Performance Products: Exploring Crank Length - Is “Tradition” Limiting Performance Gains?

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“Performance Products” provides the fitness marketplace the opportunity to link their products’ “unique selling points” that sets them apart from others and how these unique selling points benefit the cyclist to improve performance and/or prevent injury. We hope you enjoy this series and would appreciate your comments and ideas.- Ken Kontor condpress@aol.com

**Tradition:** 1: a: an inherited, established, or customary pattern of thought, action, or behavior  b: a belief or story or a body of beliefs or stories relating to the past that are commonly accepted as historical though not verifiable
2: the handing down of information, beliefs, and customs by word of mouth or by example from one generation to the next.
3: cultural continuity in social attitudes, customs, and institutions
4: characteristic manner, method, or style

Is tradition limiting performance in cycling? I think so and I am going to tell you why. First, let’s see if we can agree on a few axioms about bicycle racing.

1. Aerodynamics matter, especially in events like the time-trial.
2. The most important element in determining aerodynamic drag is the position of the rider and the frontal area presented by the rider to the wind.
3. For most frontal area is first and best reduced by lowering the head/shoulders.
4. The rider will go fastest when there is the optimum combination of aerodynamics and power. I think everyone can agree with those statements.

So, how is tradition holding us back? A 50 cm frame for a 5’ woman traditionally will come with a 170 mm cranks. A 60 cm frame for a 6’ 4” man will traditionally come with 175 mm cranks. A 20% variation in frame size but only a 3% variation in crank length! When it comes to crank length are we in a “one size fits all world?”

We all learned to ride on the cranks that came with our first bike and we now feel comfortable and powerful with what we are used to even though the “one size fits all sizing system” seems to make no sense compared to all the other tweaking we do. We all like what we are used to, our own personal tradition. Those bike builders must know what they are doing, right? And, long cranks are “manly”, while short cranks are for kids, right?

How did 170 mm crank length come to become the traditional standard? Does anyone know? I believe it evolved in the era of penny farthing racing where this crank length combined with the large wheels of the time provided the best combination of acceleration and top speed under those specific racing conditions. Is that still valid in 2012 where gearing is easily...
and reliably changed on the fly and aerodynamics has become so important to race performance?

This article is directed to a group of coaches. Most of you have some formula that you use now to determine optimum crank length and most are based on femur length, leg length or some other size metric but rarely does that formula take you wildly away from the 170-5 mm nominal length. You believe the formula you use to be correct and will give you the athlete’s optimum crank length within a few mm. Have you ever really thought about how any of these formulas were determined? What science supports your formula as being best? Exactly what are we trying to optimize anyway? Is there a better way?

A couple of years ago I started thinking about optimizing aerodynamics. Most riders have terrible aerodynamics because they lack the flexibility to get very low in front and I was thinking that if we had shorter cranks, the knee at top dead center would be further away from the chest, making it easier to put the rider into a better, lower, aerodynamic position. But, the question came up, “How short can one go on the crank before one starts to lose significant power to negate any aero improvements that might occur?” Investigate that question and you will find there has been only one good study looking at this question and this study concluded that power didn’t drop until crank length dropped to less than 145 mm. ([Martin JC, Spirduso WW, Determinants of maximal cycling power: crank length, pedaling rate and pedal speed. Eur J Appl Physiol. 2001 May;84(5):413-8](https://doi.org/10.1007/s004210100716)) Here is the figure from this study that best shows these results:

Unfortunately, even though power was highest at 145 mm Martin concluded that because the power wasn’t “significantly” higher at 145 mm it was ok for riders to use their traditional crank length. I, for one, would have concluded that this finding needed more study because, in racing, even a 1% difference might be important. Further, he based his conclusion considering maximum power alone, since that is all the study evaluated. His conclusion did not take into account the effect of upper body position on power as it relates to crank length or the potential effect of better positioning possible with shorter crank length on aerodynamics.

Based upon this study, and its shortcomings, I started exploring this question and made cranks that could adjust to as short as 145 mm. I easily adapted to riding 145 mm cranks within a week and I found the shorter length made it much easier to get into a good aero position. I shared my thoughts to a sponsored triathlete, Courtney Ogden, and he decided to try this, spent some time training with 145mm PowerCranks and liked what he saw. then found some 145 cranks on the internet. He raced and won Ironman Western Australia 6 weeks after making this change on 145 mm cranks he bought on the internet for $22.

Despite this success, I kept wondering what the the limit really was because I felt position probably had a big effect on how crank length affects power, especially when riding in the aerodynamic position. So I made some prototype cranks to allow experimenting all the way down to 90 mm crank length (I couldn’t imagine anyone would find 90 optimal but I have since changed my mind). I started talking this up to our pros and other experienced riders to see if I could find any willing to really experiment with this to see what we would find. A few took me seriously.

Now, after a year of this I am starting to get some data from several users and here is what is being reported on average. First, the vast majority of those trying this have settled on a crank length between 110 and 130 mm as being optimum for them. This includes all kinds of racing from aerodynamic intensive TT type events to power intensive climbing events. Second, adaptation to these shorter lengths occurs very quickly, especially if the change is not so great, but is usually complete within a month even at the very short lengths. Third, when these cyclists try to go back to their previous “normal” lengths they find them difficult and strange.

When talking about this with others I am occasionally asked if we are finding any relationship between optimum crank length and leg length or femur length. I do not have enough data to answer that question. But, I think any leg length correlation is going to be related to another more important metric that is easily measured which I will shortly get into.

So, how do we explain this finding when “everyone” knows we will be losing all that leverage associated with a longer crank length? Why isn’t the extra crank arm leverage seen with longer cranks important here? Why doesn’t the loss of crank arm leverage associated with shorter cranks result in power drop? I see two explanations.

1. The loss of leverage associated with a shorter crank is easily made up for by changing the leverage in the gearing because it is the total leverage between the pedal and the tire that really counts. Power is simply average force on the pedal for an average pedal speed. Pedal speed can be kept the same by increasing cadence and, even if pedal speed ends up lower, a lower pedal speed makes it easier to apply more force to the pedal.
2. But, there is another lever that most forget about when doing this analysis - the knee. The more one bends the knee the more leverage is lost and the less force the rider can apply. Can you lift more weight from a full squat, half squat, or quarter squat position? Or, ask yourself this, if an athlete is given the option of freely choosing the best knee range of motion for maximum sustained power what would they choose? Well, this is done all the time by athletes when they are on the Stairmaster. Watch the freely chosen stair height used by most when using a Stairmaster. It is not the 14 inches dictated by 170 mm cranks but usually more like 5-6 inches. This height differential probably better represents the best range of motion of the hip and knee for maximum sustained power production than what we have come to expect when riding a bicycle. Causing the knee to bend too much causes the cyclist to lose power. That is what our early data seems to suggest and I think knee bending is a better metric of best crank length over those old formulas using leg length metrics. The only problem is I don’t know what that optimum number is but I believe if the knee is bending beyond 90-100º one is probably on cranks that are too long for maximum efficiency. This needs to be studied by someone.

I have amassed enough empirical data to convince myself I am on to something but I cannot prove my hypothesis scientifically. But, if I am right, and you don’t start investigating this for yourself then you and your athletes are potentially going to be left behind by those who do. I hope there is enough here to get you seriously thinking about this. Don’t forget, the Olympics are coming up this year!

Now, I do see several complicating factors that may make my results different from what others may have seen in the past (Martin) or that you may see if you look into this.

1. All the people we have asked to try this are well trained on independent cranks (PowerCranks, independent to teach circular pedaling technique) before starting this experiment and have been doing this experiment on independent cranks. This forces them to completely unweight on the back stroke and we have found that shorter cranks seems to facilitate applying power on the backstroke. It may be that “mashers” (those who do not do much on the backstroke) may not be able to go as short as we are finding (as found in the Martin study). After all, we are limited in how hard we can push so perhaps to go very short requires doing more work around the rest of the circle, something a trained PowerCranker is well trained to do. Even if this explains how our athletes are getting down to crank lengths of 100 mm without losing power I would still expect everyone to benefit by going shorter, the only question being how short is optimum for each person? At the present time the only way to know what is best for each rider is to experiment.

2. The Martin study only looked at one rep maximum power. I am coming to the conclusion that the longer one needs to sustain power the shorter the optimal crank length. Most of the riders who are testing this for me are endurance and ultra-endurance riders. This difference is another possible explanation as to why my riders are finding power maximizing in the 100-130 range while Martin found it to be maximum at 145mm. I now believe that, everything being equal, a sprinter will probably have a longer optimal crank length than a time-trial specialist.

3. It is probably a combination of both 1 and 2 above that are accounting for our findings being so short compared to Martin’s findings.

4. There is one more issue that keeps many who I ask to try this from moving forward. That is the ready availability of short cranks. The major players in this game (Shimano, Campagnolo, SRAM, etc.) do not make cranks shorter than 165. All I can say is if that is your reason for not trying this then you are letting others limit your potential. Shorter cranks are available. You can be assured that If there is a demand for shorter cranks in the future these manufacturers will eventually make them.

OK, so now I have, hopefully, piqued your interest and you would like to experiment with this yourself to see if this change might benefit you or your athletes. I am frequently asked, how would I test this myself, especially if I don’t have any of your adjustable PowerCranks? Here are two protocols I would recommend, one for those doing this experiment on PowerCranks and one for those using regular cranks. When doing these experiments be sure to adjust seat height appropriately as you change the crank length to keep knee angle at BDC the same. Do not change handlebar height during this phase of experimenting - many mistakenly believe that one must raise the handlebars as one raises the seat with shorter cranks but, in fact, shorter cranks make it impossible to lower the handlebars as one raises the seat but that comes later. OK, on with the protocols.

1. PowerCranks protocol. I recommend that new users start at 130 mm (or as short as they will go if your cranks are not fully adjustable). This shorter crank length greatly facilitates the transition to the “circular pedaling” style that PowerCranks require while not being so short and “strange” as to be impossible to adapt to. As soon as one can start doing regular rides at power then one can start experimenting with either longer or shorter cranks to see what happens to power and efficiency. (Most elite riders should be there in a couple of weeks.) I think the best metric to look at is what happens to the heart rate (HR) at the same power or what happens to the power at the same HR during testing on the various crank lengths. Give yourself several
days of training at the new crank length, to adapt to it, before doing your testing. 10-20 mm changes are not too severe and I believe will allow you to get very close to knowing what your optimum is (at least at this point in your training) within just a few weeks. The protocol should probably be repeated regularly as one develops the PowerCrank pedaling motion more fully.

2. Regular cranks protocol. You will need an assortment of regular cranks of varying sizes. These are readily available on the internet, one source being Bikesmith Design and Fabrication. They offer cranks as short as 90 mm. Now, none of this going from 175 to 170 stuff, that is too small a change to really detect much benefit so you will be wasting your time and money. Start with a crank length 20-25 mm shorter than what you ride now (145-150 mm crank length for most) and spend a week or so on them and then test to see if your power has changed at the same HR or HR has changed with the same power. If you don’t see any big drop off then get a shorter crank still and repeat the trial. Repeat until you see a big drop off in power. Your optimum crank length will be close to the previous length tested then you can do “fine tuning” if you desire. You should be able to achieve this in 4-6 weeks at a minimal cost.

One more thing to do. Once you have found how power/HR varies with crank length then go out and measure your speed with the smallest best combo and I will bet you find you are faster than you used to be at the same power (even if the power is down slightly). This improvement is simply from the naturally better aerodynamics that occur as the seat moves higher and the pelvis is moved more into the wind shadow of the chest/shoulders. But, the next thing to do is to try to lower your handlebars to see what happens. You will be surprised how easy it is to lower the handlebars substantially, beyond where you are now, and still maintain good power because the knee is now further away from the chest at TDC because of the shorter cranks. (If you are the exception and already have an excellent aerodynamic position you will probably notice an improvement in power with this change.) The picture represents the actual change in race position pro triathlete Courtney Ogden was able to make after moving from 172.5 to 115 crank length. Note his seat is higher and his handlebars lower with the shorter cranks. Does anyone not see the improved race potential from this change if power is essentially the same? Courtney thinks this lower position is saving him about 20 minutes over the Ironman distance, taking him from an approximate 4:50 to 4:30 bike split potential for the 112 miles.

A couple of things to watch out for when making this change.

1. One cautionary note when doing this. While we have not seen any major injury issues from people making this change, our numbers are small and everything is possible when changing the pedaling dynamic. Listen to the body and slow the process down if twinges are being felt. Most will adapt rapidly but don’t try to do too much too fast if something is telling you to slow down.

2. Another potential issue, this can change bike handling because bringing the head down also brings it forward, moving the center of gravity forward, putting more weight on the front wheel and less on the rear. Another elite triathlete tells me he saw zero drop in power as he went shorter but as he went shorter than 135 mm he started having trouble using the rear brakes without losing traction, so he has stopped there. I suspect this issue can be mitigated with some fit tweaking but right now he is content with his cranks only being 40 mm shorter than they were last season. After only 8 weeks of experimenting he writes: “I am completely adapted to riding short right now and love it.”

In summary, I am very excited as to the possibilities shorter cranks offer the cyclist and in potentially helping them to get beyond the limitations “traditional” crank lengths place on the athlete. Beyond what is discussed above, shorter cranks have other potential positives. For example, shorter cranks offer increased ground clearance for cornering or in rough terrain. Another possibility is to build a bike with a lower bottom bracket in order to lower the center of gravity of the rider to enhance cornering on the track (we know of one person exploring this possibility now).

So, is tradition limiting the performance potential of cyclists? I think I make a pretty good argument that it is.