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The hypertriglyceridemic waist phenotype and metabolic syndrome by differing criteria in type 2 diabetic patients and their relation to lipids and blood glucose control

Fenotyp typu „talia hipertriglicerydemiczna" i zespół metaboliczny określany na podstawie różnych kryteriów oraz zależności między tymi zaburzeniami a kontrolą stężeń lipidów i glikemii u chorych na cukrzycę typu 2

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Abstract

Background: Metabolic syndrome (MetS) describes clustering of obesity, dyslipidemia, hyperglycemia and hypertension and increases risk for cardiovascular disease and type 2 diabetes. The 'hypertriglyceridemic waist' phenotype (HTGW) represents a simple approach to identifying individuals with increased risk. The aim of the study was to determine the prevalence of HTGW and MetS in type 2 diabetic patients, and to examine their relation to lipids and blood glucose control.

Material and methods: 300 type 2 diabetic patients were analysed, and their history of diabetes, anthropometric measures, measurements of blood pressure (BP), lipids and glycemic control parameters were taken.

Results: In type 2 diabetic patients, the prevalence of MetS was 71.0% by the AHA/NHLBI definition and 75.33% by the IDF definition. The prevalence was 62.58% and 66.45% in men, and 80% and 84.83% in women by the same definitions, respectively. There were 41.33% of patients with HTGW (42.76% among women and 40% among men). There were statistically significant differences of age, fasting plasma glucose (FPG) and postprandial glucose (PPG) in women with and without MetS according to both definitions, and of total and LDL cholesterol with and without MetS according to AHA/NHLBI (but not IDF). In men, there were statistically significant differences of total cholesterol and of HbA_{1c} with and without MetS according to AHA/NHLBI (but not IDF). Women with HTGW had higher levels of total and LDL cholesterol, systolic and diastolic BP. Men with HTGW had higher levels of total cholesterol, diastolic BP, HbA_{1c}, FPG and PPG.

Conclusions: Determining MetS or HTGW helps identify those with increased cardiovascular risk. **(Pol J Endocrinol 2011; 62 (4): 316–323)**

Key words: *hypertriglyceridemic waist, metabolic syndrome, type 2 diabetes mellitus, blood lipids, blood glucose control*

Streszczenie

Wstęp: Zespół metaboliczny (MetS) obejmujący otyłość, dyslipidemię, hiperglikemię i nadciśnienie tętnicze zwiększa ryzyko chorób sercowo-naczyniowych i cukrzycy typu 2. Określanie fenotypu „talii hipertriglicemicznej" (HTGW) jest prostą metodą identyfikowania chorych z grupy wysokiego ryzyka. Celem badania było ustalenie częstości HTGW i MetS u chorych na cukrzycę typu 2 oraz ocena zależności miedzy tymi zaburzeniami a kontrolą stężeń lipidów i glikemii.

Materiał i metody: Do badania włączono 300 chorych na cukrzycę typu 2 i przeanalizowano dane dotyczące przebiegu cukrzycy, parametrów antropometrycznych, wartości ciśnienia tętniczego, stężeń lipidów i kontroli glikemii.

Wyniki: U chorych na cukrzycę typu 2 kryteria MetS według definicji AHA/NHLBI spełniało71,0%, a kryteria IDF — 75,33%; odsetek chorych z MetS wynosił wśród mężczyzn odpowiednio 62,58% i 66,45%, a wśród kobiet 80% i 84,83%. U 41,33% chorych stwierdzono cechy HTGW, 42,76% tej grupy stanowiły kobiety, a 40% mężczyźni. U kobiet wykazano istotne statystycznie różnice w zakresie wieku, glikemii na czczo (FPG) i glikemii poposiłkowej (PPG) między grupami z MetS i bez niego, rozpoznanym na podstawie obu definicji, natomiast w zakresie stężenia cholesterolu całkowitego i frakcji LDL różniły się one tylko między grupami z MetS i bez niego wydzielonymi na podstawie definicji AHA/NHLBI (a nie na podstawie kryteriów IDF). U mężczyzn wykazano statystycznie istotne różnice stężeń cholesterolu całkowitego HbA_{1c} między grupami z MetS i bez niego określonym według AHA/NHLBI (ale nie według IDF). U kobiet z HTGW stwierdzono wyższe stężenia cholesterolu całkowitego i cholesterolu frakcji LDL oraz wyższe wartości ciśnienia skurczowego i rozkurczowego. U mężczyzn z HTGW odnotowano wyższe wartości stężeń cholesterolu całkowitego, rozkurczowego ciśnienia tętniczego, HbA_{1c}, FPG i PPG.

Wnioski: Rozpoznanie MetS lub HTGW pozwala zidentyfikować osoby obciążone zwiększonym ryzykiem sercowo-naczyniowym.
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Słowa kluczowe: *talia hipertriglicemiczna, zespół metaboliczny, cukrzyca typu 2, profil lipidowy, kontrola glikemii*

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Introduction

Metabolic syndrome (MetS) describes a constellation of clinical characteristics that are associated with an increased risk of developing atherosclerotic cardiovascular disease (CVD) and type 2 diabetes (DM), including central obesity, glucose intolerance, hypertension, low HDL (high density lipoprotein) cholesterol, and elevated triglycerides. It has been demonstrated that individuals with MetS are at increased (2 to 3 times) risk of cardiovascular events, and a five times greater risk of diabetes [1, 2]. The underlying causes of MetS are considered to be central adiposity, insulin resistance, and genetic predisposition [2].

Since its initial description by Reaven in 1988, several definitions of MetS have emerged. The first global definition of MetS was by the World Health Organisation (WHO) in 1998, followed by the European Group for the Study of Insulin Resistance (EGIR) in 1999 [3, 4]. Two years later, in 2001, the USA's National Cholesterol Education Program — Third Adult Treatment Panel (NCEP-ATP III) introduced the NCEP definition which assumes that MetS is a clinical utility by treating all its components as equally important and does not include a specific measure of insulin [5]. The NCEP definition became popular because of its simplicity and feasibility in that its components could be easily and routinely determined in most clinical and research settings. This definition was not only simple and practical but has also been shown to be superior in predicting CVD [6]. The American Heart Association/National Heart, Lung and Blood Institute Scientific Statement (AHA/NHLBI) revised the NCEP definition in 2005 [7].

In 2005, the International Diabetes Federation (IDF) proposed a definition of MetS similar to that of the NCEP, but with increased waist circumference (WC) as a necessary requirement, emphasising the central importance of abdominal obesity. The IDF has recommended that the cut off points for waist circumference should be specific to an ethnic group [8].

The various MetS definitions include the same core criteria of central obesity, hyperglycaemia, dyslipidemia and high blood pressure, but differ in the cut-off points for individual criteria, in specific mandatory requirements (e.g. abdominal obesity or insulin resistance) and in the inclusion of additional factors (e.g. microalbuminuria). Hence, they identify broadly similar, but not identical, groups of individuals with MetS.

The criteria which are used for the definition of MetS based on the recommendations described above are shown in Table I.

It has been demonstrated by previous large scale studies that central obesity, as measured by WC, is closely related to coronary heart disease (CHD) risk [9,10]. Although there is accumulating evidence supporting the significant role of WC in predicting CHD events, it has not been translated into an enhancement of predictability of the IDF criteria for MetS on the development of CHD, given that in the IDF definition, WC is a required component for labelling individuals with MetS. On the contrary, studies have reported that MetS definitions have a similar ability to predict an incident

Table I. *Three definitions of metabolic syndrome*
Tabela I. *Trzy definicje zespołu metabolicznego*

NCEP ATP III 2001, ref 5 **At least three of the following:**	**AHA/NHLBI 2005, ref 7** **At least three of the following:**	**IDF 2005, ref 8** **Waist circumference (for subjects of European origin) ≥ 94 cm (men), ≥ 80 cm (women), plus any two of the following:**
1. Fasting plasma glucose ≥ 6.1 mmol/l	1. Fasting plasma glucose ≥ 5.6 mmol/l or drug treatment for elevated glucose	1. Fasting plasma glucose ≥ 5.6 mmol/l or known type 2 diabetes
2. Blood pressure ≥ 130 mm Hg/≥ 85 mm Hg	2. Systolic BP ≥ 130 mm Hg or diastolic BP ≥ 85 mm Hg or treatment for hypertension	2. Systolic BP ≥ 130 mm Hg and/or diastolic BP ≥ 85 mm Hg or treatment for hypertension
3. Triglycerides ≥ 1.7 mmol/l	3. Triglycerides ≥ 1.7 mmol/l or drug treatment for elevated triglycerides	3. Triglycerides ≥ 1.7 mmol/l or specific treatment
4. HDL-cholesterol < 1.03 mmol/l (men) or < 1.29 mmol/l (women)	4. HDL-cholesterol < 1.03 mmol/l (men) or < 1.29 mmol/l (women) or drug treatment for low HDL-cholesterol	4. HDL-cholesterol < 1.03 mmol/l (men) or < 1.29 mmol/l (women) or specific treatment
5. Waist circumference > 102 cm (men), > 88 cm (women)	5. Waist circumference ≥ 102 cm (men), ≥ 88 cm (women)	

of CHD [11, 12]. The debate continues as to whether the metabolic syndrome is really a discrete syndrome adding predictive value over and above the sum of its components [13, 14].

Increasing evidence identifies factors other than ordinary lipid profile to be predictors of atherosclerosis. Many studies performed on nontraditional risk factors have proposed a metabolic "triad" comprising increased serum level of apolipoprotein B, hyperinsulinaemia and high small, dense LDL (low density lipoprotein) cholesterol as a risk factor of cardiovascular diseases [15]. It is suggested that the simultaneous measurement and interpretation of waist circumference and fasting triglyceride concentration could be used as inexpensive screening tools to identify men characterised by the atherogenic metabolic triad and at high risk for CHD. The "hypertriglyceridemic waist" phenotype (HTGW), consisting of a waist wider than 90 cm in men and 85 cm in women, along with a plasma triglyceride concentration of 2.0 mmol/l or over, may be a simple screening approach for identifying individuals with increased cardiometabolic risk [16].

Whichever definition is used, large epidemiological surveys show that MetS is common. The prevalence of MetS is increasing, in parallel with the ageing population and the "epidemic" of obesity, and its increasing prevalence could possibly reverse the gains made through recent declining CVD mortality. Strategies to combat the forecast epidemic of type 2 diabetes and its vascular complications should focus on preventing and intervening early in metabolic syndrome [17].

The aim of this study was to determine the prevalence of the "hypertriglyceridemic waist" phenotype and the metabolic syndrome, using the most popular definitions, in type 2 diabetic patients, and to examine the relationship between 'hypertriglyceridemic waist' phenotype and the metabolic syndrome and blood lipids and blood glucose control in these patients.

Material and methods

300 subjects with type 2 diabetes who were consecutively admitted to the Clinic for Endocrinology, Diabetes and Diseases of Metabolism, Clinical Centre Niš were included in this observational prospective study over a three-month period. None of these patients was excluded, so as to reflect the true clinical picture of the CVD risk profile in this patient cohort.

All the data was gathered as part of the routine clinical work up, and informed consent was obtained from all patients for all the procedures and to allow use of data for research purposes.

For each subject, the following data were collected as part of their routine clinical care: age, sex, diabetes duration, weight, height, body mass index (BMI), waist circumference (WC), blood pressure (BP), total cholesterol, HDL cholesterol, LDL cholesterol, triglyceride, fasting plasma glucose (FPG), postprandial glucose (PPG) and glycated haemoglobin A_{1c} (HbA_{1c}).

Height, weight, and waist circumference were measured with the subject standing. Weight was measured while they were minimally clothed without shoes, using digital scales and recorded to the nearest 100 g. Height was measured in a standing position without shoes, using a standard anthropometer. Body mass index was calculated as weight in kilograms divided by height in metres squared. With the participant standing and breathing normally, waist circumference was measured midway between the superior iliac crest and the costal margin (at the level of the umbilicus), using a tape measure. Two blood pressures at five minute intervals were recorded after the subject had been seated for at least five minutes, and the arithmetic mean used in data analysis. Blood samples were obtained in the early morning after 12 to 14 hours of overnight fasting for biochemical measurements. Blood samples were obtained from an antecubital vein while participants were sitting and centrifuged within 45 minutes of collection; all blood analyses being done at the Central Laboratory of the Clinical Centre Niš on the day of blood collection. Blood samples for PPG were obtained two hours after breakfast. FPG, PPG, total cholesterol, HDL cholesterol and triglycerides were measured by the standard enzymatic colorimetric method using commercially available enzymatic reagents kits provided by Olympus; LDL cholesterol was calculated by the Friedewald formula, and HbA_{1c} was measured by a standard immunochemistry method using reagents kits provided by Olympus. All parameters were measured on an Olympus AU 680 automatic analyser at the accredited university hospital laboratory in Niš.

MetS was defined according to each of the AHA/NHLBI [7] and IDF [8] definitions as described in Table 1. The main difference between the NCEP definition and the AHA/NHLBI definition is in terms of the hyperglycaemia criterion [5, 7]. Since our patients were diabetic, they fulfilled both these criteria simultaneously. The hypertriglyceridemic waist phenotype was defined as having both a high waist circumference (wider than 90 cm in men and 85 cm in women) and increased fasting triglyceride levels (2.0 mmol/l or over) [16].

Continuous variables were reported as mean ± standard deviation (SD) and categorical variables were reported as percentages. The χ^2 test was used for the comparison of categorical variables. Student's

t-test was used for the comparison of continuous variables. $P < 0.05$ was considered as statistically significant.

Results

Of the 300 T2DM patients, there were 145 women (48.33%) and 155 men (51.67%). Average duration of DM was 11.93 ± 8.21 years (12.35 ± 8.08 in women and 11.54 ± 8.33 in men).

According to the AHA/NHLBI criteria, there were 213 patients with MetS (71.0%); 116 of these were women (54.46%) and 97 men (45.54%), or 80% of the women (116 of 145) and 62.58% of the men (97 of 155). According to the IDF criteria, there were 226 patients with MetS (75.33%); 123 of these were women (54.42%) and 103 men (45.58%), or 84.83% of the women (123 of 145) and 66.45% of the men (103 of 155). There were 124 patients with HTGW (41.33%), 62 women (50%) and 62 men (50%), or 42.76% of the women (62 of 145) and 40% of the men (62 of 155).

There were no significant differences in the prevalence of MetS according to AHA/NHLBI or IDF criteria, neither in the whole group of patients, nor in women or in men. There was a significantly higher prevalence of MetS in women than in men (when using both criteria). There were no significant differences in the prevalence of HTGW among women and men. There were significantly fewer patients with HTGW than with MetS, both in women and in men and with using both criteria for MetS.

Comparison of age and duration of DM in patients with and without MetS or HTGW, as well as parameters of blood glucose control and blood lipids, is shown in Tables II and III. Apart from differences in parameters comprising MetS (WC, blood pressure, HDL, triglycerides), there were statistically significant differences of age, FPG and PPG in women with and without MetS according to both definitions and of total and LDL cholesterol with and without MetS according to the AHA/NHLBI definition (but not the IDF definition). In men there were statistically significant differences in parameters comprising MetS (WC, blood pressure, HDL, triglycerides), and of total cholesterol and of HbA_{1c} with and without MetS according to the AHA/NHLBI definition (but not IDF definition). Women with HTGW have significantly higher levels of total and LDL cholesterol, systolic and diastolic BP. Men with HTGW have

Table II. *Characteristics of 145 female subjects with type 2 diabetes classified according to the two definitions of metabolic syndrome and the "hypertriglyceridemic waist" phenotype*

Tabela II. *Charakterystyka 145 kobiet chorujących na cukrzycę typu 2 w grupach wydzielonych na podstawie dwóch definicji zespołu metabolicznego i fenotypu "talii hipertriglicemicznej"*

	AHA/NHLBI definition		IDF definition		"Hypertriglyceridemic waist" phenotype	
Subjects	MetS	No MetS	MetS	No MetS	HTGW	No HTGW
No. (%)	116 (80)	29 (20)	123 (84.83)	22 (15.17)	62 (42.76)	83 (57.24)
Age (years)	62.34 ± 9.37*	58.17 ± 9.68	62.34 ± 9.21**	56.86 ± 10.25	61.85 ± 9.55	61.25 ± 9.59
Duration of DM (years)	12.38 ± 7.72	12.24 ± 9.56	12.20 ± 7.95	13.23 ± 8.93	12.06 ± 7.07	12.57 ± 8.80
BMI [kg/m^2]	30.06 ± 4.20**	26.15 ± 4.28	29.87 ± 4.15**	25.97 ± 4.89	30.34 ± 3.69**	28.49 ± 4.86
WC [cm]	98.13 ± 8.64**	84.10 ± 11.06	97.42 ± 8.83**	83.59 ± 12.91	99.35 ± 6.54**	92.31 ± 12.20
SBP [mm Hg]	142.76 ± 20.01**	122.93 ± 16.34	141.83 ± 20.50**	121.82 ± 13.68	142.58 ± 19.87*	135.96 ± 21.25
DBP [mm Hg]	83.62 ± 10.25**	75.86 ± 8.67	83.09 ± 10.23**	76.36 ± 9.66	83.95 ± 10.17*	80.66 ± 10.41
TC [mmol/l]	6.09 ± 1.40**	5.37 ± 0.94	6.03 ± 1.41	5.47 ± 0.80	6.57 ± 1.21**	5.47 ± 1.26
HDL-C (mmol/l)	1.36 ± 0.37*	1.50 ± 0.23	1.36 ± 0.37**	1.55 ± 0.19	1.39 ± 0.42	1.40 ± 0.30
LDL-C [mmol/l]	3.69 ± 1.12**	3.13 ± 0.91	3.63 ± 1.16	3.31 ± 0.68	3.90 ± 1.03**	3.35 ± 1.10
TG [mmol/l]	2.32 ± 1.22**	1.15 ± 0.57	2.25 ± 1.22**	1.18 ± 0.63	3.06 ± 1.18**	1.35 ± 0.53
HbA_{1c} (%)	8.21 ± 1.75	7.66 ± 2.30	8.15 ± 1.78	7.83 ± 2.39	8.29 ± 1.91	7.96 ± 1.85
FPG (mmol/l)	9.12 ± 3.12**	7.14 ± 3.70	8.97 ± 3.17*	7.37 ± 3.92	9.23 ± 3.09	8.35 ± 3.46
PPG (mmol/l)	12.97 ± 3.90**	10.91 ± 5.01	12.83 ± 4.01*	11.07 ± 5.01	13.30 ± 4.22*	12.01 ± 4.13

AHA/NHLBI — American Heart Association/National Heart, Lung and Blood Institute; IDF — International Diabetes Federation; MetS — metabolic syndrome; HTGW — "hypertriglyceridemic waist"; BMI — body mass index; WC — waist circumference; SBP — systolic blood pressure; DBP — diastolic blood pressure; TC — total cholesterol; HDL-C — high density lipoprotein cholesterol; LDL-C — low density lipoprotein cholesterol; TG — triglyceride; HbA_{1c} — glycated haemoglobin A_{1c}; FPG — fasting plasma glucose; PPG — postprandial glucose; Data are mean ± SD; *MetS *vs.* no MetS or HTGW *vs.* no HTGW $p < 0.05$; **MetS *vs.* no MetS or HTGW *vs.* no HTGW $p < 0.01$

Table III. *Characteristics of 155 male subjects with type 2 diabetes classified according to the two definitions of metabolic syndrome and the "hypertriglyceridemic waist" phenotype*

Tabela III. *Charakterystyka 155 mężczyzn chorujących na cukrzycę typu 2 w grupach wydzielonych na podstawie dwóch definicji zespołu metabolicznego i fenotypu "talii hipertriglicemicznej"*

	AHA/NHLBI definition		IDF definition		"Hypertriglyceridemic waist" phenotype	
Subjects	MetS	No MetS	MetS	No MetS	HTGW	No HTGW
No. (%)	97 (62.58)	58 (37.42)	103 (66.45)	52 (33.55)	62 (40)	93 (60)
Age (years)	61.36 ± 9.85	60.83 ± 9.81	61.93 ± 9.86	59.63 ± 9.63	59.73 ± 10.15	62.12 ± 9.51
Duration of DM (years)	12.24 ± 8.12	10.36 ± 8.62	12.37 ± 8.97	9.88 ± 6.68	11.42 ± 8.16	11.61 ± 8.49
BMI [kg/m^2]	28.68 ± 4.03**	24.89 ± 3.56	28.84 ± 3.73**	24.12 ± 3.48	29.33 ± 4.08**	25.88 ± 3.82
WC [cm]	102.15 ± 8.92**	92.21 ± 9.23	103.17 ± 7.19**	89.04 ± 8.76	103.82 ± 7.88**	94.84 ± 10.05
SBP [mm Hg]	141.55 ± 17.40**	129.83 ± 20.02	140.05 ± 17.62**	131.44 ± 21.08	138.55 ± 17.49	136.24 ± 20.33
DBP [mm Hg]	84.02 ± 10.74**	78.71 ± 9.89	84.13 ± 10.58**	77.88 ± 9.82	84.19 ± 10.13*	80.59 ± 10.91
TC [mmol/l]	6.08 ± 1.93*	5.55 ± 0.96	6.03 ± 1.82	5.57 ± 1.18	6.49 ± 2.13**	5.47 ± 1.07
HDL-C [mmol/l]	1.22 ± 0.45**	1.41 ± 0.30	1.26 ± 0.44*	1.36 ± 0.34	1.24 ± 0.49	1.32 ± 0.35
LDL-C [mmol/l]	3.40 ± 0.96	3.44 ± 0.86	3.42 ± 0.82	3.40 ± 1.09	3.49 ± 0.88	3.37 ± 0.94
TG [mmol/l]	3.66 ± 4.36**	1.40 ± 0.68	3.41 ± 4.25**	1.62 ± 1.31	4.55 ± 5.05**	1.66 ± 1.38
HbA_{1c} (%)	8.02 ± 1.87*	7.45 ± 1.75	7.86 ± 1.82	7.70 ± 1.91	8.28 ± 1.97**	7.49 ± 1.69
FPG [mmol/l]	8.89 ± 3.45	8.08 ± 3.67	8.77 ± 3.38	8.23 ± 3.86	9.65 ± 3.56**	7.88 ± 3.37
PPG [mmol/l]	12.35 ± 3.66	11.65 ± 4.22	12.06 ± 3.61	12.15 ± 4.40	13.02 ± 3.67**	11.47 ± 3.91

AHA/NHLBI — American Heart Association/National Heart, Lung and Blood Institute; IDF — International Diabetes Federation; MetS — metabolic syndrome; HTGW — "hypertriglyceridemic waist"; BMI — body mass index; WC — waist circumference; SBP — systolic blood pressure; DBP — diastolic blood pressure; TC — total cholesterol; HDL-C — high density lipoprotein cholesterol; LDL-C — low density lipoprotein cholesterol; TG — triglyceride; HbA_{1c} — glycated haemoglobin A1c; FPG — fasting plasma glucose; PPG — postprandial glucose; Data are mean ± SD; *MetS *vs.* no MetS or HTGW *vs.* no HTGW $p < 0.05$; **MetS *vs.* no MetS or HTGW *vs.* no HTGW $p < 0.01$

significantly higher levels of total cholesterol, diastolic BP, HbA_{1c}, FPG and PPG.

Discussion

Data regarding the prevalence of MetS varies in different populations. In the general population, MetS is found in around one third of people. Using the US national data, and the definition of MetS proposed by the IDF, almost 40% of U.S. adults were classified as having MetS, an estimate higher than that reached using the NCEP definition (34.5%). The prevalence of MetS in a high risk population is much higher. A study of a population of diabetic patients found the prevalence of MetS to be 72.1% (NCEP) and 84.4% (IDF) [18]. There is very great concordance between the two definitions in identifying MetS. In the abovementioned study, around 93% of patients were classified in the same way as having or not having MetS. In a Chinese population, agreement of the two definitions in the risk population of hypertensive patients was 94.4% in men and 97% in women. Almost one third of hypertensive men, and one half of hypertensive women, have MetS [19].

Our results, showing that almost three quarters of type 2 diabetic patients have MetS, are in accordance with this and other published results on the prevalence of MetS. They confirm the importance and magnitude of the problem of MetS, especially in high risk populations such as diabetic patients. Our results showed no differences in the number of patients with MetS when using both definitions. This high concordance of the two definitions is perhaps not surprising given that these definitions use almost identical variables, except for the central obesity criteria.

In our study, the prevalence of MetS was higher in women than in men (defined by both definitions). Published data on the prevalence of MetS differs: in Western societies, MetS is more common in men than in women [18, 20], but in Chinese and Arab populations it has been found to be more common in women than in men [21-23], as it was in our study. In an elderly Iranian population, the prevalence of MetS ranged between 41.9% (IDF) and 50.8% (NCEP) and it was higher in women than in men, with high concordance between the two definitions [24].

Data in the general population of men shows that the prevalence of HTGW is high (around 20%) and

that it is associated with increased risk of CVD even in the absence of DM [25]. There are similarities in terms of the lipid disorders in diabetic patients and in non-diabetics with HTGW, above all in the lowering of the level of HDL cholesterol which bears elevated risk for CVD [26]. The prevalence of HTGW in the general population of women is lower than in men and is around 15% but the risk for CVD is also elevated as in men [27]. As it is with MetS, the presence of HTGW is almost two fold higher in the high risk populations such as diabetic patients. Our results, showing 40% of men and 43% of women having HTGW, are similar to that data.

Many studies have estimated the effect of the presence of MetS on the risk for CVD. Most show that the presence of MetS is an important risk factor for all the manifestations of CHD and its complications. We examined the relationship of the presence of MetS or HTGW and known risk factors for atherosclerosis (dyslipidemia) and blood glucose control in diabetic patients. It can be assumed that the presence of MetS increases risk for CVD, by among other things worsening dyslipidemia and blood glucose control.

In a study of 4,350 diabetic patients, those with MetS according to NCEP criteria had the highest risk for CHD, while the IDF definition of MetS did not show significance in predicting future cardiovascular events. The authors think that despite having hypertension and dyslipidemia, patients without central obesity will not be categorised as having metabolic syndrome using the IDF criteria. For those individuals who did not have central obesity, the application of the NCEP ATP III criteria identified a subgroup at even higher risk of CHD. Individuals in the NCEP-only group were thinner and had worse glycemic control, lipid profiles, renal function, and albuminuria, which all are known risk factors for CHD. By using individual cardiovascular risk factors in regression analysis, blood pressure and HDL cholesterol were identified as the strongest predictors of CHD [12].

In the Strong Heart Study in diabetic patients, the presence of MetS according to the NCEP criteria was connected to the highest cardiovascular risk. The presence of MetS according to the IDF criteria was connected to a smaller risk, but that difference was not statistically significant [21]. These two results can be correlated with our findings that the presence of MetS according to the AHA/NHLBI criteria is connected to higher levels of cholesterol and LDL cholesterol. Similarly, in a prospective study of 750 subjects who underwent coronary angiography, the NCEP definition of MetS yielded a significantly higher risk of vascular events than did the IDF definition [11]. Another study has shown that the revised NCEP definition in males, and the IDF definition in females, are the strongest predictors of carotid atherosclerosis [28]. In a Chinese population, the presence of MetS according to the IDF definition was more strongly associated with CHD than the presence of MetS according to the NCEP definition, but the agreement of the two definitions was very high in this study [19].

On the other hand, there is data of the general population (not only diabetic patients) indicating that the definition proposed by the IDF may be more accurate in identifying individuals at very high cardiovascular risk compared to the NCEP-ATP III and NHLBI definitions. Greek authors showed the presence of MetS in 81.2% and 79.1% (by the NHLBI and IDF criteria, respectively) of patients with acute coronary syndrome (ACS), and in the final analysis found that presence of MetS according to IDF criteria was a significantly better predictor of ACS [29]. They assumed that the IDF definition would be more likely to have stronger discriminatory power than the other definitions in identifying future CHD events, because it emphasises WC, an established index of abdominal obesity which provides information not only for conventional risk factors but also for cardiometabolic risk profile among individuals [9, 10].

Similar results were found in a group of Japanese patients who underwent percutaneous coronary intervention in which the prevalence of MetS was 36%, which is similar to the prevalence noted in previous studies of Western populations, highlighting the fact that the risk of MetS may not be different among various ethnic groups, even though the definition of obesity varies according to ethnicity, as mentioned in the IDF definition of MetS [30]. In that study, patients with obesity, defined as BMI $\geq$ 25 kg/m^2, have a higher risk of a subsequent cardiac event than patients with any other component of MetS, giving consequently a certain advantage to the IDF definition.

Our results correlate with data showing that in a population of diabetic patients, the use of the AHA/NHLBI definition has certain advantages since it better defines those with more dyslipidemia and consequently a higher risk for CVD.

A study comparing the ability of the three clinical approaches (i.e. defining MetS by NCEP or IDF criteria or the hypertriglyceridemic waist phenotype) to identify individuals at increased cardiometabolic risk has shown that a large proportion of men with HTGW also met the NCEP-ATP III (82.7%) or IDF (89.2%) criteria. The Framingham risk score of men meeting any of the three screening tools criteria was higher, and was similar across the three approaches [4.2 (HTGW), 3.8 (NCEP) and 3.7 (IDF)]. The authors

concluded that HTGW may be as discriminatory as the NCEP-ATP III or the IDF criteria and could be used as an initial screening approach to identify individuals with deteriorated cardiometabolic risk markers [31].

In a study looking at a population of diabetic patients, the authors concluded that the "hypertriglyceridemic waist" phenotype, an inexpensive and simple tool identifying subjects with metabolic syndrome features, is a significant marker of CHD manifestations occurring at an earlier age in those with glucose intolerance or type 2 diabetes [32]. HTGW is associated with increased coronary risk factors among women as for men [27]. HTGW is associated with a hostile lipid profile that includes higher levels of small, dense LDL cholesterol and decreased LDL particle size [33].

Our results show significant differences in a majority of studied risk factors when HTGW is present and it correlates with most of the aforementioned data, but those differences are more present in men than in women. Therefore our results differ somewhat compared to previous results.

Conclusions

Bearing in mind all the results reported in our patients, it can be concluded that metabolic syndrome is present in a large number of type 2 diabetic patients, with almost three quarters fulfilling both AHA/NHLBI and IDF criteria. Women have metabolic syndrome more often than men and that is the case using either definition. More than 40% of type 2 diabetic patients have a hypertriglyceridemic waist phenotype, equally among men and women. This number of patients is significantly smaller than those having metabolic syndrome.

In a population of diabetic patients, the use of the AHA/NHLBI definition has certain advantages since it better correlates with worse lipid profile and consequently with higher risk for cardiovascular diseases.

Determining "hypertriglyceridemic waist" phenotype in diabetic patients is a simple tool for identifying subjects with increased risk for cardiovascular diseases, especially in men in whom it identifies those with worse lipid profile and poor blood glucose control.

Because recent decades have seen steep rises in the prevalence of obesity and type 2 diabetes, it is very important to identify those with increased cardiovascular risk as soon as possible. Using a definition of metabolic syndrome or, even easier, determining a "hypertriglyceridemic waist" phenotype gives the opportunity for early preventive intervention.

References

1. Cameron AJ, Shaw JE, Zimmet PZ. The metabolic syndrome: prevalence in worldwide populations. Endocrinol Metab Clin N Am 2004; 33: 351–376.
2. Eckel RH, Grundy SM, Zimmet PZ. The metabolic syndrome. Lancet 2005; 365: 1415–1428.
3. Alberti KG, Zimmet PZ. Definition, diagnosis and classification of diabetes mellitus and its complications. Part 1: diagnosis and classification of diabetes mellitus provisional report of a WHO consultation. Diabet Med 1998; 15: 539–553.
4. Balkau B, Charles MA. Comment on the provisional report from the WHO consultation: European Group for the Study of Insulin Resistance (EGIR). Diabet Med 1999; 16: 442–443.
5. Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults. Executive summary of the third report of the National Cholesterol Education Program (NCEP) expert panel on detection, evaluation, and treatment of high blood cholesterol in adults (Adult Treatment Panel III). JAMA 2001; 285: 2486–2497.
6. Hunt KJ, Resendez RG, Williams K, Haffner SM, Stern MP. San Antonio Heart Study. National Cholesterol Education Program versus World Health Organization metabolic syndrome in relation to all-cause and cardiovascular mortality in the San Antonio Heart Study. Circulation 2004; 110: 1251–1257.
7. Grundy SM, Cleeman JI, Daniels SR et al. Diagnosis and management of the metabolic syndrome: an American Heart Association/National Heart, Lung, and Blood Institute Scientific Statement. Circulation 2005; 112: 2735–2752.
8. Alberti KG, Zimmet P, Shaw J. IDF Epidemiology Task Force Consensus Group. The metabolic syndrome — a new worldwide definition. Lancet 2005; 366: 1059–1062.
9. Balkau B, Deanfield JE, Després JP et al. International Day for the Evaluation of Abdominal Obesity (IDEA): a study of waist circumference, cardiovascular disease, and diabetes mellitus in 168,000 primary care patients in 63 countries. Circulation 2007; 116: 1942–1951.
10. Carr DB, Utzschneider KM, Hull RL et al. Intra-abdominal fat is a major determinant of the National Cholesterol Education Program Adult Treatment Panel III criteria for the metabolic syndrome. Diabetes 2004; 53: 2087–2094.
11. Saely CH, Koch L, Schmid F et al. Adult Treatment Panel III 2001, but not International Diabetes Federation 2005 criteria of the metabolic syndrome, predict clinical cardiovascular events in subjects who underwent coronary angiography. Diabetes Care 2006; 29: 901–907.
12. Tong PC, Kong AP, So WY et al. The usefulness of the International Diabetes Federation and the National Cholesterol Education Program's Adult Treatment Panel III definitions of the metabolic syndrome in predicting coronary heart disease in subjects with type 2 diabetes. Diabetes Care 2007; 30: 1206–1211.
13. McNeill AM, Rosamond WD, Girman CJ et al. The metabolic syndrome and 11-year risk of incident cardiovascular disease in the atherosclerosis risk in communities study. Diabetes Care 2005; 28: 385–390.
14. Gami AS, Witt BJ, Howard DE et al. Metabolic syndrome and risk of incident cardiovascular events and death: a systematic review and meta-analysis of longitudinal studies. J Am Coll Cardiol 2007; 49: 403–414.
15. Lamarche B, Tchernof A, Mauriège P et al. Fasting insulin and apolipoprotein B levels and low-density lipoprotein particle size as risk factors for ischemic heart disease. JAMA 1998; 279: 1955–1961.
16. Lemieux I, Pascot A, Couillard C et al. Hypertriglyceridemic waist. A marker of the atherogenic metabolic triad (hyperinsulinemia, hyperapolipoprotein B, small, dense LDL) in men? Circulation 2000; 102: 179–184.
17. Zimmet P, Alberti KG, Shaw J. Global and societal implications of the diabetes epidemic. Nature 2001; 414: 782–787.
18. Ford ES. Prevalence of the metabolic syndrome defined by the International Diabetes Federation among adults in the U.S. Diabetes Care 2005; 28: 2745–2749.
19. Li WJ, Xue H, Sun K et al. Cardiovascular risk and prevalence of metabolic syndrome by differing criteria. Chin Med J 2008; 121: 1532–1536.
20. Welin L, Adlerberth A, Caidahl K et al. Prevalence of cardiovascular risk factors and the metabolic syndrome in middle-aged men and women in Gothenburg, Sweden. BMC Public Health 2008; 8: 403.
21. de Simone G, Devereux RB, Chinali M et al. Prognostic impact of metabolic syndrome by different definitions in a population with high prevalence of obesity and diabetes: the Strong Heart Study. Diabetes Care 2007; 30: 1851–1856.
22. Gu D, Reynolds K, Wu X et al. Inter ASIA Collaborative Group, Prevalence of the metabolic syndrome and overweight among adults in China. Lancet 2005; 365: 1398–1405.
23. Harzallah F, Alberti H, Khalifa FB. The metabolic syndrome in an Arab population: a first look at the new International Diabetes Federation criteria. Diabetic Medicine 2006; 23: 441–444.
24. Hadaegh F, Zabetian A, Tohidi M, Ghasemi A, Sheikholeslami F, Azizi F. Prevalence of metabolic syndrome by the Adult Treatment Panel III, Inter-

national Diabetes Federation, and World Health Organization definitions and their association with coronary heart disease in an elderly Iranian population. Ann Acad Med Singapore 2009; 38: 142–149.
25. Lemieux I, Alméras N, Mauriège P et al. Prevalence of 'hypertriglyceridemic waist' in men who participated in the Quebec Health Survey: association with atherogenic and diabetogenic metabolic risk factors. Can J Cardiol 2002; 18: 725–732.
26. Laakso M, Pyörälä K, Voutilainen E, Marniemi J. Plasma insulin and serum lipids and lipoproteins in middle-aged non-insulin-dependent diabetic and non-diabetic subjects. Am J Epidemiol 1987; 125: 611–621.
27. LaMonte MJ, Ainsworth BE, DuBose KD et al. The hypertriglyceridemic waist phenotype among women. Atherosclerosis 2003; 171: 123–130.
28. Skilton MR, Moulin P, Serusclat A, Nony P, Bonnet F. A comparison of the NCEP–ATPIII, IDF and AHA/NHLBI metabolic syndrome definitions with relation to early carotid atherosclerosis in subjects with hypercholesterolemia or at risk of CVD: evidence for sex-specific differences. Atherosclerosis 2007; 190: 416–422.
29. Koutsovasilis A, Protopsaltis J, Triposkiadis F et al. Comparative performance of three metabolic syndrome definitions in the prediction of acute coronary syndrome. Intern Med 2009; 48: 179–187.
30. Kasai T, Miyauchi K, Kurata T et al. Prognostic value of the metabolic syndrome for long-term outcomes in patients undergoing percutaneous coronary intervention. Circ J 2006; 70: 1531–1537.
31. Blackburn P, Lemieux I, Alméras N et al. The hypertriglyceridemic waist phenotype versus the National Cholesterol Education Program — Adult Treatment Panel III and International Diabetes Federation clinical criteria to identify high-risk men with an altered cardiometabolic risk profile. Metabolism 2009; 58: 1123–1130.
32. St-Pierre J, Lemieux I, Perron P et al. Relation of the "hypertriglyceridemic waist" phenotype to earlier manifestations of coronary artery disease in patients with glucose intolerance and type 2 diabetes mellitus. Am J Cardiol 2007; 99: 369–373.
33. Gazi IF, Filippatos TD, Tsimihodimos V et al. The hypertriglyceridemic waist phenotype is a predictor of elevated levels of small, dense LDL cholesterol. Lipids 2006; 41: 647–654.