CYCLING SCIENCE & PERFORMANCE

By Dario Fredrick

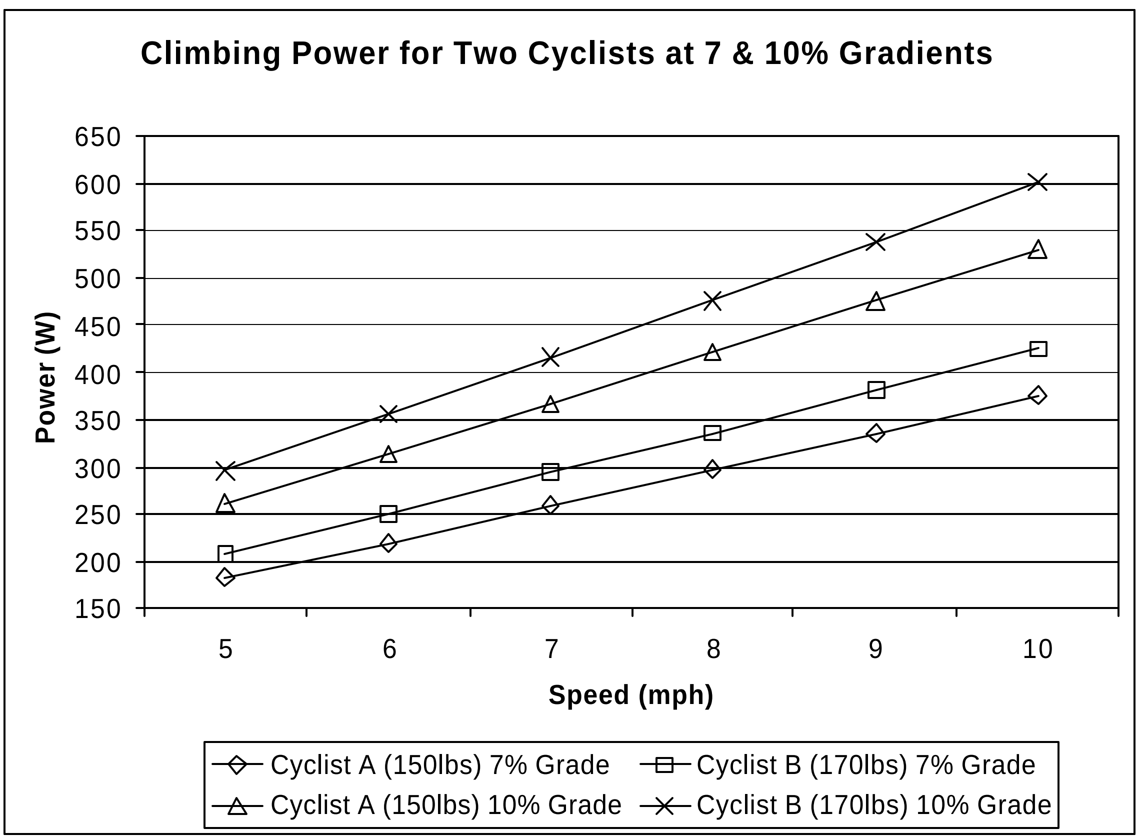
Climbing Performance

The ability to climb well is a skill that many competitive cyclists strive for. Changing gradients can play a decisive role in a race's outcome, emphasizing the importance of climbing ability. Images of the world's greatest climbers battling in the Alps and Pyrenees are undoubtedly impressive and inspiring. But is the ability to climb well purely a function of one's power output and size? How is it that heavier riders can sometimes climb as well or better than lighter ones? Can specific training improve one's ability to climb well? Understanding the principles that govern climbing speed can help maximize one's approach to optimal climbing performance. In this edition of *CS&P*, we will examine climbing closely, looking at ways to optimize this important area of performance.

Power to Weight Ratio

While some "climbers" may be naturally gifted in terms of body type and physical ability, most cyclists must work hard to develop their climbing. In order to illustrate the different power requirements for cyclists of different weights, we will compare two cyclists, cyclist A & cyclist B. Cyclist A weighs 150lbs and cyclist B 170lbs. Because gravity is a constant force, it is logical that the heavier rider, cyclist B will need to produce more power to maintain the same speed for a given grade (Figure 1).

Figure 1*



*Power data are based on zero wind conditions and do not take into account rider position or frontal area.

Body mass (weight) and power output are the two basic components of climbing speed. Power to weight ratio is typically measured as one's maximal steady state (MSS) power divided by body weight (in kilograms). If we examine the world's best climbers for example, they typically boast a power to weight ratio of 6-7 watts per kg of body mass[5]. This means that a rider weighing ~150lbs would produce between 410-475 watts at MSS! While the ratio of power to weight can provide a general idea of one's climbing potential, there are other factors that can affect climbing performance. Indeed, aerodynamics and efficiency both directly contribute to the translation of power output to climbing speed.

Aerodynamics

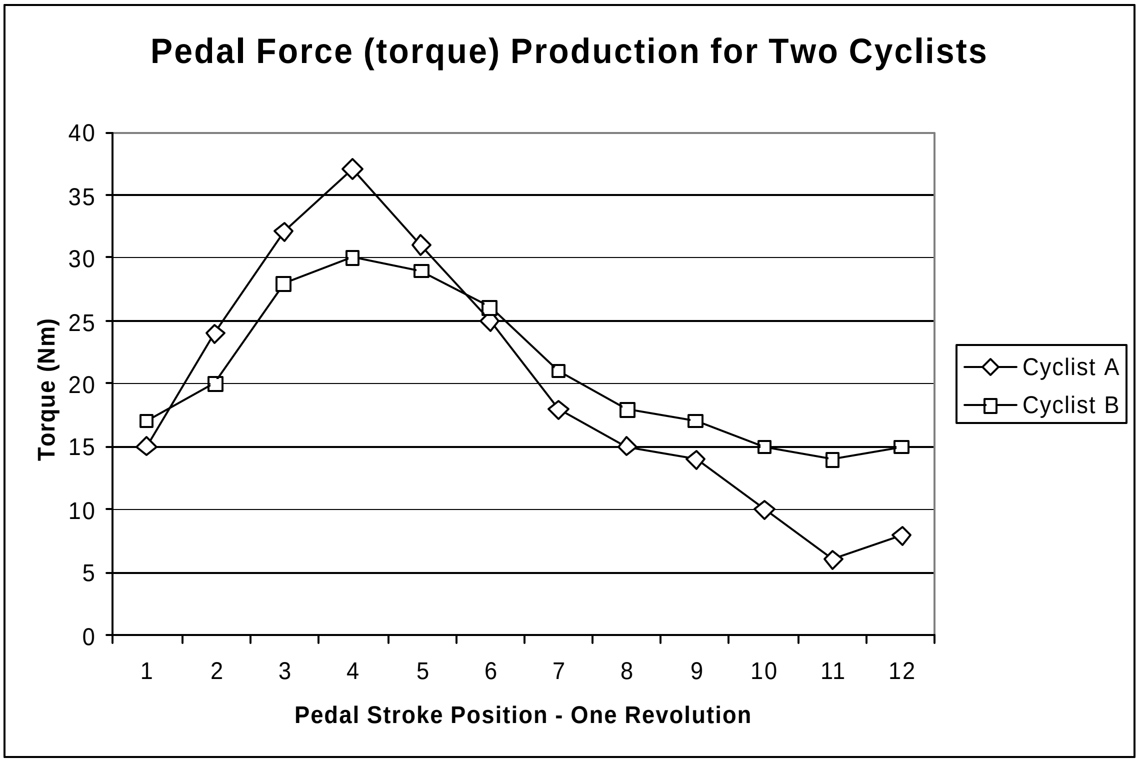
Many cyclists consider aerodynamics to be important only on flat terrain and at higher speeds. However, even riding at speeds as low as 8-10mph, one's position on the bike can affect aerodynamic drag and thus climbing speed[7]. For example, climbing with hands on the brake hoods as compared with hands on the tops of the handlebars (straight arms) can reduce **drag area** (=*frontal area* x *coefficient of drag*) significantly, increasing speed for the same relative power output. To define the two elements of drag area, frontal area can be considered the visible area of one's profile as seen from head on, while coefficient of drag refers to the surfaces along which the air moves over the rider (bicycle, wheels, clothing material, helmet, etc.). Aerodynamics can certainly have a more dramatic effect on higher speeds such as when time trialing on flat terrain. But consider the situation where you thought "if I could just ride ½ mph faster up that climb…"

Climbing out of the saddle is necessary in certain situations, such as accelerating or maintaining pace up a steeper pitch. However, it is the least aerodynamic position (compared with the handlebar tops and brake hoods) with the highest energy cost[4]. Frontal area is increased which requires more power to maintain the same relative speed. Furthermore, since more body muscle is required to stabilize the trunk, demands for fuel and circulation increase as well. Minimizing time spent climbing out of the saddle on sustained climbs will improve aerodynamics, reduce muscular demands, and thus reduce necessary power output.

Efficiency

If your body weight is optimized, your drag area is low, and power output is at its peak for this time of year, you can still improve your climbing speed. Increasing efficiency can help. There are two main types of efficiency that directly affect climbing speed: **biomechanical efficiency** and **aerobic efficiency**. Mechanical efficiency refers to the distribution of force around the pedal stroke. The key to optimizing mechanical efficiency is to eliminate any extremely high or low impulses of force in each pedal stroke. For example, if your force distribution along the area of the pedal stroke from 6-12 o'clock is neglected, the amount of downward force (1-5 o'clock) to drive the pedal stroke increases dramatically to maintain power. The higher the force required, the more easily fatigued the muscles become. Figure 2 illustrates this point by comparing the force production (torque) of two cyclists' pedal strokes. While both cyclists produce the same amount of power, cyclist A relies heavily on downward force, while cyclist B is able to reduce the maximum amount of force in each revolution with a more even distribution of force around the pedal stroke.

Figure 2



Climbing typically requires lower gears and a lower cadence than on flat terrain. A lower cadence means that more force is required to produce the same relative power (since power = force x cadence). Therefore, if cadence can be maximized without compromising efficiency, force production can be reduced while maintaining power. Research suggests that the optimal range of cadence for trained cyclists ranges between 70-90rpm when climbing[1, 3, 8].

Directly interacting with mechanical efficiency, aerobic efficiency addresses a cyclist's fitness. When we talk about improving "fitness" in cycling, this usually refers to aerobic efficiency. Since we are always using both aerobic and anaerobic metabolism at any one time, the key here is to maximize the aerobic contribution to fueling work while relying on anaerobic metabolism to fuel work as little as necessary. As many of us well know, excessive reliance on the anaerobic pathway to fuel work fatigues the muscles quickly, exhausting fast fuel (glycogen) stores prematurely. The endurance characteristics of muscle are improved with highly aerobic work, improving sustainable climbing power[2, 6]. Thus, being aerobically efficient means that the ability to use aerobic metabolism to fuel work even at high workloads has been maximized.

Biomechanics

Since most cyclists climb in a position that is different from that while riding on flat roads, it is necessary to adapt to that particular position. Not only is the upper body in a typically more upright position, but the pelvis is usually rotated back and sometimes further back on the saddle. This suggests that specific muscular recruitment takes place in the legs while climbing, which is different from riding flat terrain. So in order to optimize climbing performance in races, training on the bike should include significant climbing time in the saddle.

Summary

To summarize the components of climbing performance, the two main determinants of climbing speed are power output and body mass (power to weight ratio). Reducing weight to a minimum and maximizing power are certainly important, but are only the beginning in the quest for optimal climbing performance. Position on the bike can also affect the amount of power required to climb at various speeds due to the effects of aerodynamic drag. Climbing out of the saddle requires more power and has a higher energy cost than other positions.

Efficiency plays an important role in determining climbing speed as well. Mechanical efficiency can alter the amount of force required to climb at a particular speed, directly affecting fatigue and muscular endurance. Avoiding extremely high impulses of force while applying force more evenly throughout the pedal stroke can help maximize mechanical efficiency. Aerobic efficiency can determine how long an effort can be maintained, and the amount of sustainable climbing power. A high level of aerobic "fitness" can contribute to a high level of sustainable power.

Climbing well takes more than just being a "climber" in stature, but also combines elements of position, efficiency and fitness. Even if you may not be blessed with a light frame or powerful legs, climbing performance can improve with attention to efficiency, cadence and position.

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