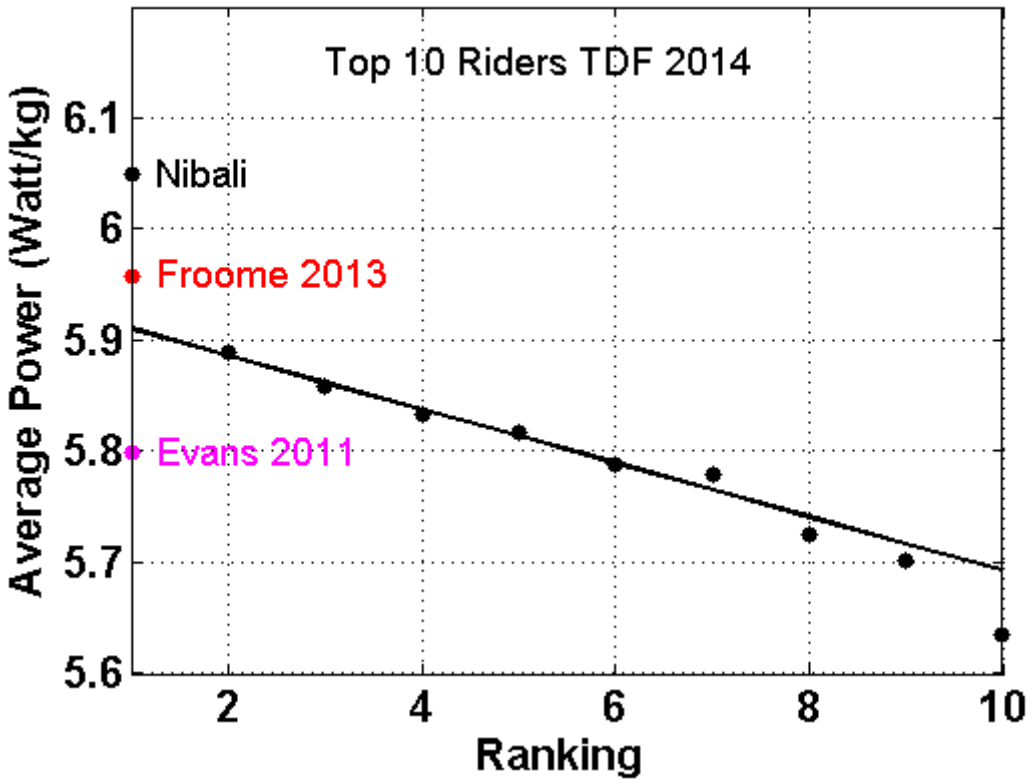
Was the TDF 2014 clean ?

Charles.dauwe@telenet.be
Dept. Physics and Astronomy, Ghent State University, Belgium

The Tour 2014 ended with a supreme victory of Vicenzo Nibali distancing his closest opponent by more than 7 minutes. Two questions are raised and repeated endlessly. First of all ”would Nibali have won against Froome and Contador ?” and second “Considering the extreme supremacy of Nibali, must we regard his performance as suspect or even worse?” These two questions mostly brought forward by the same people in fact are mutually exclusive and lead to a duality. If we say or imply that Nibali was not as good as Froome and Contador, we show a disrespect for his performance and for his combativity but we also imply that all possible doubts on his cleanness must be applied likewise to his two absent opponents. Of course we all saw that none of the French riders who took the other podium places did even come close to Nibali and we saw how he dropped everyone. It is an understandable reaction of the public and the would-be specialists to yell that this is “not normal”. However, is it not simply possible that his opponents were too weak and that they would drop off the podium in any normal Tour?

Average Climbing Power

So what if Nibali had failed, or fallen, or got a virus? Then Péraud wins the Tour, with Pinot in second and a clearly failing Valverde in third place. We like to believe like most commenters that Péraud and Pinot, training and riding in France with the most stringent anti-doping controls, are absolutely clean riders. Therefore in my opinion the real question is “ How big is the difference between Nibali and his opponents, and is this difference suspect or not?”



This tour was decided on the 5 final climbs to La Planche des Belles Filles, Chamrousse, Risoul, Pla d'Adet and Hautacam and we could observe that all the top riders went to the end of their potential on all climbs. Let us therefore observe the graphics of the time-weighted average climbing power on the 5 climbs for all top10-riders . We have also included the average power for Froome in his winning Tour of 2013, and of Evans in the Tour 2011.

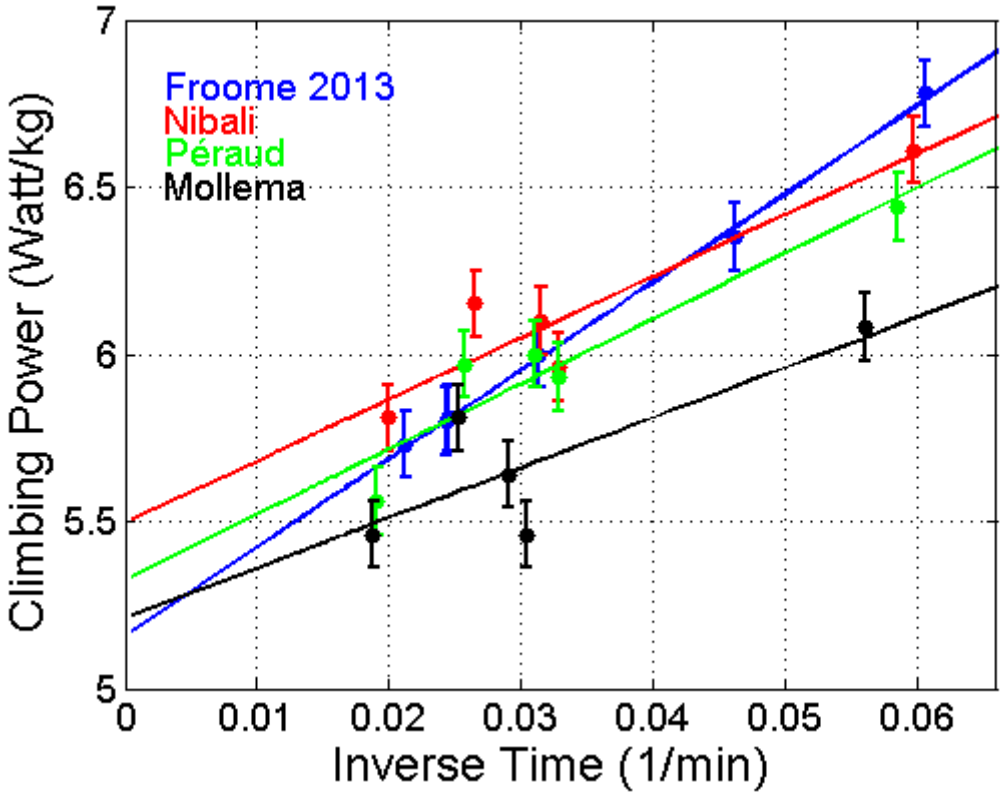
We see that the average power of riders 2 (Péraud) to 9 (Ten Dam) are well described by a linear relationship between their ranking and average power. Only rider 10 (Mollema) shows a decrease below linearity, which we will see increasingly at higher rankings. Nibali clearly lies far above the line of linear expectation but does this mean that there is something wrong with Nibali? Let us see exactly how much stronger he is; From the line we estimate that in order to win he would have needed only average power of 5.91 W/kg but that he effectively produced 6.05 W/kg. This means that he was 2.3 % better than an equivalent rider with the same intrinsic talent as Péraud, Pinot and the likes. Now the question is whether a difference in climbing power of 2.3 % is due to a superior talent combined with better training and diets, or not. Simply let us open Mr. Vayer's book Pouvez-vous gagner le tour?, and look on page 45 what Indurain, Riis, Ullrich and Pantani did. They show average power on multiple final climbs of 6.35 W/kg, a difference of 7.3 %. The real advantage of talent + epo-doping is more than 7 % or to say it in other words; Péraud would have ended more than 20 minutes behind Indurain, and Nibali would have lost at least 12 minutes to Indurain. This sounds like good news but the picture also shows that Froome developed "only" 5.96 W/kg in his winning Tour. Clearly the numbers indicate that Nibali wins against Froome and that it would not be wise to be blind to the possibility that Nibali is not entirely clean. Things get really worse when considering also the performance of Cadel Evans in 2011; The best Evans with his average climbing power of 5.80 W/kg could not do better than 6th place in 2014! And what about the Armstrong era? Armstrong 's climbing power in his winning tours from 1999 to 2005 was 5.74, 6.0, 6.15, 5.94, 6.04, 6.27, and 6.11 W/kg. Number wise, Nibali would have lost to Armstrong in 3 years namely 2005, 2004 and 2001. He would have won against Armstrong in 1999 and in 2002 he is par in 2000 and 2003.
Unfortunately (or fortunately if you wish) these numbers cannot give a definite answer, but Nibali is clearly in the grey zone of suspicion.

Aerobic power and anaerobic energy

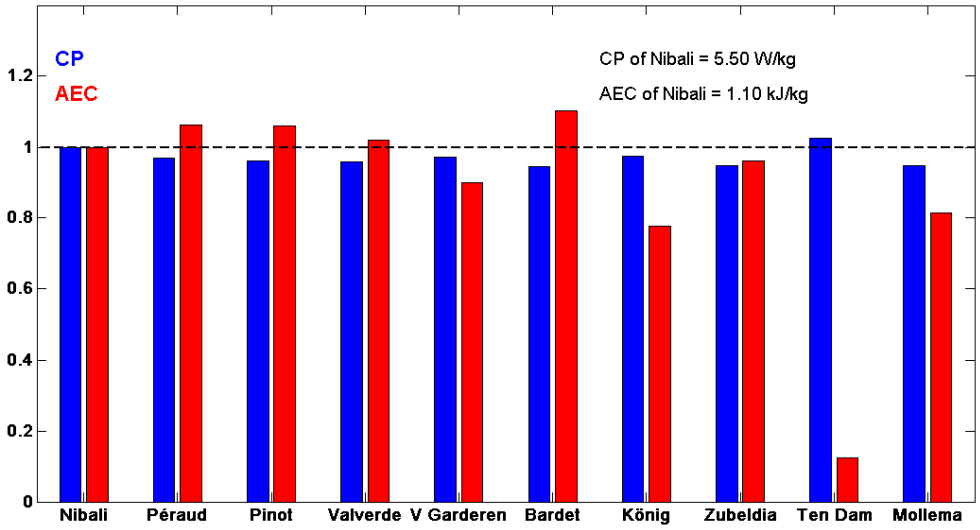
But average climbing power does not tell the whole story. Comparing average climbing power between different years is subject to small variations. The number of climbs, their length, steepness and detailed profile lead to these small variations. Commenters also point out that the performance on a final climb is affected by fatigue from previous climbs in a multiple climbing stage. While this is partly true, modern racing and pacing has found an effective remedy for this. Let us take the example of stage 14 from Grenoble to Risoul. According to the Pioneer powermeter of one of the top-10 riders the col du Lautaret was climbed at a mere 3.6 W/kg. One of the giants of the Alps, the Izoard was climbed by the bunch of the yellow jersey at a pace of 4.7 - 4.9 W/kg, which is way below the sustainable aerobic power of the main contenders. The trick is to ride the non-important climbs at a leisurely pace and come to the final climb with full potential. Successful modern riders and teams are extremely good at energy management.
To discover what makes the difference between the winner and the just-not winner we must look at

two performance parameters, sustainable aerobic or Critical Power CP, and limited anaerobic energy AEC. Further details on the application of the Critical Power analysis can be found here and here.

We have computed the CP and AEC of all top-10 riders in a way as illustrated in next figure. The horizontal axis presents the inverse of the climbing times on each of the final climbs Planche des Belles Filles, Chamrousse, Risoul, Pla d'Adet and Hautacam. Because of the inversion of time the short climbs are seen at the right hand side of the figure, the long climbs at the left side. We have presented the data and the CP-model fitting lines for Nibali (red), Péraud (green), Mollema (black), and also the data for Froome (blue) in previous years. From each data set we obtain the critical power CP, being the intersection of the lines with the vertical axis. The anaerobic capacity AEC is obtained from the slope of the fitted lines, a steep line indicates a high value of AEC. We see that the red, green, black lines seem almost parallel but analysis indicates that the AEC of Nibali (1.1 kJ/kg), Péraud (1.17 kJ/kg) and Mollema (0.90 kJ/kg) are different. The zero intersections or CP vary from ~5.25 W/kg (Mollema) to ~5.50 W/kg (Nibali). If we could shift up the Mollema line by 0.25 W/kg, it would almost coincide with the Nibali line. In other words, if Mollema could increase his sustainable aerobic power by 0.25 W/kg (which is huge at this level of performance) he would be a serious contender for winning the Tour. But there is more to be learnt . The blue performance line of Froome is quite different from all others. It starts at a low value of CP = 5.16 W/kg but has a very high slope. Surprisingly Froome has a low sustainable aerobic power, but a very high AEC. As a result he can outpace everyone on the short climbs such as Planche des Belles Filles, and Ax-3 Domaines (which was not climbed in 2014). However according to the numbers Froome would have lost against Nibali on the longer climb Chamrousse and Risoul. Thus these numbers confirm the results from de average power analysis and that Nibali would have distanced Froome.



All these numbers indicate that it is not sufficient to have a high sustainable aerobic power but that also the anaerobic component plays an important role and that a balanced composition of CP and AEC is necessary for a successful grand tour rider. Let us therefore look at the CP and AEC of the top-10 riders in next figure



The blue bars are the CP and the red bars the AEC for each of the riders. The values are normalized to the values of Nibali. We see that all but one (Ten Dam) have CP lower than Nibali, thus as expected CP seems to be the most important contribution. But interestingly the ranking 2 to 5 is determined by the decrease of AEC from Péraud to Van Garderen. If Van Garderen wants to come up to the position of Péraud he should only have a better AEC, but if he wants to come up to the level of Nibali he should have both a higher CP and AEC. There is so much more that can be discovered from this figure that I leave it to the attention of the interested reader.

Physiological considerations.

Recently Ross Tucker at sportsscientists.com/2014/07/the-physiology-at-the-front-of-the-tour wrote an interesting comment on the physiological plausibility of the performances in the Tour 2014. On the basis of climbing power in W/kg, and based on some known or supposed values of the maximal oxygen uptake VO2max, he tries to evaluate at what fraction of maximal power a particular climb is performed. He concludes that Nibali needs to ride full climbs at 91% of his maximal power, while Péraud would be riding at only 85% of his max power. Because Ross leisurely plays around with parameters such as supposed VO2max and efficiencies between 23% and 25%, and because he does not take into account the different aerobic/anaerobic balance between riders, I propose a slightly alternative way of looking at plausibility.
What we need is:

The energetic equivalent of 1 liter of oxygen consumption. This number depends a little on the fuel being burned. Because high-intensity efforts will dominantly burn glucose we settle for a value of known value of 20 kJ per liter oxygen.

The energetic efficiency of 23%. We may also settle for a value of 23.5% or any other value but we prefer not to adapt this value to different riders, unless compulsive reasons are given.

Because we use critical power instead of average power, we need to know the relation between CP and VO2max. The best value being found in the scientific literature is 80%. We settle for this value. We are aware that this may be the Achilles heel of the calculations, particularly because this value is obtained in a statistical study of well trained but top riders, but let us go forward.

All together 1 W/kg at CP corresponds to 15.95 ml/min/kg at VO2max.

Let us now look at Péraud. In my analysis he has CP of 5.33 W/kg and thus a calculated VO2max of 85.01 ml/min/kg. Ross states that Péraud has a measured VO2max of 85 ml/min/kg. Too nice to be true?

What about Nibali ? CP of Nibali is 5.50 W/kg, and calculated VO2max of 87.7 ml/min/kg.

CP of Ten Dam is 5.64 W/kg which corresponds to a very impressive and implausible VO2max of 89.9 ml/min/kg

And what about Froome in 2013? CP of 5.16 W/kg, and calculated VO2max of 82.3 ml/min/kg

Once again this calculated VO2max for Nibali is unreasonably high, and even worse for Ten Dam. Clearly there is something wrong with these calculations. Of course now we can adjust numbers, changing the energetic efficiency from 23% or changing the 80% of conversion from CP to VO2max, but numbers are only numbers. For instance Ross proposes to anchor sustainable intensity at 85% of VO2max. In this case all computed VO2max are reduced, and Nibali would come down to 82.5 ml/min/kg. Setting his efficiency at 23.5% would reduce his VO2max further to 80.8 ml/min/kg. Let us also have a closer look at Ten Dam. He has an extremely low AEC which means that the power he delivers at volitional exhaustion is almost entirely delivered by his aerobic metabolism. A rider with zero AEC has no type II anaerobic fast twitch muscle fibers, cannot ride above his CP but is also virtually inexhaustible, such as is the case for the stern, as bird that could fly around the earth if it had not to land for food. In our analysis Ten Dam has a CP of 5.65 W/kg and if we accept 90% conversion of CP to VO2max, we arrive at VO2max = 79.9 ml/min/kg. From private communications we know that the highest value ever measured in physiological test for Laurens Ten Dam was VO2max = 80.7 ml/min/kg
A discussion of the physiological plausibility, i.e. the possibility of a clean performance, thus depend essentially on the knowledge of VO2CP, the oxygen consumption at CP, the maximum consumption VO2max and of the ratio between these 2 quantities. At the actual state of our knowledge we can only situate this ratio between 80% and 90%, and it depends strongly on the anaerobic capacity of each individual cyclist.

As long as no precise data of efficiency and the relation of VO2CP to VO2max are available for each rider, the physiological plausibility of performance belongs to the realm of speculation.