Pitfalls of efficiency determination in cycling ergometry

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TO THE EDITOR: Muscular efficiency is a typical topic of traditional exercise physiology, but the results of seemingly simple approaches may be misinterpreted. There is a variety of pitfalls that have to be avoided during efficiency determination (e.g., Ref. 1). This is rather simple during cycling, because it is an uncomplicated movement mastered by nearly everybody; furthermore the amount of negative exercise is minimal, but pedaling frequency has to be standardized for comparisons. When using O₂ consumption and CO₂ production for energy turnover measurements (indirect calorimetry), anaerobic metabolism has to be minimal. This is the case during the steady state of moderate exercise with constant lactic acid concentration; for other conditions oxygen debt has to be measured. For comparisons between subjects either loads with equal work rates have to be used or an efficiency measure that is not dependent on power has to be calculated. Surprisingly Hopker et al. (3) did not consider some obvious traps.

They conclude from ergometric measurements in young and old cyclists compared with untrained controls that training improves gross efficiency; cadence was either free chosen or fixed. But at low intensity, gross and net exercise efficiency are remarkably influenced by pedal rate, with maximal values around 60 rpm and a decrease especially at higher rates (2). A main cause is that already unloaded movements of the legs contribute to energy consumption but not to measured exercise; therefore this extra O₂ uptake increases with cadence (also derivable from Table 2, last columns in Ref. 3). With high intensity the effect is reduced, because the fractional contribution of idling to total oxygen consumption declines.

Hopker et al. (3) let their subjects pedal initially (from 100 W up to 60% maximal power) with their preferred pedal rate and detected a higher efficiency in trained than in untrained subjects. But this may simply be caused by different pedal rates. Possibly the athletes tended to lower frequencies because of their high leg muscle strength. Only for negligible differences in cadence, the conclusions of the authors might hold but pedal rates were not communicated.

Additionally Hopker et al. (3) performed measurements at constant equal pedal rate (60 and 120 rpm) in both groups. But now they selected equal percentages (60%) of individual maximal power, e.g., 161 W in the untrained and 211 W in the trained young subjects, and again obtained significant differences in gross efficiency between groups. This result was, however, inevitable: independent of training state gross efficiency increases with work rate because it is not corrected for the contribution of resting metabolism like net efficiency. Therefore the higher values in athletes are at least partly caused by the higher work load and not by a real improvement of efficiency. Only a significant difference in net efficiency, which changes only slightly with load, would prove such an effect in these experiments.

Thus the widely accepted opinion that training has only a very limited effect on the efficiency of muscular exercise during cycling (evidenced in many references in Hopker’s article!) probably remains intact.

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