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Body Mass Index, Waist Circumference and Waist-to-Hip Ratio: Which Anthropometric Indicator is Better Predictor for the Hypertension Development in Women Population of the Island Cres

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A B S T R A C T

The aim of this research was to investigate the prevalence of obesity and high blood pressure and to prove which of three anthropometric indicators of obesity – waist circumference, body mass index (BMI) waist-to-hip ratio – is better predictor for the development of hypertension in women population of the island of Cres. We approached separately groups of women with measured high blood pressure and with previously diagnosed. The research was preformed within the research project »Genetic and biomedical characteristics of the population of the island of Cres«. This was the cross sectional study and data were obtained on the sample of 247 females over 18 years old that voluntarily participated in this study. In our study group the prevalence of overweight was 39.0%, obesity 27.5%, increased waist circumference was present in 69.4% while increased blood pressure was found in 53.0% examinees. Our results indicate that age, BMI, impaired glucose concentration and serum cholesterol could be considered as predictors for the development of arterial hypertension, whether measured or previously diagnosed.

Key words: *body mass index (BMI), waist circumference, waist-to-hip ratio, arterial hypertension, women, island of Cres*

Introduction

The aim of this research was to evaluate which of anthropometric indicators of obesity is better predictor of the development of hypertension. Hypertension is leading cause of morbidity and mortality from cardiovascular disease. It is well documented that overweight and obesity are risk factors for the development of high blood pressure. According to some studies BMI is a better predictor, while according to others, central obesity defined by waist circumference and waist-to-hip ratio are better predictors for the development of hypertension[1–7].

Overweight and obesity are significant public health problems all over the world[8]. Although the terms overweight and obesity are often considered as synonyms, the first one relates to enlarged body mass in relation with high, while the second term relates to increased amount of fat tissue. Obesity is a serious illness whose development is not inevitable and which can be prevented greatly by changes in lifestyle habits. The aetiology of obesity is multifactor and includes both genetic and environmental factors. The most important environmental factors include sedentary life, lack of physical activity and nutritional habits[9]. During the last few decades the nutritional habits have changed with higher consumption of refined sugars, eating oils, animal food, and diminished intake of foods rich in fibres and vitamins that results in greater energetic intake to the organism. The advances

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in technology transport and communications have abrogated the traditional occupations that demanded greater physical activity and efforts[10].

According to World Health Organisation (WHO), the obesity is present in five of ten leading causes of death in developed countries. These five causes of death are: heart diseases, cerebrovascular insult, diabetes mellitus, atherosclerosis, hyperlipidemia and certain types of tumours (endometrial, breast and colon)[11,12].

Further, a serious health problems are consequences of obesity including sleep disorders, fatigue, poor physical condition, arthritis (as a consequence of degenerative processes as a result of damaged metabolic mechanisms), and social isolation with consequential reduction of life quality and the development of the depression[13,14]. Definition of overweight and obesity can be preformed by several methods. Simple, generally acceptable and direct measures include the anthropometric ones: body mass index (BMI), waist circumference and waist-to-hip ratio. There are other methods for the estimation of body composition and fat distribution, as computerized tomography and magnetic resonance but they require special indication, they are very complex for usage in everyday clinical practice and are not practical in epidemiological researches[15]. WHO have accepted the BMI as a good indicator for general evaluation of nutrition and it is calculated as a ratio of body mass and square of height expressed in kg/m^2. On the other hand, waist circumference and waist-to-hip ratio describe abdominal or central adiposity. Waist circumference is the best indicator of intraabdominal fat tissue quantity that is responsible for several metabolic changes in the organism of obese person[16]. However, WHO had introduced BMI as a criterion in determination of the degree of adiposity[15,17]. Finally, we can add that obesity is one of the components of the metabolic syndrome.

A great number of studies have shown that cardiovascular morbidity and mortality are strongly correlated with increased diastolic and systolic blood pressure[19,20]. In some European countries the correlation was less pronounced in coronary disease compared with stroke which is therefore designated as the most important complication of high blood pressure. On the contrary, the correlation is greater with the mortality from coronary disease in other European countries[21,22]. The association of high blood pressure with morbidity and mortality from cardiovascular diseases was reported also for the United States of America[23,24]. This association is present in both genders, in younger adults and older persons within populations of different ethnic groups[25,26]. High blood pressure could therefore be considered as one of the most important risk factors of a number of cardiovascular and related diseases as well as of diseases that increase cardiovascular risk worldwide[27]. The above mentioned together with high prevalence of high blood pressure in population explains why the WHO in its reports emphasises the high blood pressure as the leading cause of death in the world[23]. The most important factors that contribute to the development of the high blood pressure include age, adiposity, gender and lifestyle.

The island of Cres is the biggest island in Adriatic sea with lowest population density that is a result of negative trend in population growth and great emigration of the island population during the last century from economic reasons. At the island of Cres according to the last census (2001.) lives 3184 inhabitants with equal gender distribution and with 20.9% of population older than 65 years. The population held all characteristics of the island isolate from biological, geographical and cultural point of view.

Study Population and Methods

The research was preformed during November and December 2007. in primary health care units of the primary health care centre of Primorsko-goranska County in the city of Cres. The consent of each examinee was obtained before the onset of investigation. The written questionnaire and blood sampling were performed with informed consent of female population aged 18 to 95 years. The participants were informed about the research through public media, promotional materials, local authorities, primary health care providers and parish priest. All the participants were carefully informed about the goals of research and the time and place for participation. The participant came to the examination between eight and nine a.m. They were informed that it is necessary to approach fasting for the sampling of blood for biochemical tests. At the same time anthropological measurements were performed, blood pressure was measured and the questionnaire was fulfilled. The blood samples were daily transported in refrigerated containers for testing in laboratory of clinical hospital centre in Rijeka. Anthropologic measures include height, weight, waist and hip circumference and were preformed according to standard protocols[28]. From the measured variables of height and weight the BMI was calculated and from waist and hip circumferences the waist to hip ratio was determined. The participants with BMI from 18.5 kg/m^2 to 24.9 kg/m^2 were classified as persons with normal weight. Those with BMI between 25 and 29.9 kg/m^2 were considered overweight while those with BMI grater or equal to 30.0 kg/m^2 were considered as obese[16]. Central adiposity was diagnosed in case where waist circumference was greater or equal to 88 cm and while waist-to-hip ratio was greater or equal to 0.85[17]. The measured values of systolic and diastolic blood pressure were recorded after the participants were resting for ten minutes in sitting position in quiet room. The blood pressure was measured with mercury manometer twice, with the delay of 5 minutes between two measurements. The diagnosed high blood pressure was recorded if participant gave the information about previously diagnosed hypertension with or without therapy. The measured high blood pressure was recorded when the value of diastolic pressure was greater or equal to 85 mmHg or systolic pressure was greater or equal to 130 mmHg. According to the Guidelines of the European Society of Hypertension and European Society

of Cardiology these cutoff point represent high normal pressure[29].

The same cutoff points of arterial hypertension are used by Kern et al. and associated in their research of cardiovascular risk factor in Croatia[30].

The values of other measured predictors for the development of the high blood pressure were serum triglyceride concentrations above 1.69 mmol/L, total serum cholesterol above 5.2 mmol/L, HDL cholesterol below 1.29 mmol/L, LDL cholesterol above 4.1 mmol/L and fasting plasma glucose above 6.1 mmol/L according to NCEP guidelines[17]. Besides that the prevalence of active or past cigarette smokers was recorded as well as the data regarding sport activities whether active or recreational. The study was performed according to ethical standards and methodology that is usually applied for the research of population structure of the Republic of Croatia. Mentioned methods were previously used in similar researches of anthropogenetic isolates of eastern Adriatic islands[31,32]. The project and methodology of the research have the approval of the Committee for Ethical Issues of Medical Faculty, University of Rijeka.

Statistical analysis

Numerical variables were tested for normality of distribution using Kolmogorov-Smirnov test. All continuous variables were normally distributed and presented with X and standard deviation. Strength of association between outcome variables (diagnosed and measured blood pressure) and predictors were tested by using univariate and multiple logistic regressions. Continuous variables were tested for linearity in logit. All variables with $p<0.2$ in univariate analysis were included in multiple regression models. We performed check for confounding effect and effect-modification. The level of statistical significance was chosen to be $\alpha=0.05$. Statistical analysis was performed by using statistical package STATA/IC ver.11.1.

Results

In our results we show that 97 (39%) of women in the study group are overweight, 68 (27.5%) of them are classified as obese. Increased waist circumference was present in 172 (69.4%) while increased blood pressure was measured in 130 (53.0%) examinees. The previously diagnosed high blood pressure was present in 74 (30%) women in our study group. Further, we considered other risk factors that could influence the development of high blood pressure such as dyslipidemias, increased blood glucose concentrations and some lifestyle habits such as sports and smoking. Table 1 presents the data regarding measured parameters. It can be seen that increased serum triglycerides were found in 55 (22.3%), increased total serum cholesterol in 183 (73.8%), decreased values of HDL were present in 202 (81.5%), increased LDL cholesterol in 86 (35.5%) and increased blood glucose concentrations was found in 41 (16.0%) examinees. According to questionnaire, 47 (19.0%) participants declared to be active cigarette smokers and 44 (18.0%) declared to be recreational physical activities. We analyzed participants divided in two groups: first with recorded high blood pressure and the second with previously diagnosed hypertension. The analysis of predictors of age distribution revealed an average age for both groups significantly higher than the average found in a total number of participants, especially those with normal blood pressure values. Average values of anthropometric indicators (BMI, waist circumference, waist-to-hip ratio) and of several biochemical parameters (cholesterol, LDL, fasting glucose concentration) were higher in a category with previously diagnosed hypertension compared to all other groups. The results of invariant logistic regression for measured high blood pressure indicate statistical significance for the predictors age, BMI, waist circumference, waist-to-hip ratio, smoking habits, sport activities, cholesterol and glucose concentration. For the previously diagnosed high blood pressure statistically significant predictors were

TABLE 1
DESCRIPTIVE DATA

	Measured arterial hypertension (N=130) $\bar{X}$±SD or N(%)	Diagnosed arterial hypertension (N=74) $\bar{X}$±SD or N(%)	Normal blood preassure (N=109) $\bar{X}$±SD or N(%)	Total (N=247) $\bar{X}$±SD or N(%)
Age (year)	63.1±15.0	66.2±11.8	47.0±15.9	56.1±17.3
BMI (kg/m^2)	28.6±5.2	29.5±5.6	25.5±4.2	27.3±5.0
Waist circumference (cm)	98.5±15.8	101.0±17.4	90.0±11.4	94.9±14.6
Waist-to-hip ratio	0.9±0.1	0.9±0.1	0.9±0.1	0.9±0.1
Total cholesterol (mmol/L)	6.2±1.2	6.3±1.2	5.8±1.2	6.0±1.2
HDL cholesterol (mmol/L)	1.6±0.4	1.6±0.3	1.5±0.3	1.6±0.4
LDL cholesterol (mmol/L)	3.9±0.9	4.0±0.9	3.7±1.0	3.8±1.0
Triglycerides (mmol/L)	1.4±0.8	1.41±0.8	1.3±0.5	1.3±0.7
Fasting plasma glucose (mmol/L)	5.7±1.9	6.1±2.3	4.9±0.7	5.2±1.2
Current smoking – yes	10 (7.6)	5 (6.7%)	20 (18.3%)	32 (13.0%)
Phisical exercise – yes	16 (12.3)	6 (8%)	28 (25.7%)	44 (18.0%)

TABLE 2
RESULTS OF UNIVARIANT LOGISTIC REGRESSION FOR MEASURED AND PREVIOUSLY DIAG NOSED ARTERIAL HYPERTENSION

Predictor	Measured arterial hypertension			Diagnosed arterial hypertension		
	OR	p	95%CI	OR	p	95%CI
Age (year)	1.06	<0.001	1.04–1.08	1.06	<0.001	1.04–1.08
BMI (kg/m^2)	1.14	<0.001	1.07–1.21	1.14	<0.001	1.07–1.21
Waist circumference (cm)	1.03	<0.001	1.01–1.05	1.04	<0.001	1.02–1.06
Waist-to-hip ratio (× 0.1)	1.45	<0.018	1.07–1.98	1.43	<0.049	1.01–2.04
Current smoking – yes	0.42	<0.029	0.19–0.92	0.37	<0.053	0.14–1.01
Former smoker – yes	0.91	<0.867	0.32–2.62	0.5	<0.301	0.14–1.85
Phisical exercise – yes	0.45	<0.02	0.23–0.88	0.31	<0.012	0.13–0.78
Total cholesterol (mmol/L)	1.31	<0.014	1.06–1.61	1.28	<0.034	1.02–1.61
HDL cholesterol (mmol/L)	1.96	<0.063	0.96–4.0	1.43	<0.347	0.68–3.02
LDL cholesterol (mmol/L)	1.29	<0.058	0.99–1.68	1.41	<0.019	1.06 –1.88
Triglycerides (mmol/L)	1.18	<0.362	0.83–1.68	1.21	<0.303	0.84–1.75
Fasing plasma glucose (mmol/L)	1.67	<0.001	1.23–2.28	1.58	<0.001	1.23–2.02

age, BMI, waist circumference, waist-to-hip ratio, sport activities, cholesterol, LDL and glucose concentration (Table 2). The results of multiple logistic regression show that statistically significant predictors for measured high blood pressure are age and BMI while total cholesterol was kept in the model as significant confounder (Table 3). For the previously diagnosed high blood pressure statistically significant predictors are age, BMI and fasting glucose concentration (Table 4).

Discussion

In the study population of women from the island Cres we found high prevalence of risk factors for the development of cardiovascular disease. Our results suggest that 39.0% of women is overweight, 27.5% is obese and increased waist circumference is present in 69.4% of examinees. Similar studies previously published have found that in Republic of Croatia, in general adult population, these proportions were 33.6%, 20.6% and 51.13% respectively. For the adult female population of Croatia the proportions were 50.0%, 13.6% and 45.8%[33]. The results of the earlier study performed on the island of Vis were close to values found in our study, e.g. they were 45.0%, 25.7% and 60.8%[34], respectively. Such finding may be, at least partially, explained by the average age of our study population. Namely, earlier mentioned data originate from studies performed on the sample representative for general population of Croatia. In our study group of female population from the island of Cres the average age of participants was 56.1 years, an age that is higher then that found in general population and it is known that the older age is associated with an increase in proportion of adiposity. Additionally, in our study population we found that 52.0% have increased measured arterial high blood pressure, while the data regarding previously diagnosed arterial hypertension showed the 30.0% prevalence. Previous studies that were performed in female population of Croatia reported the prevalence of 44.0%[30,35] while the prevalence of measured high arterial blood pressure found in female population of the island Vis was 39.5%[34]. This finding confirms the thesis found elsewhere that the prevalence of arterial hypertension in Croatia is characterized by regional differences. We speculate that higher prevalence of arterial hypertension found in our study population compared to Vis is the consequence of at least different age of study populations, their lifestyles and nutritional habits. In previous mentioned study conducted on Vis population, more than 69% of participants belong to urban population with satisfactory access to healthcare services, while in our study the proportion of urban population was only 54%. We reasonably concluded that a great proportion of rural population in our study group with limited access to healthcare services influences on higher prevalence of measured arterial hypertension in our study. The adipos-

TABLE 3
RESULT OF MULTIPLE LOGISTIC REGRESSIONS FOR MEASURED ARTERIAL HYPERTENSION

Predictor	OR	p	95%CI
Age (years)	1.05	<0.001	1.03–1.07
BMI (kg/m^2)	1.09	<0.005	1.03–1.16
Total cholesterol (mmol/L)	1.26	<0.053	0.99–1.61

TABLE 4
RESULT OF MULTIPLE LOGISTIC REGRESSIONS FOR PREVIOUSLY DIAGNOSED ARTERIAL HYPERTENSION

Predictor	OR	p	95%CI
Age (years)	1.05	<0.001	1.03–1.07
BMI (kg/m^2)	1.09	<0.011	1.02–1.16
Fasting plasma glucose (mmol/L)	1.30	<0.016	1.05–1.62

ity is important public health problem worldwide. The data for the USA suggest that 33.2% of male and 35.5% of female population is at least obese[36]. Several reports form European countries suggest the presence of that problem among male population to be 26.6% in Cyprus, 23.9% in Czech Republic, and 24.9% in Scotland. The proportion of obese women in Europe is biggest in Scotland (26.5%), followed by Poland and Czech Republic (23.8 and 22.3%, respectively)[37]. Our results have shown that for the development of both measured and diagnosed high blood pressure statistically significant predictors are age, BMI, waist circumference, waist to hip ratio, smoking habits, sport inactivity, and high levels of cholesterol and glucose in blood. We have also concluded that BMI is better predictor for the development of high blood pressure compared with other two anthropometric indicators of adiposity. Waist circumference correlates well with BMI and waist to hip ratio, with proven influence on the development of high blood pressure, cardiovascular disease and other chronic illnesses, but the power of that risk varies between different studies and population groups[5,38]. Broad researches of the National Institute of Health, in studies with great number of participants, have proven that the waist circumference is better predictor of the development of high blood pressure and cardiovascular disease[4]. The another study performed in population of Hong Kong have proved that BMI and waist circumference is more appropriate an-0thropometric indicator for the development of cardiovascular disease in men while waist circumference and waist to hip ratio were more appropriate for women[39]. Previous study conducted in Croatia has not proved the difference between anthropometric indicators of obesity to the development of high blood pressure[2]. Female population of the island of Cres is characterised by high prevalence of risk factors that are preventable not only by the adoption of healthier lifestyles but also with better organisation and more available health care protection. High prevalence of measured high blood pressure suggests the absence of regular health care preventive exams because of poor access to health care and preventive measures. On the other hand high prevalence of obesity suggest that even our island populations are more and more characterised by features of continental urban environments. Main goals and measures focused on the protection of health of women population should be focused on preventive health programs and further studies of the influence of environmental factors to the development of high blood pressure and cardiovascular disease in women.

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INDEX TJELESNE MASE, OPSEG STRUKA I OMJER OPSEGA STRUKA I KUKOVA: KOJI ANTROPOMETRIJSKI POKAZATELJ PREDSTAVLJA VEĆI RIZIČNI ČIMBENIK ZA RAZVOJ VISOKOG KRVNOG TLAKA KOD ŽENA OTOKA CRESA

S A Ž E T A K

Cilj ovoga rada bio je procijeniti prevalenciju debljine i visokog krvnog tlaka te istražiti koji je od tri antropometrijska pokazatelja debljine – opseg struka, index tjelesne mase (ITM) i omjer opsega struka i kukova – najjače povezan s visokim krvnim tlakom u ženske populacije otoka Cresa. Zasebno smo istraživali rizične faktore za skupinu žena s izmjerenim visokim tlakom i onu sa dijagnosticiranim visokim tlakom. U radu smo se koristili podacima znanstvenoistraživačkog projekta »Genetičke i biomedicinske značajke populacije otoka Cresa«, studiji presjeka na uzorku od 247 žena odrasle dobi koje su se dobrovoljno odazvale na pregled. U ispitivanoj grupi dokazana je prevalencija prekomjerne tjelesne težine od 39%, pretilosti od 27,5%, povećan opseg struka bio je prisutan kod 69,4%, a povišeni arterijski krvni tlak kod 53% ispitanica. Rezultati ukazuju da za razvoj visokog krvnog tlaka kako izmjerenog tako i dijagnosticiranog značajan utjecaj imaju dob, ITM, glukoza u krvi natašte i kolesterol u serumu. ITM jači je prediktor za razvoj visokog krvnog tlaka od preostalih antropometrijskih pokazatelja debljine.