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Waist circumference action levels in the identification of cardiovascular risk factors: prevalence study in a random sample

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Abstract

***Objective*—To determine the frequency of cardiovascular risk factors in people categorised by previously defined "action levels" of waist circumference.**

***Design*—Prevalence study in a random population sample.**

***Setting*—Netherlands.**

***Subjects*—2183 men and 2698 women aged 20-59 years selected at random from the civil registry of Amsterdam and Maastricht.**

***Main outcome measures*—Waist circumference, waist to hip ratio, body mass index (weight (kg)/ height (m²)), total plasma cholesterol concentration, high density lipoprotein cholesterol concentration, blood pressure, age, and lifestyle.**

***Results*—A waist circumference exceeding 94 cm in men and 80 cm in women correctly identified subjects with body mass index of ≥25 and waist to hip ratios ≥0·95 in men and ≥0·80 in women with a sensitivity and specificity of ≥96%. Men and women with at least one cardiovascular risk factor (total cholesterol ≥6·5 mmol/l, high density lipoprotein cholesterol ≤0·9 mmol/l, systolic blood pressure ≥160 mm Hg, diastolic blood pressure ≥95 mm Hg) were identified with sensitivities of 57% and 67% and specificities of 72% and 62% respectively. Compared with those with waist measurements below action levels, age and lifestyle adjusted odds ratios for having at least one risk factor were 2·2 (95% confidence interval 1·8 to 2·8) in men with a waist measurement of 94-102 cm and 1·6 (1·3 to 2·1) in women with a waist measurement of 80-88 cm. In men and women with larger waist measurements these age and lifestyle adjusted odds ratios were 4·6 (3·5 to 6·0) and 2·6 (2·0 to 3·2) respectively.**

***Conclusions*—Larger waist circumference identifies people at increased cardiovascular risks.**

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Introduction

Lean *et al* recently proposed waist circumference as a simple measurement to indicate the need for weight management. Waist circumference related both to body mass index and to waist to hip ratio.[1] Two action levels of waist circumference were determined to identify people whose health risks were increasing (action level 1: men 94 cm, women 80 cm) or high (action level 2: men 102 cm, women 88 cm).

The ongoing Dutch monitoring project on risk factors for chronic diseases (MORGEN project), which started in 1993, offered the opportunity to validate these action levels in a large sample of men and women and to assess the prevalence of cardiovascular risk factors and relative risks in subjects according to their waist circumference.

Population and methods

A random sample of 2183 men and 2698 women aged 20-59 years was selected from the civil registry in Amsterdam and Maastricht. Sampling was part of the MORGEN project to determine the prevalence of risk factors for chronic diseases and also specific chronic conditions in the general population living in various parts of the Netherlands. Measurements were made in basic health service centres in Amsterdam (in the west), Doetinchem (a small town in the east), and Maastricht (in the south). To obtain similar numbers of subjects at each age we stratified the sample by sex and five year age group. The response rate to invitations was roughly 50% in Amsterdam and Maastricht and 80% in Doetinchem. All measurements were by trained investigators.

ANTHROPOMETRY

Body weight in light clothes was measured to the nearest 0·1 kg and height to the nearest 0·5 cm. Body

mass index was calculated as weight (kg) divided by height (m^2). Waist circumference midway between the lowest rib and the iliac crest and hip circumference at the level of the great trochanters were measured in duplicate to the nearest mm with flexible tape.[2]

CARDIOVASCULAR RISK FACTORS

Blood pressure was measured sitting with a random zero sphygmomanometer, small (9×18 cm), medium (12×23 cm), and large (15×33 cm) cuffs being used as appropriate. Systolic (Korotkoff phase I) and diastolic (Korotkoff phase V) blood pressure was measured twice on the left upper arm and the average used for analysis. Total and high density lipoprotein cholesterol concentrations were measured enzymatically with a Boehringer kit.[3] High density lipoprotein was isolated by precipitating apolipoprotein B containing lipoproteins with magnesium phosphotungstate.[4] All cholesterol analyses were performed at the clinical chemistry laboratory, University Hospital of Dijkzigt, Rotterdam, under standardisation programmes (World Health Organisation Regional Lipid Centre for Europe, Prague, and the Centers for Disease Control, Atlanta). Subjects completed a questionnaire which included alcohol consumption, smoking habit, physical activity, and highest educational level attained, divided into three categories.[5]

ANALYSIS

Hypercholesterolaemia was defined as plasma cholesterol concentration ≥6·5 mmol/l[6,7]; low high density lipoprotein cholesterol concentration as ≤0·9 mmol/l[7]; and hypertension as systolic blood pressure ≥160 mm Hg, or diastolic blood pressure ≥95 mm Hg, or use of antihypertensive agents.[6] Subjects were placed in either of two categories for each of the three lifestyle factors smoking (current cigarette smokers or non-smokers), drinking (alcohol drinkers or non-drinkers), and physical activity (affirmative or negative answers to the question "Do you engage in sport, including jogging and fitness training?").

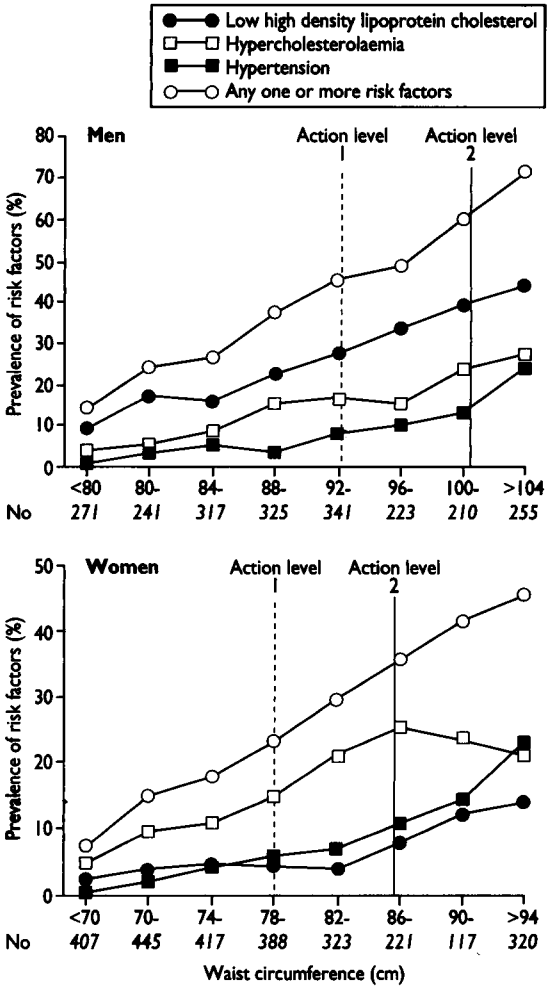
TABLE I—*Physical and metabolic characteristics of 2183 men and 2698 women*

	Men		Women	
	Mean	SD	Mean	SD
Age (years)	42·7	10·5	42·5	10·7
Weight (kg)	81·4	11·9	68·3	11·3
Height (cm)	177·9	7·4	165·1	6·8
Body mass index (kg/m^2)	25·7	3·4	25·1	4·2
Waist circumference (cm)	91·6	10·4	80·3	10·9
Hip circumference (cm)	101·7	6·4	102·1	8·3
Waist to hip ratio	0·90	0·07	0·79	0·07
Total cholesterol (mmol/l)	5·4	1·1	5·4	1·1
High density lipoprotein cholesterol (mmol/l)	1·1	0·3	1·4	0·4
Systolic blood pressure (mm Hg)	122·8	15·6	115·5	15·4
Diastolic blood pressure (mm Hg)	77·8	10·4	74·1	9·9

TABLE II—*False positive and false negative findings, sensitivity, and specificity in categorising men and women by waist circumference to identify those with body mass index ≥25 at action level 1 or ≥30 at action level 2 and those with lower body mass index values but waist to hip ratio ≥0·95 (men) or ≥0·80 (women)*

Action level of waist circumference	cm	False positive	False negative	Sensitivity (%)	Specificity (%)
		Men (n=2183)			
Action level 1	≥94	40/945	22/475	97·42	97·03
Action level 2	≥102	45/1603	7/151	97·80	97·61
		Women (n=2698)			
Action level 1	≥80	59/1219	16/710	98·64	96·17
Action level 2	≥88	22/1778	6/303	98·99	98·96

True positive describes people with high body mass index and those with lower body mass index but high waist to hip ratio, correctly identified by waist circumference above action level. True negative describes people with low body mass index and those with higher body mass index but low waist to hip ratio. False positive describes people with waist circumference above action level but low body mass index and low waist to hip ratio. False negative describes people with waist circumference below action level but with high body mass index and high waist to hip ratio. These numbers were used to determine sensitivity and specificity.[8]



Prevalence rates of men and women with low high density lipoprotein cholesterol concentration (≤0·9 mmol/l), hypercholesterolaemia (≥6·5 mmol/l), hypertension (treatment with antihypertensive agents, or systolic pressure ≥160 mm Hg, or diastolic pressure ≥95 mm Hg), and any one or more risk factors

STATISTICAL METHODS

Sensitivity was defined as the percentage of all subjects with a risk factor who were identified correctly by high (above action level) waist circumference, and specificity as the percentage of all subjects without a risk factor who were identified correctly by low (below action level) waist circumference. Positive prediction was calculated as the percentage of subjects with a waist circumference above action level who had a risk factor, and negative prediction as the percentage of subjects with a waist circumference below action level who did not have a risk factor.[8,9]

Linear regression analysis and partial correlations were used to determine the relations between variables. Logistic regression analysis was employed to determine the relative risk of the prevalence of cardiovascular risk factors in subjects categorised by the two waist circumference action levels, with adjustments for age, alcohol consumption, cigarette smoking, physical activity, and educational level. We did not adjust for body mass index and waist to hip ratio because of multicollinearity with waist circumference.[10] Height accounted for less than 0·3% of the variance in waist circumference and was excluded from the analysis. Statistical analyses used the SAS/STAT computer program (SAS Institute, Philadelphia).

Cross tabulation was used to determine the sensitivity and specificity[8] of the waist circumference action levels defined by Lean *et al*[1]—namely, action level 1:

men 94 cm, women 80 cm; action level 2: men 102 cm, women 88 cm—to identify subjects with body mass index values above 25 or above 30 for men and for women (the conventional cut off points) and waist to hip ratios above 0·95 for men and 0·80 for women. Cross tabulation with waist measurement cut off points defined by Lean *et al* at action levels 1 and 2 were used to determine the sensitivity, specificity, and positive and negative predictions[8] of the cardiovascular risk factors (high cholesterol concentration, low high density lipoprotein cholesterol concentration, hypertension) at levels defined by the WHO,[6] and the European Atherosclerosis Society.[7]

TABLE III—*Mean serum lipid concentrations and blood pressure of men and women in different categories of waist circumference*

Waist circumference (cm)	No	Total cholesterol (mmol/l) Mean (SE)	High density lipoprotein cholesterol (mmol/l) Mean (SE)	Systolic blood pressure (mm Hg) Mean (SE)	Diastolic blood pressure (mm Hg) Mean (SE)
		Men (n=2183)			
<94	1312	5·17 (0·03)	1·15 (0·01)	119·4 (0·4)	75·3 (0·3)
94-101	515	5·71 (0·05)	1·04 (0·01)	126·8 (0·6)	80·4 (0·4)
≥102	356	5·88 (0·06)	0·98 (0·02)	129·6 (0·7)	83·4 (0·4)
		Women (n=2698)			
<80	1481	5·14 (0·03)	1·47 (0·01)	111·2 (0·4)	71·3 (0·2)
80-87	608	5·59 (0·04)	1·37 (0·01)	117·5 (0·6)	75·4 (0·4)
≥88	609	5·78 (0·04)	1·26 (0·01)	123·9 (0·6)	79·6 (0·4)

All categories significantly different (analysis of variance), $P<0·001$.

TABLE IV—*Correlation coefficients between waist circumference, body mass index, and waist to hip ratio and risk factors unadjusted and adjusted for alcohol consumption, cigarette smoking, physical activity, educational levels, and age*

	Waist circumference		Body mass index		Waist to hip ratio	
	Unadjusted	Adjusted	Unadjusted	Adjusted	Unadjusted	Adjusted
		Men (n=2183)				
Total cholesterol	0·344	0·232	0·319	0·247	0·335	0·189
High density lipoprotein	−0·269	−0·305	−0·287	−0·311	−0·249	−0·292
Systolic blood pressure	0·336	0·249	0·306	0·239	0·348	0·244
Diastolic blood pressure	0·371	0·283	0·354	0·287	0·384	0·288
		Women (n=2698)				
Total cholesterol	0·265	0·106	0·217	0·099	0·290	0·114
High density lipoprotein	−0·261	−0·280	−0·254	−0·245	−0·242	−0·269
Systolic blood pressure	0·372	0·237	0·335	0·226	0·301	0·188
Diastolic blood pressure	0·374	0·261	0·345	0·250	0·330	0·203

All correlations were significant at $P<0·01$.

Results

Mean age, body mass index, hip circumference, and total plasma cholesterol concentration were similar in men and women. Men had a higher waist circumference, waist to hip ratio, and blood pressure and lower high density lipoprotein cholesterol concentration (table I).

REPLICATION OF ACTION LEVELS TO IDENTIFY SUBJECTS WITH HIGH BODY MASS INDEX AND HIGH WAIST TO HIP RATIO

The action levels defined by Lean *et al*[1] using waist circumference (action level 1: men 94 cm, women 80 cm; action level 2: men 102 cm, women 88 cm) were applied to this sample to identify subjects with a high body mass index (≥25 or ≥30 in men and in women) and high waist to hip ratio (≥0·95 in men, ≥0·80 in women). Sensitivity was over 97·5% and specificity over 96·0% with only 2% false positive results and 0.8% false negative results with action level 1 and 1·4% false positive results and 0·3% false negative results with action level 2 for the entire sample (table II).

IMPLICATIONS OF ACTION LEVELS FOR CARDIOVASCULAR RISK FACTORS

The prevalence (figure) and mean (table III) values of adverse cardiovascular risk factors (except decreases in high density lipoprotein cholesterol concentration) increased with waist circumference in men and women. Correlations of waist circumference, body mass index, and waist to hip ratio with risk factors (total cholesterol concentration, high density lipoprotein cholesterol concentration, systolic and diastolic blood pressure) were similar and remained significant in partial correlations controlling for age, alcohol consumption, cigarette smoking, physical activity, and education (table IV).

Sensitivity and specificity for identifying risk factors from waist circumference (table V) at action level 1 were between 57% and 72% in both men and women,

TABLE V—*Prevalence, positive and negative predictions, and sensitivity and specificity of high cholesterol concentration (≥6·5 mmol/l), low high density lipoprotein cholesterol concentration (≤0·9 mmol/l), and hypertension (systolic pressure ≥160 mm Hg or diastolic pressure ≥95 mm Hg or treated) in men and women by waist circumference action levels*

Risk factor	Percentage (95% confidence interval)† Prevalence‡	Prediction: Positive	Prediction: Negative	Sensitivity	Specificity
		Men (n=2183)			
Action level 1 (waist circumference ≥94 cm) (n=871)					
High total cholesterol	14·8 (13·3 to 16·3)	21·6 (18·9 to 24·3)	89·7 (88·1 to 91·4)	58·2 (54·9 to 61·5)	63·3 (60·7 to 65·9)
Low high density lipoprotein cholesterol	26·4 (24·5 to 28·2)	37·5 (34·3 to 40·8)	81·0 (78·9 to 83·1)	56·8 (53·5 to 60·1)	66·2 (63·6 to 68·7)
Hypertension	8·7 (7·6 to 9·9)	15·6 (13·2 to 18·0)	95·8 (94·7 to 96·9)	71·2 (68·2 to 74·2)	63·1 (60·5 to 65·7)
One or more risk factors	41·1 (39·1 to 43·2)	58·8 (55·5 to 62·1)	70·6 (68·1 to 73·0)	57·0 (53·7 to 60·3)	72·1 (69·6 to 74·5)
Action level 2 (waist circumference ≥102 cm) (n=356)					
High total cholesterol	14·8 (13·3 to 16·3)	27·3 (22·6 to 31·9)	87·6 (86·1 to 89·1)	30·0 (25·3 to 34·8)	86·1 (84·5 to 87·7)
Low high density lipoprotein cholesterol	26·4 (24·5 to 28·2)	44·4 (39·2 to 49·5)	77·1 (75·2 to 79·0)	27·4 (22·8 to 32·1)	87·7 (86·2 to 89·2)
Hypertension	8·7 (7·6 to 9·9)	21·6 (17·4 to 25·9)	93·8 (92·7 to 94·9)	40·3 (35·2 to 45·4)	86·0 (84·4 to 87·6)
One or more risk factors	41·1 (39·1 to 43·2)	69·9 (65·2 to 74·7)	64·5 (62·3 to 66·7)	27·7 (23·1 to 32·4)	91·7 (90·4 to 92·9)
		Women (n=2698)			
Action level 1 (waist circumference ≥80 cm) (n=1217)					
High total cholesterol	14·4 (13·5 to 16·2)	21·5 (19·2 to 23·8)	90·6 (89·1 to 92·1)	65·3 (62·7 to 68·0)	58·4 (55·9 to 60·9)
Low high density lipoprotein cholesterol	6·9 (6·0 to 7·9)	10·0 (8·3 to 11·7)	95·6 (94·6 to 96·7)	65·2 (62·6 to 67·9)	56·4 (53·9 to 58·9)
Hypertension	7·3 (6·4 to 8·3)	13·0 (11·9 to 14·9)	97·3 (96·5 to 98·1)	79·8 (77·5 to 82·1)	57·6 (55·1 to 60·2)
One or more risk factors	25·4 (23·7 to 27·0)	37·4 (34·7 to 40·1)	84·5 (82·7 to 86·4)	66·5 (63·9 to 69·2)	62·2 (59·7 to 64·6)
Action level 2 (waist circumference ≥88 cm) (n=609)					
High total cholesterol	14·4 (13·5 to 16·2)	22·8 (19·5 to 26·2)	87·5 (86·0 to 88·9)	34·7 (30·9 to 38·4)	79·5 (77·8 to 81·3)
Low high density lipoprotein cholesterol	6·9 (6·0 to 7·9)	14·0 (11·2 to 16·7)	95·1 (94·2 to 96·0)	45·5 (41·5 to 49·4)	79·9 (77·4 to 80·9)
Hypertension	7·3 (6·4 to 8·3)	18·4 (15·3 to 21·5)	95·9 (95·0 to 96·7)	56·6 (52·6 to 60·5)	80·1 (78·4 to 81·8)
One or more risk factors	25·4 (23·7 to 27·0)	44·3 (40·4 to 48·3)	80·2 (78·5 to 81·9)	39·5 (35·6 to 43·4)	83·2 (81·6 to 84·8)

†Confidence intervals were calculated from SE percentage: $\sqrt{P\ (100-P)/n}$, where P represents one percentage, (100-P) represents the other, and n is the number of subjects.[9]
‡Prevalence of risk factors in total population.

TABLE VI—*Prevalence and odds ratio of high cholesterol concentration (≤6·5 mmol/l), low high density lipoprotein cholesterol concentration (≤0·9 mmol/l), and hypertension (systolic pressure ≥160 mm Hg or diastolic blood pressure ≥95 mm Hg or treated) in different categories of waist circumference adjusted for age, alcohol consumption, cigarette smoking, physical activity, and education in men and women by waist circumference action levels*

	High total cholesterol		Low high density lipoprotein cholesterol		Hypertension		One or more risk factors	
Waist circumference (cm)	Prevalence (%)	Odds ratio (95% confidence interval)	Prevalence (%)	Odds ratio (95% confidence interval)	Prevalence (%)	Odds ratio (95% confidence interval)	Prevalence (%)	Odds ratio (95%) confidence interval)
				Men (n=2183)				
<94	10·3	1·00	19·0	1·00	4·2	1·00	29·4	1·00
94-101	17·7	1·38 (1·02 to 1·87)	32·8	2·37 (1·85 to 3·04)	11·5	1·98 (1·33 to 2·95)	51·1	2·23 (1·78 to 2·78)
≥102	27·2	2·29 (1·67 to 3·14)	44·4	3·64 (2·75 to 4·80)	21·6	4·03 (2·72 to 5·96)	69·9	4·57 (3·48 to 5·99)
				Women (n=2698)				
<80	9·4	1·00	4·4	1·00	2·7	1·00	15·5	1·00
80-87	20·2	1·51 (1·14 to 2·00)	6·1	1·54 (1·00 to 2·38)	7·6	1·84 (1·17 to 2·88)	30·4	1·64 (1·30 to 2·08)
≥88	22·8	1·42 (1·06 to 1·89)	14·0	3·80 (2·59 to 5·59)	18·4	4·23 (2·83 to 6·33)	44·3	2·55 (2·02 to 3·23)

with positive prediction varying between 16% and 38% in men and 10% and 22% in women for individual risk factors. Positive prediction increased to 59% in men and 37% in women who had one or more risk factors. Negative prediction was much higher, varying between 81% and 96% for individual risk factors and 71% in men and 85% in women who did not have any risk factors. Both positive and negative predictions at action level 1 were higher than the prevalence of subjects with (positive) and without (negative) risk factors in the whole population. Positive predictions of cardiovascular risk factors increased further in subjects identified by action level 2, with a reduction in negative predictions (table V).

The relative risk of adverse cardiovascular risk factors identified by using odds ratios (adjusted for age, alcohol consumption, cigarette smoking, physical activity, and educational levels by logistic regression) with reference to a waist circumference below action level 1 increased significantly as waist circumferences rose above action levels 1 and 2 (table VI; data adjusted for age and lifestyle). For health promotion simple waist circumference cut off points would be used. Differences in prediction with and without adjustments were similar, with the same patterns of relative risks (data not shown).

Discussion

This study supports our earlier finding that waist circumference action levels identify people with high body mass index and central fat distribution with high sensitivity and specificity.[1] In addition, the study shows the close relation between waist circumference and cardiovascular risk factors. Waist circumference cut off measurements identified (positive prediction) cardiovascular risk factors at one and a half times to twice the prevalence in the whole population at action level 1 and two and a half to three times at action level 2 (table VI). Negative prediction by action levels remained higher than the prevalence in the entire population. These results suggest that action levels based on waist measurements may provide a valuable, simple method for alerting people at increased risk of cardiovascular disease who might benefit from weight management. The risk factor criteria used (cholesterol concentration ≥6.5 mmol/l, high density lipoprotein cholesterol concentration ≤0.9 mmol/l, blood pressure ≥160/95 mm Hg) are conservative. Figures for risk prevalence would be higher if smaller levels of risk were assessed.

Waist circumference has previously been related to cardiovascular risk factors.[11-13] In this study waist circumference correlated similarly to body mass index and waist to hip ratio with most of the cardiovascular risk factors. Adjusting for influences such as age, education, and lifestyle had little effect. Higgins *et al* reached similar conclusions in the Framingham study,[11] showing that waist circumference was associated with 24 year age adjusted mortality and also that waist circumference gave better risk prediction among smokers. In this study after adjustment for age and other lifestyle factors smokers of both sexes had consistently more cardiovascular risk factors than non-smokers in any category of waist circumference (results not shown). With increasing age the serum cholesterol concentration increases substantially in women. Covariance between age and waist measurement prevents further increase in predictive power of waist circumference for high cholesterol concentration above action level 2.

Seidell reviewed anthropometric methods to assess abdominal fat, concluding that waist circumference alone was probably the most practical measurement for use in health promotion.[14] For that purpose practical cut off measurements of waist circumference are required. Waist circumference relates closely to intra-abdominal fat mass,[15-18] and changes in waist circumference reflect changes in cardiovascular risk factors.[19-22] Positive prediction of individual risk factors at the conservative levels chosen for this study was fairly low but increased considerably when one or more risk factors were being identified (table V). Recent studies found large waist circumference strongly associated with risk factors for the insulin resistance syndrome in women[23] and insulin independent diabetes mellitus in men[24] and risks of breast cancer in women[25] and colonic cancer in men,[26] suggesting that waist circumference may have a wider value as a measure of total health risks.

In conclusion, action levels of waist circumference

Key messages

- Waist circumference increases with overweight and with central fat distribution
- Both overweight and central fat distribution relate to preventable ill health
- Compared with people with waist circumferences below "action level" 1 (94 cm in men, 80 cm in women) those with waist circumferences between action levels 1 and 2 (94-101 cm in men, 80-87 cm in women) are one and a half times to twice as likely to have one or more major cardiovascular risk factors; people with waist circumferences above action level 2 are two and a half to four and a half times as likely to have one or more major cardiovascular risk factors
- A waist circumference above action level 1 should be a signal to avoid weight gain or lose weight, to maintain increased physical activity, and to give up smoking in order to reduce the risk of cardiovascular disease
- Patients with a waist circumference above action level 2 should seek advice from health professionals for weight management

proposed previously could be used to identify sections of the population at high risk of chronic disease from high total plasma cholesterol concentration, low high density lipoprotein cholesterol concentration, and hypertension who might benefit from weight management.

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Increased serum concentration of von Willebrand factor in non-insulin dependent diabetic patients with and without diabetic nephropathy

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Cardiovascular morbidity and mortality are increased in non-insulin dependent diabetic patients, particularly if microalbuminuria or macroalbuminuria is present.[1] A systemic endothelial dysfunction may be the pathogenic factor linking albuminuria to atherosclerosis in these patients,[2] as originally suggested in insulin dependent patients.[3] Previous studies have suggested that serum von Willebrand factor concentration is an indicator of generalised endothelial damage and contributes to platelet aggregation to the vascular endothelium, the first step in thrombosis. We evaluated the validity of this concept by measuring the serum concentrations of von Willebrand factor in non-insulin dependent diabetic patients with or without diabetic nephropathy.

Patients, methods, and results

We studied a prevalence cohort of white non-insulin dependent diabetic patients under 76.[1] Patients were stratified into three groups: those with normoalbuminuria (≤30 mg/24 h, n=323), microalbuminuria (31-299 mg/24 h, n=151), and persistent macroalbuminuria (≥300 mg/24 h in two of three consecutive samples, n=75). Diabetic nephropathy was diagnosed in 47 of 75 macroalbuminuric patients on the basis of previously established clinical (n=20) or biopsy (n=27) based criteria.[4] Sixty six healthy non-diabetic subjects served as controls. We analysed the results by using the statistics package SPSS for Windows version 6.0.

The table gives the results. The serum concentrations of von Willebrand factor, measured by microenzyme linked immunoabsorbent assay,[3] were significantly higher in all of the diabetic groups than in the controls. Furthermore, the patients with a urinary albumin excretion rate above 30 mg/24 h had significantly higher serum von Willebrand factor concentrations than the normoalbuminuric patients. This was the case even after adjustment for the presence of cardiovascular disease (difference 1·15 (95% confidence interval 1·07 to 1·24) U/ml).

There was a positive association between the logarithmically transformed urinary albumin excretion rate and serum von Willebrand factor concentration, which was independent of age, sex, blood pressure, tobacco smoking, plasma total cholesterol concentration, haemoglobin A_{1c}, and presence of cardiovascular disease (multiple linear regression analysis: $r=0·20$; $P<0·0001$). The presence of cardiovascular disease (World Health Organisation questionnaire, Minnesota coded electrocardiograms) was associated with higher rates of urinary albumin excretion, together with higher serum concentrations of von Willebrand factor (logistic regression analysis: $r=0·16$; $P<0·0001$ and $r=0·11$; $P<0·005$, respectively). The positive association between urinary albumin excretion and cardiovascular disease was independent of age, sex, blood pressure, tobacco smoking, plasma total cholesterol concentration, and haemoglobin A_{1c}. Apart from the