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Keep it simple —the BRI

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The Body Roundness Index (BRI) is an index created to address the fact that the Body Mass Index (BMI) is deeply flawed since it doesn't account for the fact that muscle tissue is denser than fat. It also doesn't account for the fact that fat around the middle of the body is apparently more harmful than peripheral fat. This article appeared in the Journal of the American Medical Association:

https://jamanetwork.com/journals/jamanetworkopen/fullarticle/2819558

which refers to an article in a journal called Obesity:

https://onlinelibrary.wiley.com/doi/10.1002/oby.20408

The latter paper develops a formula for the BRI based on a model of the human body as an ellipse (really an ellipsoid of revolution, but they call it an ellipse) with the semi-major axis half the height and the semi-minor axis computed from the waist measurement, treated as the circumference of a circle. This results in the following bizarre looking formula:

$$BRI = 364.2 - 365.2\sqrt{(1 - \frac{[w/2\pi]^2}{[0.5h]^2})}$$

with w the waist and h the height both measured in cm. The number in the radical is just the eccentricity of the ellipse. But where do 364.2 and 365.5 come from? The authors of the Obesity article comment, "This formula was derived solely to scale eccentricity values to a more accessible range of values." That explanation really explains nothing. If you use 300 for both of the constants, that would have the same effect. In fact 100 would work as well.

First, we remark that with trivial algebra, their formula can be immediately simplified to

$$BRI = 364.2–365.5\sqrt{1 - (\frac{r}{\pi})^2}$$

where $r = w/h$ is the ratio of the waist to the height and it doesn't matter whether the waist and height are measured in cm or inches or, for that matter, light-years or Angstroms. More important, since r/π is most likely to be $< 1/5$ and its square $< 1/25$ we can use the well-known approximation $\sqrt{1+h} \approx 1 + h/2$ when $|h|$ is small. Applying this we get

$$BRI \approx 364.2 - 365.2(1 - \tfrac{1}{2}(\tfrac{r}{\pi})^2) = 182.75(\tfrac{r}{\pi})^2 - 1.3 \approx 18.5r^2 - 1.3$$

Moreover, since the result puts you in a range (> 6.8 is bad), why bother with that odd looking 1.3? For that matter, why bother with that 18.5? Just use r^2 and say that $> .44$ is bad. If you want to avoid fractions, use 10 as the multiplier and skip the 1.3. Or simply use r and say that $r > .66$ is bad. Or even simpler, say you are obese if your waist is more than $2/3$ your height.

I should also mention that, like the BMI, your BRI can also be too low. The longevity curve is U-shaped. Your life expectation goes down significantly if your waist is less than half your height. These conclusions are much more useful than the complicated formula.

My point here isn't that what they are doing is necessarily a bad idea. Indeed I think the basic idea is sound. Some ranges are good; some are not. My point is that they have taken a very simple idea and surrounded it by unnecessarily complicated mathematical obfuscation. This may was probably caused by mathematical naiveté, but it really hides a basically simple concept–study obesity by the eccentricity of a containing ellipsoid–behind an odd formula.

I would like to thank Robert Dawson who made many useful comments and also found the articles referred to above. I had written the original based only on an article in the NY Times.
