea index (AHI), which is the number of apnoeas/h.

### Statistical calculations

Statistical calculations were made in the Statistica 13.3 program by StatSoft. For each tested feature, the probability degree p was calculated and it was determined that the results $p < 0.05$ would be considered significant. The Mann-Whitney test was used to compare two variables that did not have a normal distribution. The Kruskal-Wallis test was used to compare more than two non-normally distributed variables. Spearman's rank correlation coefficient was used in the study of the correlation between the features. The patient risk was re-evaluated according to the net reclassification index (NRI).

## Results

### Comparison of AH group with a non-AH group

Clinical characteristics of the study population:

- patient's age in group A was 69 years (62–74) and in the group B it was 61.5 years (49.5–67);
- patients with and without hypertension differed significantly in terms of age ($p = 0.01$). Younger people dominated in the group without hypertension.

**Anthropometric parameters:** patients with and without hypertension did not differ significantly in terms of anthropometric parameters. The results are presented in Table 1.

**Biochemical parameters:** patients with and without hypertension did not differ significantly in biochemical parameters. The results are presented in Table 2.

**Data from the interview:** patients with and without hypertension did not differ significantly from the interview data.

**Table 1.** Anthropometric parameters and exhaustion of the studied groups: arterial hypertension (AH) and non-AH

| Parameter | Number of subjects | | Statistical significance |
|---|---|---|---|
| | AH, n = 19 | Non-AH, n = 16 | |
| Body weight [kg] | 75.6 (72.2–88.6) | 84.25 (72–88.95) | SI |
| Height [cm] | 168 (164–172) | 169 (160.5–179) | SI |
| BMI [kg/m$^2$] | 26.9 (25.1–31.2) | 27.35 (25.45–31.05) | SI |
| Waist [cm] | 96 (87–106) | 98 (90–102) | SI |
| Hips [cm] | 107 (101–112) | 108 (102–112) | SI |
| WHR | 0.89 (0.80–0.99) | 0.89 (0.83–0.95) | SI |
| Exhaustion | 7 (4–9) | 4.5 (2.5–9.5) | SI |

BMI — body mass index; SI — statistically insignificant; WHR — waist-to-hip ratio

**Table 2.** Biochemical parameters of the studied groups: arterial hypertension (AH) and non-AH

| Parameter | Number of subjects | | Statistical significance |
|---|---|---|---|
| | AH, n = 17 | Non-AH, n = 14 | |
| Total cholesterol [mg/dL] | 201 (186–241) | 216 (210–247) | SI |
| HDL [mg/dL] | 66 (59–72) | 56 (54; 66) | SI |
| LDL [mg/dL] | 126 (101–144) | 145 (130–163) | SI |
| Triglycerides [mg/dL] | 104 (96–129) | 118 (91–120) | SI |

HDL — high-density lipoproteins; LDL — low-density lipoproteins; SI — statistically insignificant

**Table 3.** Hemodynamic characteristics of the studied groups: arterial hypertension (AH) and non-AH*

| Parameter | Number of subjects | | Statistical significance |
|---|---|---|---|
| | AH, n = 20 | Non-AH, n = 16 | |
| % body fat [%] | 33 (26–36) | 30 (22–37) | SI |
| ABI | 1.03 (0.98–1.08) | 1.03 (0.96–1.06) | SI |
| cfPWV [m/s] | 9.15 (8.4–10.5) | 8.1 (7.4–9.7) | p = 0.02 |
| ABPM-SBP [mm Hg] | 122.5 (118.5–139) | 122.5 (111–129.5) | SI |
| ABPM-DPB [mm Hg] | 74 (70–81) | 77.5 (70–80.5) | SI |

*p < 0.05; ABI — ankle–brachial index; ABPM — ambulatory blood pressure monitoring; cfPWV — carotid-femoral pulse wave velocity; DBP — diastolic arterial pressure; SBP — systolic arterial pressure; SI — statistically insignificant

**Table 4.** Cardiovascular risk determined by the Systematic COronary Risk Evaluation (SCORE) and Framingham scales of the studied groups: arterial hypertension (AH) and non-AH*

| Parameter | Number of subjects | | Statistical significance |
|---|---|---|---|
| | AH, n = 17 | AH, n = 14 | |
| SCORE [%] | 7 (5–12) | 6.5 (2–9) | SI |
| Framingham [%] | 8 (4–11) | 7 (4–12) | SI |

*p < 0.05; SI — statistically insignificant

**Table 5.** Diagnosis of sleep apnoea in the study groups: normal weight, overweight, 1st-degree obesity, 2nd-degree obesity, 3rd-degree obesity*

| Parameter | Standard, n = 6 | Overweight, n = 18 | Obesity I, n = 9 | Obesity II, n = 1 | Obesity III, n = 1 | Statistical significance |
|---|---|---|---|---|---|---|
| AHI (apnoeas/h) | 5.95 (4.1–7.3) | 4.5 (2.7–12.7) | 11.1 (5.1–24.2) | 1.7 (1.7–1.7) | 7.9 (7.9–7.9) | SI |

*p < 0.05; AHI — apnoea–hypopnoea index; SI — statistically insignificant

Hemodynamic characteristics: patients with and without hypertension differed significantly in terms of cfPWV. In the hypertensive group, the patients' arterial stiffness was greater. The results are presented in Table 3.

Diagnosis of sleep apnoea: AHI (apnoeas/h) in group A was 5.8/h (3.9–12.7) and in group B it was 4.7/h (2.05–14), so patients with and without hypertension did not differ significantly in the number of apnoea per hour.

Cardiovascular risk scales: patients with and without hypertension did not differ significantly in terms of cardiovascular risk determined on the SCORE and Framingham scales. The results are presented in Table 4.

## Comparison of AHI in risk groups according to the SCORE scale

There are significant differences between the groups. The high-risk group has more apnoeas per hour [11.9/h (5.8/h; 28.9/h)] than the moderate-risk group [4.4/h (2.1/h; 5.1/h)], p = 0.02. There were no significant differences between the very high-risk group [5.6/h (2.7/h; 6.3/h)] and other groups.

## Comparison of AHI in risk groups according to the Framingham scale

The low- and intermediate-risk Framingham patients did not differ significantly in the number of apnoea per hour. AHI in the low-risk group was 5.35/h (2.8/h; 12.7/h) and in the intermediate-risk group was 5.8/h (4.3/h; 14.8/h).

## Comparison of AHI in BMI groups

Patients' BMI did not affect their apnoeas per hour. The results are presented in Table 5.

Correlations:

— mutual correlations between AHI and selected parameters of patients' characteristics, depending on the prevalence of AH. The R-value of the Spearman's rank correlation coefficient and the statistical significance coefficient p;

— there is a correlation between AHI and exhaustion in Beck's scale in the AH group. Rs > 0, so the higher AHI, the higher the degree of exhaustion. The results are presented in Table 6 and Figure 1.

**Table 6.** Correlations between apnoea–hypopnoea index (AHI) and various parameters of the studied groups: arterial hypertension (AH) and non-AH*

| Parameter | AH, n = 19 | Non-AH, n = 16 |
|---|---|---|
| AHI vs. BMI | 0.35, p = 0.14 | 0.27, p = 0.30 |
| AHI vs. total cholesterol | –0.11, p = 0.65 | –0.23, p = 0.42 |
| AHI vs. exhaustion | **0.46, p = 0.04** | 0.02, p = 0.91 |
| AHI vs. % fat | 0.31, p = 0.19 | –0.22, p = 0.41 |
| AHI vs. LDL | –0.13, p = 0.63 | –0.22, p = 0.44 |
| AHI vs. age | 0.41, p = 0.08 | –0.10, p = 0.71 |
| AHI vs. body weight | 0.21, p = 0.39 | 0.36, p = 0.17 |
| AHI vs. height | –0.16, p = 0.52 | 0.31, p = 0.24 |
| AHI vs. waist | 0.14, p = 0.56 | 0.33, p = 0.22 |
| AHI vs. hip | 0.38, p = 0.11 | 0.16, p = 0.56 |
| AHI vs. WHR | –0.16, p = 0.51 | 0.25, p = 0.36 |
| AHI vs. HDL | 0.03, p = 0.90 | 0.04, p = 0.88 |
| AHI vs. triglycerides | –0.30, p = 0.24 | 0.07, p = 0.81 |
| AHI vs. body weight composition | 0.31, p = 0.20 | –0.23, p = 0.42 |
| AHI vs. cfPWF | 0.29, p = 0.22 | –0.20, p = 0.47 |
| AHI vs. ABPM-SBP | –0.20, p = 0.42 | –0.27, p = 0.32 |
| AHI vs. ABPM-DBP | –0.09, p = 0.73 | –0.25, p = 0.34 |
| AHI vs. ABI | –0.10, p = 0.69 | –0.07, p = 0.81 |

*Spearman's correlation R value, p < 0.05; ABI — ankle–brachial index; ABPM — ambulatory blood pressure monitoring; BMI — body mass index; cfPWV — carotid-femoral pulse wave velocity; DBP — diastolic arterial pressure; HDL — high-density lipoproteins; LDL — low-density lipoproteins; SBP — systolic arterial pressure; WHR — waist-to-hip ratio

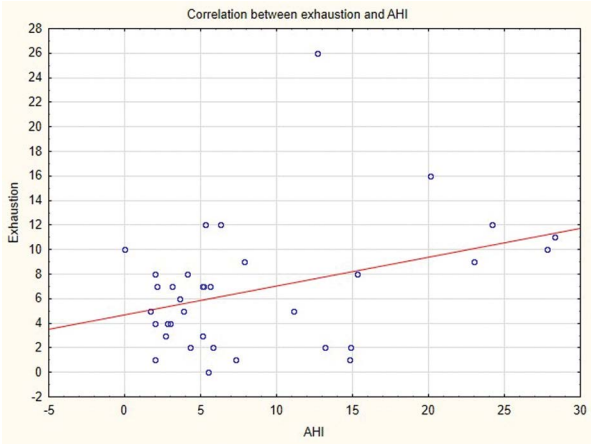


**Figure 1.** Correlation between apnoea–hypopnoea index (AHI) and exhaustion in the arterial hypertension (AH) group (p < 0.05)

Correlations between AHI and cardiovascular risk according to SCORE and Framingham: there is no correlation between AHI and cardiovascular risk as determined by the SCORE and Framingham scales. The results are shown in Table 7.

NRI: NRI was calculated to better define cardiovascular risk for SCORE and Framingham and AHI scales. SCORE and AHI had NRI = –0.048 at p = 0.41 (p > 0.05), and for Framingham and AHI NRI = 0.056 at p = 0.59, so adding AHI to the SCORE and Framingham scales will not result in a significant reclassification of cardiovascular risk in patients.

## Discussion

Cardiovascular diseases are very common among the populations of Europe and the United States. The assessment

**Table 7.** Correlations between apnoea–hypopnoea index (AHI) and cardiovascular risk according to Systematic COronary Risk Evaluation (SCORE) and Framingham of study groups: arterial hypertension (AH) and non-AH*

| Parameter | AH, n = 17 | Non-AH, n = 14 |
|---|---|---|
| AHI vs. SCORE | 0.34, p = 0.18 | 0.001, p = 0.997 |
| AHI vs. Framingham | 0.27, p = 0.30 | –0.02, p = 0.95 |

*Spearman's correlation R value; p < 0.05

of cardiovascular risk includes the SCORE [2] and Framingham [3] scales, which evaluate the patient in terms of parameters conducive to atherosclerosis. However, it should be remembered that apart from the criteria assessed by the scales, other factors may also influence the risk. There are several studies in the literature on the relationship between sleep apnoea syndrome and the development of cardiovascular complications. They showed that apnoea is strongly and independently of other factors associated with patient mortality. The combined assessment of sleep apnoea and comorbidities appears to be a good risk prediction concept for hypertensive patients [4, 5]. Obstructive sleep apnoea, according to some estimates, may affect about 25% of men over 40 [6]. It results in a constant feeling of lack of sleep, fatigue and lack of concentration. The disease is difficult to diagnose early and is associated with an increased risk of complications, such as arterial hypertension that is resistant to treatment, an increased risk of heart attack, stroke or even death. The standard for the assessment of sleep apnoea is polysomnography. This test allows for the simultaneous determination of blood oxygenation, analysis of sleep position, ECG and the assessment of selected neurological parameters. In my study, I used a device that assessed airflow, heart rate and blood oxygenation. This made it possible to find patients with AHI (apnoeas/h) > 5/h, which defined them as patients with sleep apnoea, considering the reported symptoms. Treatment of sleep apnoea includes several components: loss of excess body weight, ENT consultation to assess anatomical abnormalities that hinder proper breathing, and the use of a CPAP device [7].

Some studies have shown an association between the occurrence of sleep apnoea and hypertension in middle-aged and elderly patients, with no gender differences. Patients with AHI > 30/h developed hypertension more frequently than patients with AHI < 1.5/h [8]. However, the link between sleep apnoea and cardiovascular risk remains to be found. Statistically, this can be helped by the NRI, the net reclassification index, which shows how the classification of patients will change when a new parameter is added to the main study data. In my study, I did not find a significant change in the cardiovascular risk group after considering the occurrence of sleep apnoea.

Arterial stiffness determined by cfPWV is greater in hypertensive patients. One can see a direct relationship between this phenomenon, as the occurrence of arterial hypertension is a consequence of increased arterial stiffness. At the same time, arterial hypertension changes the structure of the vessels and leads to their stiffening [9].

Linking sleep apnoea and mental illness has been the subject of numerous studies, but the results are not conclusive. The prevalence of sleep apnoea in people with depression ranges from 11 to 18% [10], and the incidence of depression in people with apnoea may be as high as 63% [11]. A large study of a group of veterans in the United States has shown that sleep apnoea is a significant risk factor for depression. However, it should be remembered that most of the respondents were men [12]. In my study, I obtained a statistically significant correlation between AHI and exhaustion according to the Beck Depression Rating Scale. This can be a confirmation of the relationship between sleep apnoea and depression.

## Conclusions

Both hypertensive and non-hypertensive patients had similar anthropometric, biochemical and haemodynamic parameters, as well as data from the interview. They differed only in arterial stiffness expressed by cfPWV, which confirms the changes that occur in blood vessels with concomitant arterial hypertension.

There were no differences in the frequency of sleep apnoea in the groups of people with and without hypertension. However, there was a difference in AHI between the high and moderate cardiovascular risk groups, according to the SCORE scale. More reliable results would probably be obtained with more patients tested.

A significant correlation has been shown between the occurrence of sleep apnoea and depression, which confirms similar results of studies conducted in other countries.

It has not been shown that the addition of the sleep apnoea parameter (AHI) to the SCORE and Framingham charts will change these classifications and help to better assess cardiovascular risk in the studied patients.

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## Conflict of interest

The authors report no conflict of interests.

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## Streszczenie

**Wstęp.** Bezdech senny jest schorzeniem, które ma trudny do wczesnej diagnostyki przebieg, a może zwiększać ryzyko różnych powikłań narządowych. Jednakże jego wartość diagnostyczna w ocenie ryzyka sercowo-naczyniowego jest wciąż niepewna.

Celem badania było wykazanie korelacji między występowaniem bezdechu sennego a zwiększonym ryzykiem sercowo-naczyniowym z uwzględnieniem konwencjonalnych i niekonwencjonalnych czynników ryzyka w grupie pacjentów chorujących na nadciśnienie tętnicze.

**Materiał i metody.** Przeprowadzono badanie bezdechu sennego metodą poligraficzną, ambulatoryjne monitorowanie ciśnienia tętniczego, pomiar prędkości fali tętna między tętnicą szyjną a udową (cfPWV), wskaźnika kostka–ramię, składu masy ciała metodą bioimpedancji elektrycznej, a także zebrano wyniki badań biochemicznych i dane z wywiadu od 35 pacjentów zakwalifikowanych do jednej z dwóch grup — pacjentów z nadciśnieniem tętniczym lub bez nadciśnienia tętniczego. Dane podano jako wartości mediany (kwartyle), wartości p oceniono za pomocą testu ANOVA Manna-Whitneya.

**Wyniki.** W badaniu kohortowym u 19 pacjentów stwierdzono nadciśnienie tętnicze (grupa A), a u 15 brak nadciśnienia tętniczego (grupa B). Nie zaobserwowano istotnych statystycznie różnic między grupami pod względem parametrów antropometrycznych, parametrów biochemicznych, diagnostyki bezdechu sennego, określenia ryzyka sercowo-naczyniowego, charakterystyki hemodynamicznej. Wyjątkiem była różnica między cfPWV z istotnością statystyczną p = 0,02: 9,15 m/s (8,4–10,5), 8,1 m/s (7,4–9,7), odpowiednio dla grup A i B.

**Wnioski.** U pacjentów chorujących na nadciśnienie tętnicze sztywność tętnic wyrażona jako wartość cfPWV, była większa niż u pacjentów bez nadciśnienia tętniczego, mimo osiągnięcia porównywalnych wyników w zakresie innych ocenianych parametrów charakterystyki klinicznej badanej populacji.


Słowa kluczowe: ryzyko sercowo-naczyniowe, nadciśnienie tętnicze, bezdech senny

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