specifically to help establish good breast-feeding technique and build-up the milk supply, is another possibility.[4,13] Referring the mother to knowledgeable health workers after discharge is important to encourage and help her in breast-feeding the infant. Attention to these factors should result in an increase in the breast-feeding rate on discharge.

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THE METABOLIC SYNDROME IN BLACK HYPERTENSIVE WOMEN — WAIST CIRCUMFERENCE MORE STRONGLY RELATED THAN BODY MASS INDEX

P Rheeder, R P Stolk, J F Veenhouwer, D E Grobbee

Objective. To examine the association between measures of obesity and features of the metabolic syndrome in treated black female hypertensive subjects.

Design. Cross-sectional study.

Setting. An urban primary health care centre in Mamelodi, Pretoria.

Subjects. Women with hypertension and without known diabetes mellitus or secondary causes of hypertension. In total 124 women participated, with a mean age of 56.9 years (standard deviation (SD) 11.0) and mean body mass index (BMI) of 34.1 kg/m² (SD 8.1).

Main outcome measures. Blood pressure, glucose, insulin and lipid levels.

Results. Waist circumference and waist-hip ratio were more strongly associated with insulin, uric acid, glucose and triglycerides than was BMI. Statistically significant associations were found between waist circumference and low high-density lipoprotein HDL cholesterol (standardised regression coefficient –0.006, standard error of the mean (SEM) 0.002), log triglycerides (0.007, SEM 0.003), uric acid (0.002, SEM 0.001) and log insulin (0.012, SEM 0.003). BMI was only significantly associated with uric acid (0.002, SEM 0.002) and log insulin (0.009, SEM 0.004).

Conclusion. In a group of black hypertensive women measures of central obesity were more strongly associated with components of the metabolic syndrome than BMI.

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Department of Internal Medicine and Clinical Epidemiology Unit, University of Pretoria
P Rheeder, FCP (SA), MMed, MSc

Julius Center for General Practice and Patient-Oriented Research, University Medical Center, Utrecht, the Netherlands
R P Stolk, PhD
D E Grobbee, PhD

Department of Internal Medicine, University of Pretoria
J F Veenhouwer, medical student

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General obesity is a risk factor for cardiovascular disease in both men and women.[1,2] The excess risk associated with obesity is largely mediated by other risk factors such as hypertension, hyperlipidaemia and hyperglycaemia. Results from some studies, however, have shown obesity to be a risk factor for coronary artery disease independently of these factors.[2,3]

The abdominal distribution of adiposity appears to be even more important than obesity *per se* for coronary risk. Cross-sectional analyses have shown that intra-abdominal fat is increased in men with signs of coronary heart disease (CHD).[4] Intra-abdominal adiposity also explains the increased risk of CHD among South Asians in London.[5] Central or abdominal obesity is linked to insulin resistance and frequently clusters with other cardiac risk factors. Called Syndrome X by Reaven in 1988,[6] it is now more often referred to as the metabolic syndrome.[7] This syndrome has been described in various ethnic groups such as Europids, AfroAmericans, Asian Indians, Australian Aborigines, Polynesians and Micronesians.[8,9]

The intercorrelations of obesity, blood pressure (BP) and glucose intolerance, hyperinsulinaemia, high plasma triglycerides and low high-density lipoprotein (HDL) cholesterol in population surveys have led to the idea of a common underlying disturbance.[10,11] It has been proposed that resistance to insulin-stimulated glucose uptake is the key to this clustering of components.[12]

Obesity is particularly prevalent in South African black women and some urban and rural studies have shown that in these subjects obesity does not necessarily accompany hypertension, diabetes or hyperlipidaemia.[13,14] In contrast, Omar *et al.*[15] found that black women with diabetes did have a higher body mass index (BMI) than women without diabetes. Waist circumference has been shown to predict type 2 diabetes mellitus (DM) and to cluster with cardiovascular risk factors in subjects of mixed ancestry.[16,17]

Few studies specifically address obesity or insulin resistance and the associated cardiovascular risk factors in South African black hypertensive patients.

The aim of this study was to examine the association between measures of obesity and other cardiovascular risk factors in treated black female hypertensive subjects.

SUBJECTS AND METHODS

Mamelodi Hospital was selected for the study as it serves largely as a primary health care facility for the community of Mamelodi (approximately 500 000 inhabitants), a stable community of lower to middle class inhabitants, north-east of Pretoria and now part of the city of Pretoria. The hospital is run by the Department of Family Medicine and its main focus is on ambulatory medicine. For most patients consulting these doctors this is their first contact with the health care system.

Few patients are referred from general practitioners in the community. There are no laboratory facilities. Specimens are sent to Pretoria Academic Hospital for analysis. For this reason routine blood tests are seldom done and only if indicated clinically. An estimated 3 000 subjects are seen annually at Mamelodi Hospital in the outpatient facility with either hypertension or diabetes.

At the outpatient clinic for hypertension women were sequentially invited to participate in the study. Patients with known DM (defined as a previous fasting blood glucose of > 7 mmol/l or a random value of > 11.1 mmol/l or using glucose-lowering medication) were excluded. There were no subjects with known secondary causes of hypertension. Of the 214 women thus selected, 81 were not proficient in English and 9 refused to participate. All patients included in this study were known hypertensives ($N = 124$) on drug treatment.

All clinical measurements were done by a single observer (JFV). BP was measured in the sitting position using a Baumanometer after at least 5 minutes' rest. Two measurements were taken, with at least 1 minute between measurements. When there was a difference of more than 5 mmHg between readings a third reading was taken and the mean of the two closest measurements was used to determine the mean BP. Mid-arm circumference was measured and a large cuff (15 cm rubber bladder) was used for an arm circumference 35 cm or greater.

Weight was determined to the nearest 0.1 kg, with the patient standing barefoot in light clothing on a balance-beam scale that was calibrated weekly. Height was determined to the nearest 0.1 cm using a measuring stick attached to the scale, and for each patient BMI was calculated according to the formula weight/height.[2] Waist-hip ratio (WHR) was determined by measuring the waist at the smallest diameter between the xyphoid process and the umbilicus (at the end of a mild expiration), and the hip at the level of the maximal protrusion of the gluteus maximus muscles posteriorly and the symphysis pubis anteriorly. Two measurements were taken and if there was more than 2 cm difference a third was taken. The mean of the two measurements or the closest two in the case of three measurements was used to calculate the WHR.

On a separate visit, fasting blood samples were collected from a cubital fossa vein. Blood was taken between 07h30 and 10h00; it was centrifuged within 2 hours and the plasma separated. Analyses of urea and electrolytes, liver enzymes, calcium, phosphate and total cholesterol were done on an automated Technicon DAX analyser (Bayer). HDL was analysed using a heparin-manganese precipitation method (Merck reagent kits) and low-density lipoprotein (LDL) using a differential precipitation method (Merck). Triglycerides were analysed using a Synchron CX system (Beckman instruments). A Synchron CX Delta system, using an oxygen rate method employing a Beckman Oxygen electrode, was used for plasma

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glucose determination. A radio-immunoassay (RIA) (Pharmacia) was used for serum insulin (cross reactivity with pro-insulin 41%).

Between-group comparisons were done using Mann-Whitney U or Kruskal-Wallis tests. In order to normalise their distributions for regression purposes some variables were log transformed (HDL cholesterol, triglycerides, glucose, insulin). Multivariate regression analysis was done to determine the age-adjusted regression coefficients between the different measures of obesity and the studied metabolic factors. Because it is not possible to compare the magnitude of different regression coefficients directly, regression coefficients can be normalised by the ratio of the standard deviation (SD) of the regressor to the SD of the dependent variable. These coefficients are unitless and their magnitude can be compared. The fit of the model was assessed using adjusted r^2 and the Akaike information criterion (obtained from best subset regression using age and the specified obesity measure in the bivariate model).[18]

P-values < 0.05 were regarded as being statistically significant. Analyses were done on Statistica software.

RESULTS

The baseline characteristics of the women are given in Table I. Fourteen women (11.3%) were on oestrogen replacement therapy (10 of them on combined oestrogen and medroxyprogesterone). The prevalence of the different components of the metabolic syndrome[7] was: 66.1% had BMIs > 30 kg/m², 25.8% had WHRs > 0.9, 13.2% had impaired

Table I. Clinical characteristics of 124 black hypertensive women (mean (SD))

Age (yrs)	56.9	11.0
Systolic blood pressure (mmHg)	149.5	22.7
Diastolic blood pressure (mmHg)	90.7	11.0
Body mass index (kg/m²)	34.1	8.1
Waist-hip ratio	0.81	0.10
Uric acid (mmol/l)	0.36	0.09
Creatinine (μmol/l)	88.9	17.1
Total cholesterol (mmol/l)	5.3	1.1
LDL cholesterol (mmol/l)	3.6	1.1
HDL cholesterol (mmol/l)	1.17	0.32
Triglycerides (mmol/l)	1.49	0.67
Glucose (mmol/l)	5.7	1.6
Insulin (μU/ml)	11.6	5.3
Median number of anti-hypertensive drugs	2.0	Range: 1 - 4
On ACE inhibitors (%)	39.5	
On diuretics (%)	97.6	
Impaired fasting glucose (%)	13.0	
Diabetes mellitus (%)	9.1	

fasting glycaemia (IFG) (fasting plasma glucose 6.1 - 7.0 mmol/l), 9.1% had diabetes (fasting plasma glucose ≥ 7.0 mmol/l), and 38.5% dyslipidaemia (fasting plasma triglycerides ≥ 1.7 mmol/l and/or HDL < 1.0 mmol/l). In 13% of the women none of the components was present, whereas 42% had two or more components.

Angiotensin-converting enzyme (ACE) inhibitors were used by 39.5% of the women in our study, all but one in combination with low-dose thiazide diuretics. Subjects on ACE inhibitors had higher LDL levels (3.92 mmol/l, SD 1.21) than those without (3.36 mmol/l, SD 0.92, P < 0.01). They also had lower HDL levels (1.10 mmol/l, SD 0.28 versus 1.22 mmol/l, SD 0.33, P < 0.05). There were no statistically significant differences in BMI, WHR and insulin levels.

There was no statistically significant difference between oestrogen users and non-users with regard to BP, BMI, waist measurement, uric acid, lipid measurements, glucose or insulin levels.

The age-adjusted and standardised regression coefficients for waist circumference, WHR and BMI and metabolic risk factors are given in Table II. HDL, triglycerides, uric acid and insulin all showed a significant relationship with waist circumference. The significance of none of these was altered if subjects with diabetes were excluded from the analysis. The association with BMI and WHR were less marked. Additional adjustment for the use of ACE inhibitors did not change the results either. Diuretic use is associated with changes in lipids and uric acid.[19] However, for diuretic dose to be a confounder it has to be associated with both features of the metabolic syndrome as well as measures of obesity.[20] We found marginal age-adjusted differences in total cholesterol (P = 0.09) and LDL (P = 0.06), but waist (P = 0.99), WHR (P = 0.45) and BMI (P = 0.83) did not differ significantly between different dosage groups. As expected, adjusting for diuretic dose in the regression analyses did not change the findings in a meaningful way (data not shown).

Waist circumference was the only significant determinant of HDL, whereas WHR was a better predictor of triglycerides than waist circumference (larger standardised regression coefficient). Waist circumference but not WHR was related to uric acid. All three measures of obesity were related to insulin, with waist circumference having the largest standardised coefficient. There was, however, no statistically significant difference between the coefficients of waist circumference and BMI for uric acid and insulin. The adjusted r^2 values as well as the Akaike information criterion concurred with the standardised regression coefficients regarding the best coefficients for predicting components of the metabolic syndrome.

We had no data concerning menopausal status and arbitrarily divided the women into those younger than 50 years and those 50 years and older. Adjusting for ACE

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Table II. Age-adjusted associations between obesity measures and metabolic factors (coefficients (SEM)

Regression coefficients			Standardised coefficients*			
Waist	WHR	BMI	Waist	WHR	BMI	Adjusted $r^{2\dagger}$
Systolic blood pressure						
-0.146	20.009	-0.202	-0.072	0.091	-0.072	0.05
(0.178)	(19.217)	(0.245)	(0.088)	(0.088)	(0.088)	
Diastolic blood pressure						
-0.024	8.660	0.012	-0.024	0.081	0.009	0.04
(0.087)	(9.387)	(0.120)	(0.088)	(0.088)	(0.088)	
Total cholesterol						
-0.002	-0.294	-0.001	-0.018	-0.029	-0.005	0.04
(0.008)	(0.900)	(0.011)	(0.088)	(0.088)	(0.088)	
LDL cholesterol						
0.004	0.397	-0.0003	0.042	0.038	-0.002	0.01
(0.009)	(0.928)	(0.012)	(0.090)	(0.090)	(0.090)	
Log HDL cholesterol						
-0.006‡	-0.373	-0.003	-0.246	-0.151	-0.098	0.06
(0.002)	(0.220)	(0.003)	(0.087)	(0.089)	(0.090)	
Log triglycerides						
0.007§	0.973‡	0.001	0.208	0.250	0.022	0.07
(0.003)	(0.342)	(0.004)	(0.089)	(0.088)	(0.091)	
Log glucose						
0.003	0.294	0.002	0.171	0.159	0.095	0.05
(0.002)	(0.165)	(0.002)	(0.089)	(0.089)	(0.090)	
Uric acid						
0.002π	0.127	0.002‡	0.316	0.150	0.201	0.13
(0.001)	(0.075)	(0.001)	(0.084)	(0.088)	(0.087)	
Log insulin						
0.012‡	0.833	0.009‡	0.342	0.229	0.184	0.11
(0.003)	(0.324)	(0.004)	(0.086)	(0.089)	(0.090)	

* See method section for details.
† For model with largest standardised coefficient.
‡ $P < 0.01$
§ $P < 0.05$.
π $P < 0.001$.

inhibitor use, but not for age, neither waist circumference nor WHR were related to HDL or triglycerides in those < 50 years, but both were in the older age group. For log HDL the coefficient of waist was -0.008 (standard error of the mean (SEM) 0.002, $P < 0.01$) and of WHR -0.714 (0.342, $P < 0.05$); for log triglycerides the coefficient of waist was 0.008 (0.004, $P < 0.05$) and of WHR 1.538 (0.505, $P < 0.01$). For uric acid and insulin this discrepancy between the pre- and postmenopausal women was not found.

The associations between BMI, and uric acid and insulin were no longer statistically significant if the women with diabetes were excluded from the analyses. However, the associations between WHR, and glucose and uric acid became statistically significant (regression coefficients 0.260 (SEM 0.096, $P < 0.01$) and 0.149 (0.074, $P < 0.05$), respectively).

DISCUSSION

Our study shows that in treated black South African hypertensive women there is an association between measures of central obesity and components of the metabolic syndrome. Waist circumference best predicted insulin, uric acid and glucose whereas WHR best predicted triglycerides (based on the standardised regression coefficients). The association between waist circumference and HDL cholesterol as well as triglycerides was only found in women older than 50 years.

The selected women do not represent a true random sample of hypertensive women from the community as they were selected from the outpatient clinic. Women unable to communicate in English were excluded. This may have biased our sample towards women with a more westernised lifestyle in whom obesity may be more pronounced. The community of Mamelodi, however, is relatively homogeneous socio-economically. Also, as westernisation of lifestyle (including diet) is increasing in South African black communities, this group is of particular interest.

Age and menopause effect changes on cardiovascular parameters, as is also shown in our data. In a review of the literature Spencer et al.[21] found that increased insulin resistance and decreased insulin secretion were found at or after the

menopause. In our relatively small study the effect of insulin was more marked in the pre-menopausal group.

Prospective studies have reported clear associations between body fat distribution and the incidence of type 2 DM and cardiovascular disease.[22,23] A recent study examining the differential aspects of BMI on diabetes risk among black and white Americans found that there is a higher risk for blacks than whites at a low BMI, and an equivalent risk for both groups at a high BMI. The authors conclude that a lower degree of visceral adiposity among blacks at higher BMI or a greater impact of visceral adiposity among blacks at lower BMI may help to explain the interaction of race and BMI on diabetes risk.[24]

The effect of visceral fat may not be the same in African Americans versus Africans. Some authors suggest that BMI, a general indicator of obesity, is a better correlate of BP than the WHR among African Americans,[25] whereas others found that waist circumference was positively correlated with BP in Nigerians, Jamaicans and African Americans.[26]

Euglycaemic clamp studies in South African blacks have shown that hypertension *per se* is associated with insulin resistance and relative hyperinsulinaemia.[27] In a study of elderly Nigerians, insulin resistance was found in 35%. In regression analysis this was linked to BP and body mass, particularly in women. Twenty per cent of subjects had more than four risk factors for CHD in spite of a low reported incidence of CHD.[28]

The question whether insulin resistance or visceral fat is the underlying disturbance in the metabolic syndrome has not yet been resolved. Moreover, most studies on this topic have been performed in Caucasian populations. It is not evident if these results can be applied to black subjects.

Concomitant antihypertensive therapy may influence several metabolic factors such as lipids and insulin. Joffe *et al.*[29] have shown that thiazide diuretics incurred greater changes in the lipid profile of black subjects than did DM. These authors suggested that the metabolic syndrome does not apply to the South African black population as obesity and type 2 DM commonly occur with minimal elevation of serum lipids and a low prevalence of ischaemic heart disease. Their study supported the hypothesis that thiazide-treated hypertension may have greater atherogenic potential than diabetes. Diuretic use is often regarded as a confounder in the study of relationships with cardiovascular risk factors. The associations we describe, however, cannot be confounded by diuretic use as virtually all the subjects were on diuretic-based therapy (independent of their obesity measures).

Our study of thiazide-treated hypertensives shows a very strong association between measures of central adiposity and measures of insulin, glucose and lipids. This suggests that apart from the effect of thiazide diuretics, clustering of

metabolic risk factors does occur in these hypertensives and is related to central adiposity.

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