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### Title

RATIOS AND REGRESSIONS IN BODY-SIZE AND FUNCTION - REPLY

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# letters to the editor

leading. We suggested that the problem is not with ratios but rather with the inappropriate use of any statistical calculation of data. Cotes and Reed and Tanner (2), who unfortunately began the furor over ratios in the 1940s, have confused two distinct issues: 1) the biological insights that can be derived from ratios of function to body size and 2) how best to determine standard values in populations that vary in size, gender, age, etc.

Cotes and Reed state that "standardization in terms of  $y/x$  is only appropriate where . . .  $y/x$  is independent of  $x$ ," and they are concerned about ". . . potentially serious errors of interpretation in patients . . ." that could result if ratios were incorrectly used as standards. But these concerns, while legitimate, are simply not substantiated in practice. There are numerous clinical examples of physiological data expressed as  $y/x$  when  $y/x$  is not independent of  $x$ . For example (as we noted in our commentary), both total hemoglobin (the  $y$  variable) and whole body blood volume (the  $x$  variable) increase as children grow and become adults, but hemoglobin concentrations are significantly greater in healthy young adults ( $y/x$  is not independent of  $x$ ). Despite this, pediatricians do not consider all children clinically anemic simply because their hemoglobin concentrations are lower.

Establishing normal values or standards is an empirical process in which many factors (e.g., gender, age, size, etc.) must be considered, and these factors are important whether using ratios, power functions, or directly measured values. Cotes and Reed (1) point out that  $FEV_1/FVC$  is independent of lung volume (FVC), whereas  $DL_{CO}/VA$  is not. Surely, based on these important distinctions, no one should use a single standard value for the  $DL_{CO}/VA$  to determine whether a given subject has a normal diffusing capacity. But the ratios highlight real differences in the relationship between different aspect of lung function and lung size.

Physiologists ought to be intrigued by these observations and use them to uncover more fundamental mechanisms that link size and function. Finally, we should be allowed the freedom to analyze data in many ways without a priori assumptions that straightforward calculations, like ratios, are inherently misleading, dangerous, or spurious.

## REFERENCES

1. Cooper, D. M., and N. Berman. Ratios and regressions in body size and function: a commentary. *J. Appl. Physiol.* 77: 2015–2017, 1994.
2. Tanner, J. M. Fallacy of per-weight and per-surface area standards and their relation to spurious correlation. *J. Appl. Physiol.* 2: 1–15, 1949.

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## REPLY

*To the Editor:* We appreciated the thoughtful letter of Cotes and Reed. In our commentary (1), we objected to a widely held view that simple ratios of physiological function to body size are, in and of themselves, mis-