Normalized Power (NP), Intensity Factor (IF), and Training Stress Score (TSS)

By. Andrew R. Coggan, Ph.D.

One of the first things that catches the attention of any beginning power meter user is how variable, or "jumpy", their power output tends to be. This is largely due to the constantly changing resistances (e.g., small changes in elevation, gusts of wind) that must be overcome when cycling outdoors. Because of this variability, training with a power meter is not directly comparable to training using a heart rate monitor. In particular, it is very difficult (as well as counterproductive) to try to keep power constantly within a certain range, or zone, at all times during a training session. Just as importantly, this variability means that the overall average power for a ride or part of a ride is often a poor indicator of the actual intensity of the effort. This is especially true for races, since power can vary dramatically from one moment to the next as, e.g., a rider first tries to conserve energy and then attacks.

To account for this variability, TrainingPeaks uses a special algorithm to calculate an adjusted or ***normalized power*** for each ride or segment of a ride (longer than 30 seconds) that you analyze. This algorithm is somewhat complicated, but importantly it incorporates two key pieces of information: 1) the physiological responses to rapid changes in exercise intensity are not instantaneous, but follow a predictable time course, and 2) many critical physiological responses (e.g., glycogen utilization, lactate production, stress hormone levels) are curvilinearly, rather than linearly, related to exercise intensity, By taking these factors into account, normalized power provides a better measure of the true physiological demands of a given training session - in essence, it is an estimate of the power that you could have maintained for the same physiological "cost" if your power output had been perfectly constant (e.g., as on a stationary cycle ergometer), rather than variable. Keeping track of normalized power is therefore a more accurate way of quantifying the actual intensity of training sessions, or even races. For example, it is common for average power to be lower during criteriums than during equally-difficult road races, simply because of the time spent soft-pedaling or coasting through sharp turns during a criterium. Assuming that they are about the same duration, however, the normalized power for both types of events will generally be very similar, reflecting their equivalent intensity. In fact, normalized power during a **hard** ~1 hour long criterium or road race will often be similar to what a rider can average when pedaling continuously during flat 40k time trial - the normalized power from mass start races can therefore often be used to provide an initial estimate of a rider's threshold power (see below).

Although normalized power is a better measure of training intensity than average power, it does not take into account differences in fitness within or between individuals. TrainingPeaks therefore also calculates an ***intensity factor (IF)*** for every workout or time range analyzed. IF is simply the ratio of the normalized power as described above to your threshold power (entered under "Athlete Settings" at your "Athlete Home"). For example, if your normalized power for a long training ride done early in the year is 210 W and your threshold power at the time is 280 W, then the IF for that workout would be 0.75. However, if you did that same exact ride later in the year after your threshold power had risen to 300 W, then the IF would be lower, i.e., 0.70. IF therefore provides a valid and convenient way of comparing the relative intensity of a training session or race either within or between riders, taking into account changes or differences in threshold power. Typical IF values for various training sessions or races are as follows:

Typical IF values for various training sessions or races are as follows:

- Less than 0.75 recovery rides
- 0.75-0.85 endurance-paced training rides
- 0.85-0.95 tempo rides, aerobic and anaerobic interval workouts (work and rest periods combined), longer (>2.5 h) road races
- 0.95-1.05 lactate threshold intervals (work period only), shorter (<2.5 h) road races, criteriums, circuit races, longer (e.g., 40 km) TTs
- 1.05-1.15 shorter (e.g., 15 km) TTs, track points race
- Greater than 1.15 prologue TT, track pursuit, track miss-and-out

Note that one particularly useful application of IF is to check for changes in threshold power - specifically, an IF of more than 1.05 for a race that is approximately 1 hour in duration is often a sign that the rider's threshold power is actually greater than that presently entered into the program. Thus, by simply examining a rider's IF for various events during the course of a season, increases or decreases in threshold power can often be revealed without the need for frequent formal testing.

While exercise intensity is clearly an important factor in determining the type and magnitude of physiological adaptations to training, exercise frequency and duration - which together determine the overall training volume - are important factors as well. However, there is obviously an interaction between training intensity and volume, i.e., at some point as intensity goes up volume must come down, and vice-versa, or else an you will become overtrained. To quantify the overall training load and hopefully help avoid such a situation, TrainingPeaks uses your power data to calculate a ***training stress score (TSS)*** for every workout, and provides a graphical summary of your recent TSS on your Athlete Home page. TSS, which is modeled after Dr. Eric Bannister's heart rate-based training impulse (TRIMPS), takes into account both the intensity (i.e., IF) and the duration of each training session, and might be best viewed as a predictor of the amount of glycogen utilized in each workout. Thus, a very high TSS resulting from a single race or training session can be used an indicator that one or more days should be scheduled. For example, while individuals will tend to differ in how much training they can tolerate, depending on their training background, natural abilities, etc., the following scale can be used as an approximate guide:

The following scale can be used as an approximate guide:

- Less than 150 - low (recovery generally complete by following day)
- 150-300 - medium (some residual fatigue may be present the next day, but gone by 2nd day)
- 300-450 - high (some residual fatigue may be present even after 2 days)
- Greater than 450 - very high (residual fatigue lasting several days likely)

As well, the cumulative TSS per week or per month can be used help identify the maximum intensity and volume of training that still leads to improvements, rather than overtraining.

By allowing convenient tracking of normalized power, IF, and TSS for each workout and over time, TrainingPeaks provides both individual athletes and coaches a powerful tool for analyzing the enormous amount of data gathered by training with a power meter. The results

of such analyses can then serve as the springboard for improvements in training and, ultimately, race performance.