

Christopher J. Gore, Michael J. Ashenden, Ken Sharpe and David T. Martin
J Appl Physiol 105:1020-, 2008. doi:10.1152/japphysiol.90459.2008

You might find this additional information useful...

This article cites 6 articles, 3 of which you can access free at:

<http://jap.physiology.org/cgi/content/full/105/3/1020#BIBL>

This article has been cited by 1 other HighWire hosted article:

Reply to Gore, Ashenden, Sharpe, and Martin

E. F. Coyle

J Appl Physiol, September 1, 2008; 105 (3): 1021-1021.

[Full Text] [PDF]

Medline items on this article's topics can be found at <http://highwire.stanford.edu/lists/artbytopic.dtl> on the following topics:

Physiology .. Exertion

Medicine .. Orchiectomy

Medicine .. Resting Metabolic Rate

Medicine .. Exercise

Updated information and services including high-resolution figures, can be found at:

<http://jap.physiology.org/cgi/content/full/105/3/1020>

Additional material and information about *Journal of Applied Physiology* can be found at:

<http://www.the-aps.org/publications/jappl>

This information is current as of November 9, 2009 .

Delta efficiency calculation in Tour de France champion is wrong

Christopher J. Gore,^{1,2} Michael J. Ashenden,³ Ken Sharpe,⁴ and David T. Martin¹¹Department of Physiology, Australian Institute of Sport, Canberra; ²Exercise Physiology Laboratory, School of Education, Flinders University, Adelaide; ³Science and Industry Against Blood-Doping (SIAB) Research Consortium, Gold Coast; and ⁴Department of Mathematics and Statistics, The University of Melbourne, Melbourne, Australia

TO THE EDITOR: We previously raised concerns (6) about the methodology used to assess Lance Armstrong's muscle efficiency in the popular *Journal of Applied Physiology* paper entitled "Improved muscle efficiency displayed as Tour de France champion matures" (1). Subsequently, Coyle made available raw data from the January 1993 test that revealed several additional deviations from the published methodology. Coyle used a 20-min ergometer protocol (not 25 min), including 2- and 3-min stages where respiratory exchange ratios (RER) exceeded 1.00. An RER >1.00 invalidates use of the Lusk equations (5) to estimate energy expenditure.

A review of the raw data established that the published delta efficiency (DE) values in the Armstrong paper were calculated using the wrong equation. Coyle's published methodology (1) and that used by his group on several previous occasions (2, 4, 7) stipulates that linear regression ($y = mx + b$) be used to calculate DE, as the reciprocal of the slope from the relationship between the energy equivalent of oxygen uptake and cycling power output. However, Coyle calculated DE using the general formula $100 \times \Sigma(X \times Y) / \Sigma(X^2)$. This calculation is equivalent to linear regression using $y = mx$, which forces the regression line through the origin. Resting metabolic rate (RMR) as well as the cost of cycling without load (including the variable cost of ventilation and circulation) mandate that the regression line used to calculate DE cannot pass through the origin.

In their benchmark paper, Gaesser and Brooks (3) argue that DE, as the first derivative of the increase in caloric cost of exercise with respect to ordered increases in work, is a "floating base-line" method. Hence it is essential that the regression is not forced through zero when calculating DE. By employing $y = mx$ for each of the four data sets used to calculate DE, Coyle has assumed that Armstrong's RMR and cost of cycling without a load was not influenced by orchiectomy and chemo-

therapy, plus well-publicized weight fluctuations during the 7-year study.

Gross efficiency values reported by Coyle, which demonstrate an $r = 0.999$ correlation with his DE data, have been cogently dismissed by Gaesser and Brooks (3) as being of little value in understanding muscular efficiency. This interpretation is recognized by Coyle who notes on p. 2194 of his publication (1), "delta efficiency . . . provides the best reflection of power production . . . as it eliminates or minimizes the influence of the energy cost of unloaded cycling, ventilatory work, and other metabolic processes not directly linked to muscle power production."

Using the correct equation, we recalculated Armstrong's DE as 23.55% in January 1993 (23.02% if the 2-min stage is included), which exceeds the 23.12% value for the final test in November 1999. This is 8% higher than the reported value of 21.75%. The magnitude of this error warrants recalculation of the entire data set, but raw data from the remaining test sessions are not available from the author.

In conclusion, all of the published delta efficiency values are wrong. Thus there exists no credible evidence to support Coyle's conclusion that Armstrong's muscle efficiency improved.

REFERENCES

1. Coyle EF. Improved muscular efficiency displayed as Tour de France champion matures. *J Appl Physiol* 98: 2191–2196, 2005.
2. Coyle EF, Sidossis LS, Horowitz JF, Beltz JD. Cycling efficiency is related to the percentage of type I muscle fibers. *Med Sci Sports Exerc* 24: 782–788, 1992.
3. Gaesser GA, Brooks GA. Muscular efficiency during steady-rate exercise: effects of speed and work rate. *J Appl Physiol* 38: 1132–1139, 1975.
4. Horowitz JF, Sidossis LS, Coyle EF. High efficiency of type I muscle fibers improves performance. *Int J Sports Med* 15: 152–157, 1994.
5. Lusk G. In: *The Elements of the Science of Nutrition*. New York: Johnson Reprint, 1976, p. 65.
6. Martin DT, Quod MJ, Gore CJ, Coyle EF. Has Armstrong's cycle efficiency improved? *J Appl Physiol* 99: 1628–1629, 2005.
7. Sidossis LS, Horowitz JF, Coyle EF. Load and velocity of contraction influence gross and delta mechanical efficiency. *Int J Sports Med* 13: 407–411, 1992.

Address for reprint requests and other correspondence: C. J. Gore, Australian Institute of Sport, PO Box 176, Belconnen ACT 2616, Australia (e-mail: chris.gore@ausport.gov.au).