Newsletter

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Body mass index (BMI): Is the formula flawed?

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Body mass index, or BMI, has been used for over 100 years to help health professionals decide whether a patient is overweight or underweight. It is used in population studies, by doctors, personal trainers, and others.

However, BMI has some important flaws. For example, it does not measure overall fat or lean tissue (muscle) content. BMI is derived from a simple math formula. It was devised in the 1830s by Lambert Adolphe Jacques Quetelet, a Belgian astronomer, mathematician, statistician and sociologist. It aims to estimate whether a person has a healthy weight by dividing their weight in kilograms (kg) by their height in meters squared.

Fast facts on BMI:

Here are some key points about BMI. More detail is in the main article.

- BMI has been used to give an idea about whether people are overweight or underweight for over 100 years.
- It divides a person's weight by their height squared.
- A BMI of between 18.5 and 24.99 is considered healthy, but some people are healthy with other BMIs.
- Other solutions have been offered, such as a new way to calculate BMI, measuring fat, or using waist-to-height ratio.

What is the BMI formula?

The current BMI calculator divides a person's weight by their height to the power of 2, or squared:

BMI = weight (kg) / height ^{2}

According to most criteria accepted around the world:

- A BMI of 18.49 or below means a person is underweight
- A BMI of 18.5 to 24.99 means they are of normal weight
- A BMI of 25 to 29.99 means they are overweight
- A BMI of 30 or more means they are obese

If you want to find out what your BMI is, use our BMI calculator.

Is it too simple?

When Quetelet devised the BMI formula, there were no computers, calculators, or electronic devices, so he developed a simple system.

Now, some people argue, we have technology that can help us add some complexity to the calculation. After all, people are three-dimensional, not two-dimensional, and healthy bodies grow in different shapes and sizes.

In 2013, Prof. Nick Trefethen, a mathematician from Oxford University in the United Kingdom (U.K.) wrote a letter to *The Economist*, in which he questioned the usefulness of the current BMI formula, calling it a "bizarre measure."

Trefethen argued that the formula leads to confusion and misinformation. The height term, he says, divides the weight by too much when people are short, and by too little when they are tall.

The result is that short people being told they are thinner than they really are, while tall people are made to think that they are fatter than they are.

He recommends a "new BMI calculator," which:

- multiplies the weight by 1.3 for metric measures (kilograms), or by 5,734 for imperial measures (pounds)
- divides the weight by height to the power of 2.5, instead of 2, or squared

BMI (metric) = 1.3 x weight (kg) / height (m)$^{2.5}$
or
BMI (imperial) = 5734*weight(lb)/height(in)$^{2.5}$

You can try it here.

Trefethen points out that any calculation that assigns one number to a person will not be perfect.

Humans are too complex to be described by a single figure. However, he believes this new calculation gives a closer approximation to the reality of human shape and size.

Muscle or fat?

One problem with BMI is that it does not distinguish between muscle and fat.

Consider this:

- A person who does no exercise, is 1.83 meters, or 6 feet tall and weighs 92 kg, or 203 pounds (lbs), would have a BMI of 27.
- An Olympic athlete, 1.83 meters, or 6 feet tall, and weighs 96 kilograms, or 211 lbs, would have a BMI of 28.

According to this, the athlete is more "overweight" than the person who does no exercise.

However, muscle weighs about 18 percent more than fat, so this is clearly not true.

Still, Trefethen points out that if muscle is 18 percent denser than fat, a person who exercised enough to convert 10 percent of their fat into muscle would still increase their BMI by just 1.8 percent. The BMI would still not represent the increase in fitness.

What would Quetelet say?

Prof. Alain Goriely, also a mathematician from Oxford University, says that Quetelet would probably have supported the new way of calculating BMI.

In 1842, Quetelet apparently wrote, "If man increased equally in all dimensions, his weight at different ages would be as the cube of his height."

He went on to explain that in the first year of life, our breadth is indeed larger in proportion to our height, but, after that, we grow taller in relation to our width.

From this, Prof. Goriely understands that Quetelet thought the height should be cubed for infants up to one year, and then squared by the time they were adults. Why not tweak this figure to something in between?

Other options

Other options have been proposed for assessing whether a person is overweight or not.
Waist circumference and waist-to-height ratio

Waist-height ratio may be a better way to assess cardiometabolic health risk.

One suggestion is to combine BMI with waist circumference (WC) for a more accurate measure.

However, some scientists argue that waist-to-height ratio (WHtR) might be more appropriate than BMI alone or BMI with WC, as it has been proven a predictor of cardiometabolic health.

Researchers have suggested keeping waist circumference to less than half the height to maximize health and life expectancy.

A person with fat around the abdomen has a higher risk of heart disease and metabolic disorders, as the fat affects the internal organs such as the liver, heart, and kidneys. Fat around the hips and thighs is believed to be less risky.

Measuring body fat

Another option is to measure body fat. Men and women need different amounts of fat.

- For a man, 2 to 4 percent fat is considered healthy, and over 25 percent is classed as obesity.
- For a woman, 10 to 13 percent fat is healthy, but over 32 percent is considered a sign of obesity.

Studies have suggested that measuring fat gives a more accurate view of health and health risks, but getting an accurate measure is not easy.

Methods include:

- Callipers
- air displacement plethysmography
- near-infrared interactance
- dual energy X-ray absorptiometry (DXA)

However, there is still more work to be done until this becomes as easy as using a BMI calculator.

Millions misclassified by BMI measures

A person whose BMI says they are overweight or obese is often considered unhealthy, while people with normal BMI are often seen as healthy, but research published in 2016 suggested that this was incorrect for 75 million Americans.

Researchers found that 54 million Americans had been classed as overweight or obese, but cardiometabolic measures showed they were healthy. Another 21 million were classed as "normal" in terms of BMI, but they were unhealthy.

Other scientists, however, have suggested that although some people may appear to be overweight but healthy, the extra weight puts them at higher risk of certain diseases as they get older.

What is my ideal healthy weight?

A healthy weight is hard to figure exactly. One size does not fit all.

Factors that affect healthy weight include:

- general health
- height
- muscle-fat-ratio
- bone density
- body type
- sex
- age

BMI is useful when studying populations and trends, and it can give a rough idea of our health and weight status. In fact, for now, it is probably the best guide we have.

More important, perhaps, is to follow a healthful lifestyle with a balanced diet and regular exercise, to prevent piling on the pounds in the first place.