



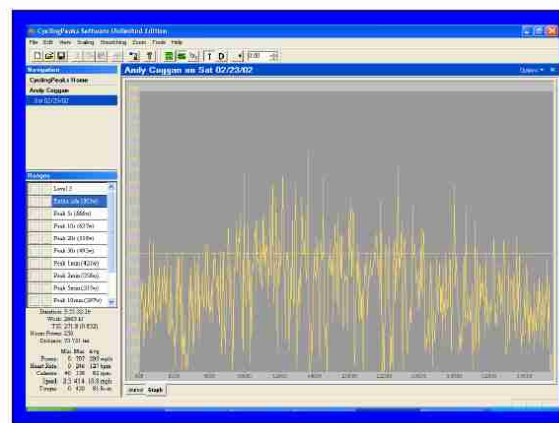
## Power Based Training: Advantages

Luisa Sullivan  
 MS Integrative physiology  
[www.davanticycling.com](http://www.davanticycling.com)  
[luisa@davanticycling.com](mailto:luisa@davanticycling.com)

The use of power meters is becoming more popular not only among professional or elite cyclists but also among competitive cyclists at the amateur level.

However, many athletes still debate and question on the “real” advantage of training with a power meter versus heart rate (HR) monitor or versus, the still common, “just following the body’s sensations”. In this article I will try to address advantages and limitations of power vs. HR based training.

Let’s start with some basics.

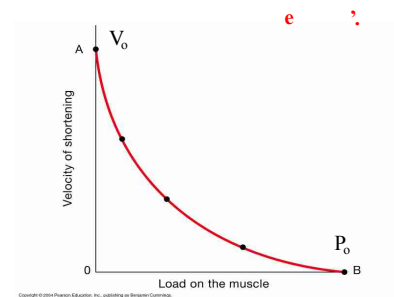


### 1. Definition of Power

**Power is the amount of work done or energy released in a measured time frame, normally expressed as a watt.  $P = \text{Work}/t$**

**Work** is a mechanical representation of energy equal to force x distance.  $W = F \cdot d \Rightarrow P = F \cdot d/t$  but since  $d/t = \text{velocity} \Rightarrow P = F \cdot v$

**Force** is a vector quantity that produces an acceleration of a body in the direction of its application or in a language more familiar to cyclists: *Force is the amount of pressure applied to the pedals or rear hub or a measure of strength.*



**Velocity** is the distance traveled in a given time frame normally expressed in meters per second, kilometers per hour, or miles per hour or more simply : **Speed**.

Power is function of two factors: the Force applied on the pedal and how fast the athlete is able to turn those pedals. This relationship is not linear, but curvilinear as you can see in the figure on the side.

Infact Power is close to zero either for very high values of Force and very low values of velocity or for very high values of velocity and very low value of Force. The maximum power is given from the optimal combination of force and velocity.

**What does this imply training wise.** Training, athletes need to develop both components (force & velocity) separately first and then integrate them together to develop power. At the beginning of the off-season, training should be focus in developing speed with short high velocity sprints at low resistance, then in second phase, training should focus on developing force, with strength training by weight lifting and specific workouts on the bike at low RPM and high resistance (steady climbs at low RPM). Then in the 3<sup>rd</sup> phase, training should focus on applying both Force and velocity at the same time to develop and increase power.

Moreover, plotting the power data of an athlete's race in terms of force and velocity and analyzing the resulting graph is possible to identify whether his/her weakens is the force or the velocity and consequently better address and focus the training.

## 2. The main advantage of Power

The main advantage of power in comparison to other physiological responses, like heart rate, is that **power is an immediate response** to an increase of intensity during exercise.

Power: 0 sec.

Heart rate/cardiac output: ~25 s

Sweat: ~25 s

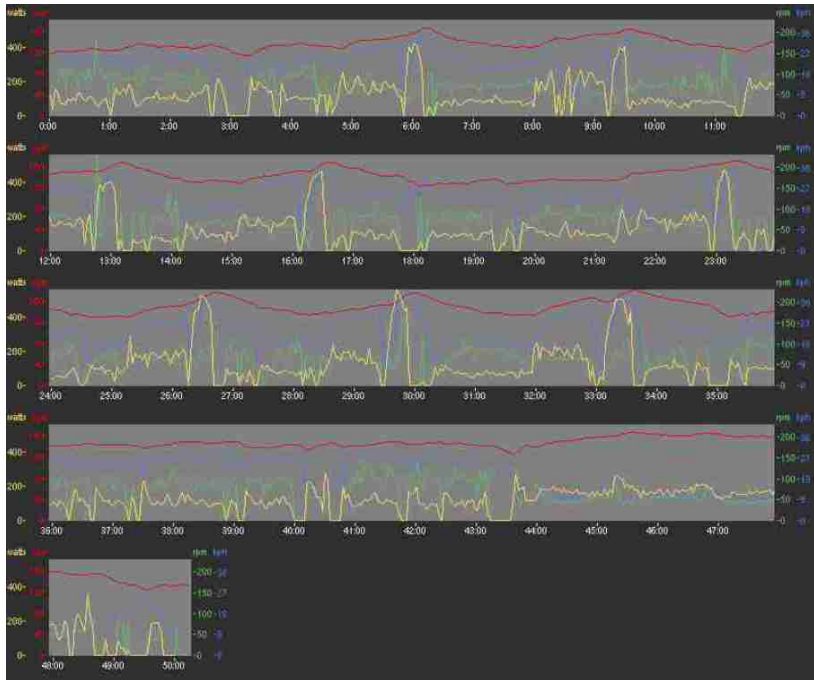
VO<sub>2</sub> (Oxygen consumption): ~30 s

CO<sub>2</sub>: ~45 s

Respiratory response: ~50 s

Core Temperature: ~70 s

This is very important, for example, during short burst of exercise last 10-15 sec, where HR does not respond fast enough and it's impossible to evaluate if the target intensity is achieved without power. In the figure below, **it's evident how the peak of HR (red line) follows the peak of power (yellow line):**



Power is a **direct measurement of exercise intensity** while **heart rate** is an **indirect measurement of exercise intensity** and not always direct way => indirect way.

## Limitation of Heart Rate (HR)

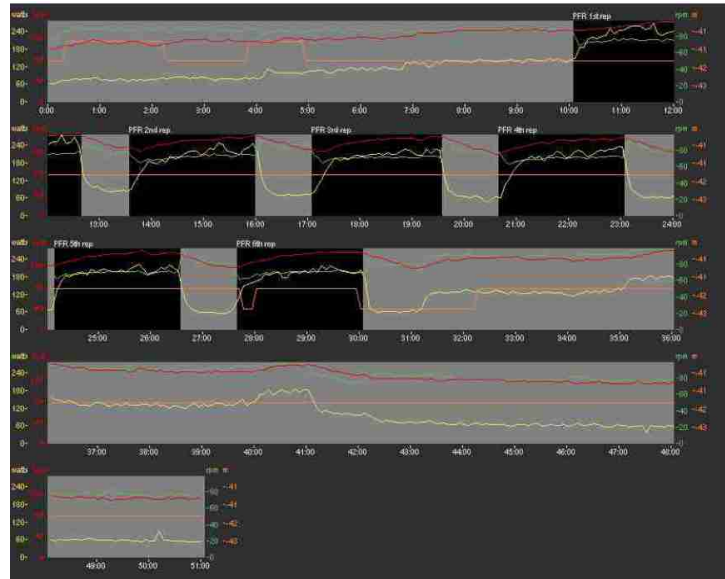
HR is influenced by many factors: Climate, altitude, caffeine intake, sleeping hours, psychological stress, illness and fatigue.

1. Cases where **HR is higher for the same power output:**
  - In case of exposure to high heat, altitude and caffeine intake HR response is higher for the same power output.
  - In case of fatigue, decrease in performance or fitness or illness, during exercise, HR keeps going up for the same or even lower power output. Therefore, based only on HR response a coach could erroneously conclude that the intensity of the workout was higher and may believe in a correspondent increase in power. For example, in case of acute exposure to altitude or soon after weight training where, for two different reasons, the ability of the working muscles to extract oxygen may decrease, HR increases to increase cardiac output to increase the amount of blood delivered to the muscles and to maintain the same oxygen demand to maintain the same intensity, which means the same power output,
2. Cases where **HR lower, does not go up but power output is the same.** This happens for example during stage races or just during several intense workouts back to back. Based only on HR response, the misinterpretation could be a loss of performance.

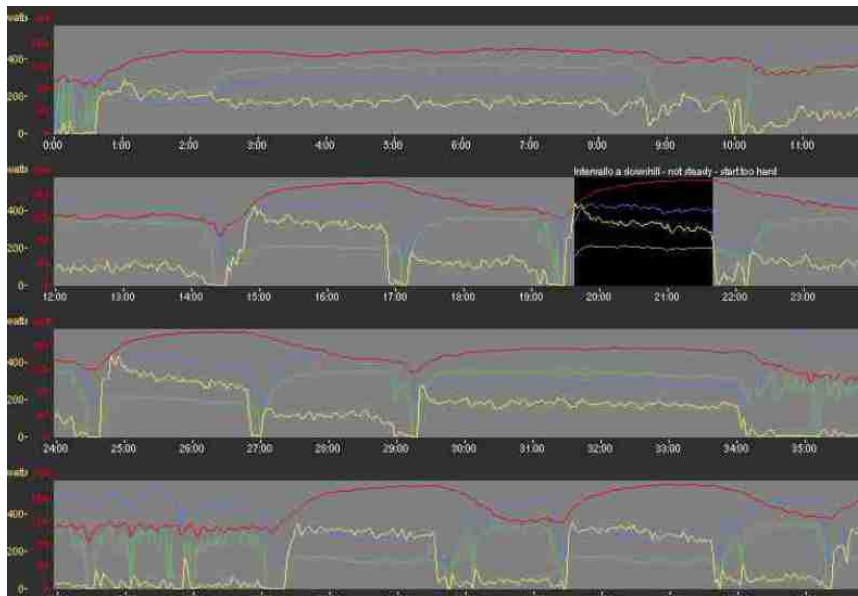
3. **HR is the same and power output ↓. During Interval Training**, based only on HR, coach could erroneously believe that the athlete was able to hold the same intensity through all the intervals. Instead, power consistently decreased during the last interval/indicating that, probably, the number or the length of the intervals were not appropriate for the current training status of the athlete. Fig. 2.

Last rep:

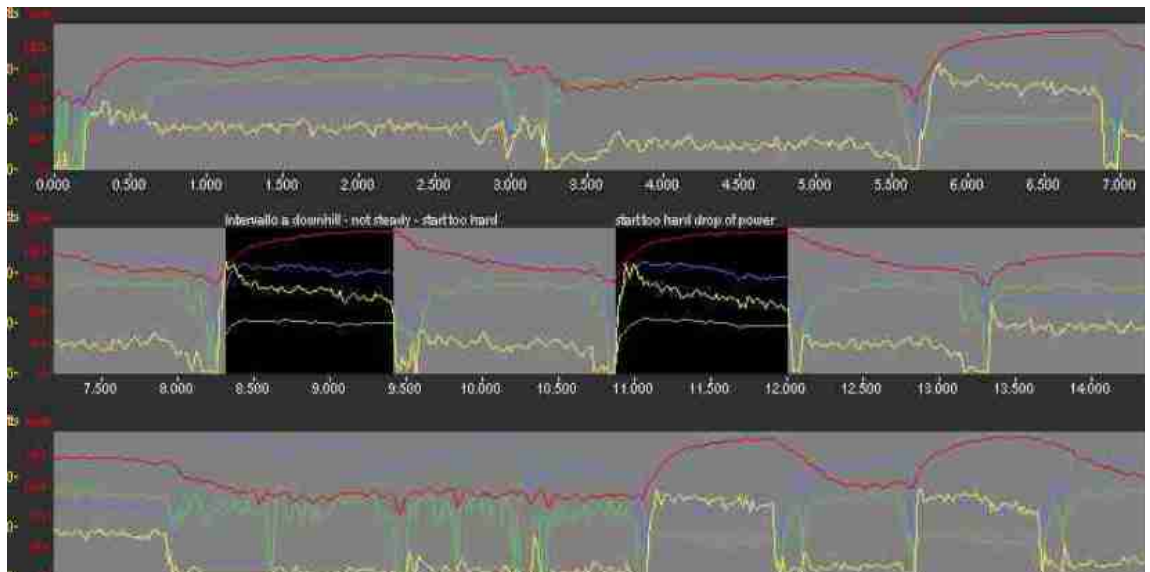
- -18 watts
- -2 bpm



4. Cases where **HR ↑ and power output ↓**. Another typical example that may occur **during interval training**. Two scenarios: the first one is when HR is higher during the last intervals but power progressively decreases. This clearly indicates fatigue, but if based on HR evaluation, it could be misinterpreted as ability to increase exercise intensity over several intervals. Second scenario: during the same interval HR keeps going up but power progressively goes down (Fig. 3). If based only on HR, this scenario could be misinterpreted as a correct progression of intensity, instead the exact opposite occurred. The athlete started too hard and was not able to maintain the initial power through the entire interval. **Fig. 3** (the dark highlighted interval: the red line indicating HR, keeps going up during the interval, and the yellow line, indicating power, is much lower)



5. Avg HR or RPM does not show if an interval has been executed correctly or not. For example: **TT intervals**: detection of “start too hard” : HR keeps going up and power goes down.



## Power: Useful Tool to evaluate and analyze training sessions.

From the examples above, it's evident how **Power is also a useful tool** :

1. **for a correct evaluation of the training sessions** to avoid misinterpretations
1. **to verify** if the workouts have been executed correctly.
2. **to evaluate** training status and performance
3. **to monitor** training load, overload and progress
4. **to identify** weaknesses
5. **to design appropriate** number and length of intervals
6. **to decide** race strategy

## Is Power more important than HR?

**The correct answer is : NO , We need BOTH**

**The Ratio HR/PW is the real indicator of progress in fitness. We want this ratio to get smaller as training progresses to claim a fitness improvement. Lower HR for the same power output: That's the goal!**

We can use this ratio to compare athletes and predict performance.

## Is everything wonderful about Power based Training?

### **NO! Disadvantages of Power based Training**

- Complexity: Athletes need an expert coach able to interpret correctly the outputs.
- Difficult to interpret the data correctly and understand the physiological implications
- Psychological dependence from numbers
- Cost

## **Conclusions:**

Power based training is highly recommended to athletes who race with goals of placing themselves or who want to make remarkable results.

Athletes can have a terrific advantage in their training progress using power meter but they have also to choose a competent “power certified” coach with sport science background. On the other side, the coach should always leave some room in the training plan for “free” spirit rides, where the power meter can be there but does need to be looked at it.

*For any question*

**[\[Contact us\]](#)**

*Luisa Sullivan*

*MS Integrative Physiology*

*USA Cycling Federation*

*Certified Level II Coach*

*Power Based Training Certified*