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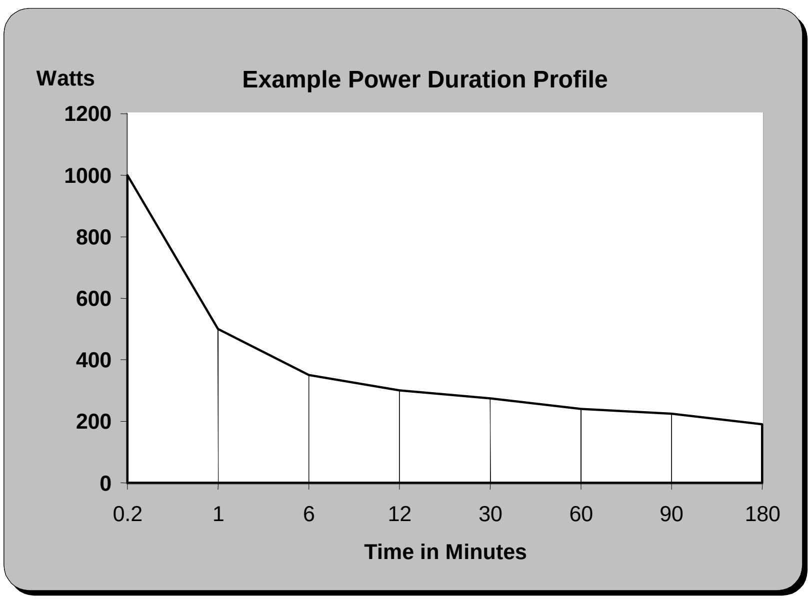
Using the Critical Power Model to Predict Various Points Along the Power-duration Curve

Joe Friel refers to the power duration relationship as critical power points.[1] The average power an athlete can sustain for six minutes thus becomes her CP6. Which of these points to monitor will depend in part upon your event focus and where you are in your training program. Not all segments need to be tested or monitored; for example, I don't routinely test beyond CP30 and I don't prescribe workouts less intense than CP90 because at intensities lower than this, I generally find heart rate to be easier to govern and a reasonable proxy for intensity.



Unfortunately, Monod and Scherrer (1965) first developed a concept called "critical power" which had a very different meaning than how we are using it. They used it to refer to a power level that could be sustained for "a very long time without fatigue." While subsequent studies have shown that the model is less robust than originally thought (Housh et al, 1990; Jenkins et al, 1990 and 1991; Pringle and Jones, 2002), it is still quite useful to us. In spite of the different meanings, we can use their work to predict

[1] While some scientists are disturbed that we advocates of Joe Friel's methodologies use "CPxx" to describe power-duration levels, think of it simply as average power for any given duration.

with fairly good reliability various points along the power-duration curve with as few as two power tests, though I recommend using three tests. For example, you could test CP3, CP6 and CP12 and based on those results predict average power levels that could be sustained for CP30, CP60 and CP90. You can use any duration from CP1 to CP30, though exercise physiologist Andy Coggan, Ph.D. suggests using tests in the 3- to 20-minute range because using primarily short tests (e.g., 1-, 2-, and 3-mins) will tend to overestimate CP based on the impact of anaerobic work capacity (AWC), while using primarily overly long tests may underestimate it.

To use the model based on Monod's and Scherrer's work, you need to know your weight, test duration in seconds and average watts (which is converted into joules of Work per kilogram) for each of the tests. The model is simply a regression of Work against Time, with the slope of the line equaling Critical Power in watts/kilogram and the intercept equaling anaerobic work capacity:

Work in Joules/kg = AWC + CP x Duration

With this equation, we can then predict Work and therefore average power output for any duration. The table below provides example test results, with the first row noting the calculations for each variable:

(A) Test	(B) Weight (lbs)	(C) Weight (kg)	(D) Minutes	(E) Seconds	(F) Average Watts	(G) W/kg	(H) Work (Joules/kg)
Ex	Input	=B/2.2	Input	=D*60	Input	=F/C	=G*E
#1	**160.0**	72.7	**1**	60	**625**	8.6	516
#2	**160.0**	72.7	**6**	360	**380**	5.2	1,881
#3	**160.0**	72.7	**12**	720	**325**	4.5	3,218

Now all you have to do is perform a regression of Work (column H) against time in seconds (column E). The slope of the resulting line will be Critical Power in watts/kilogram and the intercept will be Anaerobic Work Capacity. Based on these data, CP would be 4.1 watts/kilogram and AWC would be 321. Suppose we wanted to predict the maximum power we could sustain for 30 minutes (i.e,. our "CP30"), just run through the formula:

AWC + CP watts/kilogram x Time in seconds = Joules of Work /kilogram

321 + 4.1 w/kg x 1800 seconds = 7,667 Joules/kilogram

The formula for converting Joules/kilogram into Watts is:

Average Watts = Joules of Work/kilogram x Weight in kilograms / Time in seconds

Which ultimately gives us our prediction of 310 watts for a 30-minute effort:

7,667 Joules x 72.7 kilograms / 1,800 seconds = 310 Watts

Remember, the predictions are estimates and subject to the quality of the inputs. In other words, *"garbage in, garbage out."* If your r-squared (a measure of the fit of the resulting line) is anything less than 0.98, you most likely have an issue with your input data. The r-squared will almost always be 0.99. No worries if you were daydreaming about winning the Tour during math class, as I've made it easy for you by providing a ready-to-use Excel workbook here.

Why not just test all the points? Well, for starters, testing all the points can be both time consuming in terms of the number of workouts needed to test. Furthermore, I have found that many athletes, myself included, get psychologically stressed out with excessive testing. Testing any three points along the power-duration curve yields a pretty good view of the entire curve in less time and with less fatigue. Additionally, you can select points that are pertinent to areas of training focus, given wherever you are in your Annual Training Plan.

On a final note, you don't have to make Duration the governing factor when testing. You could for example, pick a given wattage and hold that wattage as long as possible. This may be an especially useful approach for those of you with an ergometer (e.g., Velodyne or Computrainer).

Eddie Monnier focuses on helping cyclists and runners train intelligently through his coaching business, Velo-Fit, LLC™. Power-based training for cycling is one of his specialties, though he also coaches athletes by perceived exertion and heart rate (or better yet, all three). He is also an Expert level USA Cycling certified coach and a member of cyclingnews.com's Form & Fitness Panel. To access other articles he has written, visit www.velo-fit.com. He can be reached at eddie@velo-fit.com.

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