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Training With Power Measurement: A New Era in Cycling Training

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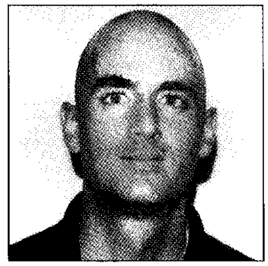

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PROVIDING CYCLISTS WITH A reliable measure of exercise intensity presents unique challenges. Environmental factors such as wind speed, road grade and surface texture, and air density interactively influence the resistance encountered during cycling and thus alter the speed a cyclist can maintain while riding at any specific intensity. For example, a cyclist might be capable of averaging 40 km/h in a tailwind with very little effort, but might be unable to maintain 20 km/h when climbing a hill at maximal effort. Consequently, speed, which was the first and most basic measure for quantifying cycling intensity in a field setting, is not a reliable measure of intensity because it does not account for variations in environmental factors. Monitoring heart rate, a physiological response to exercise, was perhaps the next step in measuring endurance exercise intensity. Indeed, heart rate provides a good representation of intensity during steady-state submaximal exercise. Cycling, however, is a non–steady-state activity involving intermittent maximal effort. Consequently, heart rate does accurately represent cycling intensity. Recently, devices that measure power during actual road and off-road cycling have become commercially available, and we believe they represent the next evolutionary step in quantifying cycling intensity.

Exercise physiologists have long recognized the close relationship between mechanical power output and metabolic rate (intensity). Indeed, McDaniel et al. (3) recently reported that mechanical power output accounted for 95% of the variability in metabolic cost of cycling, even when cycling with a wide range of pedaling rates and crank lengths. Not surprisingly, most exercise physiology labs use carefully calibrated ergometers to set exercise intensity during training studies and research protocols. Until recently, the benefits of training at a precisely monitored power output, unfortunately, were limited to laboratory settings.

Recently, 3 companies (SRM, PowerTap, and Polar) have begun producing devices for measuring power during road and off-road cycling. Those devices take advantage of the fact that power can be calculated as the product of force and velocity, or torque and angular velocity. Consequently, cycling power can be determined by measuring pedaling rate and crank torque (SRM), rear wheel angular velocity and rear hub torque (PowerTap), or chain tension and speed (Polar). The SRM device has been validated by comparison with laboratory power measurement equipment (2). These devices provide essentially real-time power measurement and thus allow the cyclist to control his or her exercise intensity during training in a way that was previously only possible in a laboratory setting. Additionally, these devices are of similar dimension and weight to the racing bicycle parts that they replace, so they can be used in competition without compromising performance. Consequently, these devices can provide a record of exercise performance during competition when athletes are maximally motivated.

Earlier, we wrote that power represents the next evolutionary step in quantifying cycling intensity although heart rate is a direct physiological response to exercise. Although heart rate provides some understanding of the exercise intensity, it is limited in 2 ways. First, heart rate does not respond instantaneously to changes in intensity. Rather, heart rate lags behind instantaneous intensity. For example, given the instruction to cycle at 200 W (starting from rest), the athlete begins pedaling at 200 W of power output instantly, but the heart rate lags with a half-time response of about 40 seconds (1). A similar lag will occur if a cyclist increases power output from 200 to 300 W during a race. This time lag makes heart rate less than ideal for measuring non–steady-state exercise intensity, and cycling is a dynamic activity in which intensity is constantly changed in response to environmental (wind, grade, temperature) and competitive (pace, strategy) factors. Power measurement has the advantage of providing a near real-time understanding of the physical demands of cycling.

Heart rate can also be misleading because of factors that systematically affect heart rate response to any specific exercise intensity. These include but are not limited to ambient temperature, hydration status, circadian variation, and ergogenics (e.g., caffeine). These factors may increase or decrease heart rate response to any given cycling task, such that

Observed heart rate response = Heart rate response to cycling exercise + Heart rate response to systematic factors.

The daily variation in these systematic factors can introduce error and inconsistency if heart rate is used to monitor training intensity for a cycling program. The advantage of measuring power is the consistency and simplicity of the quantity of power. Power simply is a measure of force delivered to the external environment and the velocity at which that force is delivered. Power is consistent across a wide range of systematic factors. Cycling at a power of 200 W on a windless day will be comparable to producing 200 W on another day where the wind is significant, although speed might differ. Similarly, riding at 200 W in a fully hydrated state is similar to producing 200 W in a dehydrated state, although the heart rate response may be dramatically different.

To summarize, measuring power provides a more accurate and instantaneous measure of exercise intensity for monitoring cycling performance and training. Quantifying power removes much of the variability associated with external systematic factors, which serve to reduce the effectiveness of heart rate as a monitoring tool. Power measuring devices have been shown to provide valid data compared with laboratory-based measurement methods. We believe that power measurement for cycling in actual field conditions represents the next evolutionary step in quantifying intensity during training and racing. ▲

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