The survival of patients in group B, who presented late, was found to be significantly better than the survival of patients in group A, who presented early. This finding is consistent with the view that the onset of AIDS is delayed in patients who receive early medical intervention in HIV infection.[10-12] However, the finding suggests that the subsequent survival of these patients when they develop AIDS may be commensurately decreased. We believe that our data are compatible with the results of the Concorde and other studies, in which early intervention with zidovudine delayed the development of AIDS but did not affect survival overall.[10 12 13]

In conclusion, this study highlights the scale of the public health problem posed by patients presenting with AIDS coincidental with their first positive result in an HIV test. It also contributes to the debate on the effects of medical intervention on survival after an AIDS defining illness has developed.

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Waist circumference as a measure for indicating need for weight management

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Abstract

***Objective*—To test the hypothesis that a single measurement, waist circumference, might be used to identify people at health risk both from being overweight and from having a central fat distribution.**

***Design*—A community derived random sample of men and women and a second, validation sample.**

***Setting*—North Glasgow.**

***Subjects*—904 men and 1014 women (first sample); 86 men and 202 women (validation sample).**

***Main outcome measures*—Waist circumference, body mass index, waist:hip ratio.**

***Results*—Waist circumference ⩾94 cm for men and ⩾80 cm for women identified subjects with high body mass index (⩾25 kg/m²) and those with lower body mass index but high waist:hip ratio (⩾0.95 for men, ⩾0.80 women) with a sensitivity of >96% and specificity >97·5%. Waist circumference ⩾102 cm for men or ⩾88 cm for women identified subjects with body mass index ⩾30 and those with lower body mass index but high waist:hip ratio with a sensitivity of >96% and specificity >98%, with only about 2% of the sample being misclassified.**

***Conclusions*—Waist circumference could be used in health promotion programmes to identify individuals who should seek and be offered weight management. Men with waist circumference ⩾94 cm and women with waist circumference ⩾80 cm should gain no further weight; men with waist circumference ⩾102 cm and women with waist circumference ⩾88 cm should reduce their weight.**

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Introduction

About half of all British adults have a body mass index (weight (kg)/(height (m)²)) of >25, while almost 15% have an index of >30, and these proportions are rising.[1 2] Given the lack of success in the management of obesity and increasing associated health costs,[3 4] greater emphasis on prevention is needed, particularly in young people, who often have little contact with health services. While many health professionals are now familiar with the acceptable range for body mass index (20-25),[2 5] most members of the public cannot readily calculate their index to establish their own risk or need for weight management. Charts developed by the Health Education Authority are helpful but are still not understood by many.[6] Height must be measured accurately as small errors in the denominator are exaggerated by squaring.

The major metabolic cardiovascular risk factors (high blood pressure, plasma lipids, insulin resistance) all aggregate independently with both body mass index and waist:hip ratio[7 8] and improve with weight loss.[9-13] The circumference of the waist relates closely to body mass index and is also the dominant measurement in the waist:hip ratio, which reflects the proportion of body fat located intra-abdominally, as opposed to subcutaneously,[7] and waist circumference is the best indicator of changes in intra-abdominal fat during weight loss.[14]

We evaluated waist circumference as a simple predictor of health risk from being overweight and through the central distribution of fat to indicate levels at which individuals should take action.

Methods

SUBJECTS

Determination study

We randomly recruited 904 men and 1014 women, aged 25 to 74 years, from the general population of north Glasgow between January and August 1992, excluding only those who were chair bound.

Validation study

We recruited separately 86 men and 202 women by advertising locally to test the proposed "action levels" (levels at which individuals may be at risk from being overweight) derived in the determination study.

ANTHROPOMETRY

All measurements were made by trained observers with standard techniques[15]: weight by digital scales (Seca, Germany) to within 100 g, without heavy clothing; height barefoot by portable stadiometer (Holtain, Crymych, United Kingdom) to within 0·5 cm; circumferences to within 1 mm with plastic tapes calibrated weekly, with waist mid-way between the lowest rib and the iliac crest with the subject standing at the end of gentle expiration, and hips at the greater trochanters. We used the same methods to determine and validate studies by different researchers.

METHODS OF ANALYSIS

Combination with indices in the range height$^{0·1}$ to height^2 did not improve the correlations of waist circumference alone with body mass index (r=0·89; P<0·001 for both sexes). According to the criteria of Khosla and Lowe,[16] height was therefore not used with waist circumference for further analyses.

We determined by cross tabulation between variables[17] two action levels for waist circumference for weight management to identify most subjects with a body mass index ≥25 (action level 1) and ≥30 (action level 2), while including a minimum of subjects who had lower body mass index and low waist:hip ratio to maximise sensitivity and specificity.[18] High body mass index was defined at two levels as ≥25 or ≥30 for both men and women.[6] On the basis of consensus from previous studies,[9-13] high waist:hip ratio was defined as 0·95 for men and 0·80 for women and low waist:hip ratio as below these cut offs.

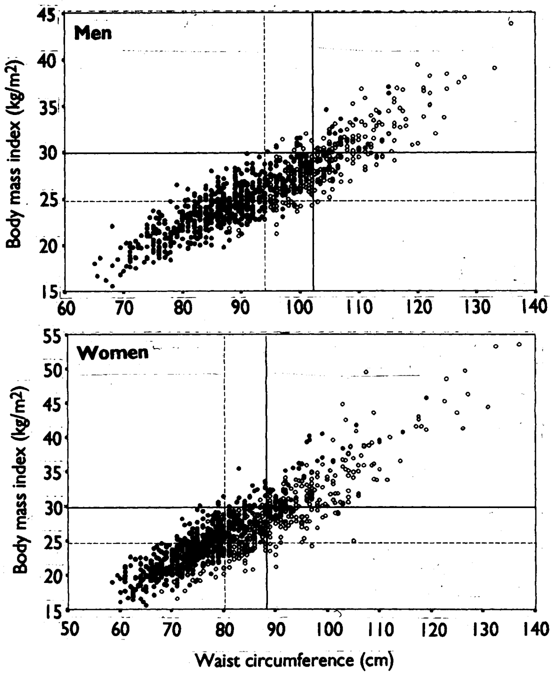
Results

DETERMINATION STUDY

The mean age (range 25 to 74 years), body mass index, and hip circumference were similar for men and for women (table I). However, men were heavier and taller and had a larger waist circumference and waist: hip ratio than women. In both sexes waist:hip ratio correlated positively with body mass index (men, r=0·63; women, r=0·39; both, P<0·001) (table II). Waist circumference correlated weakly with height in men (r=0·19, P<0·05) but not women (r=0·06, P=0·06). On average, men with a waist circumference above action level 1 were 2 cm taller than those below, accounting for 0·7 cm difference in waist circumference, but action levels for waist circumference determined for four different height categories (not shown) did not differ.

The figure shows distributions of the waist circumference related to body mass index divided by the proposed action levels. Table III shows the numbers of subjects in different categories of waist circumference, body mass index, waist:hip ratio. "True positive" subjects were those with high body mass index and those with lower body mass index but high waist:hip ratio; "true negative" subjects were those with low body mass index and those with high body mass index but low waist:hip ratio. "False positive" subjects were those with waist circumference above the action level but with low body mass index and waist:hip ratio; "false negative" subjects were those with waist circumference below the action level but with high body mass index and waist:hip ratio. These numbers were used to determine the sensitivity and specificity for waist circumference as an indicator of need for weight management (table IV).

False negative subjects, who would be missed by health education programmes that use waist circumference as an indicator of need for weight management, would represent less than 1·5% of the population. False positive subjects (1·7% of the population) would be included inappropriately in health promotion directed at those with high waist circumference. Among the subjects who were falsely positive at action level 1, men had a body mass index of 23·2-24·8 and a waist:hip ratio of 0·91-0·95, and women had a body mass index of 23·0-24·9 and a waist:hip ratio of 0·77-0·80. Among the subjects who were falsely



Relation between waist circumference and body mass index in men and in women from determination sample and the two action levels of waist circumference that identify subjects with body mass index ≥25 or ≥30 kg/m² and with waist:hip ratio ≥0·95 for men and ≥0·80 for women. Dotted line shows action level 1, solid line action level 2. ○ Waist:hip ratio ≥0·95 men, ≥0·80 women: false negative in upper left quadrant; ● waist:hip ratio ≤0·95 men, ≤0·80 women: false positive in lower right quadrant. Linear regression: body mass index= (0·307×waist circumference) −2·6 (men); body mass index= (0·394×waist circumference) −6·0 (women)

TABLE I—*Characteristics of subjects in determination sample and independent validation sample. Values are means (SD)*

	Determination sample		Validation sample	
	Men (n=904)	Women (n=1014)	Men (n=86)	Women (n=202)
Age (years)	51·0 (14·1)	50·8 (14·0)	44·9 (14·1)	37·5 (12·6)
Weight (kg)	75·9 (13·7)	65·9 (14·9)	80·3 (16·1)	66·6 (13·5)
Height (cm)	170·7 (7·0)	158·2 (6·5)	174·9 (6·6)	162·2 (6·7)
Body mass index (kg/m²)	26·0 (4·1)	26·3 (5·5)	26·2 (4·7)	25·4 (5·3)
Waist circumference (cm)	93·3 (11·9)	82·0 (12·3)	93·1 (14·8)	80·1 (14·2)
Hip circumference (cm)	100·5 (7·7)	101·7 (11·1)	99·8 (8·1)	101·7 (9·8)
Waist:hip ratio	0·93 (0·07)	0·80 (0·07)	0·93 (0·09)	0·79 (0·10)

TABLE II—*Number of subjects in determination sample in different categories of body mass index and waist:hip ratio*

	Body mass index (kg/m²)				
Waist:hip ratio	<20	20-	25-	>30	Total
Men:					
0·72-<0·95	99	241	201	23	564
0·95-1·13	0	52	183	105	340
Total	99	293	384	128	904
Women:					
0·65-<0·80	61	267	143	54	525
0·80-1·20	13	139	186	151	489
Total	74	406	329	205	1014

positive at action level 2, men had a body mass index of 26·9-29·7 and a waist:hip ratio of 0·88-0·94, and women had a body mass index of 28·7-29·6 and a waist:hip ratio of 0·79-0·80. The misclassified subjects were therefore close to the levels at which body weight control would be recommended, and the hazards of health promotion based on waist circumference action levels would be minimal.

TABLE III—*Number of men and women in different categories of body mass index and waist:hip ratio in groups classified by waist circumference action levels in determination sample and in validation sample*

	Determination sample		Validation sample	
	Men (n=904)	Women (n=1014)	Men (n=86)	Women (n=202)
Action level 1				
Waist circumference ≥94 cm for men and ≥80 cm for women	422	512	25	88
With body mass index:				
≥25	389	437	16	81
<25	33	75	9	7
<25 but high waist:hip ratio	25	68	2	4
≥25 and low waist:hip ratio*	8	7	0	3
Waist circumference <94 cm for men and <80 cm for women	482	502	61	114
With body mass index:	359	405	61	107
<25	123	97	0	7
≥25	113	83	9	7
≥25 but low waist:hip ratio	10	14	2	0
≤25 and high waist:hip ratio†				
Action level 2				
Waist circumference ≥102 cm for men and ≥88 cm for women	210	292	35	50
With body mass index:				
≥30	116	184	33	30
<30	94	108	2	20
<30 but high waist:hip ratio	82	106	9	19
≤30 and low waist:hip ratio*	12	2	0	1
Waist circumference <102 cm for men and <88 cm for women	694	722	55	156
With body mass index:				
<30	682	701	40	151
≥30	12	21	11	5
≥30 but low waist:hip ratio	8	19	0	1
≥30 and high waist:hip ratio†	4	2	0	0

High waist:hip ratio ≥0·95 for men and ≥0·80 for women; low waist:hip ratio <0·95 for men and <0·80 for women.
*False positive subjects (see results section).
†False negative subjects (see results section).

TABLE IV—*False positive and false negative subjects* and sensitivity and specificity for men and women in determination sample and in validation sample by waist circumference to identify those with body mass index ≥25 or ≥30 and those with lower body mass index but waist:hip ratio ≥0·95 (men) or ≥0·80 (women)*

Body mass index (kg/m²)	Waist circumference (cm)	False positive	False negative	Sensitivity† (%)	Specificity‡ (%)
Determination sample:					
Men (n=904):					
25-	≥94	8/340	10/288	96·8	98·2
≥30	≥102	12/541	4/105	97·9	97·8
Women (n=1014):					
25-	≥80	7/328	14/337	96·5	98·3
≥30	≥88	2/471	2/151	99·2	99·6
Validation sample:					
Men (n=86):					
25-	≥94	0/38	2/32	94·1	100
≥30	≥102	0/49	0/15	100	100
Women (n=202):					
25-	≥80	3/98	0/63	100	97·1
≥30	≥88	1/120	0/28	100	99·2

*For definition see results section.
Sensitivity was calculated as true positives/(true positives+false negatives, specificity as true negatives/(true negatives+false positives).[18]

VALIDATION STUDY

The validation sample was younger than the determination sample, but had similar ranges of anthropometric measurements (table I). The action levels for waist circumference showed similarly high sensitivity (>94%) and specificity (>97%) for identifying high risk subjects in need of weight management (tables III and IV). Waist circumference and height were not significantly related in either men (r=0·07; P=0·54) or women (r=−0.13; P=0·07).

Discussion

The influences of body mass index and waist:hip ratio on metabolic and cardiovascular disease are multiplicative,[19 20] so weight loss should be urged for all those with a high body mass index and can also be justified for those with a lower body mass index but high waist:hip ratio. Consensus emerging from prospective studies suggests cut offs of waist:hip ratio 0·95 in men and 0·80 in women—as values above which health risk increases appreciably. Metabolic risk factors, particularly serum concentrations of triglycerides and high density lipoprotein cholesterol, improve most with weight loss in men with a waist:hip ratio ≥0·95[21-23] and women with a waist:hip ratio ≥0·80 (table V).[10-12] In our study 48% of the women and 38% of the men had waist:hip ratios above these figures (table II); just over half had a body mass index 25 or above. The interaction between body mass index and waist:hip ratio offers an opportunity through measurement of waist circumference to target individuals at highest risk to maximise the benefits of interventions.[24-25]

Many analyses have found strong positive correlations between waist circumference and body mass index. This relation alone permits only limited prediction of body mass index: in our study, using waist circumference to identify those with body mass index ≥25 would have led to misclassification of about 4% of men and 7% of women and to identify those with body mass index ≥30, 10% of men and 11% of women. Health promotion targeted by waist circumference at those with body mass index ≥25 would miss about 21% of the total at risk population—that is, those with an index ≥25—and about 10% of those identified would be targeted inappropriately. However, most of those with high waist circumference but body mass index below these conventional cut offs have a high waist:hip ratio, which still justifies weight management. Most of those with higher body mass index but waist circumference below the action level have low waist:hip ratio,

TABLE V—*Studies reporting metabolic benefits of weight loss in groups with differing waist:hip ratios*

		Mean baseline data					% Change in outcome measure				
								Cholesterol			
Reference	Sex	No of subjects	Age (years)	Waist:hip ratio	Body mass index (kg/m²)	Weight loss (kg (%))	Triglycerides	Total	Low density lipoprotein	High density lipoprotein	Treatment
Den Besten *et al*[10]	F	8	37·0	0·74	31·6	9·6 (10·9)	−16·2	−7·4	NA	−7·4	Low calorie diet
Den Besten *et al*[10]	F	7	36·0	0·82	34·6	10·8 (11·4)	−38·4	−10·8	NA	−13·0	Low calorie diet
Dennis *et al*[11]	F	18	45·0	0·77	30·0	9·0 (11·0)	−22·5	−6·2	−9·3	+3·7	Low calorie diet
Dennis *et al*[11]	F	32	44·0	0·87	31·0	9·2 (11·2)	−23·4	−1·0	0·0	+11·4	Low calorie diet
Kannaley *et al*[12]	F	9	35·3	0·74	32·1	7·7 (8·8)	−8·4	NA	NA	+5·8	Low calaorie diet and exercise
Kannaley *et al*[12]	F	10	36·1	0·89	33·4	9·2 (10·3)	−20·7	NA	NA	+20·0	Low calorie diet and exercise
Lean *et al*†	F	30	51·5	0·75	28·1	6·0 (8·1)	−15·7	−5·6	−6·9	−0·6	Low calorie diet and slimming capsule‡
Lean *et al*†	F	16	57·6	0·84	28·9	5·2 (7·1)	−19·8	−3·9	−3·2	+0·7	Low calorie diet and slimming capsule‡
Lean *et al*†	F	27	52·0	0·76	33·7	8·2 (9·4)	−8·3	−2·9	−2·7	−2·0	Low calorie diet and slimming capsule‡
Lean *et al*†	F	52	53·5	0·85	35·7	6·2 (6·9)	−17·1	−2·9	−1·6	+0·5	Low calorie diet and slimming capsule‡
Sönnichsen *et al*[21]	M	40	49·7	1·02	41·4	6·4 (6·8)	−11·0	−16·5	−21·1	NA	Low calorie diet
Houmard *et al*[22]	M	13	47·2	0·96	30·4	2·0 (2·1)	−20·3	−0·3	NA	+8·2	Exercise
Wing *et al*[23]	M	101	37·3	0·97	31·0	9·8 (10·2)	−16·2	−9·8	NA	NA	Low calorie diet

NA=not available. †Unpublished data. ‡Proprietary food based capsule.

Key messages

- The proportion of overweight adults in Britain is increasing
- Body mass index is commonly used to identify those with a health risk from being overweight
- This study shows that waist circumference may be a simpler measure for identifying need for weight management
- Most men with waist circumference ≥102 cm and women with waist circumference ≥88 cm were appreciably overweight or had a high waist:hip ratio and should be urged to lose weight
- Waist circumference 94-102 cm in men and 80-88 cm in women should be a warning to avoid weight gain

which would indicate a lower health risk, and less benefit from slimming. The action levels for waist circumference derived here, based on both body mass index and waist:hip ratio, are robust in that they led to misclassification of only 1·5% of the overweight men and women.

The simplicity of measurement and its relation to both body weight and fat distribution are major advantages for waist circumference over body mass index and waist:hip ratio. Self measurement and reporting of waist circumference has been reported to be acceptable in recent epidemiological studies,[26 27] but better information will be needed about possible self reporting bias and about ability to monitor changes with weight management. Waist circumference is more strongly associated with metabolic function, however, than with waist:hip ratio in adults[22] and in children[28] and predicts myocardial infarction.[20] The proposed action levels match the results of Chan *et al*, who found progressively increasing relative risk of developing non-insulin dependent diabetes in men as waist circumference rose from 73·7-87·6 cm to 91·7-96·5 cm (relative risk 2·2) and to >102·0 cm (12).[27] Pouliot *et al* observed exponential increases in cardiovascular risk factors with waist circumference above 87 cm in men and 78 cm in women (which correspond to waist circumference of action level 1) and further risk factor increases with waist circumferences above those of action level 2.[29] Proof of the value of waist circumference action levels in predicting health risks will require longitudinal follow up of morbidity and mortality. Longitudinal data from the Framingham study suggests that waist predicts mortality better than other anthropometric measures.[30]

CONCLUSION

In conclusion, the action levels for waist circumference (measured by using bony landmarks mid-way between the iliac crests and the lowest ribs) that have been identified in our study could form the basis on which health promotion might raise awareness or urge action on weight reduction. The lower action level of waist circumference (94 cm for men and 80 cm for women) represents a threshold above which health risks are increased—particularly for young men.[27 31] Further weight gain and rise in waist circumference from action level 1 towards action level 2 should be discouraged. The upper action level (102 cm for men and 88 cm for women) correspond with the point at which symptoms of breathlessness and arthritis begin to develop from overweight, and the health risks are such that medical consultation and weight loss should be urged.

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