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THE VALUE OF DIFFERENT ANTHROPOMETRIC VARIABLES IN ASSESSING CARDIOMETABOLIC RISK

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Abstract

Objective. *To investigate which anthropometric parameter best correlates with modifications in blood glucose and blood pressure (BP).* ***Material and method.*** *135 subjects were included in the study. We measured weight, height, waist circumference (WC), BP and calculated body mass index (BMI) and waist-to-height ratio (WHtR). We determined glycated hemoglobin A1c (HbA1c) and performed an oral glucose tolerance test (OGTT) under standard conditions.* ***Results.*** *HbA1c increased with BMI, WC and WHtR. We found statistically higher values of fasting blood glucose (FBG) in obese (P=0.001), in those with large WC (P=0.028) and in those with WHtR≥0.5 (P=0.028). Using ROC curves with area under curve (AUC) of BMI, WC and WHtR, WHtR was the best predictor for HbA1c≥5.7% (AUC=0.665, 95%CI:0.570-0.760), FBG≥100mg/dl (AUC=0.705, 95%CI:0.617-0.793) and high blood pressure (AUC=0.768, 95%CI:0.689-0.848).* ***Conclusions:*** *WHtR was the best predictor for elevated HbA1c, FBG and blood pressure, hence people with a WHtR≥0.5 should be included in preventive strategies.*

keywords: *abdominal obesity, waist-to-height ratio, prediabetes, cardiovascular risk*

Background

Overweight and obesity are important risk factors for mortality and morbidity from cardiovascular disease, for type 2 diabetes mellitus, for cancer and others, that lead to approximately 3 million deaths each year [1]. Anthropometric variables like body mass index (BMI), waist circumference (WC), waist/hip ratio (WHR) and waist-to-height ratio (WHtR) are evaluated as predictors for

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cardio-metabolic risk, but there is still controvercy as to which is the best predictor. BMI is the most used marker of overweight and obesity in population studies and used by the World Health Organisation (WHO) to define the severity of the disease [2].

In 2005, and then again in 2009, the International Diabetes Federation (IDF) proposes WC to define metabolic syndrome [3], but this is dependant of sex, etnicity, and still does not have normal values for all countries. BMI is used as an indicator of total body fat, while WC, WHR and WHtR are considered surogate markers of central obesity. Many studies aim to determine an hierarchy of the different anthropometric parameters in relationship to increased cardio-metabolic risk.

A series of endocrine, metabolic and hemodynamic mechanisms are responsible for the relationship between obesity and hypertension.

Overweight and obesity and their relationship with insulin resistance, decreased insulin secretion, increase in oxidative stress and a pro-inflammatory status are the most important risk factors for the development and evolution of type 2 diabetes mellitus [4, 5]. It has been shown that minimal glycaemic modifications, in pre-diabetes and even before disglycaemia is diagnosed, are in relationship with atherosclerosis and its complications [6]. Glycated hemoglobin (HbA1c) has been used for long as a marker of long-term glycaemic control and as a predictor of micro-macrovascular complications in diabetic patients. In the last years HbA1c has been also used in non-diabetic people for predicting their evolution to type 2 diabetes mellitus and cardiovascular disease [7, 8]. The American Diabetes Association has recently adopted HbA1c as a diagnosis criterion for diabetes (HbA1c>6.5%) and for pre-diabetes (HbA1c≥5.7%) [9]. The value considered normal for fasting blood glucose has also been lowered to 100mg/dl, and it has been also suggested, based on several studies, that for the diagnosis of pre-diabetes, a high value of blood glucose at 1 hour post-glucose load should be equivalent to impaired glucose tolerance (IGT).

Material and Method

We conducted the study in Deleni, a rural community in Iaşi county. Out of the 3248 people aged 18 or over registered with the general practitioner and existing in the database from the National Health Program of 2007-2008, we extracted a sample of 135 people, representative of this population. All the subjects involved in this study signed informed consent before enroling.

We recorded anthropometric data: height, weight and waist circumferince. Height and weight data were obtained using standardized techniques and equipment. BMI was calculated by dividing weight by height squared (kg/m^2). According to WHO criteria, BMI<18.5 kg/m^2 defined underweight, BMI between 18.5-24.9kg/m^2 defined normal weight, BMI between 25-29.9kg/m^2 defined over weight and BMI≥30kg/m^2 defined obesity. We measured WC, using a fiberglass tape, at the midpoint between the bottom of the rib cage and the top of the iliac crest. Normal WC was defined as WC<80cm for women and <94 cm for men. WHtR was calculated as WC divided by height. Normal WHtR was defined as <0.5. After 5 minutes of rest while seated, blood pressure (BP) was measured 3 times with 30 seconds intervals using a standard mercury sphygmomanometer. The average of the 2nd and 3rd measurements was used in the analysis. High BP was defined as systolic blood pressure of ≥130mmHg, or diastolic blood pressure of ≥85mmHg or a known reccord of arterial hypertension. We performed an oral glucose tolerance test in the morning after at least 8 hours of fasting, with 75g of glucose in 300ml of water. Fasting blood glucose (FBG) values, and blood glucose values 1 hour and 2 hours after the glucose load were obtained from capilary samples, using One Touch® Select™ LifeScan glucometer. Glycated hemoglobin A1c (HbA1c) values were obtained also from capilary blood sample using DCA Vantage™ Analyzer, Siemens, which has a spectrophotometric method of analysis.

Statistical analysis was performed using SPSS version 16.0 for Windows (SPSS, Inc, Chicago, IL, USA). Continuous variables are expressed as the mean±SD, and discrete variables are expressed as numbers and proportions. Comparison between groups was performed using the non-parametric Mann-Whitney U test for continuous and the Pearson Chi-Square test for categorical data. We used receiver-operating characteristic (ROC) analysis to predict validity. ROC curves with area under the curve (AUC) were used to evaluate which measure of adiposity (BMI, WC, WhtR) most accurately predicted cardio-metabolic risk. AUC is a measure of the diagnostic power of a test. A perfect test will have an AUC of 1.0, and an AUC equal to 0.5 means the test performs no better than chance.

Results

We evaluated 135 subjects. The mean BMI in the studied population was 28.53 ±6.52kg/m^2, mean WC was 98.88±13.17cm and mean WHtR was 0.619±0.105. Among the subjects studied 4 (3.0%) were underweight, 37 (27.4%) were normal weight, 44 (32.6%) were overweight and 50 (37.0%) were obese. Only 24 (17.8%) had normal WC and only 12 (8.9%) had WHtR<0.5.

Table 1. Mean value of HbA1c in relationship to BMI

		N	% of Total N	Mean	Median	Std. Deviation	Minimum	Maximum
HbA1c	Underweight	4	3.0%	5.300	5.300	.2944	5.0	5.6
	Normal weight	37	27.6%	5.749	5.700	.4350	5.1	7.5
	Overweight	43	32.1%	5.781	5.700	.5400	5.2	8.1
	Obese	50	37.3%	6.056	5.800	.7822	5.2	9.1
	Total	134	100.0%	5.860	5.700	.6325	5.0	9.1

In the lot studied, 39.6% had HbA1c <5.7% and only 12.7% had HbA1c<5.4%. There was an increase in HbA1c with increased BMI (Table 1). Using the Mann-Whitney U non-parametric statistical test, we found that HbA1c was statistically higher in obese than in overweight (P=0.034). In subjects with large WC, the mean HbA1c was 5.924±0.669%, higher than in those with normal WC, who had a mean HbA1c of 5.571±0.292%. Using the Mann-Whitney U test, HbA1c was found to be statistically higher in people with large WC (P=0.005). The Pearson Chi-Square test confirmed the results regarding higher HbA1c in those with bigger WC (P=0.011). The mean HbA1c was higher (5.882±0.651%) in those with a WHtR≥0.5 than in those with WHtR<0.5 (5.642±0.342%).

In the lot studied, 69.6% had FBG <110mg/dl, but only 48.1% had a FBG<100mg/dl. FBG values were higher with increased BMI, from mean FBG of 100.92±15.92mg/dl in normal weight, to 105.5±18.01mg/dl in overweight to 114.64±26.27mg/dl in obese. The mean FBG was also higher in people with large WC (109.17±22.92mg/dl) than in people with normal WC (98.67±9.29mg/dl) and in people with WHtR>0.5 (108.32±22.12mg/dl) than in those with WHtR<0.5 (96.92±8.53mg/dl). The Mann-Whitney U test showed statistically higher values of FBG in obese than in normal weight (P=0.001), in obese than in overweight (P=0.047), in those with large WC than in those with normal WC (P=0.028) and in those with WHtR≥0.5 than in those with WHtR<0.5 (P=0.028).

At 2 hour after glucose load, the mean blood glucose value of normal weight, overweight and obese was not significantly different (135.14±36.11mg/dl for normal weight, 124.36±43.73mg/dl for overweight and 126.93±38.19mg/dl for obese); in the same way, there was no significant difference between the percentage of normal weight, overweight and obese who had blood glucose≥140mg/dl at 2 hour (40% of normal weight, 33.3% of overweight and 31.1% of obese). But, there was a significant difference in the percentage of those with large WC who had blood glucose ≥140mg/dl at 2 hour (38.2%) compared with those with normal WC (16.7%), P=0.045. Also, there was a significant difference in the percentage of those with WHtR≥0.5 who had blood glucose ≥140mg/dl at 2 hour (36.8%) compared with those with WHtR<0.5 (8.3%), P=0.048.

High blood pressure (BP) was found in 62.2% of the subjects; high BP was found in 43.2% of the normal weight, 65.9% of the overweight and 78% of the obese. In people with normal WC, the proportion of people with high BP was 50%, whereas in the group with large WC, 64.9% had high BP. 8.3% of people with normal WHtR were hypertensive, but 67.5% of people with high WHtR were hypertensive. Using ROC curves with area under curve (AUC) and 95% confidence intervals (CI) of BMI, WC and WHtR, we proved that WHtR was the best predictor for HbA1c≥5.7% (AUC=0.665, 95%CI:0.570-0.760), fasting blood glucose≥100mg/dl (AUC=0.705, 95%CI:0.617-0.793) and high blood pressure (AUC=0.768, 95%CI:0.689-0.848) (Figure 1-3).

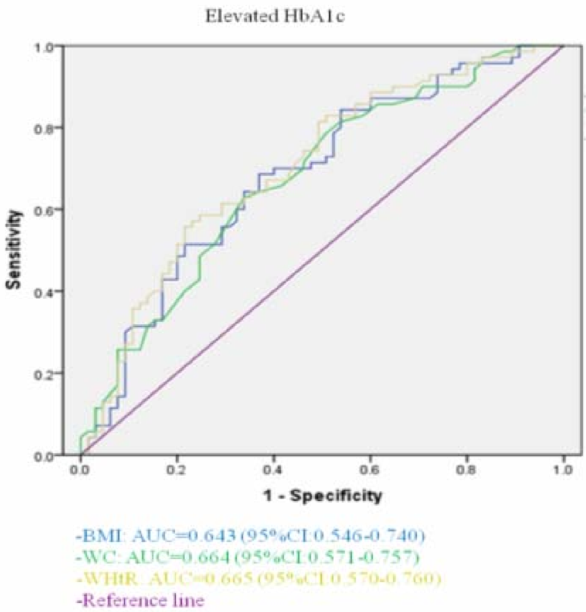

Figure 1. ROC curves with AUC of BMI, WC and WHtR for predicting elevated HbA1c

Discussions

Obesity, diabetes mellitus and arterial hypertension are considered modifiable risk factors. Placing people sooner in risk categories means earlier beginning of treatment, increasing lifespam and quality of life with minimal costs. Hence the multitude of studies which aim on one side to establish the real prevalence of disease in different regions and on the other side to find the least expensive and the easiest to use, but also the most precise, methods for identifying people at risk of disease, or who are in the early phases of the disease, from the first visit to the physician.

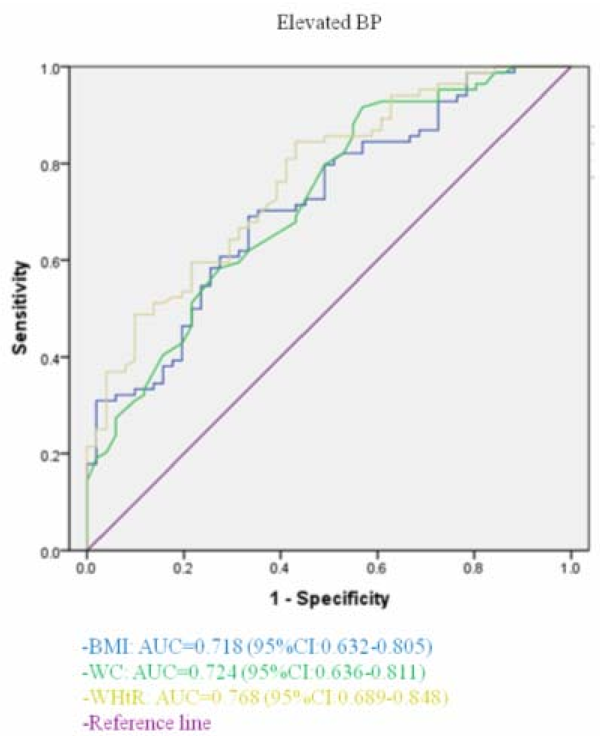

Figure 2. ROC curves with AUC of BMI, WC and WHtR for predicting elevated FBG

The increase of obesity and overweight is alarming all over the world [10]. The same increase can be seen in Romania, although there is no national register [11]. The anthromopetric variables used in our country to evaluate obesity are BMI and WC. In a previous study done on the same population [12] it has been shown that WC is a better predictor of metabolic syndrome. We did not use WHR due to its unsatisfactory reproductibility in intra-obsever and inter measurer reproductibility. With variations in weight, both WC and hip circumferince are modified, without this been shown in the WHR. The estimation of the effect of obesity based on BMI is too low [13]. Body composition seems to have a role in the cardio-metabolic risk, because there can be big differences between the percentage of lean and fat body mass in persons with the same BMI. It is debatable weather BMI or its current normal values can still be considered predictable for assessing cardio-metabolic risk [14, 15].

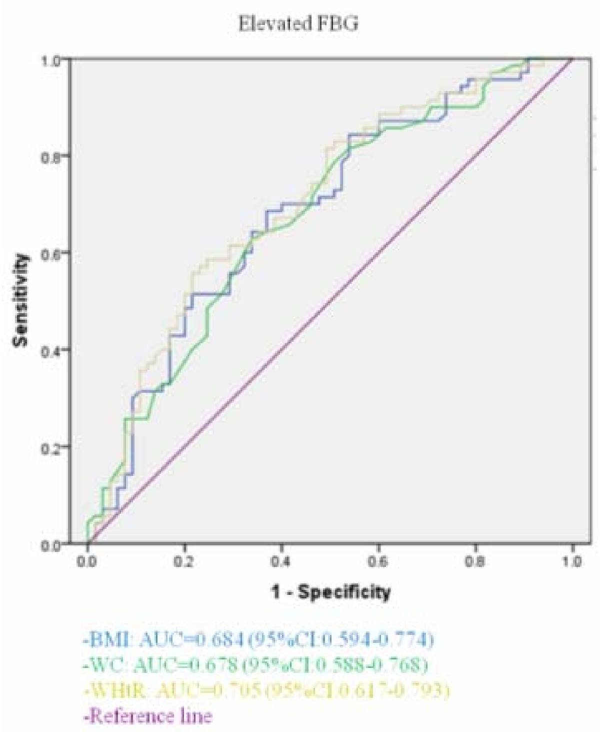

Figure 3. ROC curves with AUC of BMI, WC and WHtR for predicting elevated BP

WHtR has been used in correlating central obesity with cardiovascular risk factors since the beginning of the 1990s [16]. It continued to be of interest because it proved its applicability both in men and women, in young and old people, in different ethnic groups, and because it is cheap and easy to use. Values ≥0.5 show increased risk in all the groups mentioned above [17]. In our study the WHtR was proved to be the most accurate predictor of both pre-diabetes and arterial hypertension, as in many other studies [18, 19]. This result coincides with studies which led to the identification of the WHtR as an index of central obesity [20]. Its normal range is <0.5, which also makes it an easy number to advertise in population education strategies, as for example: „Keep your waist circumference to less than half your height" [21]. We consider that in the future people with a WHtR≥0.5 should be included in preventive strategies.

HbA1c can be considered a surogate marker of metabolic syndrome, considering a value of ≥5.4% [22]. Other studies recommend a cut-off value of 5.7% for pre-diabetes and its vascular consequences [23]. HbA1c has proved in our study to be useful and reliable in identifying people with pre-diabetes, as it is found in literature. Glycated hemoglobin incorporates the risks of hyperglycaemia, including that of post-prandial hyperglycaemic peaks, which are known to increase cardiovascular risk [24, 25]. Glycated hemoglobin is an average of 2-3 months of exposure to endogenuous glucose, including post-prandial peaks, which is why it is superior to fasting blood glucose value in assessing macrovascular risk [26]. Some authors consider fasting blood glucose a good predictor of the risk for diabetes [27], but others consider 1 hour or 2 hour post-prandial blood glucose better in identifying subjects with increased cardiovascular risk [28]. In our study predictive values were those of fasting blood glucose, after those of HbA1c.

Conclusions

WHtR was a better predictor than BMI, and even than WC of obesity-related cardio-metabolic risk, assessed by elevated HbA1c, elevated FBG and BP, in the population studied.

WHtR is a simple and reliable test, with the same cut-off value for men and women (0.5), and hence can be performed rapidly in the clinical setting and also can be promoted to the population as an easy parameter to monitor.

Subjects with WHtR≥0.5 should be screened for other cardio-metabolic risk factors and included in preventive strategies.

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