Perspectives in Nutrition

Adjustment for Size—A Possible Misuse of Ratios

WILLIAM B. WEIL, JR., M.D.*

It is hoped that Perspectives in Nutrition will review the literature selectively, interpret it moderately and present a spectrum of ideas that will serve as a continual stimulation to nutritional research applied to medical problems.

In many phases of nutrition, the indirect assessment of body composition is essential. One technic, which is used extensively, is the determination of external balance, that is, the calculation of the retention of a substance by subtracting measured excretion from measured intake. Many problems inherent in this methodology have been discussed previously.[1-4] The purpose of this communication is to consider a statistical problem concerning the misuse of ratios[5] or, more specifically, the common practice of attempting to relate data on persons of varying size by "correcting" for this variation, for example, presenting values per kilogram, per square meter and per 100 calories metabolized.

To justify the use of a ratio for expressing information about two quantities, these three conditions should be satisfied: (1) the two items considered should increase or decrease together in a linear fashion, (2) the regression line for the two variables should intercept at 0, and (3) the variance of the variable should increase with the increasing magnitude of the variables.

An example of the problem is illustrated in Figure 1. The graph on the left shows the correct relationship for the use of a ratio. The data graphed on the right, however, can be expressed correctly only by regression analysis. The use of a ratio would make the data for group I (in the right-hand figure) appear to be comparable to that of group III—as indicated by the transversal (line of dashes). However, it is clear that group I differs from group III and is, instead, similar to group II.

The more specific problem concerns the use of the ratio to "equate" data on persons of different size. It is commonly assumed that measurements made on such a group should be related on a weight or surface area basis. Obviously this produces an improper ratio unless the three general criteria mentioned previously are met. There is no way of knowing whether they will be met without examining the data in this way each time.

Figure 2 is from an actual experiment[6] showing the hydration of animals fed high and low protein diets (HP, LP) which resulted in animals of different size. Subsequently, they were deprived of food or of food and water. Since the data on the hydration of the control animals met the criteria for the use of a ratio, they could be expressed equally well as a ratio (gm. H_2O per 100 gm. fat-free dry solids [FFDS]) or (per cent H_2O) or by an expression of regression. The use of a ratio to describe the hydration of the experimental animals would make the two starved groups comparable, and the two starved and thirsted groups comparable, and would suggest incorrectly that there is a difference in the hydration of the animals related to whether they were allowed water. The use of regression expressions, on the other hand, shows correctly that the difference is not in whether the animals were allowed water, but whether they were previously fed high or low protein diets.

From the Department of Pediatrics, School of Medicine, Western Reserve University, Cleveland, Ohio.

* Assistant Professor of Pediatrics.

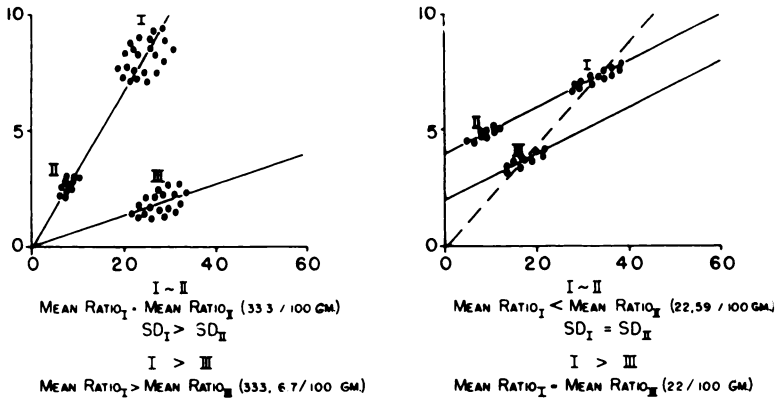

FIG. 1. Theoretical considerations concerning the use of ratios and regressions. The figure on the left shows the necessary conditions for the use of a ratio and the resulting relationships between the three groups of data. The figure on the right demonstrates a situation in which the use of a ratio would be misleading, and in which the data should be compared by a regression technic.

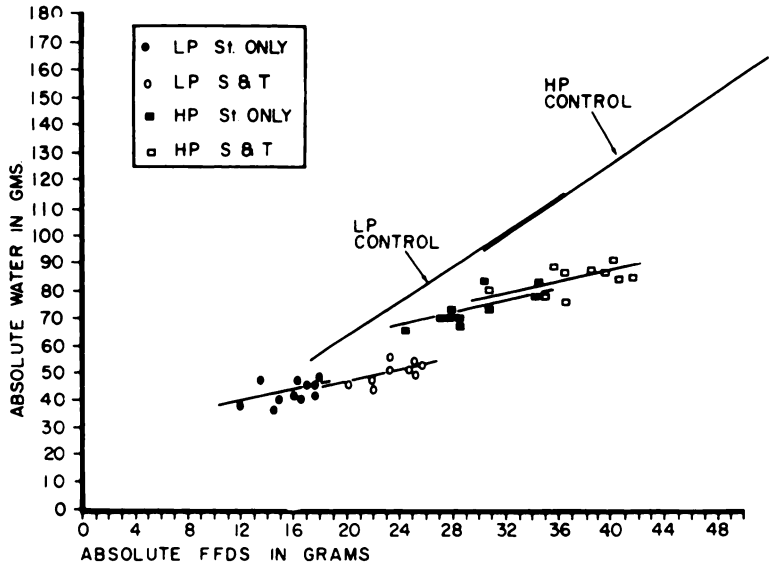

FIG. 2. The water content of rat carcasses. Control and experimental animals were fed 24 per cent protein (HP) or 12 per cent (LP) diets. The water of the carcasses is expressed in grams and compared with the weight of the fat-free dry solids (FFDS) also expressed in grams. One group of rats on each diet was starved with access to water (St. only) and another group was deprived of food and water (S & T).

This problem may occur in the field of nutrition when the retention and the intake of a substance are to be related. The usual technic is to examine this as retention per kg. versus intake per kg. It might be assumed that dividing both intake and retention by weight will "correct" both figures for the effects of weight. That this is not so may be seen in the hypothetical examples shown in Figures 3, 4 and 5. In Figure 3, the graphs on the right-hand side illustrate a situation in which neither retention nor

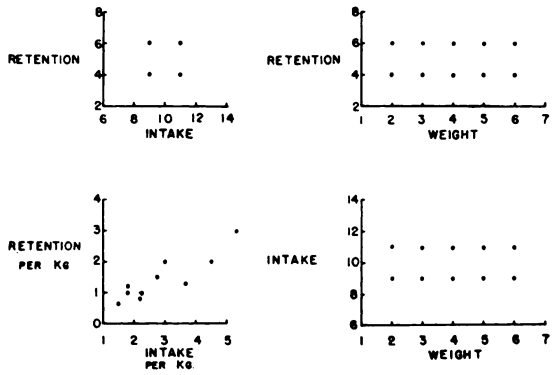

FIG. 3. A theoretical relation between intake of a nutrient and retention of the nutrient in individuals of different weights. In this case neither absolute retention nor absolute intake vary with weight (right), so that retention versus intake (upper left) gives a group of overlapping points with no correlation. Dividing by weight for each person, however, produces a positive correlation between retention per kg. and intake per kg.

intake varies with weight. Further, they do not vary with respect to each other, as can be seen in the upper left-hand portion of the figure. However, when the intakes and retentions are each divided by the appropriate weight of the person involved, a positive correlation between intake and retention is produced. This arises from taking unrelated data for two variables and dividing each pair of values by a third variable. Then the original two variables are likely to show a positive correlation when each is expressed as a ratio to the third. The greater the variation in weight is when compared with the variation in intake and retention, the greater will be the tendency to produce a positive correlation between intake per kg. and retention per kg.

Figure 4 may be more representative of physiologic data since intake increases with weight, and retention shows no relation to weight. Furthermore, absolute retention does not change with increasing intake. However, again relating retention per kg. to intake per kg. produces a positive correlation.

Finally, Figure 5 shows an interesting paradox in which absolute retention decreases with increasing intake whereas retention per kg. increases with increasing intake per kg. This results from a situation in which the larger persons ingest more of a substance absolutely but less on a per kg. basis than the smaller persons. Retention is absolutely and relatively less in the larger persons. Thus, on an absolute basis, the correlation between retention and intake is negative while on a relative basis, the correlation is positive.

Although the examples given may be extreme, they are presented to call attention to serious misinterpretations which may result from uncritical adjustment of data. Actually, when three variables like intake, retention and weight are involved, the data usually should be analyzed by multiple regression technics.

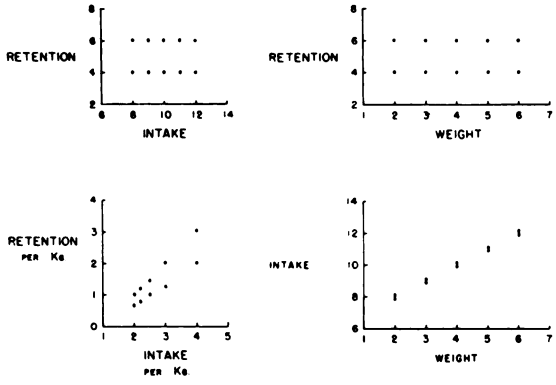

FIG. 4. Theoretical balance data. This is comparable to Figure 3 but in this example intake increases with weight whereas retention does not. There is a positive correlation between these variables only if they are both expressed per kg.

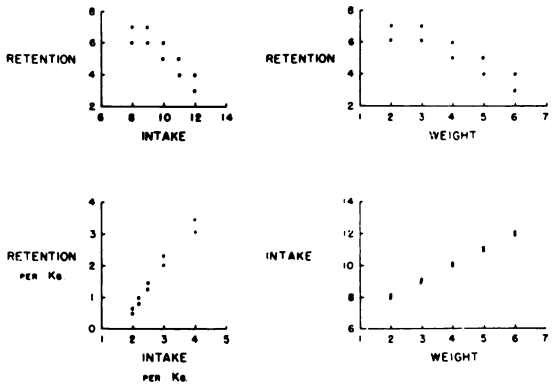

FIG. 5. Theoretical balance data. In this example a negative correlation between absolute retention and intake is made positive when both are expressed "corrected" for weight.

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