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Original article

METABOLIC SYNDROME IN A SAMPLE OF WORKING POPULATION

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Abstract

Metabolic syndrome (MetS) is a cluster of risk factors, including central obesity, hypertension, hyperglycemia, hypertriglyceridemia, and reduced HDL cholesterol, -that increase the risk of type 2 diabetes and cardiovascular diseases. Its prevalence is growing globally, and the association with occupational factors is increasingly recognized.

To determine the frequency and characteristics of MetS and its components among the working population in North Macedonia, related to gender, age, and occupation.

A cross-sectional study was conducted among 537 workers aged 20-67 years during their regular preventive medical check-ups. Participants were divided into four occupational groups based on the International Labor Organization classification. The presence of MetS was determined according to the NCEP ATP-III criteria when at least three of five factors were present.

MetS was detected in 31.5% of participants. The frequency was significantly higher in males (42%) than in females (20.3%), and higher in participants older than 45 years (45.8% *vs.* 17.6%). MetS frequency varied by occupation, being higher among workers with manual jobs (Groups 1 and 2) compared to those with sedentary jobs (Groups 3 and 4) (39.9% *vs.* 25.9%, $p = 0.0064$).

MetS is prevalent among the working population, particularly in males, older workers, and those engaged in manual labor. These findings highlight the need of targeted health promotion programs and preventive interventions to reduce cardiometabolic risk factors among workers.

Keywords: metabolic syndrome, frequency, components of metabolic syndrome, working population

Introduction

The metabolic syndrome (MetS) is a cluster of interrelated factors that are associated with the development of type 2 diabetes mellitus and the occurrence of cardiovascular diseases, including central obesity (waist circumference values), elevated blood pressure, hyperglycemia, hypertriglyceridemia and reduced values of HDL cholesterol (high-density lipoprotein cholesterol)[1].

According to the Report of the Adult Treatment Panel III of the National Cholesterol Education Program (NCEP ATP-III criteria), the presence of MetS in a person is confirmed by the presence of at least three of the five listed factors. Metabolic syndrome can also be defined as "a cluster of interrelated factors present in a person that increases the relative risk of type 2 diabetes mellitus and cardiovascular disease by five or two times, respectively, in the next five to 10 years"[2].

Each of these five factors, also known as components of MetS, represent an independent risk factor for the occurrence of cardiometabolic diseases (CMD), but their joint, combined effect that significantly increases cardiometabolic risk (CMR), should be highlighted. People with MetS have an increased risk of developing type 2 diabetes mellitus, cardiovascular disease, myocardial infarction and stroke, and double the risk for mortality from these causes compared to people without MetS[3].

In recent years, the metabolic syndrome has become a significant and growing challenge for public health worldwide, as a result of rapid urbanization, improper nutrition with excessive energy intake, obesity and a sedentary lifestyle. In 2018, a global MetS prevalence of 25% was calculated, i.e. MetS is estimated to be present in one billion people worldwide, with a further increasing trend[4].

The prevalence of MetS increases with age. Data on the prevalence of MetS in Europe ranges from 4% in the population aged 20-29 to almost 30% in the population aged 60-69[5].

Regarding gender, numerous studies point to significant differences in the frequency of MetS in men and women due to several reasons, but primarily due to differences in the etiology of MetS and its components, as well as specific hormonal influences that make up the biological profiles of men and women[6,7].

Today, the role of work and occupation in the occurrence and development of MetS is increasingly highlighted. Numerous studies from different countries in the world, using the NCEP ATP-III criteria, provide data on the frequency of MetS among workers from different sectors, which ranges from 11.7% among workers in the automotive industry in Germany, 30% among industrial workers in the United States, to as high as 51.4% among manufacturing workers in India[8-12].

The results also show that workers with occupations where lower skill levels are required (mainly workers engaged in manual work) such as machine operators, construction workers, transport workers, loading-unloading workers, etc. have the highest frequency of MetS and its components, especially obesity and hypertension[13].

In North Macedonia, surveys among the working population provide data on separate components of MetS, but despite a large number of studies in the domain, it should be noted that data on the frequency of MetS among workers from different sectors are still missing[14]. In this context, the interest in the occurrence and development of MetS among the active, working population has a special significance, considering that within the socio-economic status, work (occupation) is considered a strong predictor of morbidity and mortality from CMD[15].

Extended working life, intense changes in the way of work, the application of new technologies, automation and digitization of work processes and the increasingly prevalent sedentary way of working have a direct effect on the occurrence of increased CMR among the working population, while the occurrence of MetS among workers, also, leads to reduced productivity, increased absenteeism and disability[16].

Hence, it is of special interest to determine the frequency of MetS and its components, among the working population in North Macedonia

The aim of the study was to determine the frequency and characteristics of MetS and its components among the working population, related to their gender, age and occupation.

Material and methods

This was a descriptive-analytical cross-sectional study that was conducted among 537 workers, with different occupations, aged 20-67 years, during their regular preventive medical examinations at the Institute of Occupational Health of the Republic of North Macedonia, Skopje, during the period September 2020-September 2021. The study was conducted anonymously and voluntarily, and consent was obtained from each participant.

According to the current classification of occupations of the International Labor Organization (ILO) (17), based on skills, work tasks and workloads, participants were divided into four groups:

- Group 1 - jobs that require simple physical/manual tasks with a certain degree of physical strength and endurance (e.g. cleaners, factory line workers, loading-unloading workers),
- Group 2 - jobs requiring more precise manual tasks and communication skills (e.g. textile workers, professional drivers, hairdressers, police officers),
- Group 3 - jobs requiring complex technical and practical tasks in a specialized area (e.g. nurses, X-ray technicians, laboratory technicians),
- Group 4 - jobs requiring complex mental tasks and decision-making (e.g. teachers, engineers, doctors).

In terms of their occupational physical activity, according to this classification, participants from Group 1 and 2 have predominantly manual activities at the workplace, i.e. heavy and medium-heavy physical work, while participants from Group 3 and 4 have light and sedentary physical work at their workplace.

During the study, participants filled out the Questionnaire on demographic characteristics, workplace and work activities. Clinical-laboratory tests necessary for determining MetS were also performed.

Data on gender, age, occupation, current and past health problems, medication use were used from the Questionnaire for this paper.

The presence of MetS was determined by the presence of at least three of five factors according to the ATP-III criteria (2):

- fasting glycemia value higher than 5.6 mmol/l or use of medications for increased blood sugar level;
- value of HDL cholesterol in the blood lower than 1.0 mmol/l for men, i.e. lower than 1.3 mmol/l for women or use of medications for low HDL cholesterol;
- value of triglycerides in the blood higher than 1.7 mmol/l or use of medication for increased levels of triglycerides;
- a waist circumference greater than 102 cm for men, i.e. 88 cm for women and
- arterial blood pressure higher than 130/85 mmHg or use of antihypertensive therapy.

Laboratory tests, i.e. determining the values of glucose, triglycerides, total cholesterol and HDL cholesterol, were carried out on the Cobas c 111 device (Rosche Diagnostics Ltd, Basel, Switzerland).

Data obtained were statistically analyzed using the statistical software SPSS 26.0 for Windows. Continuous variables are expressed as minimum, maximum and mean values with standard deviation, and nominal variables as absolute numbers and percentages. Statistical processing was performed using univariate statistical models, that is, χ^2 test for testing differences in frequencies and Student t-test for testing differences in mean values. A statistically significant difference was determined by P values lower than 0.05.

Results

According to the obtained data from the Questionnaire on demographic characteristics, workplace and work activities, out of a total of 537 examined participants, 276(51.4%) were male, and 251(48.6%) female. The average age of participants was 44.3±10.9 years, with 273 participants (50.8%) younger and 264 (49.2%) older than 45 years.

The average total work experience was 19.8±10.4 years (rank 1-43 years), and 50% of them had a total work experience longer than 20 years.

Regarding the classification and characteristics of participants according to their occupation, according to the current classification of the ILO, Group 1 consisted of 58 (10.8%) participants, Group 2 - 155(28, 96%), Group 3 - 77(14.3%), and Group 4 - 247(46%) participants (Figure 1).

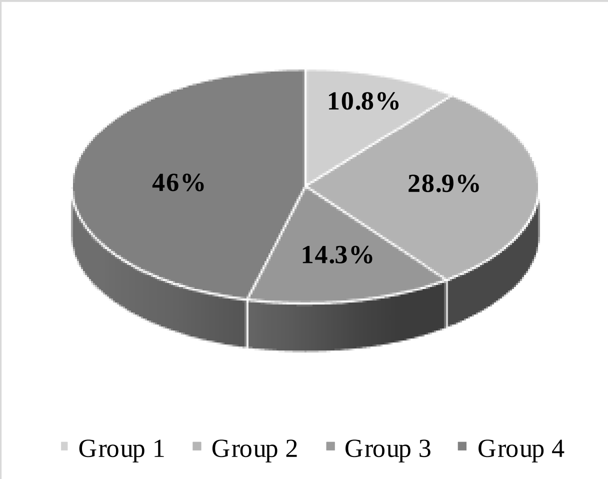

Fig. 1. Distribution of participants according to their occupation

Regarding the distribution of participants by gender, the representation of female participants was more frequent in Group 3 and Group 4 (18.4% *vs*. 10.5% and 4.3% *vs*. 43.8%), while the representation of male participants was more frequent in Group 1 and Group 2 (14.1% *vs*. 7.3% and 31.5% *vs*. 26.1%).

Regarding age, in the four groups of occupations, participants from the younger age group mostly belonged to Group 4 (57.1%), followed by Group 2, 1 and 3 (20.9%, 11.7% and 10.3%, respectively). The average age of participants was highest in Group 3 (47.5±11.1 years), followed by Group 2 (46.4±11.5 years), Group 1 (44.7±11.1 years) and Group 4 (41.7±9.8 years).

Table 1. Description of participants in terms of waist circumference, blood pressure, glycemia and lipid status

Variable	
Waist circumference/cm	
(mean ± SD) (min- max) median (IQR)	(94.2 ± 14.3) (59 – 133) 94 (84 – 105)
Blood pressure (mmHg)	
(mean ± SD) (min- max) median (IQR)	(124.3± 20.8)(70 – 210) 120 (110 – 140)
Glycemia (mmol/l)	
(mean ± SD) (min- max) median (IQR)	(5.1 ± 1.1) (3 – 16.4) 5 (4.6 – 5.5)
Total cholesterol (mmol/l)	
(mean ± SD) (min- max) median (IQR)	(5.1 ± 1.0) (1.4 – 8.6) 5.1 (4.5 – 5.8)
HDL cholesterol (mmol/l)	
(mean ± SD) (min- max) median (IQR)	(1.3 ± 0.5) (0.1 – 7.6) 1.3 (1.1 – 1.6)
Triglycerides (mmol/l)	
(mean ± SD) (min- max) median (IQR)	(1.5 ± 0.9) (0.3 – 7.1) 1.2 (0.9 – 1.8)

The components of MetS were determined in all subjects. Table 1 shows the values of MetS factors: waist circumference, blood pressure, glycemia and parameters of lipid status (total cholesterol, HDL cholesterol and triglycerides) for the entire study group. Data are shown as mean, rank (min-max) and median values.
Regarding gender, male subjects had significantly higher waist circumference, significantly higher systolic blood pressure, significantly higher blood glucose values, significantly lower HDL cholesterol and significantly lower triglycerides in relation to female respondents. No statistically significant difference was registered between genders in terms of total cholesterol values (p=0.09) (Table 2).

Table 2. Components of MetS in subjects of both genders

Gender	Statistical parameter			
	n	mean ± SD	min- max	p-value
		Waist circumference		
female	261	86.8 ± 13.1	59 – 129	t=13.5
male	276	101.2 ± 11.7	59 – 133	***p=0.0000
		Blood pressure		
female	261	116.8 ± 19.3	70 – 210	Z=8.1
male	276	131.6 ± 19.7	90 – 195	***p=0.0000
		Glycemia		
female	261	5 ± 1.1	3.2 – 16.4	Z=3.4
male	276	5.2 ± 0.9	3 – 11.3	***p=0.0007
		Total cholesterol		
female	261	5.1 ± 1	2.7 – 8.5	t=1.7
male	276	5.2 ± 1	1.4 – 8.6	p=0.09
		HDL cholesterol		
female	261	1.5 ± 0.4	0.6 – 2.8	Z=9.4
male	276	1.2 ± 0.5	0.1 – 7.6	***p=0.0000
		Triglycerides		
female	261	1.2 ± 0.7	0.4 – 4.7	Z=7.15
male	276	1.7 ± 0.9	0.3 – 7.1	***p=0.0000

Regarding age, a significant correlation was registered between age of the participants and waist circumference (p<0.0001), blood pressure (p<0.0001), glycemia (p<0.0001), total cholesterol (p<0.0001) and triglycerides (p<0.0001), while the correlation with HDL cholesterol level was not statistically significant (p=0.52) (Table 3).

Table 3. Correlations between age and values of waist circumference, blood pressure, glycemia and lipid status

	Correlations			
Age	N	Spearman R	Pearson r	p – вредност
Waist circumference	537		0.2818	***0.0000
Blood pressure	537	0.5011		***0.0000
Glycemia	537	0.3094		***0.0000
Triglycerides	537	0.2765		***0.0000
Total cholesterol	537		0.3621	***0.0000
HDL cholesterol	537		-0.0276	0.523

Subjects from the older age group had significantly higher waist circumference (p<0.0001), significantly higher blood pressure (p<0.0001), significantly higher blood glucose values (p=0.000002), significantly higher total cholesterol (p<0.0001) and significantly higher values of triglycerides in the blood (p<0.0001), in relation to participants younger than 45 years (Table 4).

Regarding occupation, participants from the four groups of occupations differed significantly in terms of the values of waist circumference, blood pressure, glycemia, HDL cholesterol and triglycerides (Table 5). The overall statistically significant difference was p=0.0006 for waist circumference, p<0.0001 for blood pressure and glycemia, p=0.01 for HDL cholesterol and p=0.0085 for triglycerides.

With the post-hoc analysis for intergroup comparisons, the following significant differences were obtained: subjects from Group 2 had a significantly larger waist circumference than participants from Group 3 (p= 0.001) and Group 4 (p=0.007); participants from Group 4 had significantly lower blood pressure than those in Group 1 (p=0.003) and Group 2 (p=0.000001), while participants from Group 1 had significantly higher glycemia than subjects from Group 2 (p <0.0001), Group 3 (p=0.0032) and Group 4 (p<0.0001).

Table 4. Waist circumference, blood pressure, glycemia and lipid status in participants younger and older than 45 years

Age	statistical parameter				p-value
	n	**mean ± SD**	**min- max**	**median (IQR)**	
			Waist circumference		
≤45	273	90.1 ± 14	59 – 128	89 (80 – 100)	t=6.9
>45	264	98.4 ± 13.4	67 – 133	100 (89 – 107)	***p=0.0000
			Blood pressure		
≤45	273	115 ± 17.4	70 – 170	115 (100 – 125)	Z=10.6
>45	264	133.9 ± 19.7	90 – 210	135 (120 – 147.5)	***p=0.0000
			Glycemia		
≤45	273	4.9 ± 0.9	3 – 16	4.8 (4.5 – 5.2)	Z=5.5
>45	264	5.3 ± 1.1	3.2 – 11.3	5.2 (4.7 – 5.7)	***p=0.000002
			Total cholesterol		
≤45	273	4.8 ± 0.9	1.4 – 7.8	4.8 (4.2 – 5.5)	t=7.1
>45	264	5.5 ± 1	2.5 – 8.6	5.3 (4.7 – 6.2)	***p=0.0000
			HDL cholesterol		
≤45	273	1.4 ± 0.5	0.6 – 7.6	1.3 (1.1 – 1.6)	t=0.16
>45	264	1.3 ± 0.4	0.1 – 2.8	1.3 (1 – 1.5)	p=0.87
			Triglycerides		
≤45	273	1.3 ± 0.8	0.3 – 5.5	1.1 (0.8 – 1.6)	Z=5.7
>45	264	1.7 ± 0.9	0.4 – 7.1	1.5 (1 – 1.9)	***p=0.0000

t (Student t-test), Z (Mann-Whitney test)
***sig p<0.0001

Table 5. Values of waist circumference, blood pressure, glycemia and lipid status in the four groups of occupations

Group of occupations	statistical parameter				p-value
	n	**mean ± SD**	**min- max**	**median (IQR)**	
			Waist circumference		
Group 1	58	95.7 ± 12.6	70 – 121	96.5 (85 – 104)	F=5.8
Group 2	155	97.6 ± 14.1	62 – 130	98 (87 – 107)	***p=0.0006
Group 3	77	90.3 ± 12.6	68 – 133	90 (81 – 96)	2 *vs.*3 p=0.001
Group 4	247	92.9 ± 14.9	59 – 129	92 (80 – 106)	2 *vs.* 4 p=0.007
			Blood pressure		
Group 1	58	130.2 ± 21.6	80 – 180	127.5 (115 – 145)	H=32.4 ***p=0.0000
Group 2	155	129.6 ± 18.9	70 – 195	130 (120 – 140)	1 *vs.* 4 p=0.003 2 *vs.* 4
Group 3	77	124.2 ± 20.2	90 – 180	120 (110 – 140)	p=0.000001
Group 4	247	119.6 ± 20.9	70 – 210	118 (105 – 130)	
			Glycemia		
Group 1	58	5.9 ± 1.3	4.2 – 11.3	5.6 (5.2 – 6.4)	H=44.6

Group 2	155	5.1 ± 1.4	3.2 – 16.4	4.9 (4.4 – 5.4)	***p=0.0000
Group 3	77	5.2 ± 0.7	3.8 – 7.4	5.1 (4.7 – 5.6)	1 *vs.* 2 p=0.0000
Group 4	247	4.9 ± 0.7	3 – 8.8	4.9 (4.6 – 5.3)	1 *vs.* 3 p=0.0032 1 *vs.* 4 p=0.000000
			Total cholesterol		
Group 1	58	5 ± 1.1	2.5 – 7.6	5 (4.1 – 5.7)	F=0.88 p=0.45
Group 2	155	5.1 ± 1.1	2.7 – 8.5	5.1 (4.3 – 5.8)	
Group 3	77	5.3 ± 1.1	2.7 – 7.9	5.2 (4.6 – 6.2)	
Group 4	247	5.2 ± 0.9	1.4 – 8.6	5 (4.6 – 5.7)	
			HDL cholesterol		
Group 1	58	1.2 ± 0.4	0.6 – 2.7	1.2 (0.9 – 1.4)	H=11.2 *p=0.01
Group 2	155	1.3 ± 0.4	0.6 – 2.6	1.3 (1.1 – 1.5)	1 *vs.* 3 p=0.024
Group 3	77	1.4 ± 0.4	0.1 – 2.8	1.4 (1.1 – 1.6)	
Group 4	247	1.4 ± 0.6	0.5 – 7.6	1.3 (1 – 1.7)	
			Triglycerides		
Group 1	58	1.6 ± 0.9	0.4 – 5	1.4 (0.2 – 1.9)	H=11.7
Group 2	155	1.6 ± 0.8	0.3 – 4.7	1.4 (0.9 – 2)	**p=0.0085
Group 3	77	1.4 ± 0.9	0.4 – 6.2	1.2 (0.8 – 1.7)	2 *vs.* 4 p=0.013
Group 4	247	1.4 ± 0.9	0.4 – 7.1	1.1 (0.9 – 1.7)	

F (Analysis of Variance), H (Kruskal-Wallis test), *sig p<0.05, **sig p<0.01, ***sig p<0.0001

Figures 2 and 3 show the average values of waist circumference, as well as the median of blood pressure for the different groups of occupations.

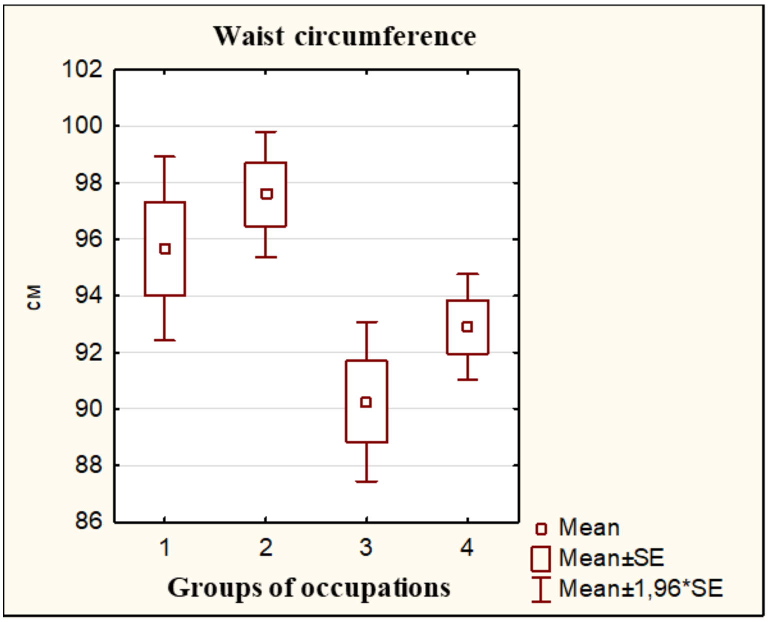

Fig. 2. Average value of waist circumference in different groups of occupations

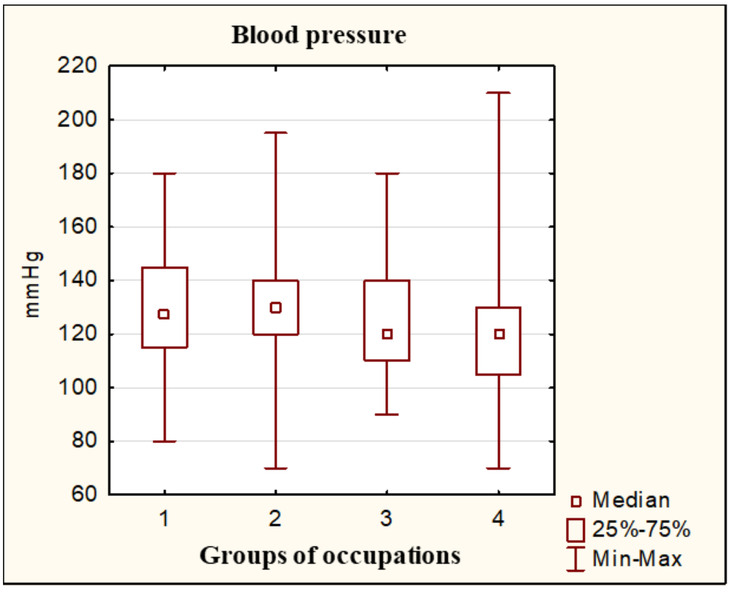

Fig. 3. Average value of blood pressure in different groups of occupations

In the entire examined group, the frequency of MetS, detected according to the previously mentioned criteria, among all respondents was 31.5% (Figure 4).

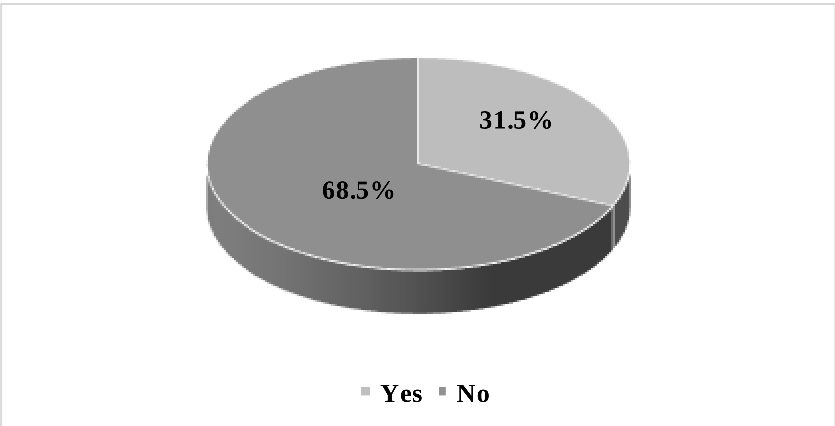

Fig. 4. Frequency of MetS among all participants

The frequency of MetS was significantly higher in male participants ($p<0.0001$) and participants older than 45 years ($p<0.0001$). Also, a statistically significant difference was registered in the frequency of MetS in the different groups of occupations ($p=0.006$), i.e. a higher frequency of MetS was registered in Group 1 (36.2%) and Group 2 (41.3%), and a lower in Group 3 (23.4%) and Group 4 (26.7%). The difference in the frequency of MetS among participants with predominantly manual activities at the workplace, i.e. heavy and medium heavy physical work (Groups 1 and 2) was significantly higher compared to participants with light and sedentary work at their workplace (Groups 3 and 4) ($p=0.0064$) (Table 6).

Table 6. Frequency of MetS according to gender, age and groups of occupations

Variable		N	MetS No n (%)	MetS Yes n (%)	p-value
Gender	female	261	208 (79.7)	53 (20.3)	X^2=29.35
	male	276	160 (58)	116 (42)	***p=0.0000
Age	≤45	273	225 (82.4)	48 (17.6)	X^2=49.67
	>45	264	143 (54.2)	121 (45.8)	***p=0.0000
Groups of occupations	Group 1	58	37 (63.8)	21 (36.2)	X^2=12.4
	Group 2	155	91 (58.7)	64 (41.3)	**p=0.006
	Group 3	77	59 (76.6)	18 (23.4)	
	Group 4	247	181 (73.3)	66 (26.7)	
Groups of occupations	Group 1+2	213	128 (60.1)	85 (39.9)	X^2=11.65 **p=0.0064
	Group 3+4	324	240 (74.1)	84 (25.9)	

X^2 (Chi-square test)
**sig p<0.01, ***sig p<0.0001

Discussion

According to the NCEP ATP-III criteria, MetS represents a cluster of conditions that include central obesity, hypertension, hyperglycemia, hypertriglyceridemia, and reduced HDL cholesterol, which are associated with the development of type 2 diabetes mellitus and cardiovascular disease [2].

Worldwide, the prevalence of MetS ranges from <10% to as high as 84%, depending on the region, environment (urban or rural), demographic characteristics of the study population (gender, age, race and ethnicity) and the criteria applied in the research. According to data from numerous studies from different countries, the frequency of MetS increases with age, and in terms of gender, some researchers report a higher frequency in men than in women, while other authors provide data with a higher frequency of MetS in women[18].

In recent years, several studies have focused on the connection of MetS with the characteristics of work activities, the specifics of the occupation, as well as the determinants of the work process, giving importance to work in the development of MetS as a significant factor in the occurrence of cardiometabolic diseases among workers from different economic sectors[12].

Having all this in mind, this study was conducted to determine the frequency and characteristics of MetS and its components among the active working population in our country, in relation to certain sociodemographic factors such as gender, age and defined groups of occupations.

In all 537 subjects in our study, the components of MetS were determined according to the NCEP ATP-III criteria and the mean values of all determined parameters were within the reference values.

Regarding gender, in our study, male subjects had significantly higher waist circumference, higher systolic blood pressure, higher blood glucose values, lower HDL cholesterol and higher triglycerides than female subjects.

In studies from different countries in the world, data on the components of MetS in terms of gender predominance vary, depending on several factors that can influence the results, such as, age, socioeconomic status and unhealthy lifestyle habits (e.g. unhealthy diet, smoking, physical inactivity).

Thus, in the Spanish study on 7256 workers, similar results were obtained as in our study, where all components of MetS, except HDL, had significantly higher values in male than in female respondents[19].

In the Canadian study by Riediger and Clara, on a representative sample of the general population, in terms of components of MetS, a greater waist circumference was present in women than in men, while significantly higher values of glycemia and triglycerides were registered in men[20].

The study by Nouri-Keshtkar *et al*., on 10,138 farmers in Iran, in 2023, showed that in women with MetS, increased waist circumference and hypertension were present more often, while in men, in addition to waist circumference, hyperglycemia and increased values of triglycerides existed[21]. Similar results were obtained in the Brazilian study by Pereira *et al.*[12].

Regarding age, in the current study, a significant correlation was registered between the age of subjects and the waist circumference, the values of blood pressure, glycemia, total cholesterol and triglycerides, while the correlation with the level of HDL cholesterol was not significant. In the older age group, participants older than 45 years, a statistically significant difference was determined - larger waist circumference, higher blood pressure, higher blood glucose values, higher total cholesterol and higher blood triglyceride compared to the younger participants, aged 45 years and under.

The results of numerous studies support the results obtained in the current study, confirming the fact that the risk of impaired values of the MetS components increases with age.

Thus, in a study on the incidence of MetS and its components, conducted in over 30,000 workers from the north of the Netherlands aged 45-65 years, similar results were obtained. These results were estimated to be caused by an unhealthy lifestyle (diet quality, physical inactivity, alcohol use and smoking), which accumulates negative effects on the body over the years[22].

Alegría *et al*., in the already mentioned study on MetS in the Spanish working population, indicated an increase in the mean values of MetS components with age[19].

This is similar to the results of an extensive European study from 2014 - MOnica, Risk, Genetics, Archiving and Monograph (MORGAM) - Project, conducted on about 70,000 subjects, represented by 36 cohorts from 10 European countries. In this study, using the NCEP-ATP III criteria, the components of MetS were defined, and to assess the influence of age on the prevalence of MetS and components, separate analyses were made for men and women in different age groups: 19-39 years, 40-49 years, 50-59 years and 60-78 years. For both genders, the mean values (median) of basic metabolic risk factors, as well as the frequency of individual components of MetS, except HDL and triglycerides in men, increased with age ($p < 0.0001$)[23].

According to the current classification of occupations of the ILO, in the present study, participants were divided into four groups (Group 1, 2, 3 and 4). According to the level of physical work at the workplace, participants from Group 1 and 2 perform heavy and medium heavy physical work, while participants from Group 3 and 4 perform light and sedentary work. According to the results obtained, the average values of the components of MetS - waist circumference, blood pressure value, glycemia and triglycerides were highest among subjects from Groups 1 and 2; the average values of total cholesterol were similar among subjects from all four groups of occupations, while the average values of HDL cholesterol were lowest in Groups 1 and 2.

It should be emphasized that the results of several studies indicate increased values of total cholesterol and decreased values of HDL cholesterol in different groups of workers. Thus, according to research results of Mohamed *et al.* in construction workers from Senegal with an average age of 45 years, increased values of total cholesterol or decreased values of HDL cholesterol were registered in more than 50% of respondents[24].

Increased values of total cholesterol were recorded in 41.3% of construction workers in Ireland[25], as well as in 24.3% of workers in the oil and gas industry in Italy in a study by Manocchi *et al.*[26].

Research conducted among different groups of workers in R.N. Macedonia provide data on separate components of MetS. Thus, hypertension diagnosed by a doctor was determined in 15.6% of construction workers and in 44.3% of textile workers, hypercholesterolemia in more than 35% of construction workers and workers who work in the production of chemical materials for construction, and increased values of the body mass index was determined among electricians, textile and administrative workers[14].

According to the NCEP ATP-III criteria, in the current study, MetS was detected in 31.5% of all participants (N=169/537). The frequency of the present MetS was statistically significantly higher in male respondents and respondents older than 45 years. Also, a statistically significant difference was registered in the frequency of MetS in the separate groups of occupations, that is, a higher frequency of MetS was registered in Group 1 and Group 2, and lower in Group 3 and Group 4. The difference in the frequency of MetS among participants with predominantly manual activities at the workplace, i.e. heavy and medium heavy physical work (Groups 1 and 2) was statistically significantly higher compared to participants doing light physical and sedentary work at the workplace (Groups 3 and 4).

The frequency of MetS in the working population is different in different countries of the world.

Thus, in South Korea, the prevalence of MetS among the working population was 23%, and the frequency was twice as high in men than in women[27].

Among Iranian health workers, MetS frequency was 22.4 %[28]. The prospective study by Mini *et al*., conducted in India among 2287 industrial workers, determined a frequency of MetS of 27%[9], while in another Indian study conducted in an urban industrial population, the prevalence was as high as 51.4%[29].

On the other hand, in a study conducted in the German automotive industry on 27,359 workers, the prevalence was only 11.7%[11].

Among employees in the IT industry in Taiwan, a frequency of MetS of around 8% was registered (significantly higher in men than in women)[16], and similar results were obtained in the already mentioned Spanish study by Alegría *et al.*[19].

A cross-sectional study in the USA reported a frequency of MetS of around 30% in industrial manufacturing workers, which is in agreement with our results[30].

In all these studies, men have a higher frequency of MetS than women, which coincides with the results of our study, but in some studies opposite results have been registered, i.e. a higher frequency of MetS among female respondents, such as in the Korean study by Cho Zoun *et al*. [31] and the Brazilian study by Pereira *et al.*[12].

All mentioned studies, including ours, but also many others, confirm the association between MetS prevalence and age. These results indicate that the risk of MetS increases with age[19,22].

The most drastic example of this is the Canadian study conducted on the general population, where age was found to be the strongest predictor of MetS: 6.5% of study participants aged 18-39 had MetS, compared to 39% of those aged 70-79 years[20].

The frequency of MetS in different groups of occupations deserves special attention. As it was pointed out in our study, the frequency of MetS among respondents with predominantly manual activities at the workplace, i.e. heavy and medium heavy physical work was statistically significantly higher compared to respondents with light physical and sedentary work at the workplace.

The results of the Spanish study coincide with our results, that is, the frequency of MetS was statistically significantly higher among manual workers compared to office workers and managers[19].

Similarly, in the study by Runge *et al*., low-skilled workers had the highest risk of developing MetS, with the authors pointing to an inappropriate lifestyle as the main reason for this phenomenon[22].

In a Nigerian study from 2017, MetS was more common among auto mechanics than among teachers (19.3% *vs.* 7.2%), with the authors citing workplace conditions and occupational exposure to chemical hazards as contributing factors to the development of MetS[33].

Strauss *et al*., in a systematic review of the literature (for the period January 2005-February 2022) on the prevalence of MetS in different groups of occupations and the possible influence of work on the occurrence of MetS, selected 10 studies from different countries in the world, which showed that MetS was the main health risk in all included groups of occupations categorized according to the statistical category of economic activities in the European Community[33].

The highest prevalence of MetS was determined among Korean workers (among women engaged in agriculture and fishing (39.2%) and among men in production and maintenance of machines (35.3%)). These values are similar to the registered frequency of MetS in the current study. The lowest prevalence of MetS in the same study was registered among men working in the IT sector in the Netherlands (6.2%) and among Spanish women working in service activities (5.9%).

In the study by Davila *et al.,* conducted on a representative sample of workers from the USA, the highest frequency of MetS was observed among transport workers, loading-unloading workers, service workers, and the lowest among engineers, scientists, executive and administrative professionals, similarly as in our study[8].

The impact of work and work activities on the occurrence of MetS can be traced through several dimensions of work engagement which are gaining importance today, and which should direct us towards new steps in our future research.

Thus, in the study by Santana *et al*., from 2020, through a systematic literature review, the relationship between work characteristics (workplace organization, job tasks, exposure to certain occupational hazards and dangers, etc.) and the occurrence of MetS in different groups of occupations was evaluated and shift work, night work and stress at work stand out as risk factors[34].

Shift work has been mentioned in recent years as a specific health challenge among workers, and research show a connection with disturbances of the circadian rhythm and the occurrence of atherosclerosis, which together can increase the risk of cardiovascular diseases. This coincides with the results of an American study, which indicate that shift work is associated with an increased frequency of carotid artery changes and progression of atherosclerosis. The results of this study suggest that shift work should be added to the list of known risk factors for CVD, such as hypertension, diabetes, and sedentary lifestyle[35].

Based on all this, it can be concluded that despite extensive research in this domain, it is necessary to conduct more randomized controlled trials. In addition, different definitions and criteria for determining the occurrence of MetS complicate accurate comparison between studies, which highlights the need to reach consensus on a universal definition of MetS in such population studies[33].

However, several factors that influence the frequency of MetS among workers remain to be discussed, such as the characteristics of the working population, the specifics of the sector and activity, the type of work, the level of education, gender and age structure of the population, the availability of health services, lifestyle, etc. This opens up space for further scientific research activities to determine and monitor MetS among the working population in our environment.

Conclusion

The results obtained in our study indicate the seriousness of the problem of MetS present in more than one third of the examined workers, especially with the risk of developing type 2 diabetes and CVD. The frequency of MetS and its components was highest among male and older workers and in workers with predominantly manual activities at the workplace, i.e. heavy and medium-heavy physical work, compared to workers engaged in light physical and sedentary work.

Accordingly, the results of this study could directly influence on the strengthening of positive effects in the prevention, timely treatment and control of the main cardiometabolic risk factors, as well as increasing the awareness of workers and employers about the possible effects and consequences on their health and work ability. Hence, a task is imposed on occupational health specialists to implement health promotion programs and public health preventive interventions to help individuals improve their health and receive appropriate health screenings and medical care in the interest of better health for all workers.

Conflict of interest statement. The authors declare no conflict of interest.

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