

# A Question Of Leverage

**STEVE HOGG** determines if the foot acts as a rigid lever during cycling and explains what this means for transferring power to the pedals.

Once again we are taking a break out from Steve Hogg's 'Positioned For Success' series of articles to answer a reader's queries on positioning. Steve has a very full schedule and although he takes time out from his cyclefitting business to write articles for *Bicycling Australia* magazine, by the time Steve had answered this and other reader queries and had written 'First Looks' for this issue, his allocated magazine time was up. However, in this article, Andrew Van Essen, a podiatrist and surgeon, queried Steve on some things he wrote regarding the action of the foot in pedalling. Here is Andrew's letter in question and after it, Steve's response.

## Question of Context

Some friends and I were discussing the article by Steve Hogg, 'Maximizing Power Transfer' (*Bicycling Australia* May/June, 2(02) over coffee after our ride the other day, which prompted me to purchase a copy of your magazine that afternoon when I was in one of the local cycling shops. I am a keen recreational cyclist and a podiatrist who specialises in surgery and sports medicine, so I read and reread Steve's article with much interest, but there were a number of things that did not sound quite right.

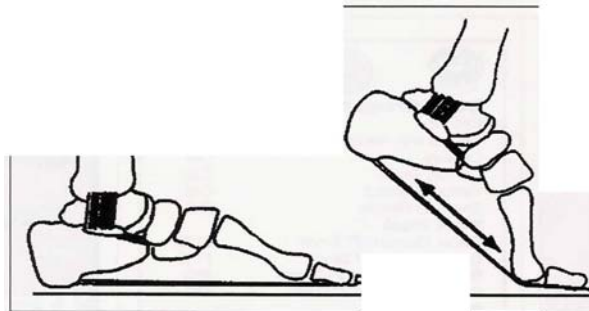
The comment was made that, 'the ankle is more stable in dorsiflexion than plantar flexion'. Steve then extrapolated that, as a result, if we cycle with the ankle dorsi flexed then less muscle power is needed to stabilise the ankle. Steve has unfortunately taken this fact out of context.

Yes, the ankle is more stable when dorsi flexed, but this is in reference to the stability of the lateral ankle joint ligaments, in particular the Anterior Talo Fibular Ligament, and not muscle effort. Minimal muscle effort is needed to stabilise the ankle during cycling as ankle sprains in cycling

are not an issue because the foot is held securely on a pedal and therefore not vulnerable to the forces that would lead to sprains.

Steve's rationale for positioning the ball of the foot forward relative to the pedal axle, to minimise muscle effort required to stabilise the foot and for the use of shoes with lower heel lift, is also flawed. As opposed to what was written in the article, the foot can, and does in fact act as a beam with every step we take.

During walking, when the heel strikes the ground it acts as a mobile shock absorber and then at heel lift, it functions as a rigid propulsive lever. The mechanics of cycling however are more like a running sprint in that propulsion is achieved through the ball of the foot without the use of the heel, so therefore the foot is acting as a beam. To allow the foot to function as a rigid lever one of the main stabilisers of the foot is what is known as the 'Windlass Mechanism' first described by Hicks in the 'Journal of Bone and Joint Surgery' in 1954.



Rigid Lever. The action of the Plantar Fascia Ligament creates the 'Windlass Mechanism' that allows the foot to function as a rigid lever. Illustration: Courtesy of Andrew Van Essen

A ligament called the plantar fascia runs from the toes under the ball of the foot and joins onto the heel. As your heel lifts, this will dorsi flex the toes and tighten the ligament joined to the heel, compacting the joints in between and stabilising the foot so it can act as a beam. This is a passive stabilising mechanism and does not require any muscle effort.

From a biomechanical perspective, cycling shoe manufacturers, the majority of who used a heel lift that reproduces the position of the foot after heel lift and places the toes in a relatively dorsi flexed position, are correct, as this helps stabilise the foot without muscle effort.

As with a running sprint, the power of propulsion will be greatest through the ball of the foot, so cleat manufacturers who also generally recommended placing the ball of the foot over the pedal axle are also correct.

Shoe /cleat / pedal set up is an extremely complex issue and there are many variables to consider and subject to many different opinions and experiences, but the underlying scientific and biomechanical principles of foot and leg function must be considered and understood.

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## Answers and Rationale

Andrew, thank you for your letter. Firstly, a couple of clarifications are in order. One, you have taken the inference that I believe we should all pedal with the ankle dorsi flexed. This is not so. If you had been able to read the subsection of my previous article entitled 'Pedalling Technique'

(*Bicycling Australia*, May/June, 2(02), this would have been apparent to you.

Two, you have taken an inference regarding ankle stability that was unintentional on my part. Upon receiving your letter and then rereading my article, I feel that in the section under the subhead, 'Pedalling Technique Under Load', if I had substituted 'control' and 'controlling' for 'stabilise' and 'stabilising', my meaning would have been accurately conveyed.

In a typical pedal stroke (there are plenty that are atypical), the ankle dorsi flexes near the top of stroke and tips into plantar flexion at some part of the stroke as the crank-arm descends. Sometimes this is accompanied by a momentary slackness or loss of control, which I assume is the talus moving forward rapidly from within the mortise. It is this movement that I seek to better control. Thank you for highlighting my poor choice of words.

However, you raise other issues that I am not in agreement with. Your description of the 'Windlass Mechanism' is as I understand it, and I have no issues with your description, though I do take issue with the context in which you place this description. I am not convinced that the Windlass Mechanism is fully at work whilst riding a bike. Here is an experiment for you - I did it with five people, including me.

Purchase two pairs of MTB shoes. One a sneaker type pair, which is basically a walking style of shoe with a reinforced area in the forefoot to which the cleat is attached. And two, a higher quality pair with a much

more rigid sole. Make sure both fit well so as to eliminate fit as a variable. Place the cleats in the same relationship to the foot in the shoe. Now go and ride each in turn over a variety of terrain and put some effort into it, but stay seated - do not ride off the saddle.

Which feels better? The rigid soled shoe. How much better? Massively better. Yet they are both reinforced at point of contact with the pedal. If the foot, in this example was functioning as a rigid beam as you suggest, then there should be little or no difference in feel. The more rigid sole on the appropriate shoe must be performing a function that the foot is not!

Now, repeat the foregoing experiment, but this time ride off the saddle up the hills and include a few sprint efforts. Which shoe feels better? You will find that off the saddle, there is much less difference. Therefore, I conclude that the compaction of the joints of the foot must be weak or incomplete during the pedalling motion whilst the rider is seated, which is the majority of the time spent on a bike. Because of this I find that your description of the mechanics of the foot as analogous to that of a running sprint to be a poor one --unless the rider is off the saddle.

Your letter prompted me to perform another experiment to quantify something that I was aware of but had never actively measured before, other than on an occasional basis. On all the people that I have positioned since your letter arrived, I have measured the toe lift and heel lift of their shoes. This has been accomplished by the following method:

Get a Look cleat and remove the robber plug so the cleat will not rock on it. Affix the cleat to the shoe in the middle of the range of adjustment. On a Look cleat there is a vertical line that equates with the pedal axle. If the cleat is on a pedal, this line will be above the axle when the cleat is pointing straight ahead. A Look cleat has a rocker to it (curve). Resting the shoe on the flat section of the rear of the cleat I then measured the heel lift using the point where shoe upper meets the sole above the vertical line as a reference. I measured the heel lift at the most rearward point of shoe upper and sole junction and the toe lift at the

**Table: Toe lift and heel lift of some leading cycling shoe brands.**

Shoe Brand	Age of Shoe	Toe Lift	Heel Lift	Rocker
Carnac	8 years	+8 mm	+30mm	38 mm
Gaerne	6 years	+8 mm	+24mm	32 mm
Shimano, nylon sole	6 years	+17 mm	+16mm	33 mm
Shimano, carbon sole	6 years	+14 mm	+17mm	31 mm
Carnac	3.5 years	+12mm	+27mm	39 mm
Shimano, carbon sole	2 years 3	+19 mm	+4mm	19 mm
Sidi	3 years	+15 mm	+4mm	19mm
Sidi	6 months	+15 mm	+4mm	19mm
Diadora	3 months	+14 mm	-3 mm	11 mm

most forward point and added these together to give a total, which I will call the rocker (old surfers will recognise the term and why I use it).

I have chosen size 42 because I saw more of these over this period.

Can you see the pattern here? And it is repeated in the other sizes and brand of shoe as well. If manufacturers are reducing the factors in shoes that allow the foot to function as a rigid beam, has anyone noticed a drop off in performance or an increase in injuries? I can only speak from my own experience (somewhere between 15,000 and 18,000 hours spent positioning riders of all levels of accomplishment) and my answer is quite the opposite. So again I cannot agree with you.

Your argument for ball of the foot over the pedal axle cleat positioning relies on the assumption that the foot functions as ~ rigid beam during cycling. In my view and experience, this is a flawed assumption and your argument falls over on those grounds.

The leverage of the femur is the main game in town regarding cycling and the conventional view of cleat positioning works the gastrocnemius and soleus harder than need be. I feel that any muscular effort (ie which costs heart beats, blood flow and oxygen) that can be relieved in this area is better made available to the primary lever, the upper leg.

I have had this discussion before with podiatrists, though in the context of me positioning them on their bicycles. I have also had this discussion with Henri Manders and Alain Descroix seven or eight years ago. At the time they were respectively, marketing manager and chief designer for Time, the French shoe and pedal manufacturer. Both of them had a bit of a track record: Manders had won stages of the Tour de France and Descroix had been Hinault's personal mechanic and frame builder and had been involved in the development of the first Look pedals for which Hinault did a lot of testing.

Their line was similar to yours. But I was telling them that the Time shoes of the day (white upper, mauve tongue with white flecks and three red straps) had far too much heel lift and the cleat positioning hardware was way too forward. They were 25 mm too far forward with the Look compatible holes and 12 to 15 mm too far forward with the Time sliders. The long and the short of it was they did not agree, but said that I had raised enough doubt in their minds that they would investigate further when they returned to France.

Then 18 months later their shoe range was totally revamped to the yellow shoes with yellow soles and three red straps, which had reduced heel lift and the potential for cleat positioning, as I had suggested. When next I saw Manders (two years after the original meeting) I asked him why. His reply was that once back in France, he had surveyed all the pro racers that they sponsored and had hired a professor of biomechanics to survey their shoe range. The thrust of both these exercises was for cleat positioning, as I had suggested. Now, I am not patting myself on the back here, but I am telling you that I am not alone in my thinking.

My reasoning for cleat position is the outcome of organising my life so that for many years I have spent the majority of my working life positioning riders on bikes. I used to think like everybody else because I had read the same books and coaching manuals. All I can say is that substantial empirical experience has caused me to change my mind.

The only other person that I know who spends his working life positioning cyclists, John Kennedy, would agree with my assertions. My livelihood depends on what I am saying here as I put this into practice on a daily basis and all I can say is that the queue for my services gets longer every year.

Thank you for taking the time to write a constructive letter, not many people do. If you are ever in Sydney, bring your bike and shoes and look me up. In the spirit of scientific enquiry I would be happy to play positioning games for a few hours. You might find this interesting.

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Steve Hogg is the owner of Cyclefitcentre.com / Pedal Pushers bike shop in Randwick, Sydney. Steve has positioned over 7,000 road and MTB cyclists and triathletes, including World Championship and Olympic medallists. .

Popular Direction. The heel lift on leading brands of cycling shoe, including Shimano, has decreased over the past eight years. Photo: Courtesy of Team Saturn.

#### Glossary

*Dorsiflexion: Raising the toes up towards the knee.*  
*Plantar Flexion: Pointing the toes downwards.*  
*Talus and Mortise: Two bones that make up part of the ankle joint.*