3 MEASURING OVERWEIGHT AND OBESITY

Obesity, or even overweight, in a person is generally not difficult to recognise. But proper diagnosis requires that clinically significant risk levels of the problem be identified, and this often necessitates some form of quantification.

In some cases it may be necessary to make a clinical judgment about the possible counter-productive effects of quantifying overweight or obesity in a person who is obviously overweight and who may be adversely affected by further measurement. In these situations, assessment of food intake, physical activity and other factors, as outlined in Chapter 2, might continue in the absence of body-fat measurement. If a more detailed assessment is called for, at some stage in the assessment it may be necessary to use a clinical measure, or measures, which should have several important characteristics:

- valid, reliable and sensitive
- clearly defined, easy-to-use, and understandable to the patient
- offering a measure of disease risk
- responsive to, and predictive of, changes in body fat.

Various measures have traditionally been used, but it is really only in recent years that the evidence has allowed a qualified assessment of their value. At present there is a lack of data on the best measures to use for Aboriginal and Torres Strait Islander peoples, so no recommendations in this regard are made here.

3.1 'GOLD STANDARD' MEASURES

At this stage the only truly valid way of measuring fat as a proportion of total body mass is to use cadavers. In the past the closest 'gold standard' approximation to this in living humans was underwater, or hydrostatic, weighing. More recently, imaging techniques such as magnetic resonance imaging,[1] computerised tomography scanning[2] and dual X-ray absorptiometry[3] have provided alternatives, but the expense and relative scarcity of the necessary equipment usually preclude use of these techniques in a clinical setting. Other devices—such as measuring skinfold thickness,[4] bio-impedence analysis[5] and near infra–red spectroscopy[6]—are available and relatively inexpensive, but they have not always been completely validated and their reliability and sensitivity in less than fully standardised conditions is questionable.[7–9] In the absence of a technological solution, therefore, the emphasis has been on anthropometric measures of body mass and body-fat distribution.

3.2 ANTHROPOMETRIC MEASURES

The most favoured measure of body mass has traditionally been either weight alone or weight adjusted for height. More recently it has been noted that body-fat distribution is more predictive of ill-health, and fat distribution measures have become increasingly popular. A combination of body mass and fat distribution measures is probably the best option for fulfilling the requirements of a clinical measure, as just outlined. The evidence for each is discussed here independently, then the appropriate combination is considered. It should be noted at the outset, however, that there are no perfect measures of overweight or obesity. In some cases, measurement may be declined. In others it may not be warranted, since it could cause greater anxiety in the patient and thus be counter-productive.[10] Some patients accept measurement on the condition that they are not told the results.

3.2.1 BMI

Eighteenth century mathematician Adolphe Quetelet was the first to correct the inadequacies of body weight alone as a measure of mass by adjusting weight for height using the formula 'body mass index = weight (in kilograms) divided by the 0.9th power of height (in metres)'. This was later rounded to the square of height, or height (in metres).[2]

BMI cut-offs for adults have been identified on the basis of associations between BMI and chronic disease and mortality[11] (see Chapter 1). The classification adopted by the World Health Organization,[12] shown in Table 3.1, is based on the international standards developed for adult people of European descent.

Table 3.1 Classification of weight by BMI[12]

Classification	BMI (kg/m^2)	Risk of co-morbidities
Underweight	<18.5	Low (but possibly increased risk of other clinical problems)
Normal range	18.5–24.9	Average
Overweight	≥25.0	
Pre-obese	25.0–29.9	Increased
Obese I	30.0–34.9	Moderate
Obese II	35.0–39.9	Severe
Obese III	≥40.0	Very severe

BMI is highly, but not perfectly, correlated with fat mass.[13-15] The measure does, however, have several limitations. In the first place, it does not distinguish fat mass from lean mass. This means that body fat calculated using BMI can be underestimated in older subjects, because of their differential loss of lean mass and decreased height,[16] and overestimated in subjects with a muscular build, such as athletes.[17,18] A second limitation is that BMI does not necessarily reflect body-fat distribution. A measure of fat distribution is important in assessing overweight and obesity because visceral (intra-abdominal) fat is a potential risk factor for disease, independently of total body fat.[19,20] BMI explains about 70 per cent of the variation in visceral fat between individuals.[2,21] However, individuals with the same BMI can have different levels of visceral fat mass. For example, the pattern of abdominal body-fat distribution is clearly influenced by gender: for any accumulation of body fat, men have on average twice the amount of abdominal fat than pre-menopausal women.[22]

In addition, BMI does not necessarily describe the same degree of fatness in different populations, partly because of differences in body proportions. For example, Asians and Indians have a more centralised distribution of body fat for a given level of BMI compared to people of European descent.[23–25] Among Asians and Indians morbidity and mortality occur at a lower BMI, and it is proposed that the BMI cut-offs for overweight and obesity in these populations be lowered to ≥23 and ≥25 respectively.[26] In contrast, African-Americans[27,28] and Polynesians[29] tend to have a lower percentage of body fat than people of European descent at the same BMI. Differing cut-offs for other ethnic groups, such as Aboriginal and Torres Strait Islander peoples, who have relatively long legs in relation to weight—a factor known to influence BMI[30]—are yet to be identified.[31–33]

Therefore, although BMI is widely used to assess obesity in populations, the fact that it can be influenced by age, gender and ethnicity makes it a less useful measure when used alone in individuals, at least where BMI is less than 30.[34] Combining BMI with a measure of fat distribution may help overcome some of the problems of using BMI alone in the clinical situation.

Evidence-based statement	Evidence level
BMI is an acceptable approximation of total body fat at the population level and can be used to estimate the relative risk of disease in most people. However, it is not always an accurate predictor of body fat or fat distribution, particularly in muscular individuals, because of differences in body-fat proportions and distribution.	III-2

Recommendation: level B

- Interpret BMI with caution when this is the only measure of body fatness in a person, particularly when measuring older people and muscular, mesomorphic individuals such as athletes.

3.2.2 Fat mass and fat distribution

As noted, the gold standard measure for determining total body fat mass in the past was hydrostatic weighing.[35] The newer techniques, such as magnetic resonance imaging, dual X-ray absorptiometry and computerised tomography,[36] are expensive and usually require access to large-scale facilities. At the clinical level, bio-impedence analysis scales are now available in portable form, and these have been found to be sufficiently valid and reliable under constant conditions to warrant their use in certain circumstances.[37,38] Total fat mass, however, while a good measure of overall body fatness, is regarded as less predictive of disease outcomes than fat distribution.

Table 3.2 updated on 19 March 2004

The importance of fat distribution in the aetiology of disease was first noted by French physician Jean Vague in 1947.[39] But little attention was paid to Vague's findings, and weight and BMI continued to be the measures of choice until the 1980s, when European researchers began to investigate the relationship between centrally distributed (that is, trunkal or abdominal) obesity and disease outcomes. Since that time increased abdominal obesity has been consistently shown to be related to an increased risk of cardiovascular disease,[40-44] type 2 diabetes[45,46] and cancer,[47,48] even though much of the evidence for this comes from cross-sectional, rather than prospective, studies.[49] Nonetheless, centrally distributed obesity is now considered a better indicator for a range of health problems than total body mass.[40,50] Above a BMI of 35, though, abdominal obesity has little predictive power of disease risk beyond that of BMI.[46,19]

Initially, the most commonly used measure of central obesity was the waist-to-hip ratio. However, in the 1990s it was recognised that this may be less valuable as a relative measure after weight loss because of the loss of hip, as well as waist, dimensions in some individuals. The waist-to-height ratio and sagittal diameter have been proposed as alternative measures,[51,52] but recent evidence suggests that waist circumference alone may be a sufficient measure, with high predictive validity[46,53,54] and less potential for error.[41,55,56] Various sites and standards for measurement have been suggested, but the best-defined site is either the narrowest part of the torso, as seen from the anterior aspect, or the smallest horizontal circumference in the area between the lowest rib and the iliac crest.[57] Table 3.2 shows suggested cut-offs for waist circumference in Caucasians.

Table 3.2 Waist circumference and risk of metabolic complications associated with obesity in Caucasian men and women

	Waist circumference (cm)		
Risk of metabolic complications	**Men**	**Women**	**Action level**
Increased	**≥94**	≥80	1
Substantially increased	≥102	≥88	2

Note: 'Action level' refers to the importance of taking action to reduce waist size, 1 being less important than 2.

Source: Reference 12.

Unlike BMI, waist circumference is independent of height[58] but, like BMI, the relationship between waist circumference and body fat differs with age[59,60] and between ethnic groups[25] in both men and women. Cut-offs for Asians and Indians at the same level of risk are thought to be lower than those shown in Table 3.2. For example, it has recently been suggested that cut-off values of 90 centimetres for Asian men and 80 centimetres for Asian women are associated with a substantially increased risk of metabolic complications.[26] The cut-off values for other racial groups, such as Pacific Islanders and African-Americans, are likely to be higher than those for people of European descent, although they have not yet been determined.[12] Waist circumference will not be an accurate measure of body fat in some situations (e.g. pregnancy or medical conditions where there is distension of the stomach).

Waist circumference—reflecting mainly subcutaneous abdominal fat storage—has been shown to be positively, although not perfectly, correlated to disease risk.[43,44,61] Waist circumference alone is a valid measure of abdominal fat mass and disease risk in individuals with a BMI of less than 35. However, where BMI is greater than 35, waist circumference adds little to the absolute measure of risk provided by BMI. More recently, visceral fat (fat stored intra-abdominally, around the organs of the trunk) has been found to be even more directly associated with metabolic risk than subcutaneous fat. Visceral fat can only be measured accurately using imaging techniques, although there is a strong correlation between it and waist circumference.[62] Sagittal diameter has also been shown to be a useful indicator of visceral fat, but it has limited advantages over waist circumference alone.[41]

Evidence-based statement	Evidence level
Waist circumference is a valid measure of abdominal fat mass and disease risk in individuals with a BMI less than 35. If BMI is 35 or more, waist circumference adds little to the absolute measure of risk provided by BMI.	III-2

Recommendation: level B

- To reduce the risk of disease, Caucasian men should aim for a waist circumference of less than 102 centimetres and women less than 88 centimetres. In Asians and Indians the target could be 10 centimetres lower, and in Pacific Islanders it could be significantly higher.

3.2.3 Combining measures

Waist circumference remains one of the most useful clinical measures of fat distribution and disease risk (particularly with a BMI less than 35), satisfying most of the requirements listed at the beginning of this chapter. When it is used in isolation, however, a proportion of subjects who need weight management may not be identified.[63] There is an indication that use of waist circumference as a measure of risk may be further improved by the addition of a metabolic measure such as plasma triglycerides,[43] although this needs to be verified. In addition, although waist circumference is a good measure of absolute risk, it is not such a good measure of relative change in body fatness: in some cases weight losses are not reflected in waist-circumference losses because fat is lost from parts of the body other than the waist.[64] Similarly, other studies have shown that using waist circumference to predict both changes in visceral fat[65] and improvements in cardiovascular risk factors[66] during weight loss has limitations in overweight men and women.

These deficiencies in the sensitivity of waist circumference as well as the validity of BMI, as discussed in Section 3.2.1, can be moderated if both measures are used in risk assessment and if both weight and waist circumference are used to measure changes in body fat over time. One way of doing this, promoted by the WHO, is shown in Table 3.3.

Table 3.3 Combining waist measurement and BMI to assess obesity and the risk of type 2 diabetes and cardiovascular disease

		Waist circumference (cm)	
Classification	**BMI (kg/m²)**	**Men: 94–102 Women: 80–88**	**102+ 88+**
Underweight	<18.5	–	–
Healthy weight	18.5–24.9	–	Increased
Overweight	25–29.9	Increased	High
Obesity	≥30	High	Very high

Note: For Maori and other Pacific Islanders, the upper range BMIs for overweight and obesity are 26 and 32; for Asians, BMI and waist circumference should be adjusted downwards (waist = 100 centimetres or less).

Source: Reference 12.

Recommendation: level B

- If patients wish to be measured, a combination of BMI and waist circumference or weight and waist circumference should be used.

Recommendations: level D

- Both weight and waist circumference should be used to assess relative changes in body fatness over time.
- For some obese patients measurement may be counter-productive; patients should be allowed to choose whether to have their fat mass measured. Other patients may prefer not to know the results of measurement.

REFERENCES

1 Kamba M, Kimura K, Koda M, Ogawa T. Proton magnetic resonance spectroscopy for assessment of human body composition. *Am J Clin Nutr* 2001;73(2):172–6.

2 Seidell JC, Oosterlee A, Deurenberg P, Hautvast JG, Ruijs JH. Abdominal fat depots measured with computed tomography: effects of degree of obesity, sex, and age. *Eur J Clin Nutr* 1988;42(9):805–15.

3 Erselcan T, Candan F, Saruhan S, Ayca T. Comparison of body composition analysis methods in clinical routine. *Ann Nutr Metab* 2000;44(5–6):243–8.

4 Durnin JV, Rahaman MM. The assessment of the amount of fat in the human body from measurements of skinfold thickness. *Br J Nutr* 1967;21(3):681–9.

5 Kushner RF, Kinug A, Alspaugh M, Andronis PT, Leitch CA, Schoeller DA. Validation of bioelectrical-impedence analysis as a measure of change in body composition in obesity. *Am J Clin Nutr* 1990;52(2):219–23.

6 Brooke-Wavell K, Jones PR, Norgan NG, Hardman AE. Evaluation of near infra-red interactance for assessment of subcutaneous and total body fat. *Eur J Clin Nutr* 1995;49(1):57–65.

7 Beddoe AH. Body fat: estimation or guesstimation? *Appl Radiat Isot* 1998;49(5–6):461–3.

8 Okasora K, Takaya R, Tokuda M, Fukunaga Y, Oguni T, Tanaka H et al. Comparison of bioelectrical impedance analysis and dual energy X-ray absorptiometry for assessment of body composition in children. *Pediatr Int* 1999;41(2):121–5.

9 Thomas DW, Ryde SJ, Ali PA, Birks JL, Evans CJ, Saunders NH et al. The performance of an infra-red interactance instrument for assessing total body fat. *Physiol Meas* 1997;18(4):305–15.

10 Kausman R. *If not dieting, then what?* Sydney: Allen and Unwin, 1998.

11 Willett WC, Dietz WH, Colditz GA. Guidelines for healthy weight. *N Engl J Med* 1999;341(6):427–34.

12 World Health Organization. Obesity: preventing and managing the global epidemic. Report of a WHO consultation. *WHO Tech Rep Ser* 2000;894(3):i–xii, 1–253.

13 Gallagher D, Visser M, Sepulveda D, Pierson RN, Harris T, Heymsfield SB. How useful is body mass index for comparison of body fatness across age, sex, and ethnic groups? *Am J Epidemiol* 1996;143(3):228–39.

14 Deurenberg P, Weststrate JA, Seidell JC. Body mass index as a measure of body fatness: age- and sex-specific prediction formulas. *Br J Nutr* 1991;65(2):105–14.

15 Pietrobelli A, Faith MS, Allison DB, Gallagher D, Chiumello G, Heymsfield SB. Body mass index as a measure of adiposity among children and adolescents: a validation study. *J Pediatr* 1998;132(2):204–10.

16 Sorkin J, Muller D, Andres R. Longitudinal change in height in men and women: implications for interpretation of the body mass index. *Am J Epidem* 1999;150:969–77.

17 Deurenberg P, Deurenberg Yap M, Wang J, Lin FP, Schmidt G. The impact of body build on the relationship between body mass index and percent body fat. *Int J Obes Relat Metab Disord* 1999;23(5):537–42.

18 Frisch RE, Snow RC, Johnson LA, Gerard B, Barbieri R, Rosen B. Magnetic resonance imag ompared to controls. *J Clin Endocrinol Metab* 1993;77(2):471–7.

19 National Institutes of Health. Clinical guidelines on the identification, evaluation, and treatment of overweight and obesity in adults: executive summary. Expert Panel on the Identification, Evaluation, and Treatment of Overweight in Adults. *Am J Clin Nutr* 1998;68(4):899–917.

20 Kissebah AH, Krakower GR. Regional adiposity and morbidity. *Physiol Rev* 1994;74:761–811.

21 Ross R, Shaw KD, Martel Y, de Guise J, Avruch L. Adipose tissue distribution measured by magnetic resonance imaging in obese women. *Am J Clin Nutr* 1993;57(4):470–5.

22 Lemieux S, Prud'homme D, Bouchard C, Tremblay A, Despres JP. Sex differences in the relation of visceral adipose tissue accumulation to total body fatness. *Am J Clin Nutr* 1993;58(4):463–7.

23 Deurenberg-Yap M, Schmidt G, van Staveren WA, Deurenberg P. The paradox of low body mass index and high body fat percentage among Chinese, Malays and Indians in Singapore. *Int J Obes Relat Metab Disord* 2000;24(8):1011–17.

24 Ko GT, Tang J, Chan JC, Sung R, Wu MM, Wai HP et al. Lower BMI cut-off value to define obesity in Hong Kong Chinese: an analysis based on body fat assessment by bioelectrical impedance. *Br J Nutr* 2000;85(2):239–42.

25 McKeigue PM, Shah B, Marmot MG. Relation of central obesity and insulin resistance with high diabetes prevalence and cardiovascular risk in South Asians. *Lancet* 1991;337(8738):382–6.

26 World Health Organization, International Obesity Taskforce & International Association for the Study of Obesity. *The Asia–Pacific perspective: redefining obesity and its treatment.* Hong Kong: WHO, IOTF & IASO, 2000.

27 Albu JB, Murphy L, Frager DH, Johnson JA, Pi-Sunyer FX. Visceral fat and race-dependent health risks in obese nondiabetic premenopausal women. *Diabetes* 1997;46(3):456–62.

28 Aloia JF, Vaswani A, Mikhail M, Flaster ER. Body composition by dual-energy X-ray absorptiometry in black compared with white women. *Osteoporos Int* 1999;10(2):114–19.

29 Swinburn BA, Craig PL, Daniel R, Dent DPD, Strauss BJG. Body composition differences between Polynesians and Caucasians assessed by bioelectrical impedance. *Int J Obes* 1996;20:889–94.

30 Norgan NG, Jones PR. The effect of standardising the body mass index for relative sitting height. *Int J Obes Relat Metab Disord* 1995;19(3):206–8.

31 Wang Z, Hoy W, McDonald S. Body mass index in Aboriginal Australians in remote communities. *Aust NZ J Pub Hlth* 2000;24(6):570–5.

32 Jones CO, White NG. Adiposity in Aboriginal people from Arnhem Land, Australia: variation in degree and distribution associated with age, sex and lifestyle. *Ann Hum Biol* 1994;21(3):207–27.

33 Hoy W, Kelly A, Jacups S, McKendry K, Baker P, MacDonald S et al. Stemming the tide: reducing cardiovascular disease and renal failure in Australian Aborigines. *Aust NZ J Med* 1999;29(3):480–3.

34 Frankenfield D, Rowe W, Cooney R, Smith J, Becker D. Limits of body mass index to detect obesity and predict body composition. *Nutrition* 2001;17(1): 26–30.

35 Behnke AR, Feen BG, Welham WC. The specific gravity of healthy men. *JAMA* 1942;118:495–8.

36 Roche AF, Heymsfield SB, Lohman TG. *Human body composition.* Champaign, IL: Human Kinetics, 1996.

37 Okasora K, Takaya R, Tokuda M, Fukunaga Y, Oguni T, Tanaka H, Konishi K, Tamai H. Comparison of bioelectrical impedance analysis and dual energy X-ray absorptiometry for assessment of body composition in children. *Paediatr Internat,* 1999;41(2):121–5.

38 Stout JR, Housh TJ, Eckerson J, Johnson GO, Betts NM.Validity of methods for estimating percent body fat in young women. *Strength and Conditioning Res,* 1996;10(1):25–9.

39 Vague J. La différenciation sexuelle, facteur determinant des formes de l'obesité. *Presse Medicale* 1947;30:339–40.

40 Seidell JC, Bouchard C. Abdominal adiposity and risk of heart disease. *JAMA* 1999;281(24):2284–5.

41 Seidell J. Are abdominal diameters abominable indicators? In: Angel A, Anderson H, Bouchard C, Lau D, Leiter L, Mendelson R, eds. *Progress in obesity research*. London: John Libbey & Co. Ltd, 1996:305–8.

42 Han TS, Lean ME. Self-reported waist circumference compared with the 'Waist Watcher' tape-measure to identify individuals at increased health risk through intra-abdominal fat accumulation. *Br J Nutr* 1998;80(1):81–8.

43 Despres JP, Lemieux I, Prud'homme D. Treatment of obesity: need to focus on high risk abdominally obese patients. *BMJ* 2001;322(7288):716–20.

44 Gillum RF, Mussolino ME, JH. M. Body fat distribution, obesity, overweight and stroke incidence in women and men: the NHANES I Epidemiologic Follow-up Study. *Int J Obes Relat Metab Disord* 2001;25(5):628–38.

45 Lean ME, Han TS, Seidell JC. Impairment of health and quality of life in people with large waist circumference. *Lancet* 1998;351(9106):853–6.

46 Chan JM, Rimm EB, Colditz GA, Stampfer MJ, Willett WC. Obesity, fat distribution, and weight gain as risk factors for clinical diabetes in men. *Diab Care* 1994;17(9):961–9.

47 den Tonkelaar I, Seidell JC, Collette HJ. Body fat distribution in relation to breast cancer in women participating in the DOM project. *Breast Cancer Res Treat* 1995;34(1):55–61.

48 Giovannucci E, Ascherio A, Rimm EB, Colditz GA, Stampfer MJ, Willett WC. Physical activity, obesity, and risk for colon cancer and adenoma in men. *Ann Intern Med* 1995;122(5):327–34.

49 Han TS, van Leer EM, Seidell JC, Lean ME. Waist circumference action levels in the identification of cardiovascular risk factors: prevalence study in a random sample. *BMJ* 1995;311(7017):1401–5.

50 Despres JP, Moorjani S, Lupien PJ, Tremblay A, Nadeau A, Bouchard C. Regional distribution of body fat, plasma lipoproteins, and cardiovascular disease. *Arteriosclerosis* 1990;10(4):497–511.

51 Ashwell M, Lejeune S, McPherson K. Ratio of waist circumference to height may be better indicator of need for weight management. *BMJ* 1996;312(7027): 377.

52 Cox BD, Whichelow M. Ratio of waist circumference to height is better predictor of death than body mass index. *BMJ* 1996;313(7070):1487.

53 Baik I, Ascherio A, Rimm EB, Giovannucci E, Spiegelman D, Stampfer MJ et al. Adiposity and mortality in men. *Am J Epidemiol* 2000;152(3):264–71.

54 Dasgupta S, Hazra SC. The utility of waist circumference in assessment of obesity. *Indian J Pub Hlth* 1999;43(4):132–5.

55 Sattar N, Tan CE, Han TS, Forster L, Lean ME, Shepherd J et al. Associations of indices of adiposity with atherogenic lipoprotein subfractions. *Int J Obes Relat Metab Disord* 1998;22(5):432–9.

56 Seidell JC, Kahn HS, Williamson DF, Lissner L, Valdez R. Report from a Centers for Disease Control and Prevention Workshop on use of adult anthropometry for public health and primary health care. *Am J Clin Nutr* 2001;73(1):123–6.

57 Lohman T, Roche A, Martorelli R. *Anthropometric standardization reference manual*. Abridged edn. Champaign, IL: Human Kinetics, 1988.

58 Han TS, Seidell JC, Currall JE, Morrison CE, Deurenberg P, Lean ME. The influences of height and age on waist circumference as an index of adiposity in adults. *Int J Obes Relat Metab Disord* 1997;21(1):83–9.

59 Lemieux S, Prud'homme D, Bouchard C, Tremblay A, Despres JP. A single threshold value of waist girth identifies normal-weight and overweight subjects with excess visceral adipose tissue. *Am J Clin Nutr* 1996;64(5):685–93.

60 Molarius A, Seidell JC, Visscher TL, Hofman A. Misclassification of high-risk older subjects using waist action levels established for young and middle-aged adults—results from the Rotterdam Study. *J Am Geriatr Soc* 2000;48(12):1638–45.

61 Pouliot MC, Despres JP, Lemieux S, Moorjani S, Bouchard C, Tremblay A et al. Waist circumference and abdominal sagittal diameter: best simple anthropometric indexes of abdominal visceral adipose tissue accumulation and related cardiovascular risk in men and women. *Am J Cardiol* 1994;73(7):460–8.

62 Despres JP, Prud'homme D, Pouliot MC, Tremblay A, Bouchard C. Estimation of deep abdominal adipose-tissue accumulation from simple anthropometric measurements in men. *Am J Clin Nutr* 1991;54(3):471–7.

63 Molarius A, Seidell JC, Sans S, Tuomilehto J, Kuulasmaa K. Varying sensitivity of waist action levels to identify subjects with overweight or obesity in 19 populations of the WHO MONICA Project. *J Clin Epidemiol* 1999;52(12): 1213–24.

64 Egger G, Dobson A. Clinical measures of obesity and weight loss in men. *Int J Obes Relat Metab Disord* 2000;24(3):354–7.

65 van der Kooy K, Leenen R, Seidell JC, Deurenberg P, Visser M. Abdominal diameters as indicators of visceral fat: comparison between magnetic resonance imaging and anthropometry. *Br J Nutr* 1993;70(1):47–58.

66 Wing RR, Jeffery RW, Burton LR, Thorson C, Kuller LH, Folsom AR. Change in waist–hip ratio with weight loss and its association with change in cardiovascular risk factors. *Am J Clin Nutr* 1992;55(6):1086–92.