Simple and Efficient Formulas for Calculating the Relative Effect of Changing Body Weight on Body Surface Area

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Body surface area (BSA) is an important clinical metric with its role in determining chemotherapy dosing, renal clearance, cardiac output, and in other physiological/pharmacological metrics (Bronson et al., 2025). In the calculation of BSA, the formulas in use are nearly always parameterized by the patient's height and weight (Burton, 2008). Of these two variables—height and weight—body weight is a much more variable aspect of an adult individual's physiology. While an adult individual's height will certainly change over their lifetime, it can be reasoned that on a shorter time-scale, body weight can fluctuate under the assumption of constant height.

From this idea, two simple formulas are proposed to easily quantify the relative effect of changing body weight on a patient's BSA assuming no change in height. The first formula computes the scaling factor on BSA and the second formula computes the percent change on BSA. Both formulas calculate the change of BSA *without* needing to calculate the actual BSAs.

Redlarski et al. (2016) and Villa et al. (2017) both illustrate that the most prevalent form of the BSA equation is the following:

$$c \cdot \text{Height}^{\alpha} \cdot \text{Weight}^{\beta} = \text{BSA}, \tag{1}$$

where c is a scaling constant, and α and β are defined exponents for height and weight, respectively. Burton (2008) describes in-depth the mathematical and biological underpinnings of this non-linear model.

In the derivation of the simplified formulas, let us consider a patient with constant height h, whose body weight has changed from w_i (initial weight) to w_f (final weight).

Calculating the Factor Change

To see the relative effect that changing body weight has on an individual's BSA, we can consider calculating the scaling factor as given by Equation (2).

$$\frac{\text{BSA}_{\text{final}}}{\text{BSA}_{\text{initial}}} = \text{Factor Change in BSA} \tag{2}$$

Using Equations (1) and (2), we can express the factor change of this patient's BSA as follows.

$$\frac{c \cdot h^{\alpha} \cdot {w_f}^{\beta}}{c \cdot h^{\alpha} \cdot {w_i}^{\beta}} = \text{Factor Change in BSA} \tag{3}$$

By algebraic manipulation, Equation (3) can be simplified, resulting in Equation (4).

$$\left(\frac{w_f}{w_i}\right)^{\beta} = \text{Factor Change in BSA} \tag{4}$$

In essence, one only needs to know the patient's change in body weight and the chosen BSA model's exponent for weight to determine the relative change in BSA. Equation (4) simplifies everything down to two arithmetic operations.

Calculating the Percent Change

To see the relative effect that changing body weight has on an individual's BSA, we can also consider calculating the percent change as given by Equation (5).

$$\left(\frac{\text{BSA}_{\text{final}}}{\text{BSA}_{\text{initial}}} - 1\right) \times 100\% = \text{Percent Change in BSA} \tag{5}$$

Inserting our scaling factor formula from Equation (4) into Equation (5), we obtain Equation (6).

$$\left[\left(\frac{w_f}{w_i}\right)^{\beta} - 1\right] \times 100\% = \text{Percent Change in BSA} \tag{6}$$

A Worked Example

Consider an individual whose body weight has increased from 60 kg to 75 kg, with no change in height. We will use the exponent for weight as given by DuBois and DuBois (1916) with $\beta = 0.425$ (as cited in Redlarski et al. (2016, p. 2)).

By Equation (4), the factor change in the patient's BSA is calculated as follows:

$$\left(\frac{75\,\text{kg}}{60\,\text{kg}}\right)^{0.425} = 1.099\times\ \text{Increase}$$

By Equation (6), the percent change in the patient's BSA is calculated as follows:

$$\left[\left(\frac{75\,\text{kg}}{60\,\text{kg}}\right)^{0.425} - 1\right] \times 100\% = +9.9\%\ \text{Percent Change in BSA}$$

Concluding Thoughts

These simplified formulas arise from algebraic manipulation as opposed to numerical approximation, and as such, there is no loss of accuracy or precision. In addition, these formulas are unit-independent. Body surface area (BSA) formulas are commonly defined with height and weight in metric units. However, these simplified formulas can use either imperial or metric measurements for body weight without the need for unit conversion. This property stems from the fact that a ratio of body weights in kilograms is equal to a ratio of body weights in pounds.

With the prevalence of BSA equations described by Equation (1), these simplified formulas will find themselves applicable to numerous BSA models (e.g., DuBois and Dubois (1916) and Mosteller (1987), as cited in Redlarski et al. (2016, p. 2)). As such, the hope is that these simplified formulas serve as an easy and efficient tool for both clinician and researcher.

References

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