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—MEASURING OVERWEIGHT AND OBESITY

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 mortality11 (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>
<thead>
<tr>
<th>Classification</th>
<th>BMI (kg/m²)</th>
<th>Risk of co-morbidities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Underweight</td>
<td>&lt;18.5</td>
<td>Low (but possibly increased risk of other clinical problems)</td>
</tr>
<tr>
<td>Normal range</td>
<td>18.5–24.9</td>
<td>Average</td>
</tr>
<tr>
<td>Overweight</td>
<td>≥25.0</td>
<td></td>
</tr>
<tr>
<td>Pre-obese</td>
<td>25.0–29.9</td>
<td>Increased</td>
</tr>
<tr>
<td>Obese I</td>
<td>30.0–34.9</td>
<td>Moderate</td>
</tr>
<tr>
<td>Obese II</td>
<td>35.0–39.9</td>
<td>Severe</td>
</tr>
<tr>
<td>Obese III</td>
<td>≥40.0</td>
<td>Very severe</td>
</tr>
</tbody>
</table>

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.\textsuperscript{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.\textsuperscript{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 $\geq 23$ and $\geq 25$ respectively.\textsuperscript{26} In contrast, African-Americans\textsuperscript{27,28} and Polynesians\textsuperscript{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\textsuperscript{30}—are yet to be identified.\textsuperscript{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.\textsuperscript{34} Combining BMI with a measure of fat distribution may help overcome some of the problems of using BMI alone in the clinical situation.

<table>
<thead>
<tr>
<th>Evidence-based statement</th>
<th>Evidence level</th>
</tr>
</thead>
<tbody>
<tr>
<td>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.</td>
<td>III-2</td>
</tr>
</tbody>
</table>

**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.\textsuperscript{35} The newer techniques, such as magnetic resonance imaging, dual X-ray absorptiometry and computerised tomography,\textsuperscript{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.\textsuperscript{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.
3—MEASURING OVERWEIGHT AND OBESITY

The importance of fat distribution in the aetiology of disease was first noted by French physician Jean Vague in 1947. 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, truncal 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, type 2 diabetes and cancer, even though much of the evidence for this comes from cross-sectional, rather than prospective, studies. Nonetheless, centrally distributed obesity is now considered a better indicator for a range of health problems than total body mass. Above a BMI of 35, though, abdominal obesity has little predictive power of disease risk beyond that of BMI.

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, but recent evidence suggests that waist circumference alone may be a sufficient measure, with high predictive validity and less potential for error. 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. Table 3.2 shows suggested cut-offs for waist circumference in Caucasians.

<table>
<thead>
<tr>
<th>Risk of metabolic complications</th>
<th>Waist circumference (cm)</th>
<th>Action level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increased</td>
<td>≥ 94 (Men)</td>
<td>≥ 80 (Women)</td>
</tr>
<tr>
<td>Substantially increased</td>
<td>≥ 102 (Men)</td>
<td>≥ 88 (Women)</td>
</tr>
</tbody>
</table>

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 but, like BMI, the relationship between waist circumference and body fat differs with age and between ethnic groups 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. 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. 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.\textsuperscript{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.\textsuperscript{62} Sagittal diameter has also been shown to be a useful indicator of visceral fat, but it has limited advantages over waist circumference alone.\textsuperscript{41}

<table>
<thead>
<tr>
<th>Evidence-based statement</th>
<th>Evidence level</th>
</tr>
</thead>
<tbody>
<tr>
<td>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.</td>
<td>III-2</td>
</tr>
</tbody>
</table>

**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.\textsuperscript{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,\textsuperscript{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.\textsuperscript{64} Similarly, other studies have shown that using waist circumference to predict both changes in visceral fat\textsuperscript{65} and improvements in cardiovascular risk factors\textsuperscript{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

<table>
<thead>
<tr>
<th>Classification</th>
<th>BMI (kg/m²)</th>
<th>Men: 94–102</th>
<th>102+</th>
</tr>
</thead>
<tbody>
<tr>
<td>Underweight</td>
<td>&lt;18.5</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Healthy weight</td>
<td>18.5–24.9</td>
<td>–</td>
<td>Increased</td>
</tr>
<tr>
<td>Overweight</td>
<td>25–29.9</td>
<td>Increased</td>
<td>High</td>
</tr>
<tr>
<td>Obesity</td>
<td>≥30</td>
<td>High</td>
<td>Very high</td>
</tr>
</tbody>
</table>

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


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.


