

Do You Believe in Fairies, Unicorns, or the BMI?

[Find picture of Sergio Oliva?]

Mathematician Keith Devlin is the Executive Director of the Human-Sciences and Technologies Advanced Research Institute ([H-STAR](#)) at Stanford University and [The Math Guy](#) on NPR's [Weekend Edition](#).

Take a look at the guy in the photo. According to the Centers for Disease Control and Prevention, he is overweight. They base this classification on a number called the body mass index, or BMI. Also overweight, according to this CDC endorsed metric, are athletes and movie stars Kobe Bryant, George Clooney, Matt Damon, Johnny Depp, Brad Pitt, Will Smith, and Denzel Washington. Tom Cruise scored even worse, being classified as downright obese, as was Arnold Schwarzenegger when he was a world champion body-builder. With definitions like that, no wonder Americans think of themselves as having an overweightness epidemic. (Using the CDC's BMI measure, 66 percent of adults in the United States are considered overweight or obese.)

Yes, it's that time of year again, when I go for my annual physical. I know the routine. My body mass index regularly comes out at around 25.1, putting me just into the "overweight category," and the doctor sends me a fact sheet telling me I need to lose weight, exercise more, and watch my diet. Notwithstanding that fact that the person *he has just examined*

has a waist of 32 inches, rides a bicycle in the California mountains between 120 and 160 miles a week, competes regularly in competitive bicycle events up to 120 miles, does regular upper-body work, has a resting pulse of 59 beats per minute, blood pressure generally below 120/80, healthy cholesterol levels, and eats so much broccoli I would not be surprised to wake up one morning to find it sprouting out of my ears.

Why do we have this annual BMI charade? Why would otherwise well-educated medical professionals ignore the evidence of their own eyes? Because the BMI is one of those all-powerful magic entities: a *number*. And not just any number, but one that is generated by a *mathematical formula*. So it has to be taken seriously, right?

Sadly, despite that fact that completion of a calculus course is a necessary prerequisite for entry into medical school, the medical profession often seems no less susceptible than the general population to a misplaced faith in anything that looks mathematical, and at times displays unbelievable naivety when it comes to numbers.

So what is the BMI? A quick web search on "BMI" or "body mass index" will return hundreds of sites, many of which offer calculators to determine your BMI. All you do is feed in your height and your weight, and out comes that magic number. Many of the sites also give you a helpful guide so you can interpret the results. For instance, the CDC [website](#) gives these ranges:

below 18.5 = Underweight
18.5 to 24.9 = Ideal
25.0 to 29.9 = Overweight
30.0 and above = Obese

... has a body mass index of 31.5, while the younger Schwarzenegger, at just over six feet tall and about 235 pounds, had a BMI over 31 [as well](#). The figures I quote for athletes and movie stars are from data available on the web, and I believe they are accurate, or were when the information was entered.)

Keith Devlin 2/15/10 8:23 PM

Deleted: 5

Some sites even tell you how this mystical number is calculated:

$$\text{BMI} = \frac{\text{weight in pounds}}{(\text{height in inches} \times \text{height in inches}) \times 703}$$

Hmmm. No mention of waist-size here? Or rump? That's odd. Isn't the amount of body fat you carry related to the size belt you need to wear or how baggy is the seat of the jeans the belt holds up?

And what about the stuff inside the body? One thing all those "overweight" and "obese" athletes and movie stars have in common is that they have very little fat and a lot of muscle, and possibly also stronger, healthier bones. Now, a quick web-search reveals that mean density figures for these three body component materials are: fat 0.9 gm/ml, muscle 1.06 gm/ml, and bone 1.85. In other words, the less fat you have, and the more your body weight is made up of muscle and bone, the greater the numerator in that formula, and the higher your BMI. In other words, if you are a fit, healthy individual with little body fat but strong bones and lots of muscle, the CDC (and other medical authorities) will classify you as overweight. Note the absurdity of the whole approach. If I actually did take my physician's BMI-triggered, form-letter advice and exercise more, I would put on even more muscle and lose even more of what little body fat I have, and my BMI would increase! With a medical profession like that, who needs high cholesterol as an enemy?

Admittedly, those same authorities also say that a male waistline of 40 inches and a female waistline of 35 inches are where "overweight" begins. But this of course is totally inconsistent with their claim that the BMI is a reliable indicator of excess body fat. In contrast, it is consistent with my observation that it is the density of the stuff inside the body that is key, not the body weight. If you ignore that wide variation in densities, then of course you will end up classifying people with 32 inch waists as overweight. Yet this blatant inconsistency does not seem to cause anyone to pause and ask if there is not something just a little odd going on here. Isn't it time to inject some science into this part of medical practice?

Time to take a look at that BMI formula and ask where it came from. I've already noted that it ignores waistline, rump-size, and the different densities of fat, muscle, and bone. Next question: Why does it mysteriously *square* the height? What possible *scientific* reason could there be to square someone's height for heaven's sake? (Multiplying height by girth at least has some rationale, as it would give an indication of total body volume, but it would put girth into the denominator in the formula, which is not what you want.) But height squared? Beats me.

Then there is that mysterious number 703. Most websites simply state it as if it were some physical constant. A few make the helpful remark that it is a "conversion factor." But I could not find a single source that explains what exactly it is converting. It did not take long to figure it out, however. The origins of the BMI, of which more later, goes back to a Belgian mathematician. The original formula would thus have been in metric units, say

$$\text{BMI} = \text{weight in kilograms}/(\text{height in meters} \times \text{height in meters})$$

To give an equivalent formula in lbs and inches, you need to solve the following equation for C

$$1\text{lb}/(1\text{in} \times 1\text{in}) \times C = 0.4536\text{kg}/(0.0254\text{m} \times 0.0254\text{m})$$

which gives $C = 703$ (to the nearest whole number).

Well that at least explains the 703. Sort of. But given that the formula is self-evidently just a kludge, why not round it to 700. Stating it as 703 gives an air of accuracy the formula cannot possibly merit, and suggests that the folks who promote this piece of numerological nonsense either have no real understanding of numbers or they want to blind us by what they think we will accept as science.

Another question: Why is the original metric formula expressed in terms of kilograms and meters? Why not grams and centimeters? Or some other units? Well, given the scientific absurdity of dividing someone's weight by the square of their height it really doesn't matter what the units are. I suspect the

ones chosen were so that the resulting number comes out between 1 and 100, and thus looks reassuringly like a percentage. I'm beginning to suspect my "blind-us-with-science" conspiracy theory may be right after all.

So which clown first dreamt up this formula and why? Well, it was actually no clown at all, but one of the smartest mathematicians in history: the Belgian polymath Lambert Adolphe Jacques Quetelet (1796 - 1874). Quetelet received a doctorate in mathematics from the University of Ghent in 1819, and went on to do world class work in mathematics, astronomy, statistics, and sociology. Indeed, he was one of the founders of both these last two disciplines, being arguably the first person to use statistical methods to draw conclusions about societies.

It is to Quetelet that we can trace back that important figure in twentieth century society, the "average man." (You know, the one with 2.4 children.) He (Quetelet, not the average man) realized that the most efficient way to organize society, allocate resources, etc. was to count and measure the population, using statistical methods to determine the (appropriate) "averages". He looked for mathematical formulas that would correlate, *numerically*, with those "average citizens."

(Elementary) statistics being the highly simplistic (but extremely powerful) tool that it is, it is generally not difficult to find simple formulas that correlate pretty well with society's averages. You just play around with a few variables until you find a formula that fits. If you can provide a scientific rationale for the formula, so much the better, and you are justified in having more confidence in your ability to use the formula predictively. But it is generally enough that your formula is empirically representative. *Provided* that all you are doing is trying to draw conclusions about society as a whole, that is. Quetelet knew what he was doing. Many since then, including, it appears, the CDC, do not.

The absurdity of using statistical formulas to make *any* claim about a single individual is made clear by the old joke about the man who had his head in the refrigerator and his feet in the fire: on average he felt fine!

Yet the CDC says, on its [website](#),

"BMI is a reliable indicator of body fatness for people."

Nonsense. It is off-the-charts unreliable for me and for millions of people like me. True, a few sentences later, the CDC - doubtless at the insistence of their lawyers - says

"However, BMI is not a diagnostic tool."

You're telling me! Come on guys, either the BMI is, as you claim, "a reliable indicator of body fatness", in which case you can so use it, or, as you also admit, it cannot be used to diagnose excess body fat. Which is it to be?

The CDC's answer becomes clear as we read on. Lest we note the disclaimer that the BMI cannot be used to diagnose excess body fat and demand a more reliable procedure, they immediately go on to mask their legal get-out by claiming,

"Calculating BMI is one of the best methods for population assessment of overweight and obesity. Because calculation requires only height and weight, it is inexpensive and easy to use for clinicians and for the general public. The use of BMI allows people to compare their own weight status to that of the general population."

I'll say it again. This statement is completely false; there are several *much* better methods - some of which the CDC actually lists on its website! The only part of this second statement that I see as having any validity is the very telling admission that the BMI method is inexpensive and easy to use.

There is another problem with the manner in which the CDC and other medical authorities explain the BMI. Notice that the interpretive ranges into the categories underweight, ideal, etc. are given to one decimal place, with equal signs. This suggests a level of precision in the formula that cannot possibly be warranted. (Some sites give two decimal places.) It would at least be more honest to give the ranges like this:

below 19 you are likely to be underweight
between 19 and 25 is the range generally viewed as ideal

between 25 and 30 suggests you may be overweight
if you are above 30 you are likely to be obese

This would not make the formula any less a piece of numerological junk, but at least would indicate that the ranges are just rough guidelines. The only possible reason for giving the ranges in the precise way the CDC does is to try to mislead patients that there is something scientific going on here. It's a classic example of "lying with numbers."

So here is the beef (lean, of course). The BMI was formulated, *by a mathematician, not a medical physician*, to provide a simple, easy-to-apply mathematical formula to give a broad, society-level measure of weight issues. It has absolutely no scientific or medical basis. It is based purely on a crude statistical analysis. It measures a general society trend, it does not predict.

Quetelet knew what he was doing. Many since then, including, it appears, the CDC, do not.

Since the majority of people today (and in Quetelet's time) lead fairly sedentary lives, and are not particularly active, the formula tacitly assumes low muscle mass and high relative fat content. It applies moderately well when applied to such people because it was formulated by focusing on them! Duh!

But this is not science - it's not even good statistics - and as a result it should not be accepted medical practice, to be regularly flouted as some magical mumbo jumbo and used as a basis for giving advice to patients. (For heavens sake, even seven times Tour de France winner Lance Armstrong's own Livestrong website provides a BMI calculator, despite the fact that the boss himself, when he first became a world champion cyclist - before chemotherapy for cancer took 20lbs off him - found himself classified as "overweight" by the wretched formula.)

As you might expect, once a piece of numerological nonsense is held up for proper scrutiny, it doesn't take long before the whole house of cards comes tumbling down. The surprising thing about the BMI is that it has survived for so long (as a diagnostic for individual patients). As I indicated earlier, I suspect that much of

the appeal is that it is a single number, easy to calculate, given an air of scientific authority by a *mathematical formula*, and (just as my earlier quote from the CDC makes clear) it is easier and quicker to base a diagnosis on a number than on properly examining a patient. *But at that point you have stopped doing medicine and are just doing kindergarten arithmetic.*

The good news is, at last there is hope of some sanity entering the story. The science (the real science) is finally coming. For instance, a study of 33,000 American adults, published recently in the American Journal of Public Health (Vol 96, No.1, January 2006, 173-178), showed that male life expectancy is greatest for BMIs of about 26 - overweight under the CDC's rule, and equivalent to 24 lb extra for the typical man. For women, the study found an optimum BMI of about 23.5, about 7 lbs heavier than the CDC's standard.

The paper's author, Dr Jerome Gronniger, a government scientist, concluded that, "I found that the current definitions of obesity and overweight are imprecise predictors of mortality risk."

"Imprecise predictors"? Gronniger was clearly using "scientific understatement." It was, after all, a scientific publication. Dr David Haslam, the clinical director of Britain's National Obesity Forum was more blatant in a statement he made to the Daily Telegraph newspaper: "It's now widely accepted that the BMI is *useless* for assessing the healthy weight of individuals." (My italics.)

Of course, any mathematician surely knew what Haslam now confirms the moment he or she took their first look at Quetelet's formula. It screams "junk math". Numbers are one of the most powerful tools we have to understand our world and to improve our lives. But like all powerful tools, when used irresponsibly, they can do more harm than good.

Medical professionals have enormous knowledge and experience that we all benefit from. I do regularly go for my annual physical, and for the most part I listen to my physician's advice. He knows a lot more than I do about the human body and health issues. I

trust him - for the most part. But when the BMI comes up, we are definitely into territory where my expertise trumps his, and I can recognize a piece of numerological nonsense when I see it, and as a result I ignore that part of the proceedings. But if trained medical practitioners, backed up by august professional organizations such as the CDC, are still so over-awed by such rubbish (mathematics does that to people, I see it all the time) that they continue to preach it as if it were gospel, then how can a patient with less mathematical sophistication hope to resist this annual incantation.

Since the entire sorry saga of the BMI was started by a mathematician - one of us - I think the onus is on [me and my mathematical colleagues](#), as the world's experts on the formulation and application of mathematical formulas, to start to eradicate this nonsense and demand the responsible use of our product.

Heavens, next thing we know, some authority will be claiming that the golden ratio is the aspect ratio of the rectangle most pleasing to the human eye. [\(Another piece of oft-touted rubbish.\)](#) Where will it all end?

After all that, I think I need a good long bike ride over the mountains to bring my blood pressure down.

[###](#)

[Additional Resources:](#)

[NPR - The Top Ten Reasons The BMI Is Bogus](#)

<http://www.npr.org/templates/story/story.php?storyId=1062684>

[39](#)