Are you a Tofi? (That's thin on the outside, fat inside)

Extraordinary images from medical scans revealed here for the first time show that many people who have normal body weight are carrying around hidden layers of fat. Stored up around vital organs, they can put outwardly healthy people at risk

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Sun 10 Dec 2006 09.02 EST First published on Sun 10 Dec 2006 09.02 EST

Ben Schwartz could hardly be described as overweight. The slimly-built 28-year-old does not like junk food and keeps busy all day, working as a runner for a television production company. Last week, with some trepidation, he had the chance to find out what his lifestyle was doing to his insides when he allowed himself to be put through a hi-tech MRI (magnetic resonance imaging) scanner.

Thanks to MRI, doctors can look at the body's composition in a new light. The remarkable images, revealed here for the first time, show how much 'internal fat' even slim people carry - and raise fresh questions about how healthy people are. Doctors are increasingly concerned that people can look slim on the outside but still have a problem with fat.

Schwartz lay on a trolley which slid inside the huge doughnut ring of the scanner as the radiographer, Julie Fitzpatrick, took picture 'slices' of his anatomy.

Professor Jimmy Bell, head of the molecular imaging group at the Medical Research Council's centre at Imperial College, London was able to analyse the images appearing on his computer screen in his office next door, as the scanner moved above Ben's abdomen, showing the paler regions of internal fat contrasting against the darker shapes of bones and organs.

Bell has spent years studying how human beings store and use their adipose tissue, or fat. He has carried out studies showing that people who would be considered slim can have large quantities of fat within them.

'This is particularly true of men who have a slim build but who do little or no exercise,' he said. 'We know now that 40 per cent of people have fat infiltration of the liver, which is linked to so many other health problems.'

He said of Schwartz: 'He is slim, he's not overweight, but you can see there are some areas where there is a bit of a build-up of visceral fat. He doesn't have a lot of subcutaneous fat [the kind that lies just under the skin], but I can see there is quite a bit around the organs and some in the muscle.'

Thanks to this new technique, Bell and others are able to understand why appearances can be so deceptive. Someone like Schwartz, who is young, falls into the category of those who need to start changing their lifestyle. Unknowingly, he is on the way to becoming what is jokingly described as a 'Tofi' - Thin on the Outside, Fat on the Inside. Tofis probably need to worry more about their health than others, because the fat deposits they carry are hidden in the white fat that lies around their vital organs, streaked through their underused muscles, and wrapped around the heart. It is this fat that sends out the chemical signals which eventually lead to insulin resistance, diabetes and heart conditions, rather than the fat lying in dimples underneath the skin.

Someone like Schwartz could hardly be described as an over-eater. He spends half his day at a desk, the rest outside helping to arrange filming and setting up interviews for television documentaries. 'I don't have the time - or, frankly, the cash - to go to a gym,' he said. 'I love surfing and I try to go down once a month to Compton Bay in the Isle of Wight, but that's about it. Often I hardly eat in the day, and only really eat properly in the evening at home.'

Genes also play an enormous role. 'Our work so far has shown that you can take two men of the same age, with the same BMI [body mass index], and find one with five litres of fat within him and another with two litres,' said Bell, who works at Hammersmith Hospital, west London. 'We've even scanned people who are underweight and found up to seven litres of fat inside them.

'What we don't yet possess is enough information about how different genetic groups store fat. But we do know that you can manipulate the way the body stores it by changing the diet.'

It would appear that nutritional alterations, such as eating more resistant starch, such as in lentils and pulses, means less fat is likely to be laid down in the abdomen. Bell is carrying out a trial on healthy volunteers to see what happens to their internal deposits of fat when they switch to a diet involving more grains and lentils.
Britain has a waistline crisis, with study after study warning that at least two-thirds of us are heading for a life of chronic illness and disability because of our weight. Tomorrow the National Institute for Health and Clinical Excellence (Nice) will produce its new guidelines on obesity in yet another attempt to produce a framework that would help the nation carry around less fat. Latest official figures suggest that the UK will see a 14 per cent rise in obesity by 2010, resulting in 27.6 million people in the obese category.

But is it possible that doctors and the public have become sidetracked by BMI, a method of measuring fat developed 150 years ago in Belgium? BMI is worked out under the metric system by taking your weight in kilograms and dividing it by your height in metres squared. Our volunteer, Schwartz, who is 5ft 10in (1.77m) and weighs 12st 5lb (79.3kg), has a BMI of 24, well within what is judged to be the 'healthy' range. The problem with BMI is that most rugby players, sporting heavy muscles, would come out with a high BMI when in fact they have low levels of visceral fat.

For Schwartz, the numbers are not terrible. His total amount of body fat - 22 per cent - is roughly what one would expect in a man with his BMI. But look underneath and you see that the total amount of internal fat is 3.75 litres, out of a total body fat measurement of 20.75 litres. According to Bell, 3.75 litres is still too much: 'It is on the high side of healthy, and I'm sure if he could do a little more exercise, it would be reduced.'

What really counts, says Bell, is how and where the body's energy supply is stored. Fat cells are extremely intelligent - 'versatile players', as the American obesity specialist Roger Unger called them - which hang on stubbornly even through crash diets. For years, doctors saw fat tissue as a kind of passive storage compartment, but new research has shown that the fat cells, or adipocytes, are dynamic beings.

In Japan, sumo wrestlers have been put through MRI scanners to look at their fat composition. Even though they have a BMI of 56 and are eating up to 5,000 calories a day, they have very little internal fat. 'They have low cholesterol, they have low insulin resistance and a low level of triglycerides [fatty acids],' said Bell. 'Their fat is all stored under the skin, on the outside.'

The Imperial College team has found that the average male has 5.4 litres of visceral fat, and for women it is 3.08 litres. But women carry more fat overall, mostly on the thighs. The total amount of fat in the average woman is 37 litres, and 30 litres for men.

Scientists are increasingly beginning to think of fat as an organ, in the way that it produces chemicals and hormones affecting our moods, our ability to think clearly and even a woman's chances of reproduction. But the problem is that it has evolved to become bigger than it need be for evolutionary reasons, as it was common thousands of years ago to go through periods of starvation when abundant fat was essential for survival.

'Fat has a policy of unlimited expandability,' said Bell. 'We are designed to store and retain fat, but we live in the West with this over-abundance of food.'

'Over the past five years, we've demonised fat and become obsessed with obesity, which is mostly talked about in terms of weight loss. But what matters is where it is distributed. As you lose weight, it tends to go from the top and bottom of your body first, so it can become concentrated in the abdomen. That is the most dangerous zone of all, and it's possible that going on a constant series of diets actually encourages the storage of fat in this region.'

So, instead of forking out a fortune on diet books, perhaps people should be investing in good walking shoes or a tracksuit. If you're more adventurous, perhaps you might take the plunge - as Schwartz will be doing on Boxing Day - into the waves off Compton Bay.

**Fat cells - the good, the bad and the ugly**

Many think of fat as chunks of greasy blobs stored under the skin, but developments in scanning have helped to show that it behaves more like an active organ, constantly changing and sending out hormones which affect your mood, ability to think clearly and fertility levels.

The fat just underneath the skin is subcutaneous fat. The fat in the abdomen and surrounding vital organs is visceral fat. The latter is the kind which is metabolised by the liver, which transforms it into cholesterol that circulates in the blood. 'Bad' cholesterol, called low-density lipoproteins, collects in the arteries where it forms plaque that narrows the arteries.

Fat cells are rather like chemical factories producing other substances which can cause huge long-term harm. They contribute to diabetes, heart disease, high blood pressure, strokes and other illnesses, including some cancers. As you put on more weight, the cells grow bigger, sending out messages to nearby cells which start to divide to produce more fat cells. A lean adult has 40bn fat cells, an obese one two to three times that.

Body shape is often governed by genetic factors. People shaped like apples, carrying excess weight in the abdomen, are more at risk than those built like pears, who deposit fat in the hips, thighs and backides. Women tend to fall into the latter category. Constant dieting may interfere with the way the body lays down fat, and there is evidence that this will increase visceral fat.