

Historically, fat (adipose tissue) was simply seen as the body's mechanism to store excess energy. It was assumed that adipose tissue was biologically inert and that fat was largely stored subcutaneously (just below the skin). We have known for some time now that fat is stored – mainly in deposits – throughout the body (Figure 1), but more recently it has become increasingly apparent that adipose tissue is biologically active.<sup>1-3</sup>

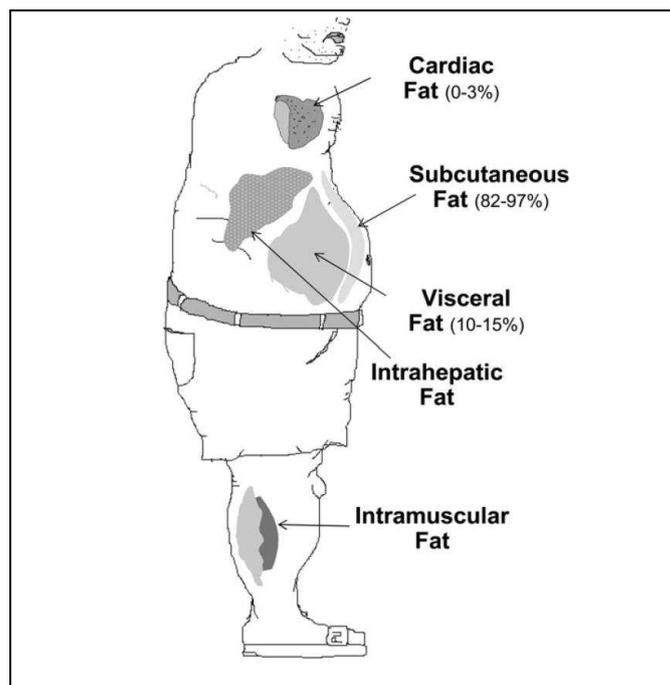


Figure 1 Major sites of fat deposition<sup>3</sup>

The link between fat distribution patterns and differential disease risk was first proposed in the 1950s, when Vague observed that “android obesity...leads to metabolic disturbances” and was “...associated with premature atherosclerosis and diabetes”.<sup>1</sup> It was not until the 1980s however that this phenomenon gained more widespread recognition when Larsson *et al.* proposed that waist-hip circumference was more strongly associated with cardiovascular disease and all-cause mortality in men than BMI (body mass index).<sup>4</sup> Waist-hip circumference and waist circumference are recognised as reasonable proxy measures of abdominal (or visceral) obesity.<sup>5-7</sup>

Typically, men have more abdominal fat than women despite having a lower fat mass. After menopause however, there is a tendency for a slow redistribution of adipose tissue and the accumulation of abdominal fat in women.<sup>8</sup>

It is now generally recognised that waist circumference is better than BMI as a predictor of obesity-related health risks.<sup>7, 9-11</sup> Elevated waist circumference has been proven to contribute to the metabolic syndrome<sup>7</sup> and be an independent risk factor for a number of chronic (or non-communicable) diseases, including:

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- type 2 diabetes mellitus,
- cardiovascular disease (hypertension, coronary artery disease, congestive heart failure, pulmonary embolism and stroke),
- some cancers (oesophagus, pancreas, bowel, breast (post-menopause), endometrium and kidney), and
- non-alcoholic fatty liver disease (NAFLD).<sup>9, 12, 13</sup>

The aetiology and pathophysiology of obesity-related diseases are complicated and far from settled, but it is now understood that adipose tissue is metabolically active.<sup>2, 14</sup> This is in contrast to the traditional view of adipose tissue as only an energy store. It is agreed that excess energy is stored as triacylglycerol (triglyceride; a molecule comprising three fatty acids and glycerol) in adipocytes (fat cells), but adipose tissue contains a number of other cell types in addition to adipocytes. These other cell types including connective tissue, nerves, immature adipocytes and immune cells are estimated to comprise 30-40 percent of the cell number in adipose tissue, but only 10-20 percent of the volume.<sup>2, 15</sup> The presence of immature adipocytes confirms that adipocytes are turned over, but it is known that this occurs very slowly.<sup>15</sup>

Adipose tissue in its entirety is considered to be a genuine endocrine organ, releasing a number of chemicals, including free fatty acids, adipocytokines (proteins) and steroid hormones.<sup>2</sup> It is also very vascular; during rest, blood supply to adipose tissue is greater than the supply to muscle.<sup>15</sup> There is therefore a clear relationship between adipose tissue volume and the levels of these chemicals circulating in the blood.<sup>7</sup> This does not however entirely explain the toxic nature of visceral fat.

At the population level, there is a reasonably clear relationship between total adipose tissue volume and visceral fat volume and ultimately disease risk.<sup>7</sup> There are however two groups that notably do not fit this pattern: obese people with lower-than-expected visceral fat and healthy weight people with higher-than-expected visceral fat.<sup>7</sup> In each case, metabolic markers of disease and disease risk are more closely associated with visceral rather than total fat volume.<sup>7</sup>

What is it that is so pathogenic about visceral fat? A number of theories have been proposed to explain the pathophysiology of visceral fat, but to date there does not appear to be consensus.<sup>16</sup> It is still not at all clear whether visceral fat is the underlying cause of metabolic complications or simply a symptom of more systemic metabolic disorder.<sup>8</sup> Either way, there is no dispute that visceral fat is a good indicator of disease risk and that weight loss results in a loss of visceral fat.<sup>8, 16</sup>

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