ARNIE BAKER CYCLING

Economy & Efficiency

Economy and efficiency are important physiological measures of performance. They do not mean the same thing. Improving economy can improve performance.

CYCLE HANDOUT

Economy

Economy has a specific sport science definition.

Economy is the power produced (in watts) divided by the volume of oxygen used to produce that power (in liters per minute).

Economy can be related to mechanics. It is defined as the energy expenditure required for a given workload. It the automotive world, economy refers to miles per gallon.

Athletes generally produce 70 to 80 watts per liter of oxygen consumed per minute.

As carbohydrates are metabolized more efficiently than fats are, and as carbohydrate use increases at high power outputs, economy generally improves in any given athlete as workload increases.

Fighting the bicycle, using the upper body too much, holding the handlebars too tightly, lateral pedal forces, and pushing down on the upstroking leg all lower cycling economy.

Consider two athletes who have the same VO_2 max. One can cycle at 200 watts using 80% of VO_2 max. The other, cycling at the same power, requires 85% of VO_2 max. The first athlete's energy expenditure is more economical.

At lower power outputs, lower revolutions per minute are generally more economical. At higher power outputs, there is less difference in economy at different rpm.

Although sitting might seem intuitively more economical than standing, scientific studies regarding this are mixed and may relate to rider size.

Efficiency

Efficiency is one of many factors that contributes to economy.

Athletic efficiency is the amount of energy produced divided by the amount of energy needed to produce that work.

Analogy: An engine produces 500 watts of power. If the engine needs 2,000 watts (or the equivalent in gasoline or electricity) to drive it, then its efficiency is 25%. The loss of power is mostly related to heat loss. When the human body is the engine being evaluated, the caloric equivalent of power is the measure used. Human muscle efficiency is generally between 20% and 25%. For example, to perform 50 calories of work, an individual might need to consume 200 calories.

We obtain energy from food. The body's engine is not 100% efficient—much energy is wasted, or lost, in heat. In order to produce a given amount of work, the athlete must use four to five times as many calories as are produced.

Efficiency is a ratio. It is not a measure of the absolute calories used by the athlete. Intuitively, most of us think of efficiency as a good quality. This is not necessarily so for the athlete. Humans are about 15% less efficient when burning fats than when burning carbohydrates. Sparing glycogen is good. At a given workload, fit athletes burn relatively more fat and relatively less glycogen; they are less efficient at burning fuels than untrained subjects.

Relating Efficiency and Economy

Efficiency and economy are not the same thing.

Athlete efficiency is just one component of economy—just like the efficiency of a car engine is just one component that contributes to the car's overall economy.

Consider two riders of the same size and with the same VO2 max. To ride at a certain speed, athlete A's muscles perform 50 calories of work per unit of time and metabolize 200 calories (150 calories are inefficiently lost to heat). Athlete B's muscles perform 60 calories of work at the same speed and metabolize 210 calories.

The efficiency of athlete A is 50/200, or 25%. The efficiency of athlete B is 60/210, or 28.6%. Athlete B is more efficient.

The economy of athlete A is better. Fewer calories are needed to travel at the same speed.

Training improves economy. It may worsen efficiency at a fixed power output.

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