Pedalling Efficiency

Steve Hogg explains the ways you can become super efficient on the bike.

When Editor Simon asked me for an article on the subject of Pedaling Efficiency, my first thought was "He must think I know something that I don't. Some trick of technique to turn a mug into a champion". Well, I don't, but on reflection there are many factors that contribute directly and indirectly to pedaling efficiency. They fall into 2 broad categories; Body and Equipment. Those two categories can be further subdivided into

BODY
Posture
Functional Stability
Flexibility
Bike Position
Technique

EQUIPMENT
Crank Length and design
Pedal Type
Cleat Position
Shoes
Correction

If I work through that list above, maybe we can gain a few insights that will enable us to perform that little bit better.

BODY

Posture

When was the last time you thought about gravity?

Not recently I'll bet. Gravity is omnipresent so we tend to forget about it. Yet over time, that constant downward pressure on our bodies, combined with poor habits pushes us into our own personal version of postural dysfunction. Poor posture equals poor ability to apply and sustain the application of force because poor posture equals less than ideal neuromuscular function.

Okay, on a bike we call posture "bike position" and we can manipulate the relationship of the contact points; seat, bars and pedals, to force us into a position or posture on the bike. But there is no getting away from the fact that poor posture off the bike leads to poor posture on the bike.

Ideally when standing and as viewed from the side, good posture means that the centre of the ear, centre of the shoulder, centre of hip and centre of the lateral malleolus (bony protrusion on the outside of the ankle) should be in a vertical line. It is an interesting exercise to have a friend stand side on to you and then to plot the relationship of those four points. A common pattern of postural dysfunction is where the centre of the ear is forward of the centre of the shoulder, which in turn is behind the centre of the hip, which is then in front of the centre of the lateral malleolus. While this is common, there are plenty of others patterns of poor posture..

Posture equals strength because good posture allows the central nervous system to work efficiently which is a precondition of having our muscles work efficiently. So stand tall and sit tall and remind yourself to do so during the day. Eventually, it becomes a habit to catch yourself when you fall into poor postures. Standing tall and sitting tall is a basic and important exercise that you can do every day at almost any time.

Functional Stability

When applying force to the pedals, we need a solid foundation to push from. A lot of people equate this possession of a good foundation with 'core strength'. Not so. Daily I see people who display quite impressive ability to stablise their core in a static situation but who completely lose that ability as soon as they move or apply force. What we need to maintain that solid foundation to resist pedaling forces is core strength during motion; in other words 'functional stability'.

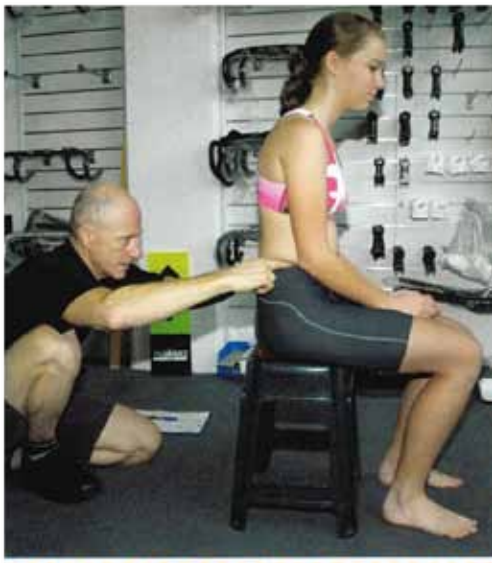
On each pedal stroke we want our legs to alternately exert significant forces on the pedals while the pelvis that the legs are connected to remains motionless or near motionless. If the pelvis rocks unnecessarily, the torso moves from side to side or bobs up and down, the muscles of the arms and shoulders need to work to control that torso movement and so on. None of this can happen without diminishing performance and increasing the risk of overuse injuries.

So there is a performance dividend in developing proper functional stability. The best and most accessible book on the subject that I have seen is "Sport, Stability and Performance Movement" by Joanne Elphinston. Any cyclist who is serious about performance should have this book on their reading list.

Flexibility

To perform well on a bike, we need reasonable flexibility. Why?

Tight muscles are weak muscles that have less contractive force. Tight muscles also restrict opposing muscles via a process called 'reciprocal inhibition' A common example is as follows. A large percentage of the population have tight hip flexors (hip flexors are a group of muscles that lift the upper leg, or if the legs are fixed, help bend the torso forward) because of poor posture and the effects of living in a chair bound society.



Checking to determine if both sides of Nikki's pelvis are the same size.

Tight hip flexors reciprocally inhibit the gluteus muscles(buttocks) The glutes are the largest and strongest muscle group in the body and on a bike, are the prime extensor of the hip (move the upper leg, our primary 'lever' down). Many, many riders have tight hip flexors and glutes that function poorly and so will always perform suboptimally.

This doesn't mean that they can't ride a bike though. Help is at hand because our bodies are brilliant at finding a way to perform a set task despite less than optimal function. Our quadriceps, the large muscles at the front of the upper leg, extend (straighten) the knee. Additionally, the feet are fixed into the pedals. That means that even with weak, dysfunctional glutes, the act of straightening the knee while there is a pedal to push against, will help generate movement at the hip, even with little or no activation of the glutes. But nothing is for free. This can only happen by localising much of the load to the quads. The rider will generate just as much power as would otherwise be the case despite poor flexibility and dysfunctional glutes, but will not be able to sustain high output as long as would be possible if the load was spread over a greater area of musculature. To do that, many riders need to be more flexible and hence more functional.

That is just one example. There are many others.

Then there is air. Wind drag is the greatest force that needs to be overcome in an effort to propel a bike. Wind drag increases as the square of the increase in speed. Translation: doubling speed means quadrupling power output. That means there is a performance pay off if we can gain a more aerodynamic position on a bike because there will be less wind drag, but the kicker is this. If you try and force yourself into an aerodynamic position that you cannot comfortably maintain, the price you will pay is increased chance of injury and diminished ability to breathe and apply force to the pedals over time.

No one needs to have the flexibility of a gymnast or yogi to ride a bike efficiently, but we do need an adequate range of motion in all of our major joints. Unfortunately, adequate flexibility means above average flexibility because the average in our society is very poor.

A simple, effective and well laid out book to look out for is "Flexibility For Cyclists" by Fred and Kele McDaniel. If you have extreme problems with flexibility, try "Overcome Neck and Back Pain" by Kit Laughlin

Bike Position

A good bike position is one that allows the rider to devote the greatest effort to propelling their bike while devoting the minimum effort to maintaining their position on the bike. How is this possible? A simple explanation is this. Our surface muscles can be broken into two categories; muscles that act posturally and muscles that act phasically. Muscles that act posturally allow us to hold a position, resist gravity and play a major part in breathing. In contrast, muscles that act phasically are the power producing muscles that we use to propel the bike.

For best performance, we need to prioritise the power producing phasic musculature but there is an inherent issue with this and that is our central nervous systems give absolute priority to the muscles that act posturally. That means that the only way that we can prioritise the muscles acting phasically is to minimise the enlistment of the postural muscles. On a UCI legal road bike, the only way to do this is to position the seat at the minimum distance behind the bottom bracket that allows the rider to cantilever their torso out from their pelvis without unnecessarily activation of the arms and shoulder complex to support that weight.

In short, the position should be largely self supporting. Above I said that this is the simple explanation and it is because other factors play a part too, like cleat position, bar position and particularly how functional the rider is. Many riders are so dysfunctional that they will always need to use the arms and shoulders at some level to maintain stability on the bike. In their case, they should strive to come up with the best achievable compromise and work to improve their posture, functional stability and flexibility.

Technique

Is there a pedaling technique that is best?
Should we drop our heels more as I hear people being advised?
Or should we imitate the action of scraping mud off the sole of the shoe as I have also heard advised?

I don't think it really matters. If you look at old video footage, Jacques Anquetil used to pedal with his toes pointed down even on steep climbs. In contrast Eddie Merckx used to slam his heels down forcefully. Meanwhile Bernard Hinault exhibited a middle of the road technique. Each of these were great riders in their eras and won most races worth winning which leads me to believe that there is no particular pedaling technique that is a defining characteristic of cycling excellence. While I won't say that pedaling technique can't be trained, many attempts to do so break down as soon as the rider is under high load and heart rate. Under those conditions, riders tend to do what comes naturally to them. Philosophically, I think it is better to accept what comes naturally and refine whatever that technique is by riding a lot. What results is probably the ideal technique for that rider and takes into account the position that they hold on the bike, the cleat position that

Speedplay Zero pedal and cleat system.

they use and the degree of neuromuscular function that they possess.

It is better to set yourself a set of positional parameters that you are happy with and then get on your bike and do the kms. What pedaling technique results is likely to be the most efficient one; at least in your case and in your bike position.

EQUIPMENT

Crank Length and design

Power is torque x rpm. Torque is the pressure you can exert on the pedal x crank length. Does that mean that we can increase our torque by increasing our crank length?

Yes.

Doesn't that mean that we will perform better?

Not necessarily.

For the sake of argument, let's assume that you are using a 170mm crank and you increase crank length to 175mm. To maintain the same overall seat height, you will need to drop the seat post 5mm into the frame to compensate for the extra crank length. There will be two consequences that flow from this change.

Firstly, the knee will rise 10mm higher at the top of the stroke. 5 mm of that is because of the extra crank length and the other 5mm is because the seat post has been lowered 5mm. This increased bend in the knee at the top of the pedal stroke increases the shear forces on the knee. This means that the upper leg is trying to slide forward over the lower leg. Too much shear force equals pain and injury and this is one factor that can potentially limit crank length.

The second consequence is that with that increased knee bend at the top of the pedal stroke, the longer crank arm has to move further past top dead centre before the rider can extend the knee enough to get over and behind the pedal axle to push it forcefully forward and down. What this means is a longer crank length does increase peak torque but also lessens the number of degrees of crank arm arc that the rider can exert force through. Cranks are available in 2.5mm increments; an approximate change in length of 1.4%, so it is unlikely that increasing or decreasing crank length by 2.5mm is going to damage a rider or massively increase their performance. I've noted over years that shorter legged riders can comfortably ride a longer crank in proportional terms than longer legged riders. There is great individual variance though and ideal crank length is not closely related to leg length. Flexibility, ratio of upper leg length to lower leg length, foot size, type of riding and other factors all play a part. The best advice I can offer is that if you are in doubt about what crank length you should be using and are trying to decide between 2 lengths, it is probably better to err on the side of conservatism. So if in doubt, shorter is probably a better long term proposition than longer.

Another factor that can play a part in pedaling efficiency is chain ring shape. This requires some explanation. A round chain ring has the same amount of teeth engaged no matter what the orientation of the crank arm. Oval chain rings allow more chain ring teeth to be engaged when the crank arm is in the high leverage position close to horizontal and a lesser number of chain ring teeth to be engaged when the crank arm is in the low leverage position close to vertical. The idea is to prolong the duration of the high leverage part of the pedal down stroke and to lessen the time spent in the low leverage 'dead zone' at and near top and bottom dead centre.

The problem to date with oval chain rings is one of phasing. Not everyone develops power on a bike in the same way. If you liken a pedal stroke to a clock face, in simple terms, the further back a given rider sits, the earlier after 12 o'clock they will be able to apply significant force to the pedals but the earlier they will lose the ability to do the same. The

CREDITS

BICYCLING AUSTRALIA

Issue No. 162 | March • April | 2010

Lake Wangary Publishing Company
PO Box 218, Port Kembla NSW 2505 Australia
Editorial Phone: (02) 4274 4884
Editorial Fax: (02) 4274 0988
Editorial Email: editorial@bicyclingaustralia.com

Founding Publishers Phil & Catie Latz
mail@bicyclingaustralia.com
Publisher Gary Hunt
gary@bicyclingaustralia.com
Editor Simon Hayes simon@bicyclingaustralia.com
Technical and Products Writer John Hardwick
john@bicyclingaustralia.com
Production Manager Nicole Lancaster
nicole@bicyclingaustralia.com
Production Coordinator Joanne Anstee
joanne@bicyclingaustralia.com
Graphic Designers
Nicole Lancaster - nicole@bicyclingaustralia.com
Tim Nightingale- tim@bicyclingaustralia.com
Photography Graham Watson, John Hardwick, Simon Hayes, Tim De Waele, Cor Vos, Jose Mendez, Jerred Gruber, C.J. Farquharson, Mark Gunter, Steve Hogg
Contributors Greg Griffiths, Adam Hansen, Susie Burrell, Matt Bissett-Johnson, Belinda Goss, Brad McGee, Peter Rox, Michael Hanslip, Anthony Tan, Rowan Dever, Emily Williams, Chloe Hosking, Matt Bryant, Jose Mendez, Nicole Lancaster, Mark Renshaw, Jerred Gruber, Steve Hogg
Proof Reader Jody David
Advertising Sales Manager Ben Chand
ben@bicyclingaustralia.com
Advertising Sales for Taiwan and China
Infotrade Media
Phone: +886 4 2249 2199, Fax: +886 4 2249 2197
Email: service@trade-eye.com, Web: www.trade-eye.com
Subscriptions Manager Genevieve Nightingale
subs@bicyclingaustralia.com
Online subscriptions via www.bicyclingaustralia.com
Freecall 1800 061 577
Phone (02) 4274 4884 Fax (02) 4274 0988
Printing Webstar
Distribution Australia: Gordon and Gotch.
New Zealand: Gordon & Gotch.
International: Pansing IMM www.pansingimm.com

Bicycling Australia is published six times a year in January/February, March/April, May/June, July/August, September/October, November/December.

ISSN No 1034-8085
Editorial contributions are welcome. Email is preferred, send it to: editorial@bicyclingaustralia.com. If posting, please include a stamped and self-addressed envelope and post to:
Bicycling Australia, PO Box 218, Port Kembla NSW 2505

Publisher's note
This magazine is dedicated to the glory of God

Don't associate with evil men: don't long for their favours and gifts. Their kindness is a trick; they want to use you as their pawn.

Proverbs 23:6
Living Translation

White leg length shims installed to compensate for limb length difference.

further forward they sit, the later after 12 o'clock they will be able to apply significant force to the pedals but the later they will run out of steam. The currently popular Rotor Q rings have many more than the standard 5 chain wheel mounting holes. That means that orientation of the ovalisation of the chain ring can be altered in small increments to best suit the position and power production pattern of a given rider. Other factors aside from seat set back play a part in an individual's pattern of power production but the use of Rotor rings allows this to be optimised to varying degrees.

It is rare to find a rider who uses Rotor rings who isn't happy with the change. Don't mistake me. If you are a mug, Rotor rings won't transform you into a champion; but they may make you a better performing mug.

Pedal Type

What makes one pedal better than another? Here's a wish list of features for an ideal pedal.

1. Easy to enter and exit
2. Double sided
3. Separate lateral and rotational adjustment
4. Multiple axle lengths
5. Adjustable rotation
6. Plentiful fore and aft adjustment
7. Low stack height

There is only one brand of pedal that fulfils that list and that is Speedplay. A quick critique of major pedal systems.

Look Keo: For – 0 degrees, 4.5 degrees and 9 degrees cleat options. This range, combined with ability to twist the cleat means that it is unlikely that the correct rotational angle can't be achieved.

Against – Newer cleats with rectangular washers have limited for and aft adjustment compared to earlier versions. Limited lateral adjustment which is combined with rotational adjustment. This means that in cases where the cleat is rotated near its adjustment limit then there is zero ability to adjust the cleat laterally. Only one axle length

Shimano Spd SL: For – Well made, durable, good value, pedal system with relatively long lasting cleats. Good fore and aft adjustment potential

Against – 0 degree and 4.5 degrees cleat options only. Also combines rotational adjustment with lateral adjustment but offers more of it than Keo. Could use a 9 degrees cleat option. Minimum spring tension too high for easy entry and exit for many small women. Only one axle length

Time: For – Plentiful rotational movement as well as ability to rotate the cleat. Good fore and aft adjustment. Ease of entry and exit. Some lateral adjustment potential by swapping left cleat to right shoe and vice versa. Even less expensive models are lightweight.

Against – Rear most two cleat screws don't use washers making it easy to over tighten them. Only one axle length.

Keywin: For – 5 axle lengths, very good fore and aft adjustment, super smooth bearings, lightweight, track option.

Against – Limited rotational adjustment

Speedplay: For – Three pedal families with differing qualities of ease of entry and exit and range of rotational adjustment. Separate lateral adjustment from rotational adjustment. Track option. 5 axle lengths. Optional base plate that increases range of fore and aft adjustment .Double sided entry

Against – Fiddly to set up properly. Expensive, heavy cleats (engagement mechanism in cleat rather than pedal)

Basically, all of the pedals above work well. Just some work better for a wider range of riders than others. For instance; we have all seen riders who pedal with their knees further out than their feet because they are inflexible in the hips and lower back. This technique leads inevitably to knee problems unless the feet can be moved outward to a position under the knee. Have a look at the average age of many bunches and it is not young. I think the least large pedal manufacturers can do is offer a choice of axle lengths.

Cleat Position

Put simply, the shorter and more intense the pedaling effort, the further forward the position of the cleats should be. The longer and more sustained the pedaling effort, whether of high or low intensity, the further back the cleats should be. There are good reasons for this and or more detail see "Footloose" in the September / October 2008 edition of BA. For the common club crit and shorter road race rider, position the cleat so that the centre of the 1st MTP joint (ball of the foot) is over or slightly in front of the pedal axle and point of greatest heel drop under severe load. Rule of thumb recommendations are as follows.

Shoe size 36 - 38: centre of ball of foot 7 – 9 mm in front of the centre of the pedal axle
Shoe sizes 39 - 41: 8 – 10 mm in front
Shoe sizes 42 - 43: 9 – 11 mm in front
Shoe sizes 44 - 45: 10 – 12 mm in front
Shoe sizes 46 - 47: 11 – 14 mm front
Shoe sizes 48 - 50: 12 – 16 mm in front

All measured with the shoe leveled from where the sole joins the upper under mid heel to where the sole joins the upper at the area of cleat attachment.

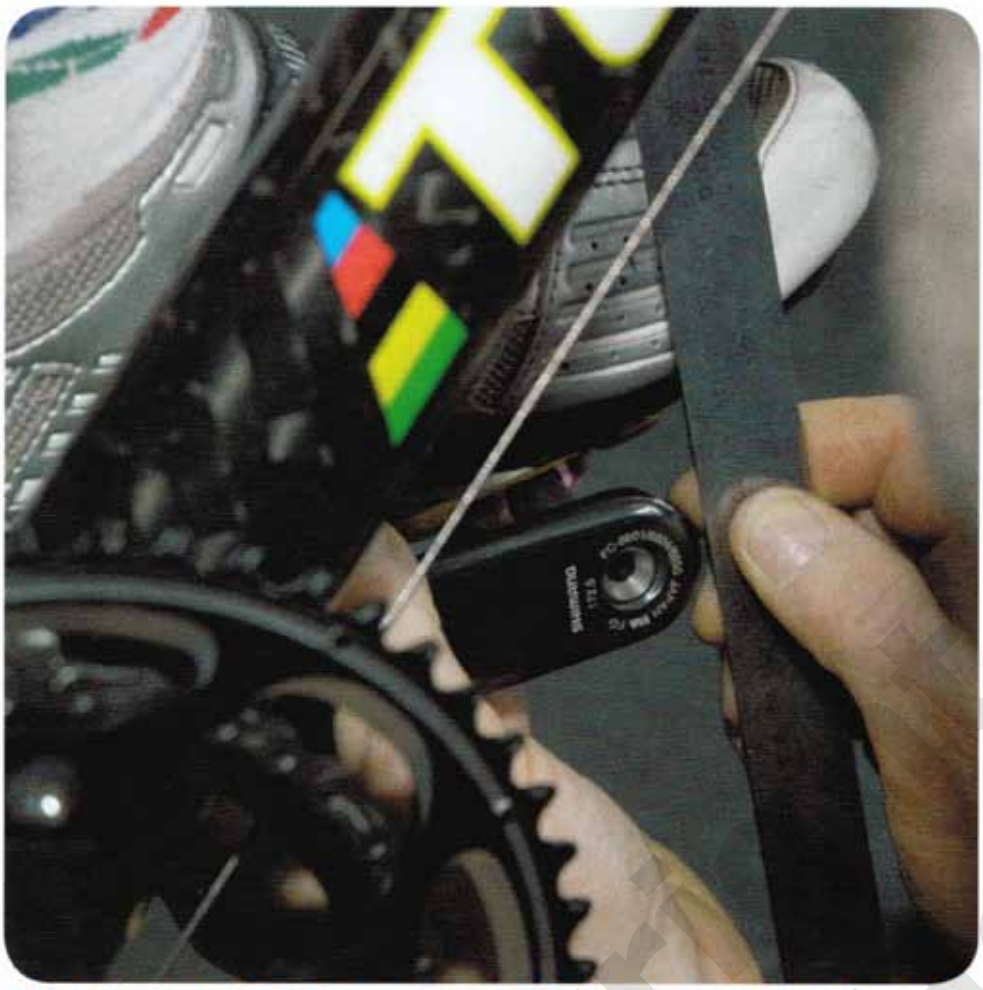
For the dedicated distance rider; Audax, 24 hour mtb'er or similar as well as TT riders, mid foot cleat position is an option well worth considering, but no large manufacturer is currently making shoes that allow this type of cleat position without substantial modification.

Shoes

Most cycling shoes now have relatively low heel lift lasts; a good thing, but there is some variation in cleat mounting hole positioning. The brands that have generally the best cleat mounting hole position are, in no particular order: Shimano, Gaerne, Sidi, Diadora, Bont and Specialized. Northwave and Louis Garneau used to have quite forward placement of the cleat mounting holes but from the small sample of recent models that I have seen, this appears to be changing.

If you have a pair of shoes that doesn't allow you to get your cleats back far enough, you need to change them to shoes that do or change your

These two pictures show how a wedge is installed & the difference it can make to the way your shoe sits on the pedal.



Checking fore and aft position of cleats is essential.

pedals to Speedplay and use the alternative base plate, part no. 13330.

The other issue with shoes is how well they fit. A shoe should be an extension of the foot and there should not be movement between foot and shoe. This has to be accomplished comfortably. Too often I see people in ill fitting shoes because they have wide feet and have gone up one or two sizes in length in an effort to gain width. The problem with this is that a larger size shoe has cleat mounting holes further from the heel than a smaller size and so cleat position is often problematic. Shimano make several models in an E fitting and Sidi make a couple in their Mega triple E fitting. For those with hard to fit feet, a custom shoe may be necessary for best performance. A shoe should fit snugly, particularly at the heel, but must allow some toe wiggling room with out any sense of lateral compression of the MTP joints (base knuckle of toes).

Correction

By correction I mean wedging to alter the cant of the foot and / or shimming to compensate for a functional or measurable leg length discrepancy. This has been my major area of interest for several years and the research that I have been doing can be summed up as –

Just over 99% of riders should be using cleat wedges under one or both cleats and that almost 76% should be using a shim of some size under one cleat. Keeping this brief, the explanation is as follows.

I can demonstrate that better than 99% of riders have clear proprioceptive awareness of all the major joints involved in pedaling a bike (hips, knees and ankles) but not of the feet. Proprioception is the central nervous system's awareness of the body in space and it is immensely important in terms of performance and injury prevention, that the motor control and movement integration centres of the central nervous system have clear awareness of the feet through which we transfer power to the bike. Lack of clear awareness of the feet doesn't prevent anyone from riding a bike but it is a major trigger for increased asymmetry of technique and a major contributor to overuse injuries because of the patterns of compensation that riders' autonomically evolve to try and work around this lack of proprioceptive clarity.

The solution is to use BFS cleat wedges as a corrective medium. Done properly, and for 100% effectiveness, the amount of wedging has to be within 1 degree of ideal for that rider, then clarity of proprioceptive awareness is restored. To digress briefly. Recently I gave an address on this subject at the TDU Sports Medicine conference and both the subjects used showed a marked tendency to drop and rotate their right hips forward on each right leg pedal stroke. This is a common pattern of dysfunction. In each case this caused the left leg to over extend, the right leg to under extend and the poorly controlled, asymmetric pelvic movement was obvious to all. Post wedging, both riders still showed the same basic pattern of dysfunction but this was lessened by 90% or so. The amount of extraneous pelvic movement had gone from gross and obvious to perceptible but minor. Any lack of full awareness of what the body is doing in space under load leads to an increased tendency to favour one side. The correct number of BFS cleat wedges resolve or markedly improve this situation.

The same research also tells me that nearly 76% of riders should be using a shim, sometimes of as little as 2mm. One of the major things required of a rider for best performance is as high a degree of functional symmetry on a bike as possible. The rider should sit as squarely as possible on the seat and have both legs reaching through the bottom of the pedal stroke as fluently and evenly as possible. Because of limb length differences and differences in patterns of tightness between right and left sides, the majority of riders need some sort of shimming under one or the other cleat to help alleviate the feeling of having one 'strong' leg and one 'weak' leg.

Conclusion

As always, lack of space means that articles of this type have to be more general than I would ideally like. However, I hope there is enough here to get a few people thinking more critically about pedaling efficiency.

- Steve Hogg