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**THE INTERDEPENDENCE OF NUTRITIONAL STATUS AND BLOOD PRESSURE
IN FEMALE STUDENTS**

**WSPÓLZALEŻNOŚĆ MIĘDZY STANEM ODŻYWIENIA A CIŚNIENIEM TĘTNICZYM
U STUDENTEK**

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S u m m a r y

Introduction: The value of blood pressure is affected by a number of factors, nutritional status being of utmost importance.

The aim of the study was an assessment of the interdependence between the nutritional status and systolic blood pressure (SBP) as well as diastolic blood pressure (DBP) in female students.

Material and method: The research included 66 women aged 20.5 ± 0.71 , studying in Bydgoszcz. The systolic and diastolic blood pressure was taken. The nutritional status of the students was estimated with the use of anthropometric parameters. To assess the status, nutritional indexes such as the Body Mass Index (BMI) and the percentage of fat in the body (%FM) were applied.

Results: The mean systolic and diastolic pressure of the female students was optimal. Hypertension was identified only in one person (1.5% of the female students) and high normal blood pressure - in the eight all those (12% of the female students). The normal BMI was found in 42.4% of the female students. However, low body mass was found in

every 5th person and undernutrition in every 3rd person. The percentage of body fat was high ($31.1 \pm 4.6\%$), and obesity was identified in about 60% of the students (%FM>30%). A significant correlation was observed between systolic pressure and body mass ($r=0.4$ $p<0.001$), %FM ($r=0.5$ $p<0.001$) and BMI ($r=0.4$ $p=0.002$). A significantly higher systolic pressure (121 vs. 111 mmHg $p<0.001$) and diastolic pressure (77 vs. 73 mmHg $p=0.013$) was observed in the obese female students compared to the non-obese students.

Conclusions:

1. Disorders in nutritional status (including underweight, low body mass, overweight and obesity) were identified in over a half of the students.

2. Interdependence between body mass, body mass index, body fat in female students and systolic pressure was shown.

3. A significantly higher blood pressure and more frequent occurrence of higher blood pressure categories were observed in obese female students.

S t r e s z c z e n i e

Wstęp Na wartość ciśnienia tętniczego krwi wpływa szereg czynników, spośród których duże znaczenia ma stan odżywienia.

Celem pracy było określenie współzależności między ciśnieniem tętniczym skurczowym (SBP) i rozkurczowym (DBP) u studentek a ich stanem odżywienia.

Materiał i metody: Badaniem objęto 66 kobiet w wieku $20,5 \pm 0,71$ lat z bydgoskich uczelni wyższych. U studentek dokonano pomiaru ciśnienia tętniczego krwi

i pomiarów antropometrycznych. Do oceny stanu odżywienia wykorzystano wskaźniki stanu odżywienia m.in. wskaźnik masy ciała (BMI), procentową zawartość tłuszczu w ciele (%FM).

Wyniki: U studentek średnie ciśnienie tętnicze skurczowe i rozkurczowe było optymalne (117/75 mmHg). Nadciśnienie tętnicze odnotowano jedynie u jednej studentki (1,5% studentek), a wysokie prawidłowe u ośmiu studentek (12% badanych). Prawidłowe wartości wskaźnika masy ciała

(BMI) wykazano u 42,4% studentek (BMI 20,0-24,9 kg/m²). Jednak u co 5 osoby wykazano niską masę ciała, a u co 3 niedożywienie. Procentowa zawartości tłuszczu w ciele studentek była wysoka (31,1±4,6%), a nadmierne otłuszczenie odnotowano aż u ok. 60% studentek (%FM). Odnotowano istotną korelację pomiędzy ciśnieniem skurczowym oraz masą ciała ($r=0,4$ $p<0,001$), %FM ($r=0,5$ $p<0,001$) i BMI ($r=0,4$ $p=0,002$). U studentek z nadmierną ilością tłuszczu odnotowano istotnie wyższe ciśnienie skurczowe (121 vs. 111 mmHg $p<0,001$) i rozkurczowe (77 vs. 73 mmHg $p=0,013$) w porównaniu z osobami z prawidłową zawartością tłuszczu w ciele.

Key words: female students, blood pressure, nutritional status, body mass, Body Mass Index (BMI), percentage of fat in the body (%FM)

Słowa kluczowe: studentki, ciśnienie tętnicze, stan odżywienia, masa ciała, wskaźnik masy ciała (BMI), procentowa zawartość tłuszczu w ciele (%FM)

INTRODUCTION

The value of blood pressure is affected by a number of factors, nutritional status being of utmost importance [1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11]. Appropriate body weight and body composition is very important for maintaining good health. The development of hypertension can be prevented primarily by certain impact on the environmental conditions, and in particular the lifestyle of the patient (diet, physical activity) [1,2,12,13,14,15,16]. Prevention (prophylaxis) should be addressed in particular to children and young people, in whom development of the disease (hypertension) has not yet occurred [2, 3, 10].

THE AIM

The aim of the study was an assessment of the interdependence between the nutritional status and systolic blood pressure (SBP) as well as diastolic blood pressure (DBP) in female students.

MATERIAL AND METHOD

The research included 66 women aged 20.5±0.71, studying in Bydgoszcz as first or second year students. The research was conducted from November 2010 to May 2011, on the basis of an agreement of the Bioethics Commission of the Nicolaus Copernicus University in Toruń Collegium Medicum in Bydgoszcz. The systolic and diastolic blood pressure (SBP and DBP) and anthropometric measurements were taken. Anthropometric measurements included the specification of body mass (kg) and height (cm), arm circumference (cm) and 4 skinfold thicknesses:

Wnioski:

1. Występowanie zaburzeń w stanie odżywienia (łącznie: niedowaga, niska masa ciała, nadwaga i otyłość) wykazano u ponad połowy studentek.

2. Wykazano zależność między masą ciała, wskaźnikiem masy ciała i zawartością tłuszczu w ciele studentek a skurczowym ciśnieniem tętniczym.

3. U studentek z wyższą zawartością tłuszczu w ciele odnotowano istotnie wyższe wartości ciśnienia tętniczego i częstsze występowanie wyższych kategorii ciśnienia.

triceps skinfold (TSF, mm), biceps skinfold (BSF, mm), subscapular skinfold (SCSF, mm) and suprailiac skinfold (SISF, mm) measurements. The nutritional status of the students was estimated with the use of anthropometric parameters. To assess the status, nutritional indexes such as the Body Mass Index (BMI), the percentage of fat in the body (%FM), waist to hip ratio (WHR) and arm muscle circumference (AMC) were applied. The value of indicators underwent classification according to the following criteria: the BMI-WHO (2003), waist circumference (<80cm vs. ≥80 cm), % FM (non-obesity<30% vs. obesity >30%). The classification of blood pressure was made in accordance with the guidelines of the Polish Society of Hypertension [1], the guidelines of the ESH and ESC [2].

The statistical analysis was carried out with the STATISTICA PL v.9.0 computer program of the StatSoft where the significance level was ≤0.05. The blood pressure, anthropometric parameters and indicators of nutritional status were displayed as mean value (x), standard deviation (SD), median (Me), minimum (Min) i maximum (Max). In order to determine the correlation of pressure and nutritional status parameters, the Pearson correlation coefficient was calculated. Evaluation of the variation in pressure between students of different nutritional status was carried out using the t-Students test or the Kruskal-Wallis test. The evaluation of population distribution in the classes: obesity/non-obesity (according to the % FM) was carried out using Chi-square test.

RESULTS

The mean systolic pressure (SBP) of the female students in Bydgoszcz was at 117.2 ± 9.8 mm Hg, and the diastolic pressure (DBP) was 75.4 ± 7.7 mm Hg. The mean heart rate was 74.9 ± 11.1 beats/minute (Tab. I).

Table I. Average value of systolic blood pressure (SBP), diastolic blood pressure (DBP) and pulse in female students

Tabela I. Średnia wartość ciśnienia tętniczego skurczowego (SBP), rozkurczowego (DBP) i tętna studentek

Parametr/ parameter	x± SD	Me	Min	Max
SBP [mm Hg]	117.2±9.8	117.5	92.0	137.0
DBP [mm Hg]	75.4±7.7	75.0	57.0	90.0
Tętno [uderzeń/min] / Heart rate [beats/minute]	74.9±11.1	72.0	57.0	120.0

x – średnia, SD - odchylenie standardowe, Me – mediana, Min – minimum, Max – maximum

x – mean, SD - standard deviation, Me – median, Min – minimum, Max – maximum

The optimum arterial SBP and DBP pressure was found respectively in 59.1% and 69.7% of students (Tab.II). The normal value of the systolic blood pressure occurred in nearly one-third of all the students (31.8%), and the normal value of diastolic pressure – in 16.7% of the population. High normal SBP and DBP pressure was identified in 9.1% and 12.1% of the students respectively. Among all the students, the SBP value does not show hypertension. Hypertension was identified only in one person. Only in 1.5% of the students an increase in the value of DBP above the limit was observed and hypertension was found (Tab. II).

Table II. Classification of blood pressure in female students

Tabela II. Klasyfikacja ciśnienia tętniczego wśród studentek

Kategoria / Category	N=66	%N
SBP		
Optymalne / Optimal	39	59.1
Normalne / Normal	21	31.8
Wysokie prawidłowe / High normal	6	9.1
Nadciśnienie / Hypertension	0	0
DBP		
Optymalne / Optimal	46	69.7
Normalne / Normal	11	16.7
Wysokie prawidłowe / High normal	8	12.1
Nadciśnienie / Hypertension	1	1.5

SBP – ciśnienie tętnicze skurczowe, DBP – ciśnienie tętnicze rozkurczowe, N – liczebność, %N - odsetek populacji.

SBP - systolic blood pressure, DBP - diastolic blood pressure, N – number, %N – percentage of population

Table III. The average value of the anthropometric parameter measurements and nutritional status in female students

Tabela III. Średnie wartości parametrów antropometrycznych i wskaźników stanu odżywienia wśród studentek

Parametr/ parameter	x±	SD	Min	Max
Wysokość/Weight [cm]	166.5 ±	5.1	152.0	181.0
Masa ciała/Body mass [kg]	56.6 ±	10.1	42.4	98.0
A [cm]	24.4 ±	3.0	20.0	30.5
W [cm]	73.9 ±	6.3	64.0	96.0
H [cm]	90.8 ±	5.0	82.5	107.5
TSF [mm]	20.7 ±	7.7	9.7	37.6
BSF [mm]	15.6 ±	7.7	4.0	35.1
SCSF [mm]	14.8 ±	5.5	8.2	31.5
SISF [mm]	20.7 ±	7.5	6.4	36.1
% FM [%]	31.1 ±	4.6	19.6	40.1
WHR	0.8 ±	0.1	0.7	1.0
BMI [BMI kg/m ²]	20.3 ±	2.7	17.0	29.9
AMC [cm]	17.9 ±	2.6	10.7	25.6

x – średnia; SD - odchylenie standardowe; Min - minimum; Max - maximum; A – obwód ramienia, W – obwód talii, H – obwód bioder; grubość fałdu skórno-tłuszczowego nad: TSF – trójcepcem, BSF - biceps; SCSF - dolnym kątem łopatki; SISF - grzebieniem kości biodrowej; % FM - procentowa zawartość tłuszczu w ciele; WHR - wskaźnik talia -biodro; BMI - wskaźnik masy ciała; AMC - obwód mięśni ramienia

x – mean, SD - standard deviation, Me – median, Min – minimum, Max – maximum; A - Arm circumference, W - Waist circumference, H – Hip circumference, TSF- triceps skinfold thickness, BSF- biceps skinfold thickness; SCSF- subscapular skinfold thickness; SISF- suprailiac skinfold thickness; % FM - the percentage of fat in the body; WHR- Waist to Hip Ratio; BMI- Body Mass Index; AMC- arm muscle circumference

The characteristics of the anthropometric parameters and indicators of nutritional status were shown in the Tab. III. Statistical analysis showed no statistically significant differences between blood pressure among students with waist circumferences <80 cm vs. ≥80 cm (Tab.IV). Statistical analysis showed a statistically significant difference between blood pressure values according to the percentage of body fat (%FM). In obese female students the mean value of systolic pressure was 121 ± 8.0 mm Hg and was higher compared to the non-obese students (111 ± 9.2 mm Hg, Tab.IV), while the average value of diastolic pressure among non-obese students amounted to 77 ± 8.0 mm Hg and was higher than in the group without obesity (73 ± 6.3 mm Hg, Tab. IV).

Table IV. Blood pressure and pulse of the sample depending on nutritional status

Tabela IV. Ciśnienie tętnicze i tętno studentek w zależności od stanu odżywienia

Kategoria/Category	N	%N	SBP [mm Hg]	DBP [mm Hg]	Tętno [uderz./min.] / Heart rate (beats/minute)
			$\bar{x} \pm SD$	$\bar{x} \pm SD$	$\bar{x} \pm SD$
Obwód talii (cm) / Waist circumference (cm)					
<80 cm	56	84.8	117±10,2	76±7,3	75±11,4
≥80 cm	10	15.2	119±1,0	75±9,7	72±29,3
			p=0,501	p=0,815	p=0,401
BMI [kg/m ²]					
<16.0 – niedożywienie 3 ^o / underweight 3 ^o	0	0	-	-	-
16.0-16.9 – niedożywienie 2 ^o / underweight 2 ^o	1	1.5	121#	83	57
17.0-18.4 – niedożywienie 1 ^o / underweight 1 ^o	22	33.3	113±2.5*	75±7.5	75±12.4
18.5-19.9 – niska masa ciała/low	13	19.7	117±2.2	75±7.6	73±10.9
20.0-24.9 – prawidłowa/normal	28	42.4	120±1.5*	75±7.6	77±10.2
25.0-29.9 – nadwaga /overweight	2	3.0	128±0.0#	88±0.7	70±2.1
>30.0 – otyłość /obesity	0	0.0	-	-	-
			p=0,012	0=0,074	p=0,435
%FM					
<30% brak otyłości / no obesity	27	40.9	111±9.2	73±6.3	72±12.4
>30% otyłość / obesity	39	59.1	121±8.0	77±8.0	77±9.8
			p<0,001	p=0,014	p=0,525

SBP - ciśnienie tętnicze skurczowe; DBP - ciśnienie tętnicze rozkurczowe; \bar{x} - średnia;
SD - odchylenie standardowe; BMI - wskaźnik masy ciała, % FM - procentowa zawartość tłuszczu w ciele; p - poziom istotności testu t-Studenta lub Kruskala-Wallisa, # wykluczono z analizy statystycznej (zbyt mała liczebność)

SBP - systolic blood pressure, DBP - diastolic blood pressure, \bar{x} - mean, SD - standard deviation, BMI- Body Mass Index; %FM - the percentage of fat in the body; p - significant level of the t-Students test lub the Kruskala-Wallis test, #excluded from the analysis (to small size)

Analysis of the diversity of blood pressure according to the BMI was carried out for all the students with normal body mass and first degree malnutrition (other categories were excluded from the analysis due to small sample sizes). Statistical analysis showed statistically significant differences in systolic pressure values between the students with first degree malnutrition and the students with correct weight. The average value of systolic pressure in the normal BMI students was 120±1.5 mm Hg and was higher by 7 mm Hg compared to the students with first degree malnutrition (113±2.5 mm Hg) (Tab.IV, p=0.012).

An analysis of the interdependence between blood pressure and body mass showed a positive correlation between the systolic pressure and body mass in the female students (Fig.1). The analysis showed no relationship between the diastolic pressure and body mass (Tab. V). A significant correlation was observed

between the students' systolic pressure and the BMI (r=0.4 p=0.002, Fig. 2). A significant correlation was not observed between the diastolic pressure (DBP) and the BMI in the student population (Tab.V). No correlation was observed between either the systolic or diastolic pressure (DBP) and waist circumference or hip circumference of the examined population of Bydgoszcz female students (Tab.V).

Table V. Correlation between blood pressure and parameters of nutritional status

Tabela V. Korelacja ciśnienia i parametrów stanu odżywienia

	SBP	DBP
Masa ciała	r=0.4 p<0.001	r=0.2 p=0.177
BMI	r=0.4 p=0.002	r=0.1 p=0.347
Obwód talii	r=0.2 p=0.110	r=0.0 p=0.852
Obwód bioder	r=0.2 p=0.095	r=0.2 p=0.075
%FM	r=0.5 p<0.001	r=0.3 p=0.019

r - współczynnik korelacji, r - the correlation coefficient

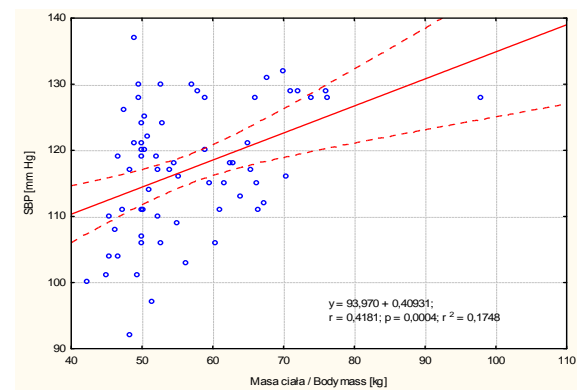


Fig. 1. Correlation between systolic blood pressure and body mass

Ryc. 1. Zależność między ciśnieniem skurczowym (SBP) a masą ciała

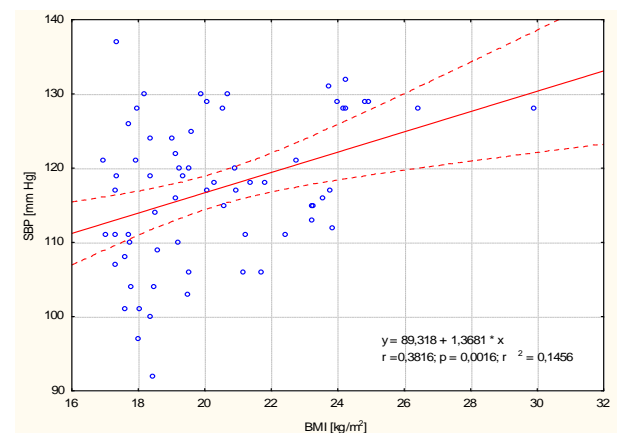


Fig. 2. Correlation between systolic blood pressure and body mass index (BMI)

Ryc. 2. Zależność między ciśnieniem skurczowym (SBP) a wskaźnikiem masy ciała (BMI)

The analysis of interdependence between blood pressure and body fat showed a high positive correlation between systolic pressure and body fat ($r=0.5$ $p<0.001$, Fig.3) and a weak positive correlation between diastolic pressure and body fat in the female students ($r=0.3$ $p=0.019$, Fig.4).

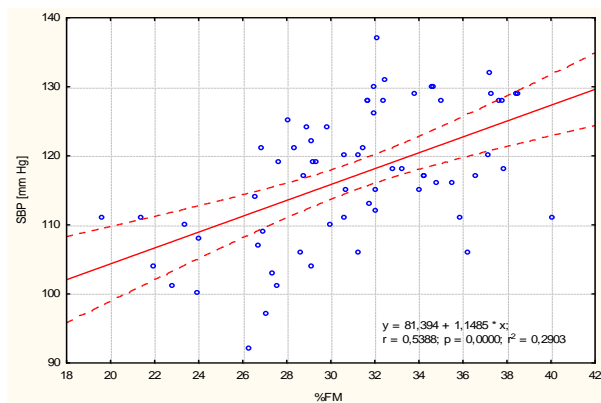


Fig. 3. Correlation between systolic blood pressure and body fat percentage (%FM)

Ryc. 3. Zależność między ciśnieniem skurczowym (SBP) a procentową zawartością tkanki tłuszczowej (%FM)

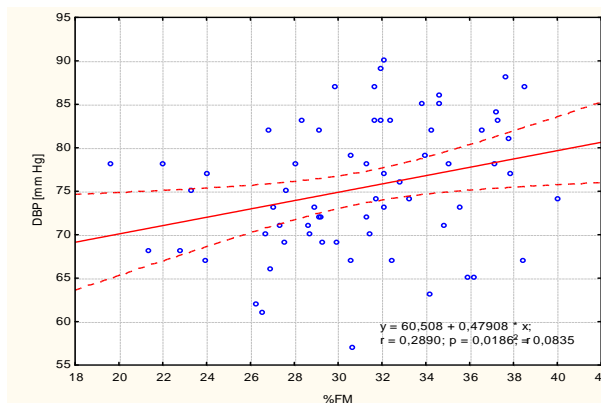


Fig. 4. Correlation between diastolic blood pressure and body fat percentage (%FM)

Ryc. 4. Zależność między ciśnieniem rozkurczowym (DBP) a procentową zawartością tkanki tłuszczowej (%FM)

Statistical analysis showed the existence of substantial variations in the distribution of the population in terms of systolic pressure depending on the percentage of body fat (% FM). Among the students with optimal systolic pressure only just over a half (53.9%) had a percentage of fat in the body <30%. The others were obese. For all those with normal systolic pressure, the presence of obesity was observed in more than 70% of the persons (71.4%), and all those

with a high normal systolic pressure were obese (Tab. VI). Statistical analysis did not show the existence of substantial variations in the distribution of population in terms of diastolic pressure depending on the percentage of body fat (% FM). However, there has been a trend of increase in the percentage of obese people in subsequent diastolic pressure classes (from optimum and normal to high normal). In the group with normal diastolic pressure, almost $\frac{3}{4}$ of the subpopulation was obese. Among all those with a high normal pressure, the percentage of obese people was close to 90%. Hypertension was shown in one obese student (Tab.VI).

Table VI. Distribution of female students in terms of blood pressure depending on the percentage of fat in the body (%FM)

Tabela VI. Rozkład studentek w kategoriach ciśnienia w zależności od zawartości tłuszczu w ciele (%FM)

Otyłość/brak otyłości wg FM	Ciśnienie / Blood pressure								p
	optymalne / optimal		normalne / normal		wysokie prawidłowe / high normal		nadciśnienie / hypertension		
Obesity/non-obesity wg FM	N	N%	N	N%	N	N%	N	N%	
Ciśnienie skurczowe / systolic blood pressure									
Brak otyłości / non-obesity	21	53.9	6	28.6	0	0.0	0	0.0	0.017
Otyłość / obesity	18	46.2	15	71.4	6	100.0	0	0.0	
Ciśnienie rozkurczowe / diastolic blood pressure									
Brak otyłości / non-obesity	23	50.0	3	27.3	1	12.5	0	0.0	0.080
Otyłość / obesity	23	50.0	8	72.7	7	87.5	1	100	

N - liczebność populacji; N% - odsetek populacji; p - poziom istotności testu χ^2 , brak otyłości - %FM<30%, otyłość - %FM>30%

N - number ; N% - percentage of population; p - significant level of χ^2 test, non- obesity - %FM<30%, obesity - %FM>30%

DISCUSSION

The mean systolic and diastolic pressure of Bydgoszcz female students was optimal (117/75 mmHg). Recorded values were comparable to those observed in the work of Krzych [3,4,5]. Paradowska-Stankiewicz and Grzybowski [7] have slightly lower average systolic and diastolic pressure values than in the test group from Bydgoszcz. However, in Nowicki's work [6], among all the students in Bydgoszcz, the mean systolic and diastolic pressure values derogated both from the results obtained in the test and from those of the other authors (138.4 mm Hg and 88.7 mm Hg).

Hypertension was identified only in 1.5% of the Bydgoszcz students and the result is similar to the one recorded by Nowicki. [6]; whereas the highest percentage of students with hypertension was reported

among the students of School of Medicine (9-10%). The results of research among Polish adults LIPIDOGRAM [8], WOBASZ [13] and the NATPOL-PLUS [15,16] indicated a significant prevalence of hypertension (29-42%) and a significant percentage of people at risk of its development (11-30%).

The mean nutritional status of female students from Bydgoszcz according to the BMI was adequate (BMI=20.3±2.7 kg/m²). However, the analysis of distribution in nutritional status classes showed low body mass in every 5th person and underweight in every 3rd person. Despite the underweight and low body weight, the concern was body composition of young women, as the average percentage of fat tissue in the body was very high indeed (31.1±4.6%). Obesity was identified in about 60% of the students. High content of androidal fat in the body of students with a low or normal BMI was observed in research [17,18,19]. For all those with high androidal fat in the body the authors suggest the presence of metabolic hazards is similar to the one in obese people.

The assessment of interdependence between blood pressure and nutritional status showed a significant relationship between the systolic pressure and body mass, the % FM and the BMI. The strongest correlation was found between the content of fat in the body and the systolic pressure ($r=0.5$ $p<0.001$). In female students with the proper content of fat in the body (<30%), the SBP and DBP was optimal. A significantly higher systolic and diastolic blood pressure was observed in obese female students compared to the non-obese students. The systolic pressure was up to 10 mm Hg higher in obese students, and despite their young age it already reached the high normal value. These results indicate the presence of risks of the development of hypertension in all those young students. The basic preventive treatment for this group should include, among others, moderate amount of daily physical activity and diet modification [1, 2].

CONCLUSIONS

1. Disorders in nutritional status (including underweight, low body mass, overweight and obesity) were identified in over a half of the students.

2. Interdependence between body mass, body mass index, body fat in female students and systolic pressure was shown.

3. A significantly higher blood pressure and more frequent occurrences of higher blood pressure categories were observed in obese female students.

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