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Metabolic Syndrome among the Inhabitants of the Island of Cres

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A B S T R A C T

Metabolic syndrome presents a significant public health problem today, in Croatia as well as the rest of the world, considering the fact that the World Health Organization classifies its diagnostic criteria, such as high blood pressure and obesity, among ten major risk factors for health. The research of the prevalence of metabolic syndrome among the inhabitants of the island of Cres included a total of 385 adult subjects, 249 women and 136 men. The incidence of metabolic syndrome in two subpopulations of the inhabitants: the inhabitants of the town of Cres (urban population) and the inhabitants of other settlements (rural population), was analysed. The incidence of metabolic syndrome among the inhabitants of the island of Cres was determined according to definitions of the WHO (World Health Organization) and the NCEP--ATP III program (National Cholesterol Education Program – Third Adult Treatment Panel III). It was established that the overall prevalence of metabolic syndrome on the island of Cres was 14% according to the WHO definition (20.6% in men and 10.4% in women) and 24.9% according to the NCEP-ATP III definition (33.1% in men and 20.5% in women). The study also showed that the prevalence of risk factors for developing metabolic syndrome and complex diseases was much higher among the subjects from other settlements than among the subjects from the town of Cres, a consequence of age and a lifestyle with lack of physical activity.

***Key words**: metabolic syndrome, island of Cres, WHO, NCEP-ATP III, prevalence*

Introduction

Metabolic syndrome is a condition where a group of metabolic disorders such as abdominal obesity, low concentration of high density lipoproteins, elevated concentration of triglycerides, high blood pressure and hyperglycaemia, occur together[1]. Individuals with metabolic syndrome more often than healthy individuals develop cardiovascular disease and type 2 diabetes. For these reasons, and also due to its increasing prevalence not only in developed but also in developing countries, metabolic syndrome presents very serious public health problem in the 21st century[2]. In developed European countries and USA, the prevalence of metabolic syndrome accounts for one third of adult population[3–6].

Environmental factors such as unhealthy diet, tobacco use, sedentary lifestyle, hereditary and many other factors, interreacting mutually, have impact on the development of the disease[2,7]. Still, obesity, especially the abdominal type, is considered to be the primary risk factor for developing metabolic syndrome[8,9].

Today, there are number of definitions and classifications of metabolic syndrome[1]. In our research, we applied the definitions of the WHO (World Health Organization) and the NCEP program (National Cholesterol Education Program – Third Adult Treatment Panel III), but it should be mentioned that, when applying the definition of metabolic syndrome according to WHO, fasting blood sugar concentrations above 6.1 mmol/L or type 2 diabetes were taken as an obligatory criterion.

The majority of prospective cohort studies conducted in European countries and USA, included in meta-analyses, established the prevalence of metabolic syndrome, according to the NCEP-ATP III definition, which in general population ranged from 23% to 46%, with different shares of risk factors for cardiovascular disease[10].

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The increasing prevalence of metabolic syndrome around the world is undoubtedly the consequence of the global epidemic of obesity[11,12] and the fact that the prevalence of metabolic syndrome is on the increase among children and adolescents is also concerning[13].

The lowest prevalence of metabolic syndrome was registered in Japan and, according to the WHO definition, amounted to 3.4% for men and 2.5% for women, according to the NCEP definition 8.1% for men and 9.9% for women, and according to the IDF definition 7.5% for men and 11.3% for women[14.]

Studies of the prevalence of metabolic syndrome in Croatia, although not abundant, surely deserve attention. The studies by Kolčić, Vuletić, Marković, Deka, Tucak-Zorić et al. are particularly significant. Thus Kolčić et al. investigated the prevalence of metabolic syndrome on the Adriatic islands: Rab, Vis, Lastovo, Mljet[15].

The prevalence of metabolic syndrome among the adult population of Adriatic islands was 34% (25% in the town of Rab and 52% on the Mljet Island). In the research, the NCEP definition was applied and a BMI ≥30 kg/m^2 was taken as the obesity criterion. Higher prevalence of metabolic syndrome was registered in women (39%) than in men (28%).

On the island of Vis, the prevalence of 34% was registered in the town of Vis and of 33% in Komiža, whereas on the Lastovo Island the prevalence was 30%. Regarding the presence of the components of metabolic syndrome in this meta-population study, low concentration of HDL cholesterol was most common (72%), followed by increased arterial pressure (60%), whereas the other components were present with less than 30%[15].

In the research of the prevalence of metabolic syndrome among the population of the island of Hvar according to the NCEP criteria (BMI as obesity criterion was taken as a predictor) the prevalence was 26% in the overall population (32% in men and 24% in women). When waist-to-hip ratio was taken as a predictor, the prevalence of metabolic syndrome was higher, amounting to 42% (57% in men and 36% in women) in overall population[16].

Very significant was a study conducted on a sample from the mainland Croatia, including Croats, Hungarians and Serbs from the Baranja region. Despite the fact that, contrary to previously studied island populations, the inhabitants in this part of Croatia were not reproductively isolated, and were also ethnically heterogeneous, it was determined that lifestyles in both parts of Croatia were similar, which also had an effect on similar incidence of metabolic syndrome and its high overall prevalence. According to the WHO criteria, the incidence in men was 26% and in women 38%, whereas according to the NCEP criteria, the prevalence in men amounted to no less than 84% and in women to 71%[17].

TABLE 1
THE GROUP DISTRIBUTION OF EXAMINEES

Domicile	N	%
Town of Cres	201	(52.2)
Other settlements	184	(47.8)
Total	385	(100.0)

Sample and Methods

Aim of research

The island of Cres, together with islands of Krk, Mali Lošinj and Rab, falls into the group of Northern Adriatic islands. It covers a surface of 405.78 km^2, with the coast of 247.7 km, which makes it the largest Adriatic island. According to the census of 2001, the island of Cres has 3.184 inhabitants and the population density of 8.6 inhabitants *per* km^2 [18]. The biggest settlement, and also the main administrative centre, is the town of Cres with 2.333 inhabitants, which accounts for 73.3% of the total Island's population.

Despite its geographical vicinity to the mainland, the island of Cres has kept all the characteristics of an island isolate, not only in geographical, but also in socio-cultural sense. Like the majority of Adriatic islands, it has undergone a large emigrant wave in the last century that up to present day was not accompanied by a parallel influx of settlers. Although in the middle of the last century the island of Cres was left by nearly two thirds of its inhabitants, compared to the other densely populated Adriatic islands, it has one of the highest rates of the autochthonous population share in the total number of inhabitants[19].

Methods and subjects

Our research is a cross-sectional study on a sample of adult inhabitants of the island of Cres. Prior to the beginning of the research, the inhabitants of Cres were informed about and invited to take part in the research by their chosen primary health care practitioners, municipal authorities, community offices, parish offices and public media. Few days before the beginning of the research, subjects had the opportunity to get written and oral instructions on type, procedures and scope of the foreseen tests in the office of chosen practitioner. Subjects who agreed to participate were administered a questionnaire containing genealogical data, which they had to complete and bring along in order to enter the research. When they were handed over the materials, subjects were given instructions on the required conduct and diet before taking part in the research. The research included 385 subjects, 201 from the town of Cres region and 184 inhabitants of the neighbouring settlements (Table 1).

The research was conducted during the November and December 2007. It took place in primary health care offices of the Health Centre Mali Lošinj of Primorsko-Goranska County in Cres, Martinščica and in the premises specially arranged and equipped for this research in community offices in Orlec, Beli, Osor and Valun. Data collecting, completing of questionnaires, anthropometric

measurements and blood sampling were carried out by highly educated health care and scientific staff of the Rijeka School of Medicine, Health Centre of Primorsko-Goranska County, Institute for Anthropological Research – Zagreb and Clinical Hospital Centre Rijeka.

Distribution of inhabitants according to domicile and gender is shown in Figure 1.

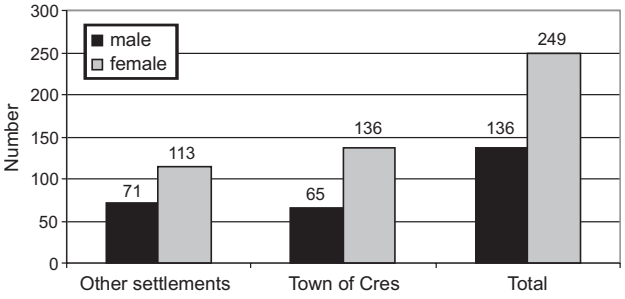

Fig. 1. Distribution of inhabitants according to domicile and gender.

At arrival, in the morning hours, blood samples were taken from subjects for biochemical tests. After the blood sampling, anthropometric measurements were performed, blood pressure was measured and detailed anamnestic data on chronic and previous diseases were collected.

Biochemical tests were performed using standard laboratory methods in biochemical laboratory of the Clinical Hospital Centre in Rijeka and in haematological-biochemical laboratory of the Health Centre of Primorje-Gorski kotar County in Mali Lošinj. Biochemical tests including: fasting blood glucose (FBG), total cholesterol, LDL cholesterol, HDL cholesterol and triglycerides were done. Subjects had increased values of biochemical parameters if their levels of fasting glucose were above 6.1 mmol/L, of total cholesterol above 5.2 mmol/L, LDL cholesterol above 4.1 mmol/L, HDL cholesterol in men below 0.9 mmol/L, in women below 1.0 mmol/L and serum triglycerides above 1.7 mmol/L.

Metabolic syndrome was defined according to the WHO diagnostic criteria (27) and the NCEP-ATP III definition[20].

Anthropometric measurements were performed using standard techniques and guidelines of the Institute for Anthropological Research[21–23]. The following anthropometric measures were included in the analysis: height, body weight, waist and hip circumference. Body mass index (BMI) measure was derived from anthropometric variables of body height and weight, and waist-to-hip ratio measure was derived from anthropometric variables of waist and hip circumference. According to BMI, subjects were classified in three groups: normal (BMI up to 25 kg/m^2), overweight (BMI 25–30 (kg/m^2) and obese (BMI >30 (kg/m^2) (27.29). Waist circumference, as a predictor of abdominal (or central) obesity, was categorised as increased if it exceeded 102 cm in men and 88 cm in women. Waist-to-hip ratio variable was derived from anthropometric measures of waist and hip circumference. Waist-to-hip ratio was categorised as increased if it was 0.9 and higher in men and 0.85 and higher in women.

Two arterial blood pressure measurements were performed at an interval of five minutes. In both instances the systolic and diastolic blood pressures were recorded. Measurements of arterial pressure were performed using a mercury manometer and adjusted cuff. Subjects had first measurement of arterial blood pressure after sitting for ten minutes in a quiet room.

Statistical data processing

Statistical analysis covered a description of all variables included in the research. Quantitative variables were represented by distributions of absolute and relative frequencies. Depending on data distribution, continuous variables were represented by arithmetic mean and standard deviation or median and interquartile range.

Numerical variables were tested for normality of distribution using the Kolmogorov-Smirnov test. To test the differences between the groups of numerical variables, parametric tests (t-test, ANOVA...) were used in the case of normal distribution, and non-parametric tests (Mann-Whitney U or Kruskal-Walis) in the case of deviation from normal distribution. Distributions were presented using graphs and tables.

For the comparison of nominal categorical variables, χ^2-test and Fisher's exact test were used. For the comparison of ordinal categorical variables, Mann-Whitney U or Kruskal-Wallis test were used.

For the associations between nominal output variables, multiple logistic regression was used, by which adjusted odds ratios were calculated. For the associations between numerical variables, parametric and non-parametric coefficients of correlation were used (Pearson or Spearman test). The level of statistical significance for this research was determined as α=0.05. Data processing was performed using program package Stata ver 11.

Results

Gender and age are known to be significant factors for the development of a number of chronic diseases. Therefore, pursuant to the objectives of this research, we performed the analysis of the aforementioned demographic parameters for the inhabitants of the town of Cres, neighbouring settlements and overall analysed population.

The analysis of age structure showed the existence of an age difference between the subjects from the town of Cres and other settlements. The results of the Kolmogorov-Smirnov test showed that the age was not distributed according to normal distribution (p=0.014).

Median age value for the subjects from the town of Cres was 52 years compared to 65 years in the neighbouring settlements (Table 2).

Non-parametric Mann-Whitney U-test showed the existence of a statistically significant difference in the median age with regard to domicile ($p<0.001$), and that the inhabitants of the town of Cres were statistically significantly younger than the inhabitants of other settlements.

A statistically significant age difference was found in both sexes. Median age value for the male subjects from the town of Cres was 53 compared to 65 found in subjects from other settlements ($p<0.001$). Similar situation was observed also in female subjects where median values were 52 and 65 years ($p<0.001$).

The prevalence of metabolic syndrome according to the definition of World Health Organisation (WHO)

According to the definition of World Health Organisation, metabolic syndrome, beside diabetes, glucose intolerance and insulin resistance, includes a presence of two more of the following criteria: abdominal or central obesity (waist-to-hip ratio) and/or body mass index, high blood pressure (or pressure under therapy), dyslipidemia (elevated triglyceride concentrations or low HDL serum concentrations) and microalbuminuria.

Out of a total of 385 subjects from the island of Cres, 54 (14.0%) met the criteria for metabolic syndrome according to the WHO definition (Table 3).

The analysis confirmed the diagnosis of metabolic syndrome according to the WHO criteria in 28 men (20.6%) and 26 women (10.4%) (Table 4).

Fisher's exact test established the existence of a statistically significant link between metabolic syndrome according to WHO and gender ($p=0.009$): metabolic syndrome occurred more often in male population (20.6%) than in female (10.4%).

Out of a total of 75 subjects with diagnosed diabetes and elevated blood glucose levels, 54 were diagnosed with metabolic syndrome. Metabolic syndrome, according to the WHO definition, was more present among the subjects from neighbouring settlements (19.2%) than among the subjects from the town of Cres (9.4%) (Table 5).

Fisher's exact test established a statically significant link between metabolic syndrome according to WHO and domicile ($p=0.008$).

TABLE 2
MEDIAN AGE VALUE OF THE EXAMINEES

Group	$\overline{X}$	SD	Median	$Q_1 - Q_3$	N	p
Town of Cres	51.95	15.8928	52.0	40.0–65.0	200	<0.001
Other settlements	61.97	17.2393	65.0	48.0–75.0	180	
Total	56.70	17.2646	55.0	42.0–70.3	380	

TABLE 3
THE FREQUENCY OF DIAGNOSTIC CRITERIA FOR THE EVALUATION OF METABOLIC SYNDROME ACCORDING TO WHO DEFINITION

Diagnostic criteria		No		Yes		Missing		Total	
		N	(%)	N	(%)	N	(%)	N	(%)
Diabetes	Previously diagnosed	351	(91.1)	33	(8.6)	1	(0.3)	385	(100.0)
	Blood glucose >6.1 mmol/L	309	(80.3)	67	(17.4)	9	(2.3)	385	(100.0)
	Previously diagnosed and/or >6.1 mmol/L	310	(80.5)	75	(19.5)			385	(100.0)
Obesity	BMI >30 kg/m^2	281	(73.0)	102	(26.5)	2	(0.5)	385	(100.0)
	Waist-to-hip ratio >0.9 male; >0.85 female	88	(22.9)	292	(75.8)	5	(1.3)	385	(100.0)
	BMI >30 kg/m^2 and/or waist-to-hip ratio >0.9 male; >0.85 female	85	(22.1)	300	(77.9)				
Dyslipidemia	Triglycerides >1.7 mmol/L	303	(78.7)	82	(21.3)	0	(0.0)	385	(100.0)
	HDL <0.9 mmol/L male or <1.0 mmol/L female	381	(99.0)	4	(1.0)	0	(0.0)	385	(100.0)
	Triglycerides >1.7 mmol/L and/or HDL <0.9 mmol/L male or <1.0 mmol/L female	302	(78.4)	83	(21.6)			385	(100.0)
Elevated blood pressure	≥ 140/90 mmHg	281	(73.0)	104	(27.0)	0	(0.0)	385	(100.0)
	Previously diagnosed	254	(66.0)	130	(33.7)	1	(0.3)	385	(100.0)
	≥ 140/90 mmHg measured or previously diagnosed	212	(55.1)	173	(44.9)			385	(100.0)

TABLE 4
METABOLIC SYNDROME ACCORDING TO THE WHO CRITERIA AND GENDER

Metabolic syndrome according WHO criteria	Gender				Total	
	male		female			
	N	(%)	N	(%)	N	(%)
No	108	(79.4)	223	(89.6)	331	(86.0)
Yes	28	(20.6)	26	(10.4)	54	(14.0)
Total	136	(100.0)	249	(100.0)	385	(100.0)

TABLE 5
METABOLIC SYNDROME ACCORDING WHO CRITERIA AND DOMICILE

Metabolic syndrome according WHO criteria	Domicile				Total	
	Town of Cres		Other settlements			
	N	(%)	N	(%)	N	(%)
No	184	(90.6)	147	(80.8)	331	(86.0)
Yes	19	(9.4)	35	(19.2)	54	(14.0)
Total	203	(100.0)	182	(100.0)	385	(100.0)

TABLE 6
THE RESULTS OF LOGISTIC REGRESSION FOR THE PREDICTION OF METABOLIC SYNDROME FROM CHRONIC DISEASES

Chronic disease		Metabolic syndrome according WHO						Logistic regression				
		No		Yes		Total					95.0% IP for OR	
		N	(%)	N	(%)	N	(%)	Reference values	p	OR	Upper limit	Lower limit
Elevated blood pressure (previously diagnosed or measured)	No	207	(97.6)	5	(2.4)	212	(100.0)	1	<0.001	16.895	5.049	56.543
	Yes	124	(71.7)	49	(28.3)	173	(100.0)					
Coronary disease	No	286	(90.8)	29	(9.2)	315	(100.0)	1	0.042	2.338	1.031	5.300
	Yes	44	(63.8)	25	(36.2)	69	(100.0)					
Brain infarction	No	326	(86.2)	52	(13.8)	378	(100.0)	1	0.556	0.444	0.030	6.596
	Yes	4	(66.7)	2	(33.3)	6	(100.0)					
Diabetes	No	322	(91.7)	29	(8.3)	351	(100.0)	1	<0.001	54.346	15.487	190.708
	Yes	8	(24.2)	25	(75.8)	33	(100.0)					
Malignant tumour	No	316	(87.8)	44	(12.2)	360	(100.0)	1	0.018	3.826	1.257	11.643
	Yes	14	(58.3)	10	(41.7)	24	(100.0)					

High blood pressure, coronary disease, diabetes and malignant tumour proved to be statistically significant predictors for metabolic syndrome according to WHO. It was found that subjects with diagnosed or measured high blood pressure were almost 17 times more likely to have metabolic syndrome than subjects without diagnosed or measured high blood pressure ($p<0.001$). Also, subjects with coronary disease were 2.3 likely to have metabolic syndrome than subjects without coronary disease ($p=0.042$). Subjects with diabetes were 54 times more likely to have metabolic syndrome than subjects without diabetes ($p<0.001$), while subjects with malignant tumour were 3.8 times more likely to have metabolic syndrome than subjects without malignant tumour ($p=0.018$).

The prevalence of metabolic syndrome according to the NCEP-ATP III definition

Diagnosis of metabolic syndrome according to the NCEP-ATP definition requires the existence of three or

more of the following criteria: increased waist circumference, high blood pressure, elevated triglycerides and/or low HDL, elevated fasting blood glucose.

Out of a total of 385 subjects, 96 (24.9%) met the criteria for metabolic syndrome according to the NCEP-ATP III definition. The frequency of diagnostic criteria for the evaluation of metabolic syndrome according to NCEP is shown in Table 7.

The most common criterion was increased waist circumference 317 (82.3%), followed by hypertension 198 (51.4%) and dyslipidemia 123 (31.9%).

The study determined that 45 men (33.1%) and 51 women (20.5%) had diagnosis of metabolic syndrome according to the NCEP criteria (Table 8), 24.9% subjects in total.

Fisher's exact test established a statistically significant link between metabolic syndrome according to NCEP and gender ($p=0.009$): metabolic syndrome according to NCEP occurred more often in male population (33%) than in female (21%).

Metabolic syndrome according to the NCEP criteria was also more present in neighbouring settlements than in the town of Cres (Table 9).

Fisher's exact test established a statistically significant link between metabolic syndrome according to NCEP and domicile ($p=0.045$): there was a smaller share of subjects with metabolic syndrome according to NCEP with domicile in Cres (20.7%) than in other settlements (29.7%).

Multiple regression analysis yielded one statistically significant predictor that accounts for only 1% of predictor variance, a consumption of lard or any other animal fat ($\beta=0.109$; $p=0.046$). Metabolic syndrome according to the NCEP-ATP III definition and chronic diseases are shown in Table 10.

High blood pressure and diabetes proved to be statistically significant predictors for metabolic syndrome according to NCEP-ATP III. Subjects with diagnosed or measured high blood pressure were 8.4 times more likely to have metabolic syndrome (according to NCEP) than subjects without diagnosed or measured high blood pressure $p<0.001$), while subjects with diabetes were 7.4 times likely to have metabolic syndrome (according to NCEP) than subjects without diabetes ($p<0.001$).

Discussion

Determined prevalence of metabolic syndrome among the population of Cres Island according to the definition of World Health Organisation was 14.0% (20.6% in men

TABLE 7
THE FREQUENCY OF DIAGNOSTIC CRITERIA FOR THE EVALUATION OF METABOLIC SYNDROME ACCORDING TO NCEP-ATP III DEFINITION

Diagnostic criteria		No		Yes		Missing		Total	
		N	(%)	N	(%)	N	(%)	N	(%)
Obesitas	Waist circumference: >102 cm male or >88 cm female.	62	(16.1)	317	(82.3)	3	(1.6)	385	(100.0)
Dyslipidemia	Triglycerides >1.695 mmol/L or	290	(75.3)	95	(24.7)	0	(0.0)	385	(100.0)
	HDL<1.036 male or<1.295 female.	324	(84.2)	61	(15.8)	0	(0.0)	385	(100.0)
	Triglycerides >1.695 mmol/L or HDL <1.036 male or <1.295 female.	262	(68.1)	123	(31.9)			385	(100.0)
Elevated blood pressure	≥130/85 mmHg	234	(60.8)	151	(39.2)	0	(0.0)	385	(100.0)
	Previously diagnosed	254	(66.0)	131	(34.0)	0	(0.0)	385	(100.0)
	≥130/85 mmHg measured or previously diagnosed	187	(48.6)	198	(51.4)			385	(100.0)
Fasting plasma glukose ≥ 6.1 mmol/L		305	(79.3)	71	(18.4)	9	(2.3)	385	(100.0)

TABLE 8
METABOLIC SYNDROME ACCORDING TO THE NCEP – ATP III CRITERIA AND GENDER

Metabolic syndrome according NCEP-ATP III	Gender				Total	
	Male		Female			
	N	(%)	N	(%)	N	(%)
No	91	(66.9)	198	(79.5)	289	(75.1)
Yes	45	(33.1)	51	(20.5)	96	(24.9)
Total	136	(100.0)	249	(100.0)	385	(100.0)

TABLE 9
METABOLIC SYNDROME ACCORDING NCEPO-ATP III CRITERIA AND DOMICILE

Metabolic syndrome according NCEP-ATP III	Domicile				Total	
	Town of Cres		Other settlements			
	N	(%)	N	(%)	N	(%)
No	161	(79.3)	128	(70.3)	289	(75.1)
Yes	42	(20.7)	54	(29.7)	96	(24.9)
Total	203	(100.0)	182	(100.0)	385	(100.0)

TABLE 10
METABOLIC SYNDROME ACCORDING TO THE NCEP-ATP III DEFINITION AND CHRONIC DISEASES

Chronic disease		Metabolic syndrom according NCEP						Logistic regression				
		No		Yes		Total					95.0% IP for OR	
		N	(%)	N	(%)	N	(%)	Reference values	p	OR	Upper limit	Lower limit
Elevated blood pressure (previously diagnosed or measured) >140/90 mmHg)	No	194	(91.5)	18	(8.5)	212	(100.0)	1	<0.001	8.373	4.575	15.326
	Yes	95	(54.9)	78	(45.1)	173	(100.0)					
Coronary disease	No	246	(78.1)	69	(21.9)	315	(100.0)	1	0.815	0.924	0.478	1.787
	Yes	42	(60.9)	27	(39.1)	69	(100.0)					
Brain infarction	No	283	(74.9)	95	(25.1)	378	(100.0)	1	0.080	0.117	0.011	1.290
	Yes	5	(83.3)	1	(16.7)	6	(100.0)					
Diabetes	No	277	(78.9)	74	(21.1)	351	(100.0)	1	<0.001	7.390	2.934	18.617
	Yes	11	(33.3)	22	(66.7)	33	(100.0)					
Cancer	No	274	(76.1)	86	(23.9)	360	(100.0)	1	0.588	1.310	0.494	3.475
	Yes	14	(58.3)	10	(41.7)	24	(100.0)					

and 10.4% in women), while according to the NCEP-ATP III definition it was 24.9% (33.1% in men and 20.5% in women). The definitions of WHO and NCEP-ATP III are most commonly applied in diagnostics of the prevalence of metabolic syndrome and are in agreement regarding the major components of metabolic syndrome: insulin resistance, obesity, dyslipidemia and hypertension. The WHO was among the first to define metabolic syndrome. Its criteria are considered suitable for research work but hardly applicable and too complex for clinical and broader epidemic studies. The main deficiency of this definition are precisely the diagnostically complicated obligatory criteria of insulin resistance.

In recent studies, this strict criterion was replaced by diagnosed diabetes or elevated levels of fasting glucose. The elevated fasting glucose level criterion was applied also in this study. The NCEP-ATP III definition is simpler and, although having the same components as the WHO definition, it does not specify an obligatory condition to be met, but the presence of three or more of the following criteria is enough: increased waist circumference, high blood pressure, elevated triglycerides and/or low HDL, elevated fasting glucose. The reason is simpler measurement of abdominal obesity (waist circumference) and avoiding insulin resistance as an obligatory criterion[24,25].

In the majority of the prevalence of metabolic syndrome studies in Croatia the NCEP-ATP III definition was applied, with certain indicated modifications[15,16,26,27].

The analysis of the components of metabolic syndrome among the subjects from Cres Island showed that majority of them had increased waist-to-hip ratio (75.8%), BMI >30 kg/m^2 (26.5%), followed by high blood pressure (44.9%), diagnosed diabetes or increased fasting glucose values (19.5%), elevated serum triglycerides and low HDL cholesterol (1%). Diagnosis of metabolic syndrome was established in 54 (72%) out of a total of 75 subjects with diagnosed diabetes and elevated blood glucose levels. Metabolic syndrome, according to the WHO definition, was more present in subjects from neighbouring

settlements (19.2%) than in subjects from the town of Cres (9.4%). That difference could be partly explained by subjects' age difference but also by an increased prevalence of the components of metabolic syndrome among the subjects from other settlements. Metabolic syndrome is a pronounced risk factor for developing cardiovascular disease and type 2 diabetes. Multiple logistic regression showed high blood pressure, coronary disease, diabetes and malignant tumour to be statistically significant predictors for metabolic syndrome according to WHO. According to the WHO definition, there is a significant link between metabolic syndrome and elevated fasting blood glucose levels. Namely, 73.1% of the subjects with elevated glucose had metabolic syndrome.

The prevalence of metabolic syndrome among the Cres Islanders, according to the NCEP-ATP III definition, was 24.9% (33.1% in men and 20.5% in women). Diagnosis of metabolic syndrome according to NCEP-ATP III requires the presence of three and more of the following criteria: increased waist circumference, high blood pressure, elevated triglycerides and/or low HDL, elevated fasting blood glucose. The most commonly present criterion among the subjects from the island of Cres was increased waist circumference (82.3%), hypertension (51.4%) and dyslipidemia (31.9%), fasting glucose concentrations (18.4%). In the neighbouring settlements, the prevalence of metabolic syndrome was 29.7%, and in the town of Cres 20.7%.

The high prevalence of metabolic syndrome in Baranja established in a previous study by Tucak-Zorić et al. is more expected, considering the continental nutritional habits that include higher intake of saturated fats, meat and processed-meat products, but the high prevalence of metabolic syndrome on Mljet Island, in Lopar and Banjol on Rab Island and in Vis is surprising. Compared to the values for Croatian subpopulations obtained from the previous studies, the prevalence of metabolic syndrome on the island of Cres, amounting to 24.9% according to the NCEP-ATP III definition, is similar to that found in the town of Rab (25%) and lower than that found in all studies of Adriatic island isolates. Interestingly, the metabolic syndrome was more present in men than in women, which was only the case on the island of Hvar[16]. In all other island settlements, it was found that women were more often affected by metabolic syndrome than men.

A comparison with some Mediterranean countries is interesting also in view of the assumed similar nutritional and life habits. On Sicily, the established prevalence of metabolic syndrome according to NCEP-ATP III was 22% (12.4% men and 31.5% women), which is similar to the Cres Island, with an important remark: on Sicily, the prevalence was significantly higher in women[28].

The prevalence of metabolic syndrome in Europe, according to the NCEP-ATP III definition, ranges from the lowest in Italy (15% for men and 18% for women) to the highest in Greece population 41.8%[29]. According to the same definition, the prevalence of metabolic syndrome in Europe and abroad is as follows: France 23% men, 16.9% women, Germany 23.5% men, 17.6% women, Netherlands 19% men, 32% women, Spain 22.3% men, 30.7% women, Portugal 19.1% men, 27% women, England 29.8% women, Greece 63% men and 37% women, Finland 47% men, 25% women.

According to WHO, the lowest prevalence of metabolic syndrome was registered in Japan, amounting to 3.4% for men and 2.5% for women[14]. The prevalence of metabolic syndrome according to the WHO definition in Netherlands was 26% in men and 26% in women, on Canary Islands 26.5% in men and 17.6% in women, while the general prevalence in Italy was 34.1%, in England 20.9%, and in Australia 21.7%[28,29].

Among the studied population of the island of Cres, male population had higher prevalence rate of metabolic syndrome according both to WHO and NCEP-ATP III definitions, which is consistent with the studies of the population of the island of Hvar (71), studies of the prevalence of metabolic syndrome in France, Germany and Finland (41) and studies of USA population[31–39]. On the other hand, higher prevalence of metabolic syndrome in women was registered in Netherlands, Portugal, Italy, South Korea, China and India[14]. That incidence is probably due to the factors related to lifestyle, life habits, socio-cultural status, economic possibilities, age, health and level of health care, including hormonal and series of other physiological factors[32].

The most common components of metabolic syndrome, when the NCEP-ATP III definition was applied, were: increased waist circumference (82.3%), high blood pressure (51.4%), elevated triglycerides (24.7%), elevated blood glucose (18.4%) and low HDL cholesterol values (15.8%). The components more present in men were high blood pressure, elevated fasting blood glucose concentrations, elevated triglycerides and low level of HDL cholesterol, BMI greater than 30 kg/m^2, waist-to-hip ratio above normal. Increased waist circumference component was more present in women. A similar study of metabolic syndrome on the island of Vis showed that men more often met the conditions of elevated concentration of serum triglycerides, elevated fasting blood glucose and high blood pressure, while in women were more present low HDL cholesterol concentration and increased waist circumference components[33].

Multiple logistic regression showed that statistically significant predictors for metabolic syndrome according to NCEP were high blood pressure and diabetes, and statistically significant predictors also were elevated triglycerides and elevated glucose. Namely, subjects with elevated triglycerides were 33 times more likely to have also metabolic syndrome (according to NCEP) than subjects without elevated triglycerides and subjects with elevated glucose were 97 times more likely to have metabolic syndrome (according to NCEP) than subjects without elevated glucose.

Beside gender differences, the prevalence of metabolic syndrome is more present and increases with age. In this study, this was established by the analysis of each of the components, which are significantly higher in elderly

subjects. Also, the incidence of metabolic syndrome was significantly higher among the subjects from other settlements (rural areas) than among the subjects from the town of Cres (urban area).

The results of this study also showed obesity to be a strong predictor in the incidence of metabolic syndrome and chronic diseases, indicating that 82.3% of the subjects with increased waist circumference had metabolic syndrome according to NCEP-ATP III, and 75.8% of the subjects with increased waist-to-hip ratio had metabolic syndrome according to WHO definition[34].

Conclusion

This study investigated the prevalence of metabolic syndrome in two subpopulations of inhabitants of the island of Cres: the town of Cres and other settlements. The overall established prevalence of metabolic syndrome was 14% according to the WHO definition (20.6% in men and 10.4% in women) and 24.9% according to the NCEP--ATP III definition (33.1% in men and 20.5% in women).

The study showed that the prevalence of risk factors for developing metabolic syndrome and complex diseases was much higher among the subjects from other settlements than among the subjects from the town of Cres. Subjects from other settlements were significantly older, more overweight and obese, affected by hypertension and diabetes. The analysis of nutritional habits and their relation with complex diseases did not establish a statistically significant correlation.

The causes of metabolic syndrome are multifactorial and environmental factors, together with heritage and age, undoubtedly play an important role in the occurrence of metabolic syndrome. Environmental factors such as lifestyle, physical activity, diet, but also availability of health care, have an impact on the incidence of complex diseases like hypertension, cardiovascular disease, diabetes, and it is precisely these diseases that are significantly more common among the subjects from other settlements.

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This research was conducted according to ethical principles and methodology previously applied in investigations of population structure and studies of anthropogenetic isolates of Eastern Adriatic.

REFERENCES

1. ZIMMET P, GEORGE K, ALBERTI MM, SERRANO RIOS M, Rev Esp Cardiol, 58 (2005) 1371. DOI: 10.1016/S0300-8932(05)74065-3. — 2. ECKEL RH, GRUNDY SM, ZIMMET PZ, Lancet, 365 (2005) 1415. DOI: 10.1016/S0140-6736(05)66378-7. — 3. HU G, QIAO Q, TUOMILHTO J, BALKAU B, BORCH-JOHNSEN K, PYORALA K, Arch Intern Med, 164 (2004) 1066. DOI: 10.1001/archinte.164.10.1066. — 4. FORD ES, GILES WH, MOKDAD AH, Diabetes Care, 27 (2004) 2444. DOI: 10.2337/diacare.27.10.2444. — 5. WILSON PW, D'AGOSTINO RB, PARISE H, SULLIVAN L, MEIGS JB, Circulation, 112 (2005) 3066. DOI: 10.1161/CIRCULATIONAHA.105.539528. — 6. HU G, LINDSTRÖM J, JOUSILAHTI P, PELTONEN M. SJÖBERG L, KAAJA R, SUNDVALL J,TUOMILEHTO J, J Clin Endocrinol Metab, 93 (2008) 832. DOI: 10.1210/jc.2007-1883. — 7. LIESE AD, MAYER-DAVIS EJ, HAFFNER SM. Epidemiol Rev, 20 (1998) 157. — 8. LAAKSONEN DE, NISKANEN L, LAKKA HM, LAKKA TA, USITUPA M, Ann Med, 36 (2004) 332. — 9. INTERNATIONAL ASSOCIATION FOR THE STUDY OF OBESITY, Global Prevalence of Adult Obesity, accessed 5.02.2011. Available from: URL: www.iaso.org/site_media/uploads/AdultEU27March2010notonwebyetupdtev2 pdf. — 10. GALASSI A, REYNOLDS K, HE, Am J Med, 119 (2006) 812. DOI: 10.1016/j.amjmed. 2006.02.031. — 11. SEIDELL JC, Obes Res 3, Suppl 2 (1995) 89s. — 12. FLEGAL KM, CARROLL MD, OGDEN CL, JOHNSON CL, JAMA, 288 (2002) 1723. DOI: 10.1001/jama.288.14.1723. — 13. COOK S, AUINGFR P, LI C, FORD ES, Journal of Pediatrics, 152 (2008) 165. DOI: 10.1016/j.jpeds.2007.06.004. — 14. LEE CM, HUXLEY RR, WOODWARD M, ZIMMET P, SHAW J, CHO NH, KIM HR,VIALI S, TOMINAGA M, VISTISEN D, BORCH-JOHNSEN, COLAGIURI S, MetabSyndr RelatDisord, 6 (2008) 37. — 15. KOLČIĆ I, VORKO-JOVIĆ A, SALZER B, SMOLJANOVIĆ M, KERN J, VULETIĆS, Croat Med J, 47 (2006) 585. — 16. DEKA R, NARANCIC NS, XI H, TUREK S, ČUBRILO--TUREK M, VRHOVSKI-HEBRANG D, JANIČIJEVIĆ B, TOMLJENOVIĆ A, SZIROVICZA L, JIN L, CHAKRABORTY R, RUDAN P, Coll Antropol, 32 (2008) 85. — 17. TUCAK-ZORIĆ S, CURCIC IB, MIHALJ H, DUMANČIĆ I, ZELIĆ Ž, MAJETIĆ-CETINA N, SMOLIĆ R, VOLAREVIĆ M, MISSONI S, TOMLJENOVIĆ A, SZIROVICZAL, DURAKOVIĆ Z, XI H, CHAKRABORTY R, DEKA R, TUCAK A, RUDAN P, Coll Antropol, 32 (2008) 659. — 18. URED ZA STATISTIKU PRIMORSKO-GORANSKE ŽUPANIJE, Statistički ljetopis županije Primorsko-goranske 2002. Rijeka: Županija Primorsko-goranske; 2002. — 19. SMOLJANOVIĆ M, SMOLJANOVIĆ A, RUDAN I, Stanovništvo Hrvatskih otoka [In Croat] (Zagreb: Laser plus, 2008). — 20. THIRD REPORT OF THE NATIONAL CHOLESTEROL EDUCATION PROGRAM EXPERT PANEL on detection, evaluation, and treatment of high blood cholesterolinadults (Adult Treatment Panel III). Executive summary. National Institutes of Health, National Heart, Lung, and Blood Institute, 2001. (Accessed at april 7, 2011, Available from: URL: http://www.nhlbi.nih.gov/guidelines/cholesterol/atp3xsum.pdf). — 21. THE WELLCOME TRUST, Clinical Research Facility Guidelines, London: The Wellcome Trust, (2001). — 22. DEKANIĆ D, DURAKOVIĆ Z, GRGIĆ Z, Fiziološke metode-I. Praktikum biološke antropologije [In Croat] (RSIZZ, ZLH, HAD, Zagreb, 1979). — 23. DEKANIĆ D, DURAKOVIĆ Z, GOMZI M, GRGIĆ Z, HARAMUT M, HEIMER S, JANIČIJEVIĆ B, KOVAČEVIĆ M, KUŠEC V, MAVER H, RUDAN P, SMOLEJ NARANČIĆ N, ŽUŠKIN E, Praktikum biološke antropologije – Fiziološke metode u antropologijskim istraživanjima [In Croat] (RSIZZ, ZLH, HAD, Zagreb, 1987). — 24. ALBERTI KG, ZIMMET PZ, Diabet Med, 15 (1998) 539. DOI: 10.1002/(SICI)1096-9136(199807)15:7< 535:AID-DIA670>3.0.CO;2-Q. — 25. GRUNDY SM, CLEEMAN JI, DANIELS SR, DONATO KA, ECKEL RH, FRANKLINBA,GORDON DJ, KRAUSS RM, SAVAGE PJ, SMITH Jr SC, SPERTUS JA, COSTA F, Circulation, 112 (2005) 2735. DOI: 10.1161/CIRCULATIONAHA.105. 169405. — 26. MISSONI S, Doktorska disertacija: Međuodnos prehrambenih navika i kompleksnih fenotipskih svojstava stanovništva otoka Visa [In Croat] (University of Zagreb, Zagreb 2009). — 27. KUZMANIĆ M, VRDOLJAK D, RUMBOLDT M, PETRIC D, Med Jad, 38 (2008) 13. — 28. CAMERON AJ, MAGLIANO DJ, ZIMMET PZ, WELBORN T, SHAW JE, Diabetes Research and Clinical Practice, 77 (2007) 471. DOI: 10. 1016/J.diabres 2007. 02.002. — 29. GRUNDY SM, Arteriosclerosis Thrombosis and Vascular Biology, 28 (2008) 629. DOI: 10.1161/ ATVBAHA.107.151092. — 30. ALBERTI KG, ZIMMET P, SHAW J, Lancet, 366 (2005) 1059. DOI: 10.1016/

S0140-6736(05)67402-8. — 31. FORD ES, Diabetes Care, 28 (2005) 2745. DOI: 10.2337/diacare.28.11.2745. — 32. SALSBERRY PJ, CORWIN E, REAGAN PB, Am J Prev Med, 33 (2007) 114. DOI: 10.1016/j.amepre. 2007.03.017. — 33. KOLČIĆ I, Populacijsko-genetičke i okolišne odrednice metaboličkog sindroma u populaciji otoka Visa. [In Croat] PhD thesis. (University of Zagreb, School of Medicine, Zagreb, 2009). — 34. WORLD HEALTH ORGANIZATION. Definition, diagnosis and classification of diabetes mellitus and its complications: report of a WHO Consultation. Part 1: Diagnosis and classification of diabetes mellitus (Geneva, WHO/NCD/NCS/99.2, 1999). — 35. BILOGLAV Z, Demografske odrednice genetske strukture stanovništva otoka Lastova, Mljeta, Raba, Suska i Visa. [In Croat] PhD thesis (University of Zagreb, School of Medicine, Zagreb, 2006).

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METABOLIČKI SINDROM STANOVNIKA OTOKA CRESA

S A Ž E T A K

U radu je istražena prevalencija metaboličkog sindroma u dvije subpopulacije stanovništva otoka Cresa: grada Cresa i ostalih naselja. Dokazana je ukupna prevalencija metaboličkog sindroma od 14% prema definiciji SZO (20,6% među muškarcima i 10,4% među ženama) i 24,9% prema NCEP-ATP III definiciji (33,1% među muškarcima i 20,5% među ženama). Istraživanjem je dokazano da je prevalencija rizičnih čimbenika za nastanak metaboličkog sindroma i kompleksnih bolesti mnogo viša kod ispitanika ostalih (ruralnih) naselja nego kod ispitanika grada Cresa (urbani). Također statistički značajnim prediktorima za nastanak metaboličkog sindroma pokazali su se povišeni krvni tlak i dijabetes, bolesti koje se pravovremenim zdravstvenim mjerama u velikoj mjeri mogu prevenirati.