In its 5 January 2013 issue the *Economist* published this letter from me:

> *SIR – The body-mass index that you (and the National Health Service) count on to assess obesity is a bizarre measure. We live in a three-dimensional world, yet the BMI is defined as weight divided by height squared. It was invented in the 1840s, before calculators, when a formula had to be very simple to be usable. As a consequence of this ill-founded definition, millions of short people think they are thinner than they are, and millions of tall people think they are fatter.*
>
> - Nick Trefethen, Professor of Numerical Analysis, University of Oxford

The appearance of this admittedly strongly worded letter has led to communications from many people around the world, and I would like to explain a formula that I think would be worth considering as an alternative.

Current formula: BMI = weight(kg)/height$(m)^2$ = 703*weight(lb)/height$(in)^2$

The oddity is the appearance of that exponent 2, though our world is three-dimensional. You might think that the exponent should simply be 3, but that doesn't match the data at all. It has been known for a long time that people don't scale in a perfectly linear fashion as they grow. I propose that a better approximation to the actual sizes and shapes of healthy bodies might be given by an exponent of 2.5. So here is the formula I think is worth considering as an alternative to the standard BMI:

New formula: BMI = 1.3*weight(kg)/height$(m)^{2.5}$ = 5734*weight(lb)/height$(in)^{2.5}$

The numbers 1.3 and 5734 are designed make the BMI reading unchanged for an adult of average height, which I take to be about 66.5 inches, i.e., 1.69 meters. (The square root of 1.69 is 1.3.) To find your "New BMI", try the New BMI Calculator written by Nick Hale, available online.

Are these numbers "right"? No! — for human beings are complicated, and any BMI formula will deliver just one number. No single number can be right, and indeed, the extreme reliance of today's medical and insurance establishments on a simple formula worries me a great deal. But perhaps this revised formula might reflect better than the standard one how the weights of healthy adults really depend on their heights.

Would it make a difference? Yes indeed. Roughly speaking, each person 6 feet tall would lose a point from their BMI reading, and each person 5 feet tall would gain a point. That's millions of people. If the new numbers gave a more accurate indication of actual health issues, this could be a significant change for the better.

What about the density of muscle vs. fat? We hear about this frequently in discussions of BMI (including in the *Economist* article I was responding to, which mentioned Olympic weight lifters), but it's a smaller effect. Muscle is about 18% denser than fat. This means that if you heroically exercised so much that you converted 10% of your body volume from fat to muscle (wow!), your BMI reading would go up just 1.8%. That's much less than the corrections just mentioned for short or tall people.

What about men vs. women? This is a fascinating question. On average women are about 8% shorter than men, and it follows that if we switched from current BMI to new BMI, a typical woman's reading would go up 2% and a typical man's reading would go down 2%. That may sound small, but it's around half a BMI point, so it would carry many people across the normal/overweight or overweight/obese boundaries (25 and 30, respectively). Sometimes it is said that women can get away with higher BMI readings than men before suffering the health effects of obesity. If true, is this partly an anomaly caused by the current definition of BMI? I don't know.

I must finish by emphasizing that I am an applied mathematician, not a doctor or an epidemiologist. The new formulas proposed above are not based on epidemiological studies and they may not be an improvement, for all kinds of reasons. To get a sense of the complexity of the BMI issue, a good place to start is the Wikipedia article on the subject, and for a key epidemiological paper supporting the use of the exponent 2.0, see S. B. Heymsfield et al., *American Journal of Clinical Nutrition*, 2007. Obesity will be one of the biggest health issues worldwide of the 21st century. If great reliance is going to be placed on a single formula for assessing it, the justification of that formula deserves careful discussion.

- Nick Trefethen, January 2013