03

THE BIKE FIT WINDOW

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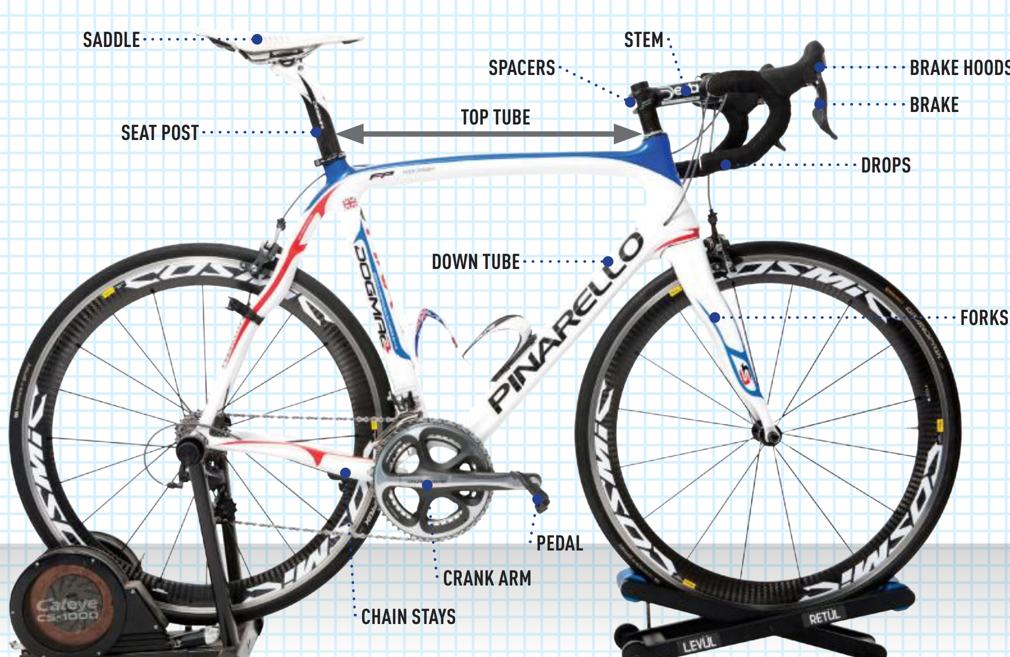
I'm often asked what the perfect position is by people. My response is: for what? The perfect position varies depending on what you are looking for: power, comfort, aerodynamics or injury avoidance.

You could easily justify setting a bike position separately for each, but in fact all positions are a compromise between these four criteria. The position is skewed towards what the rider wants, but restricted by what they can handle. So what's the perfect compromise position? I don't think it exists for longer than a day – at the most – and it is therefore irrelevant. On any given day somebody's perfect bike position will be different to the day before. Take one key parameter: a person's ability to touch his or her toes is a combination of their various 'segmental flexibilities' – at the knee, hips (hamstrings) and lumbo-pelvic region. With age and injury we all trend towards becoming less flexible and stiffer, but we do so at differing rates. Over 50 per cent of us suffer from some form of lower back pain, and this is often associated with stiffness – our sedentary lifestyles are held partly responsible.

I could fit you to your perfect position at 8am on a Friday morning after you had spent a long week at work sitting at an office desk. The position would take account of your relative inflexibility in the lower back and to accommodate this it would be more conservative, more upright and with the handlebars up. But if you came in after a weekend free of work and full of riding, your ideal position would have changed: the lumbar spine might well be more flexible relative to Friday morning, and your 'perfect position' would have to reflect this: it would be more aggressive, less upright, with the handlebars lower. Even the quality of a night's sleep can be enough to change someone's 'perfect' position.

PARTS OF A **STANDARD BIKE**



The same is true of professional riders coming off long mountain stages, suffering after sustained climbing slung back in the saddle for hours upon hours. Their ideal position changes when they enter the flat stages of a race like the Tour de France, and some are attentive enough to have different bike set-ups accordingly.

For this reason I prefer to think of the 'bike fit window' instead of a perfect position, and I aim to fit to this. I believe the phrase was first coined and made popular by Andy Pruitt but it describes perfectly how we should envisage our fluid relationship with the bike. Imagine your three major measurements and contact points with the bike: saddle height, handlebars and foot/cleat. The fit window is between the maximum and minimum for each variable. For example, I normally describe people's saddle height (assuming it is roughly correct) as high or low within the fit window. Their lowest acceptable saddle height might be 78cm, and the top 79.5cm. Beyond these boundaries the height becomes less than ideal, but within this zone someone can be perfectly comfortable and perform. Your saddle height on a Friday after work would be at the bottom of your zone (reflecting your relative inflexibility at that time) but by Monday it would be at the top – your fit window changes due to an improvement in flexibility.

The fit window is more than just that, however. It's the relationship between these key foot-to-pedal contact points. You'll often hear saddle height and foot to pedal described as the positional height of a rider, while the handlebars give the positional length because their location determines how far you reach: lower handlebars mean you have to lean further forward. The fore/aft position of saddle affects length as well, and we will discuss this later (see pp. 43–47). Most fitting concentrates on getting the back end height optimal first, as this is where power is derived – the engine room, so to speak. What I like to call the cockpit – the front end – is then set up making sure the rider is balanced, the back angle is comfortable and the arms are able to relax at the elbows. All this determines whether the head position is comfortable – whether the rider can comfortably look up the road extending from the neck.

The balance of bike fitting from the side-on view at first principles is simply this – getting the height of the engine room and position of the cockpit so the tilt of the rider is optimal. Get this wrong and the rider is either tilted to far forward or too far backwards.

THE **BALANCE** BETWEEN **HEIGHT** AND **LENGTH OF POSTURE**

BOTTOM AND TOP DEAD CENTRE

The terms 'bottom dead centre' (BDC) and 'top dead centre' (TDC) are a nice technical shorthand for the position of the leg at the very bottom and the very top, respectively, of the pedal motion. If one leg is at BDC, the other leg will be at TDC, and the pedals will sit directly over and under the centre of the crankset, and the crank arms will be vertical.

JOINT ANGLES

The bike fit window can be expressed in terms of the physical measurement of key distances over the bike such as saddle height and reach to handlebars. The parameters that determine those measurements are the rider's interaction with the bike. These are best expressed as the joint angles the rider adopts to ride the bike in a particular position. By joint angle I simply mean the angle of the bend of, say, the knee – for example a knee extension at bottom dead centre (BDC) of a pedal stroke of 35 degrees. Many keen riders know that there are optimal ranges for these joint angles, outside which the fit becomes less than ideal (i.e. injurious, uncomfortable and performance limiting). I use joint angles, not formulae, to optimise bike fit. Below is a diagram of the fit window for a road bike from a joint angle perspective.

HOW TO GET INTO YOUR BIKE FIT WINDOW

If you're a new signing to Team Sky or a young rider joining the British Cycling programme you're probably pretty good at cycling, but you'd be surprised what we see in terms of position, even with the best riders. When I first analyse a new cyclist, I take them through a process that has dynamic fit at its heart. Static fit is fine up to a point, but dynamic fit – where you can measure someone's knee position relative to their foot while they are actually cycling – is the gold standard. The goals and the essential rules of the fit window are the same, but this is a different (and I believe better) way of getting there.

SADDLE

Seat height is the Holy Grail for power. It's often argued that it is the most important cycle-position setting, and I have to agree – many other positioning recommendations (say of the handlebars or pedals) are actually trying to correct a suboptimal seat height. So it makes sense to start here.

RETÜL BASIC MEASUREMENT **AVERAGES** AND **RANGES** FOR A **ROAD BIKE**

In this book the ranges quoted for joint angles refer to the Retül standard joint ranges. This is the measurement currently used for British Cycling and Team Sky. You can discover more about how these ranges are calculated at www.retul.com. Note that in the diagram 'ankling range' refers to the amount the ankle angle should vary during the pedal cycle, and that 'hip angle min.' refers to this angle at its most acute, for instance for the left leg here. Compare with pp. 127 and 140 for time trial and mountain bikes.

> Relative seat height can be altered in many different ways other than merely moving the saddle up and down. Any change to the bike set-up that changes the distance from the seat to the pedal effectively changes seat height.

Optimum saddle height is described by the natural position of the leg fully extended at the BDC of the pedal stroke. This in turn depends on angles of the knee and ankle. A knee extension angle of 35–40 degrees is optimal for the average rider. Professional cyclists can be seen using angles of up to 30 degrees.

As with all positioning we have to create a compromise between the variables of power, comfort and injury avoidance. The graph here clearly demonstrates what we know well, that there is an optimum saddle height for power production.
If the saddle is too low, the quadriceps and glutei cannot generate enough power as they never reach their optimal length. Too high and the knee is overreaching, too extended and the leg loses its grip on the pedal therefore producing less power.

The optimal saddle height for power has to be a goal that you work towards. These saddle heights are often at the very top end of the fit window I mentioned earlier, and require knee extension angles at BDC of 30–25 degrees.

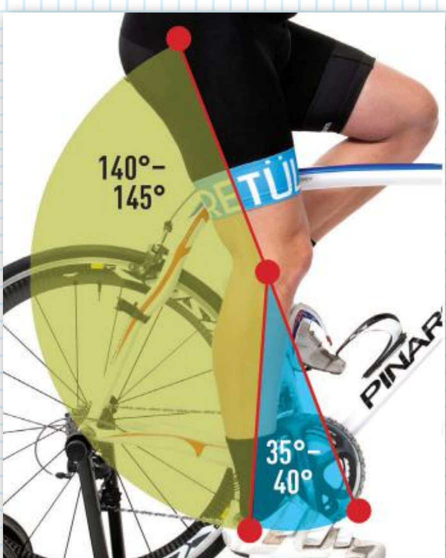
The main limiting factor for most of us in achieving this angle is our hamstring flexibility. Tight hamstrings inhibit knee extension and prevent us from rolling our pelvis forward, so a lot of us will never achieve beyond 40 degree knee extension at BDC.

Placing someone in their optimal seat height for power alone without reference to their flexibility means that they will feel strain and pain at the back of the knee and may, over time, develop an overuse injury.

Too low a saddle height, on the other hand, increases the compressive forces on the knee cap, as the leg comes over top dead centre (TDC) and pushes down. This can also cause pain and injury.

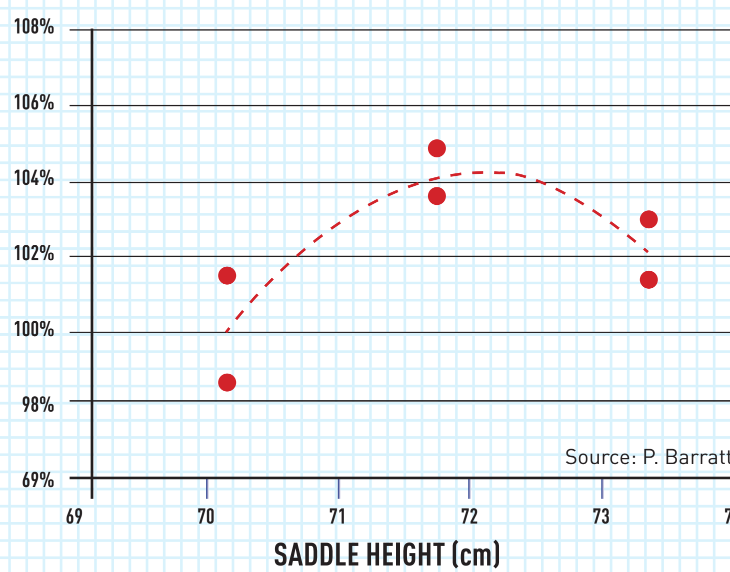
So saddle height needs to be a compromise, accommodating all of these parameters if you want to ride safely and comfortably. Ideally you should aim to get in the middle of the fit window.

KNEE ANGLES



A knee extension angle of 140–145 degrees (which in the trade we refer to as 35–40 degrees, being the angle of deviation from a straight leg) is optimal for the average rider.

POWER VERSUS SADDLE HEIGHT



As saddle height increases so does power until a point where it drops again. Just before this drop is the optimal saddle height for power production. It is less likely to be optimal for comfort.

Static methods of establishing saddle height
One of the simplest ways to establish your saddle height statically is the heel to pedal at BDC method, advocated by many over the years. When you are starting out in cycling this is a simple method to get you in the right ballpark for saddle height.

Simply sit on your bike, on your rollers or turbo trainer if you have them (or just lean against a wall, and pedal backwards with your heel on the centre of the pedal. If your saddle height is correct your knee should be completely straight as you reach BDC (the 6 o'clock position). If it is still bent or your heel completely loses contact with the pedal, adjust your saddle height accordingly.
The drawback of the static method is that there are a few factors it doesn't take account of, for example, the thickness of your cycling shoes, the position of the cleats on the shoes, how far backwards your saddle is set and pedalling style.

PEDALLING STYLE
I said earlier that saddle height is defined by the 'nature of the leg at full extension'. This consists of not just the knee angle, but also the angle of the ankle. Pedalling styles differ massively across the cycling population; someone who pedals with their toe pointed right down can achieve a higher saddle height without altering their knee angle, compared to someone who pedals heel down. At the extremes of pedalling style you can't fit solely according to knee angle.

FORMULAE
I mentioned these briefly in my introduction. Many 'magic bullet' formulae exist, but the one you're most likely to know about was popularised by Greg LeMond and his coach in the early 1980s. You measure your inseam: stand with your back against a wall, place a flat object similar to a saddle under your groin and recreate the pressure it exerts on your saddle while riding. Measure the distance between the floor and your crotch in centimetres. Multiply this figure by 0.883 and you have your saddle height, defined as the distance measured between the bottom bracket of the bike to the top of the saddle in line with the seat tube. This method has got many riders into the fit window for their saddle height.

The drawback of formulae is that they pay no respect to the nuances of the individual: flexibility, pedalling style or genetics (they will not help someone with

HEEL TO PEDAL METHOD

To be a little more precise, if trying to set your saddle height using a static method, drop 10 degrees off the recommended dead-straight angle here. This is because more dynamic analyses of saddle height look at the centre of the leg's rotation as a whole, whereas the static method is calculated using the centre of the knee.

HEEL TO PEDAL METHOD
Adjust saddle height so as your heel touches the pedal with the pedal at the bottom dead centre.

long limbs and a short torso or vice versa). Therefore this method cannot help everyone to establish an optimal saddle height.

GONIOMETRY
Another way to set your saddle height is to use a long-armed goniometer to measure your knee angle. Put the leg in the BDC (or 6 o'clock pedal position). You then measure between three key points: the greater trochanter at the hip (the widest bony mass on the side of your hip), the centre of rotation at the knee, and the bony mass on the outside of the ankle joint. The knee angle that will enable most people to ride in comfort without injury while still producing power, is ideally between 25–35 degrees.

The main drawback is that this is a static measurement requiring little attention to detail to perform and may fail to take account of actual riding or foot position. This can lead to a suboptimal setting once you actually start to ride.

Dynamic methods of establishing saddle height

To date by far the best method of setting saddle height is dynamic measure. In other words, recording the positions of someone's knee and ankle angle while they are actually riding. A system such as Retül can take thousands of data point measurements over a short time and average out the angles. In the hands of a skilled bike fitter this data can be combined with an appreciation of the rider's body limitations to place someone bang in the middle of their specific fit window.

SADDLE SETBACK OR FORE/AFT

Once you have established your saddle height, it's important to get the setback or fore/aft position of the saddle right. This parameter is key in optimising pedal power, preventing injury and setting the overall balance of the rider on the bike.

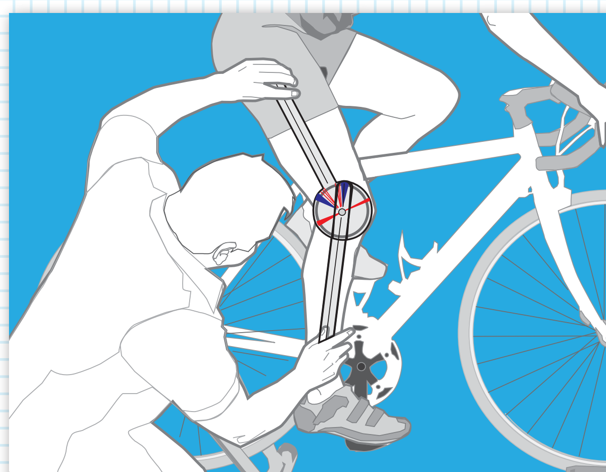
Saddle setback determines the position of your knee and hips in relation to the foot-to-pedal interface. If the knees and hip are too far behind the foot/pedal in the 3 o'clock position, it is harder to generate optimal power when pedalling.

Conversely if they are too far forward, with the knee in front of the foot/pedal interface in the 3 o'clock crank position, there is an increased risk of developing knee problems due to the increased forces placed on the kneecap.

LEMOND METHOD

INSEAM FORMULA
Multiply the inseam height by 0.883 for saddle height, according to this method. It can work for some, but not everyone has the same body proportions.

GONIOMETER



You measure knee extension angle on the bike to set your saddle height.

Source: bikefit.com ©BikeFit LLC

Try for yourself. Sit almost off the back of your saddle and try pedalling – it's hard because the point you are trying to push and control is further away. Now sit right forward, with only the very back of your bottom touching the saddle. This feels uncomfortable and bunched up, with the kneecaps under too much strain. In the fit window your saddle setback allows you to generate force from the quads and glutes, and to feel in control and free from risk of overuse injury.

Getting this coordinate of bike fit right also has a significant role in setting the correct balance of the rider on the bike. Overall balance is a sum of the relationship between all the fit points, of which this is one. If the saddle setback is too large, you will have the majority of your weight towards the back end of the bike, making handling lighter and less controlled at the front. This can be dangerous, for example when descending at speed through corners. If you are sitting too far back, you may have a very large distance to reach the handlebars, unless you have taken care to adjust the handlebars appropriately. This can lead to pain and injury from overstretched tissues. If the saddle is too far forward, the rider can experience too much weight on the hands and wrists and develop issues, the classic being ulnar neuropathy (see pp. 117–119

How to set saddle setback

STATIC

The 'KOPS' method stands for Knee Over Pedal Spindle. And that's exactly what it does – establish the correct setback position by attempting to place the knee directly above the pedal spindle with the cranks at the 3 o'clock position..

Traditionally a plumb line is dropped down from the tibial tuberosity (the bottom of the knee), and the saddle is adjusted until the line bisects the pedal spindle. There are a number of problems, conceptual and practical, with this method well documented by other authors (for instance, see the article online by Keith Bontrager called 'The Myth of KOPS'). Practically speaking it is hard for some to find the anatomical landmarks accurately, and the plumb line can move, making the vertical judgement subjective. KOPS also has some drawbacks when it comes to speciality riding, for example time trials.

KNEE **TOO FAR IN FRONT** OF THE PEDAL

Note the postion of the front of the knee in relation to the foot. In this 'knee forward of foot' position there is an increase in the forces compressing the patella.

KOPS: KNEE OVER PEDAL SPINDLE

TIBIAL TUBEROSITY

Note the difference here in the position of the knee. A vertical line down from the bottom of the knee bisects the pedal spindle, reducing the forces of the patella.

If KOPS is to be used, I like the idea of simply using a straight edge (for example a metre ruler), placing it in front of the kneecap and making sure this is in front of the pedal spindle. Used in this way KOPS has helped many riders get themselves into a safe setback position.

Of course, as with all static measuring, the drawback with this method is that it is dependent on the rider sitting exactly where they would be on the saddle while they are riding. This is surprisingly hard to mock up in a clinical environment.

DYNAMIC

The Retül system provides the setback as an average of over 10,000 data points of the knee in relation to the foot over 15 seconds of riding. This gives a clear indication of where the rider's position is while actually riding. Fitters will use this data to adjust saddle setback, in this case until the knee is on average more often behind the foot, indicating a safe saddle setback. And I know – most of us don't have a Retül system sitting in our garage. It's good to remind ourselves that while dynamic measurement systems are the most advanced method of bike fitting, they are still measurement systems – just the same as that metre ruler! The skill is in the interpretation of the data.

THE **RETÜL** SYSTEM

The very mobile and accurate Retül system is used by top professional teams all over the world, and is the dynamic bike-fitting tool of choice of British cycling.

SADDLE COMFORT

Saddle soreness is a very common complaint among all levels of cyclist. In my experience women have more issues than men, and they tend to be more serious in nature, though it isn't entirely clear why. I have not come across a magic bullet solution. However, a good principle to bear in mind is to pick a saddle shape that suits your anatomy. We are all different, and for example, a wider-hipped rider should choose a saddle with wider support. A few measuring devices have sprung up over the years to help measure the distance between the weight-bearing areas of the pelvis.

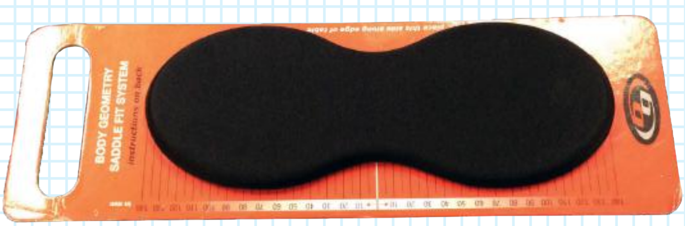
In reality it is very hard to gauge saddle comfort simply by looking at the rider and the saddle, which I believe is because 'saddle comfort' is affected by lots of factors. For instance, the length of time someone has ridden affects their acceptance of saddle shapes, stiffness and angle, because our tissues get toughened up to some degree, and adapt to sitting on a saddle. Unfortunately too much discomfort tips the equation the other way, leading to inflammation and irritation rather than adaption. I know a lot of people who have given up cycling due to saddle soreness.

This first consideration is further complicated by the rather surprising fact that experienced riders often suffer from saddle soreness on easy, long rides but not on more intense hard rides. The theory is that this is because when you ride hard you are putting less pressure on the saddle, as your legs work harder to push on the pedals, thus indirectly supporting your weight. The novice cyclist is therefore hit by a double whammy: until they learn to pedal harder, they sit more heavily on the saddle, which their tissues have to yet to adapt to.

The best advice I can give is that you should try several saddles until you find one that works for you. Try and find a good cycle shop that will allow you to sit on several different saddles. There are seat clamps now that allow the rapid transfer of saddles so you should be able do this relatively quickly.

Don't make the mistake of assuming more expensive means better, or more cushioning means better support. Many of the more expensive saddles are priced due to weight-saving strategies – carbon rails and so on – and are aimed at the racer who has adapted and can ride hard, therefore comfort

A DEVICE FOR **MEASURING SADDLES**



A SADDLE FIT CUSHION

Memory foam allows you to measure the distance between sit bones — you sit on it then stand up, leaving an impression of the sit bones. This helps prescribe saddle choice.

A CUTAWAY **SADDLE**

ADAMO SADDLE BY ITM

An example of saddle innovation that has helped some sufferers of saddle sore.

is not the primary aim of the saddle. Cushioning is important – especially around the nose of the saddle in a time trial. But it's support that you should look for first and foremost.

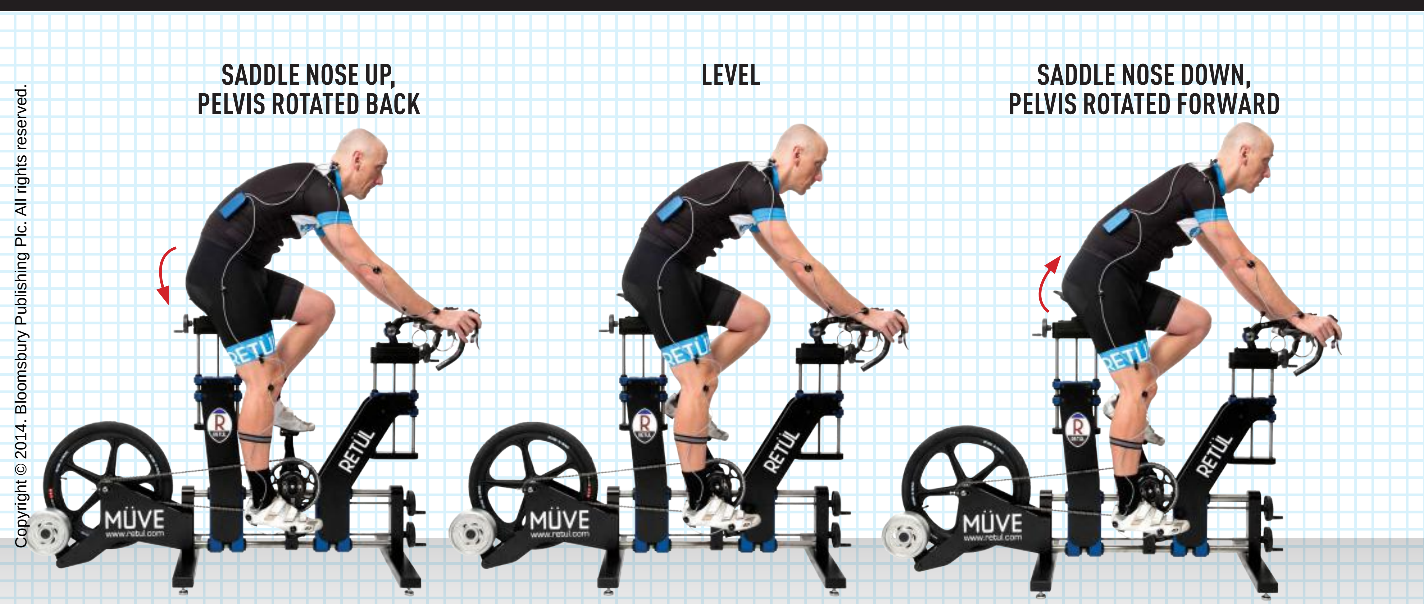
Genital numbness is a common problem in both men and women. A few years ago, cutaway saddles started to appear, intended to relieve pressure on the affected area. But this pressure has to be borne somewhere and saddles with a central cut always end up redistributing it to the sides. As a result, these saddles work for some people, but don't work for others and in some cases can even make the situation worse. They seem most useful for men suffering from central compression-related pain and numbness, and it is easy to see why. Many women, on the other hand, tend to suffer from one-sided swelling and pain or numbness of the labia, so a saddle that moves the pressure laterally – perhaps even increasing it – can make the issue worse. Saddles such as the ITM Adamo are successful in resolving issues not because of the cutaway but because the two arms of the saddle front flex and rotate with the rider as they pedal.

At British Cycling the issue of women suffering from saddle injuries was sufficiently serious to compel the then Team Doctor Roger Palfreeman and myself to work on a bespoke solution with Glenn Hunter and the UK Sport's Research and Innovation team. This approach significantly reduced our exposure to the problems, but it still doesn't work for absolutely everyone, and this shows you how individual the area of saddle selection is.

SADDLE ANGLE

If you wish to take part in a Union Cycliste Internationale-sanctioned or regulated race then I'm afraid this is a moot point. The UCI rule is that your saddle must be level. Their commissaires may allow a tolerance of 1.5 degrees but I've stood trackside with commissaires who insisted all saddles must be absolutely horizontal. For a good many people, 'level' is a sensible set-up for a saddle. To start with, it provides the opportunity for the saddle to interact with the rider as the saddle manufacturer would have intended, because saddles are produced on the assumption that the saddle is ridden level.

DIFFERENT **SADDLE ANGLES**



LEVEL OR NOSE DOWN
The angle of the saddle can make a huge difference to a person's fit due to its profound effect on the rotation of the pelvis. I recommned saddle level or slightly down always.

However, for others the UCI-regulation 'level' creates many issues. Those suffering from genital numbness often find huge relief in angling the saddle down a degree or two. The shape of some people's anatomy requires this to help roll the perineum and other tissues out of harm's way. If we examined most people's saddles they would be level or slightly down. There is no good reason I am aware of to have the nose up – and if I see this I always suggest changing it. A common reason given by those I find with a nose up is that they need to do this to avoid sliding forward on the saddle. This is a classic case of adjusting the wrong fit coordinate: it is more than likely that the saddle height or front/rear balance is incorrect, tipping the rider forward, and it these issues that need to be corrected, rather than blocking the rider into position by angling the nose of the saddle upwards.

Amateur mountain bikers prefer a slightly nose-down saddle for a simple reason – it stops them catching their shorts every time they sit down from standing on the pedals, which they do a lot more than road riders.

So why have the UCI legislated against what seems to be a perfectly logical adjustment of a contact point? The answer lies with Graeme Obree and Chris Boardman and other great innovators. The radicalisation of position by these two and others seems to have thrown the UCI into ultraconservative mode. Angling your saddle downwards has the effect of rolling your pelvis forward, enabling you to flatten the back and achieve a more aero position. It also helps the pelvis into a position more suited for the glutei to develop power and in effect allows you to come further forwards than is permitted by the UCI's ruling that the saddle tip must be 5cm behind a vertical line through the bottom bracket. Some people took this to extremes, and the UCI either thought it was dangerous or not within the spirit of the sport. For most of you, who do not have to be UCI legal, I would advise you to place your saddle either level or down by up to 2 degrees.

HANDLEBARS

There is a bedazzling array of shapes and sizes of handlebars on the market. Width is traditionally the main fit parameter but the shape and size matter too. It is generally accepted that handlebar width for road riders should be the width of your shoulders. This can be measured on and off the bike. On the bike the lateral side (outside) of the shoulders should be in line with the thumb/index finger on the brake hood.

MEASURING **HANDLEBAR WIDTH**

ON A BIKE

Note how the outside of the shoulder is in line with the thumb/ index finger on the brake hood.

OFF THE BIKE

This measure is from acromion to acromion (the pointy bit of bone you can feel where your arm meets the shoulder).

Off the bike, measure between the bony outcrops at the end of the collarbone – the acromia (singular, acromion) as they are known. This again gives a good guide to the appropriate handlebar width.

It's important to get this measure correct as too wide a hand placement leads to fatigue and numbness in the hands, due to their being splayed out. This also affects handling, making turning the bike slower. Having too narrow a hand placement can be tiring for the triceps which have to bear a greater load, and will affect the handling by making the steering quicker and the bike 'twitchier'.

Exceptions to these general rules are mountain bikers who ride with wide handlebars for control reasons, and track sprinters who prefer narrower bars to help them manoeuvre – narrower bars means it is easier for them to get in between riders. Some specialist road sprinters do this as well.

SHAPE

Most people just ride the bars that a bike comes with. If you need to change them or are having problems with reach, comfort or handling, take the opportunity to consider the shape of the handlebar. In an ideal world, your riding style, hand size and reach should determine this.

The anatomy of a handlebar is shown in the picture below. The horizontal top section is where your hands reside for most of the time when climbing. For this reason climbers often prefer this bit to be wider to give more room for changing the positions of the hands. They will sometimes also prefer an oval or flat top section to optimise hand-grip. Track sprinters on the other hand will go for a shorter horizontal top section with a rounded curve to the drops to help get the narrower bar mentioned earlier, and to avoid bumping their wrist or forearm into the top section while in the drops.

Drop and reach

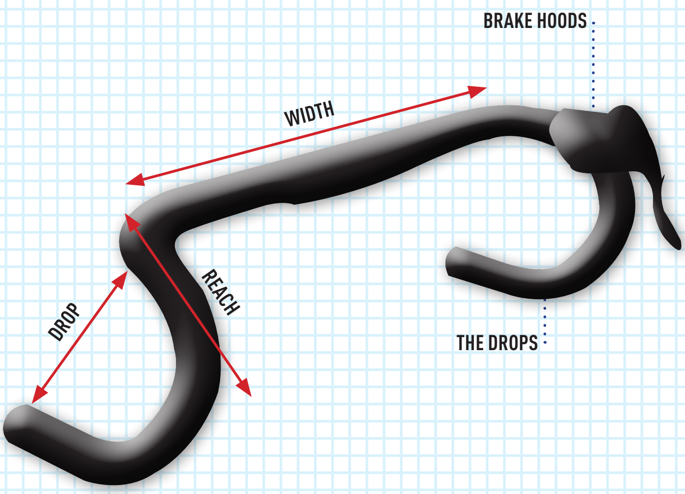
The drop and reach of the handlebar is an extension of the fit process we described earlier. Obviously the stack and reach of the frame, along with the height and length of the stem, determine drop and reach primarily, but the choice of handlebar can have a subtle influence on the drop and reach within the fit window.

Deep bars with a long reach and big drop are preferred by riders with long arms, as they help them

ANATOMY OF THE HANDLEBARS

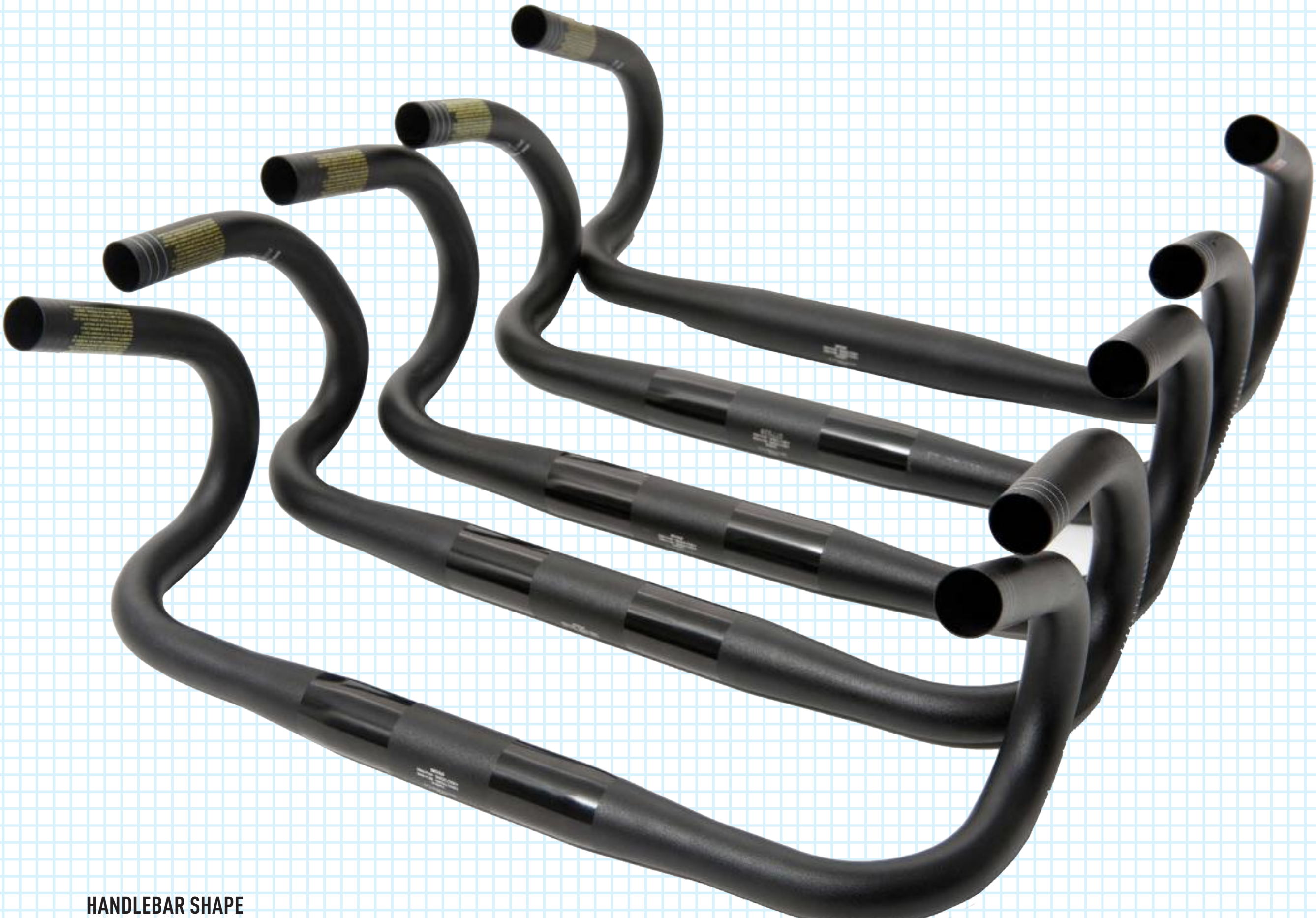
TOO WIDE

TOO NARROW



Handlebars that are too wide force the hands into a splayed, extended form, increasing the strain on the forearm, elbow and triceps. Handlebars that are too narrow force the hands to grip excessively.

DIFFERENT **DROPS**



HANDLEBAR SHAPE
Handlebars vary in more than size. Note the differing angles and depths of the drops here.


Carrefour
LCL LCL
sky
Vittel

achieve a good, low aero position when in the drops. Riders with a shorter reach generally prefer shorter, shallower handlebars that do not require them to overreach or extend into a deep drop position.

The actual shape of the handlebar drop has changed over the years with some now incorporating a flat section into the curve, these are called anatomical bars. Some riders prefer these but as with saddles, handlebar variations at this level are down to individual choice, and are most likely determined by comfort.

BRAKE LEVERS

I can't believe how many bike fits I have done where the only thing I have changed is the position of the brake lever and have found that this has solved all the rider's fit issues. The position of the brake lever is crucial and should not be overlooked. The hoods of the brake lever are where most of us rest our hands while riding. The amount of engineering that goes into shaping a Dura Ace or other top-end hood/brake lever makes it the most expensive contact point on the bike – and yet so often we pay little or no attention to its position.

The placing of the brake lever has to allow the rider to access the brakes when their hands are on the hoods and also when they move to the drops. Bike manufacturers work from this premise when designing them, so it makes sense to set them up as intended. A simple method employed by many is to set the tip of the lever in line with the end of the handlebar drop.

If you find that your brake levers are closer to the horizontal top section of the bars and this where you are comfortable, it may mean that your reach or drop is set up too long or too deep. The brake levers' position in this case is a fit compromise, trying to account for other suboptimal fit coordinates. Shortening or lowering the stem may allow the brake lever to be more correctly positioned.

Mountain bikers are an exception once again. Here the brake levers are set in line with the grip, which is determined by the arm's angle of approach to the bar, normally around 30–40 degrees. This position allows comfortable braking both in and out of the saddle.

HANDLEBAR POSITION

Where the handlebars are positioned, in terms of height and length from the saddle, determines your reach. Sometimes this is referred to as the postural

BRAKE LEVER SET-UP

Note the relaxed hand position that enables the rider to easily reach the brakes as and when needed.

MOUNTAIN BIKE HANDLEBAR SET-UP

Forearms and wrists are in line with the brake lever allowing effective braking while seated and while out of the saddle.

'length'. It is the most individual part of the bike fit as so many factors contribute to its setting once you have your seat height and setback. Apart from some very basic guidelines it is largely determined by the individual's strength and flexibility through their hamstrings, lower back, thoracic spine, shoulders, neck and arms – nearly the whole body's kinetic chain.

The position of the handlebars not only determines the reach but also the angle of the torso or back. This measurement provides a useful expression of someone's overall position and reach.

The recommended torso angle for recreational cyclists is 45–55 degrees. This allows a relaxed riding position, typically with little or no saddle-to-bar drop in height and a comfortable reach. Faster road riders have a torso or back angle of anything from 45 to 30 degrees. I describe this as being more aggressive: it's adopted to go faster, race and produce more power. Time triallists are the most aggressive, aiming for a 'flat back' – a torso angle as low as possible to achieve an aerodynamic position. The use of aero bars enables these very low front-end positions to be assumed, but they require great flexibility and a lot of adaptation. All the factors I mentioned affecting reach are in turn affected by our age. As we all get stiffer and less adaptable our ability to adopt aggressive positions (at least without a good deal of suffering) wanes.

How to set the handlebar height and length-reach

There are some old CONI-style anatomical approximations, the first of which involves putting your elbow against the saddle front and extending your arm and open hand towards the handlebars. Adjust the bar position until only an inch or two of space exists between it and your middle finger. Another method advocates measuring the width of your fist when clenched and sizing your stem to match to achieve the correct reach. As with all of these anatomical approximations, the drawback is that they are limited by a lack of sensitivity to individual characteristics. So once again they may work for some but not for others – and it's hard to tell who this method will work for.

Various authors (Silberman et al. 2005) make reference to the vertical distance between the saddle and the top of the bars – sometimes termed the saddle-to-bar drop – which should be 1–3 inches (2.5–8cm). None make reference to finding where you should set up within that range. In my

DIFFERENT **TORSO POSITIONS** ACCORDING TO **POSITION OF HANDLEBARS**

Note how the position of the handlebars in B is too long for the rider, making him stretch his arms and back and crane his neck, and C is too short and has bunched the rider up, making his torso (back angle) too high and putting too much weight on his back end.

experience there are so many factors contributing to an individual's ability to reach forwards that it is impossible to apply a simplistic rule of thumb.

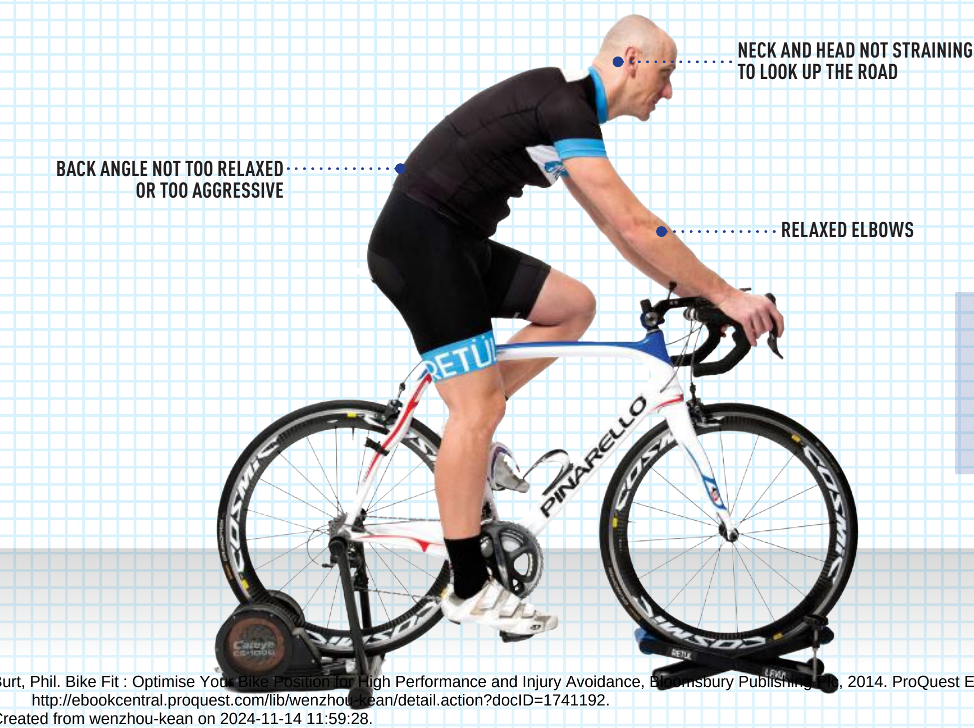
It appears so difficult to quantify that some have even suggested the 'balance' method. It's regularly quoted that a rider's weight distribution should be roughly 40–45 per cent on the front end and 55–60 per cent on the back. However, no one has developed an effective way of assessing or measuring this yet, meaning it's so subjective that while balance is important, I don't think you can use it as the primary measure to set reach. Too many components of fit contribute to balance, not reach alone.

I advocate using a large amount of common sense and 'feel' to set handlebar reach and height. The most common mistake I see is people setting themselves up in aggressive positions without consideration for their body's ability to hold them for any length of time. They often suffer these positions until they seek help or become injured.

In order to find – and I mean find in the sense of explore – your handlebar's ideal position, start by setting out to achieve the following: with your hands on the hoods or tops your arms should feel relaxed, and you should be able to ride with your elbows slightly bent and feel at ease with this. If the saddle-to-bar drop is too much for you, your arms will straighten and tend to lock out. Relaxing your arms or bending the elbows will feel difficult as there will be too much weight on the arms, meaning your hands will often become numb or tingling quickly in one position. You should also be able to look up the road while cycling easily without feeling strain or pain in your neck or in between your shoulder blades.

Set your handlebars to the above parameters first, and don't be ashamed if you have a high front end: it's like that for a reason if the above guidelines have been obeyed, because it's all your body will allow for now. We can all work on our flexibility to a point, and indeed the very nature of riding a bike helps us adapt to this particular body position. An aggressive position should be evolved over time by slowly nudging the handlebar height down or extending your stem. Remember: the bike is adjustable, the rider is adaptable. One takes seconds, the other for most of us unfortunately takes a lot longer!

AN EXAMPLE OF A **GOOD REACH POSITION**



A good reach position really balances the rider. They look comfortable and nothing – arms, back, neck – is straining.

SETTING UP HANDLEBARS

If in setting your handlebars up you have noticed a change in the bike's handling, a slight alteration is to be expected. If your bike frame size is correct a stem length of between 10 and 12cm should be normal. Less or more than this tends to change the handling of a road bike as your weight is either too far forward or is behind the hub of the front wheel. I accept 10–14 cm stem lengths with professional riders, but stems which achieve a comfortable reach at below 10cm or beyond 14cm probably indicate the frame size of the bike is less than optimal for you (see p. 67 for more on frame size).

PEDALS

The history of cycling pedals is long and rich. Take a look at the magnificent timeline on the Speedplay pedals website if you want to immerse yourself in it (www.speedplay.com/index.cfm?fuseaction=pedalmuseum.intro). Today we have many different types of pedal, from platform pedals, where your foot is free to make whatever contact you wish and clips can be added to help position the foot more rigidly, to clipless pedals with cleats that lock your cycling shoe into your pedal. The advantage of cleats is that more of your force and drive is applied directly and there is less energy or force wasted controlling your foot's position on the pedal. The extent of the cleat's locking is itself variable, from mountain bike pedals that allow you to disengage at the slightest sign that you need to, to the incredible tensioned cleats used by track sprinters to prevent them pulling their feet out of the pedal during a standing start.

The transition from free to clipless or cleated pedals is what most people struggle with. It takes time to get used to riding when locked into the pedal and therefore onto the bike. I recommend practising somewhere safe for as long as is necessary before venturing out onto busy roads or mountain bike trails where the ability to exit the pedal is vital.

The million dollar question is: which clipless pedal is right for me? As usual, there isn't a simple answer. At British Cycling, pedal choice – like that of saddle – is left to the rider's discretion. The main brands are well represented across our squads and it largely comes down to personal choice, but here are some guidelines.

When you make your choice, consider the adjustments a pedal system offers. The section on

THE BIKE IS **ADJUSTABLE** AND THE RIDER IS **ADAPTABLE**

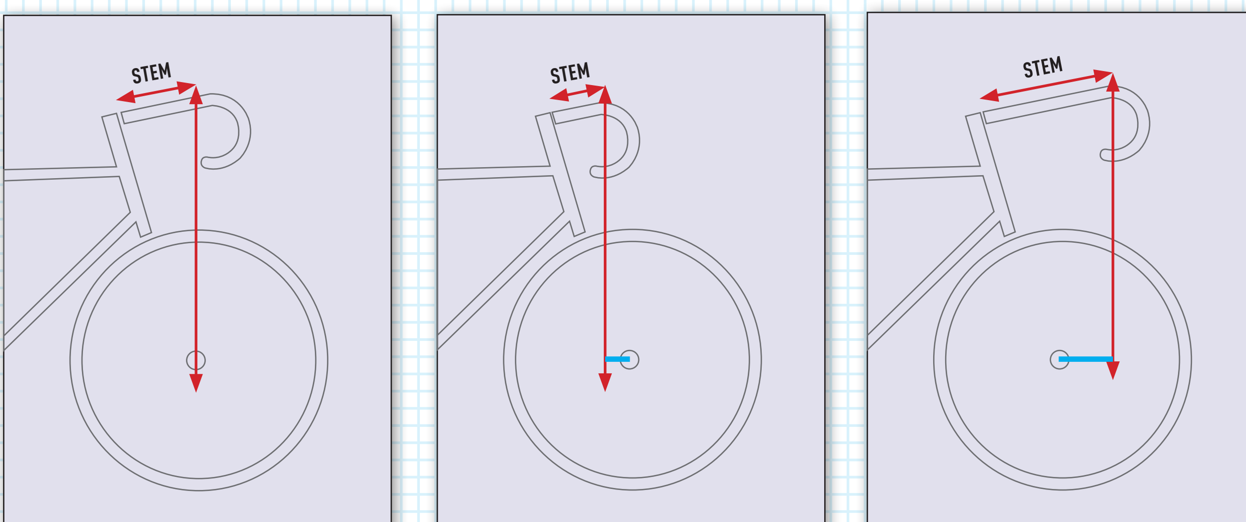
Note the aggressive road position and even more agressive time-trial postion. It takes time to adapt to these for the best of us, and unfortunately some of use need to accept that we are not adaptable enough.

float (the amount of movement a cleat allows see p. 62), underlines the importance of the set-up of the pedal/foot interaction. If you have a history of knee pain, make sure the pedal system you choose has the adjustability you need to accommodate your biomechanics. Some of us will happily slip into a fixed clipless pedal with no float and spend little time setting them up and never have a problem (these are the macro-absorbers among us!). The rest, on a sliding scale, need to spend a bit more time working out what degree of fixing we can accept, given that ours is a sport of repetitive movement. At the far end of the spectrum I have found that using Speedplay pedals can help riders who have trouble with their pedal/foot set-up. This is due to their high degree of adjustability – for example, longer spindles for a stance that suits the legs being further apart. For some riders on the road using mountain bike pedals is a good staging post. They are easy to disengage from and are less restricted, making it a good transition before taking on stronger clipless pedals. For some, previous injury history or biomechanics might mean they will keep using mountain bike pedals on a permanent basis.

It's handy to note that the type of 'float' certain pedals allow differs. Float is the allowance for slight rotational movement of the cleat/shoe on the pedal. Look and Shimano pedals have toe float, the rotation being centred at the front of the foot. Speedplay on the other hand have float centred on the ball of the foot. Some pedal systems have a spring tension that returns the cleat to the central position at the moment in the pedal cycle that the foot allows it to do so, others do not. This tension can cause issues for people unable to control it, in particular knee pain and ITB tightness.

A couple of years back there was a sudden epidemic of knee pain within Team Sky and British Cycling. Riders who had never before suffered with the issue were complaining, and the micro-adjusters were just plain unhappy. After a week or so all settled down. A common element threaded through those affected – they were all riding a new make of pedals. We asked them if anything had changed at all and just one thing had: the amount of spring tension had been increased. Just one small change like that had affected so many – it shows how sensitive we can be to change.

DIFFERENT **STEM LENGTHS** AND THEIR **IMPACT ON HANDLING THE BIKE**



At the extremes of stem length the handling of a bike can be affected some argue due to the relative postion of the hands on the handlebar behind or in front of the front wheel hub. Too short a stem and handling can become twitchy, too long and handling is laboured.

FOOT/PEDAL INTERFACE

The final piece of the puzzle is setting up your foot/pedal interface, or in other words getting your cleats in the right place on your shoes.

If you are not using a clipless pedal system, you do not need to worry about this section. Your feet will find their own happy place on a flat pedal. However, if you are using the modern clipless pedal this section needs careful attention. Cycling is a sport of repetition, and the average cyclist makes 80 revolutions per minute – that's 5400 revolutions an hour. Which position you choose to lock your foot – and thereby knee and therefore whole lower limb – in to the pedal is a big deal. It's the flip side of being locked into the bike and able to apply as much possible power to the pedal without wasting energy trying to stabilise the foot/pedal interface. If you are locked in incorrectly, you are open to any number of potential overuse injuries.

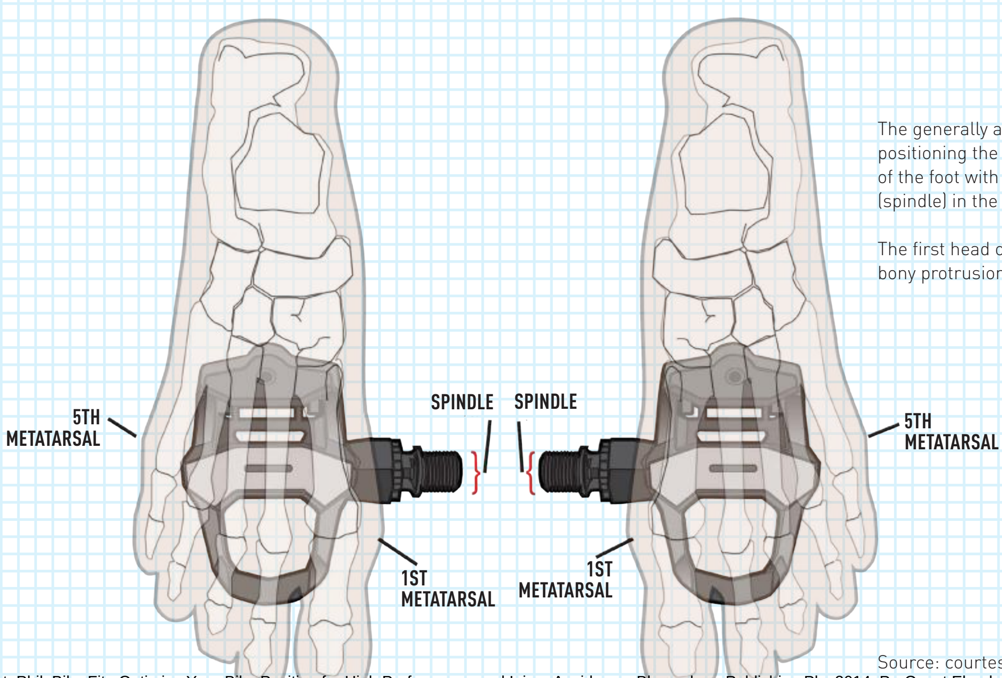
FORE/AFT

The generally accepted rule of thumb for fore/aft positioning of the cleat is to align the ball of the foot with the centre line of the pedal axle (spindle) in the 3 o'clock position. The ball of the foot (the first head of the metatarsal joint) is the big bony protrusion just behind the big toe. This is where people commonly get bunions. Traditionally this has been placed over the pedal spindle as it provides the largest contact area of the foot directly above the pedals axis of rotation, and therefore maximises the biomechanical advantages of the foot to produce optimal power output.

Andy Pruitt suggests that this approach really only works for size 9 US men's feet (UK size 8½), as larger feet need more stability, requiring the cleat to be slightly behind the pedal spindle. For smaller feet the opposite applies. Some even advocate using the second and third metatarsals, and Sanderson et al. (1994) the fifth metatarsal head as the anatomical landmark to set fore/aft to. However good the reasoning behind their arguments for this, these landmarks are hard for the non-professioanal cyclist to find accurately on their own.

I like Todd Carver's take on cleat fore/aft which is a compromise of all the above and in my experience works very well. Find the head of the first metatarsal (ball of the foot). Then find the fifth metatarsal head (if you run your fingers down the outside of your foot, it's the first large bony protrusion you come to). Align

CLEAT POSITION



The generally accepted rule of thumb for positioning the cleat fore/aft is to align the ball of the foot with the centre line of the pedal axle (spindle) in the 3 o'clock position.

The first head of the metatarsal joint is the big bony protrusion just behind the big toe.

Source: courtesy of bikefit.com © BikeFit LLC

the pedal spindle so as it bisects the first and fifth metatarsal heads. I find this method helps account for the sizing issue Pruitt highlights and generally gets people into the fit window.

Alterations can be made to this fore/aft position for numerous conditions (see Chapter 5).

The correct positioning of the pedal fore/aft is important for a number of reasons. A forward positioned cleat (and so the foot further back) results in a more up and down movement of the heel as it pivots around a longer lever arm and can result in Achilles issues. It also affects the overall bike set-up by changing the relative position of the foot in relation to the knee – see p. 46.

A rearward positioned cleat (and so the foot further forward) helps spread the pressure created when pedalling over more of the foot and specifically the mid-foot – this can help people reduce forefoot pain (often termed 'hot foot').

For riders who are duck-footed (walking toes out, heels in), moving the cleat rearward can help limit the amount of crank/heel contact.

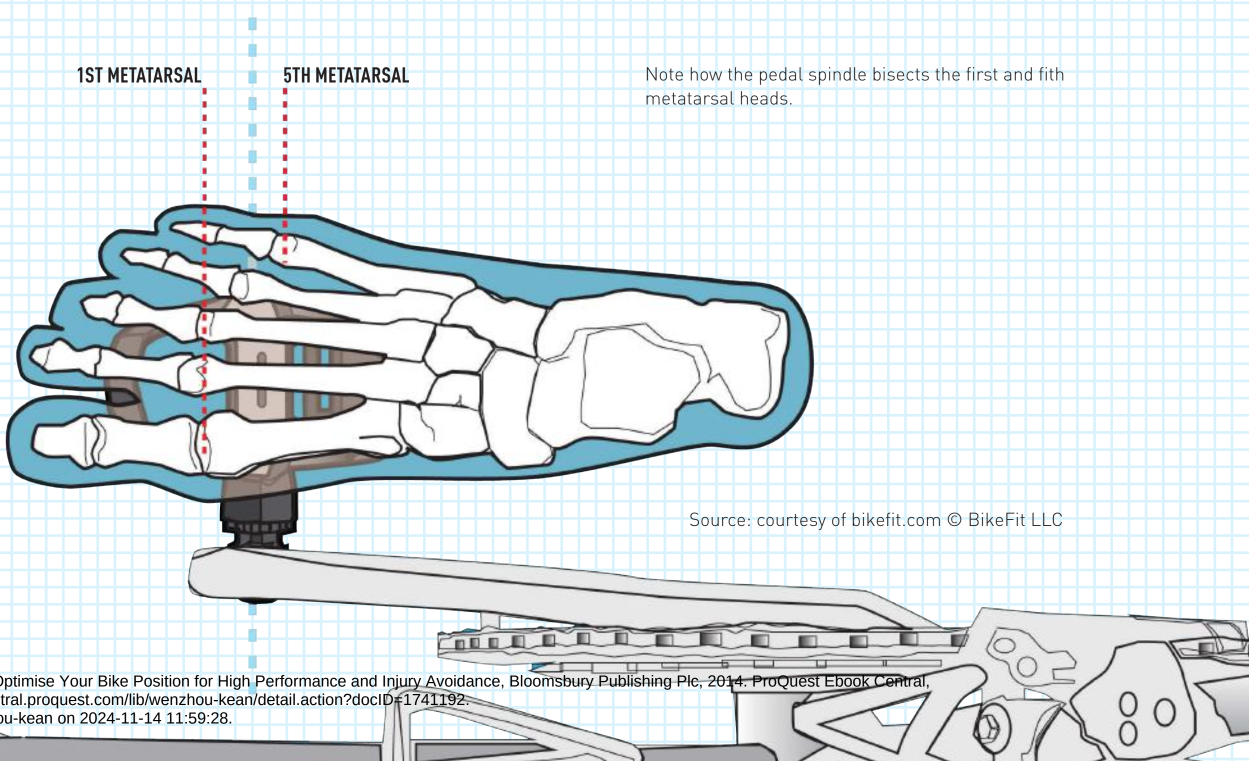
Having said all this, the jury is out on the potential performance benefits of cleat position. Many studies have tried to examine the effect on the amount of energy expended with regard to fore/aft cleat position, with inconclusive results. You can find many an internet forum or blog advocating arch or mid-foot cleat position for the most efficient power transfer from the lower limb to the pedal. The simple argument is that by shortening the lever arm of the foot/ankle pedal/cleat interaction you adopt a position that is biomechanically more advantageous for the transfer of power. To date research in this area has been limited.

ROTATION

Back in the 1970s the CONI manual advocated everyone adopting a very pigeon-toed (heels out, toes in) riding style, with the knees coming into the top tube. If followed slavishly for years, this style could end many cycling careers, or at least reduce many people's enjoyment of cycling.

The rotation, or the angle the cleats are set-up at, is important because it is a reflection of each of our individual physiques. Have a look at the next 20 or so people who walk past you. Make a mental note of whether they walk with their feet straight ahead

ALIGNMENT OF **PEDAL SPINDLE** IN RELATION TO **FIRST AND FIFTH METATARSAL HEADS**



Note how the pedal spindle bisects the first and fith metatarsal heads.

Source: courtesy of bikefit.com © BikeFit LLC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(toes/heel in line), like a duck (toes out/heels in) or like a pigeon (toes in/heels out).

If we followed the CONI guidelines only the pigeon-toed among us would be happy. The rest would soon develop overuse injuries such as iliotibial band (ITB) tightness or patello–femoral (kneecap) pain. We should instead set our cleats up to accommodate our natural and unique lower limb biomechanics. If we don't do this, our feet cannot drop the heel in, or 'pronate', as they ought to, meaning that the forces which are usually dispersed by this movement are transferred up the kinetic chain. The weakest point – usually the knee – will eventually break down.

With fixed cleat/pedal systems (without float), set-up is crucial. With pedal systems that allow rotation/float it is less important, but the midpoint of the rotation/float still needs lining up correctly to gain maximum benefit.

Summary

If a rider walks with toes pointing straight ahead they should set their pedals/cleats up so that this is the case on the bike.

If a rider walks with toes out and heels in then they should again set their pedal/cleats up to allow the heels to drop in when they pedal. This subgroup often find they have to move their cleats towards the inside of the shoe to effectively increase the stance width and stop their heels making contact with the crank arm. Some riders drop their heels in so much they often require longer pedal spindles to increase their stance width enough to stop the crank from rubbing.

A pigeon-toed rider needs to make their pedal/cleat system reflect this and have their heels pointing slightly outwards. This subgroup is small in my experience, and care should be taken adopting this set-up as it will lead to ITB tightness and irritation in all but those whose biomechanics make it necessary.

FOOT/PEDAL FLOAT

As mentioned 'float' is the small amount of rotational movement the cleat will allow so as not to leave the foot fixed too rigidly to the pedal. In the days when people just pedalled around in old-style toe clips on flat pedals, float existed by accident. In this free-pedal system people's feet were free to migrate to whatever position they needed to.

STRAIGHT WALKING STYLE

Note the straight-ahead walking style is reflected on the bike (when unaffected by float being shut off).

DUCK-FOOTED WALKING STYLE

Note how someone who walks very heel in (duck-like) drops their heel in when pedalling when float/rotation allows.

With the advent of clipless pedal systems in the 1970s, initially all degrees of float were removed. The idea for the locked-in pedal/cleat/shoe system came from ski-boot binding systems. The company Look first made these long before they were a major cycling pedal manufacturer. There was no need for float in skiing so early locking pedal systems offered none. However, it wasn't long before cyclists started to experience overuse injuries from being locked into one position. With the cleats set straight ahead as was recommended (and aesthetically pleasing), many riders developed ITB tightness and patello–femoral issues.

The reason for this is that the knee isn't simply a hinge joint, flexing and extending: it twists as well. As we push down on the pedal, the tibia rotates on the femur. Associative rotation and pronation of the foot/ankle complex occur concurrently. The fixed position of the locked-in clipless pedal system significantly reduces the degrees of motion available for this to occur, resulting in more overuse injuries seen in riders who do not use float than in those who do.

CHANGING YOUR SET-UP

If you have ridden a lot on a certain bike and pedal system, be careful when changing to a new or different set-up. I see many people who have ended up with an injury or pain without knowing that the cause is a change of equipment. For example, when swapping cleats, you should take a photo of the old position before removing each one. That way you will be able to get the new ones spot on. With our elite cyclists I always recommend keeping old shoes and cleats until any new set-up has been tried out over many rides, so that if there is a problem we not only have something to look at in order to establish the cause, we also have the old set-up to ride on until the issue is resolved.

Maury Hull (Ruby and Hull 1993) has done some of the most extensive and scientifically reliable research into the effect of the foot/pedal interface on loading at the knee. The conclusions from his extensive work include the fact that allowing 1 degree of freedom in float decreases knee-joint loads significantly. He astonished audiences of bike fit professionals at the 2007 SICI conference when he revealed his research findings suggesting that a valgus (inward) not varus (outward) forefoot posting reduced injury forces at the knee joint.

PIGEON-TOED WALKING STYLE

If a rider walks toes-in heels-out (pigeon-like) then the pedal/cleat set-up should allow them to pedal like this.

HEEL HITTING **CRANK ARM**

HEEL RUB: DUCK-FOOTED RIDER NEEDS STANCE- WIDTH CORRECTION


ULTEGRA

Interestingly, track sprint cyclists use floatless locked-in pedal systems extensively. However, they do not suffer overuse issues, as the time spent intensely pedalling with restricted movement is usually short. For them the most important thing is that their feet do not unclip when they are starting (for example in a team sprint), or making an extreme acceleration in a match sprint, and removing float helps in this area.

Old myths around float still resonate in the cycling world. Many argue that float requires more 'accessory muscle stabilisation', that is, a lot of effort just stabilising the foot on the pedal (cycling on Speedplay pedals for the first few times feels like pedalling on an ice cube), and is therefore less economical and reduces power. Equally, some argue that float shares or spreads the repetitive loads that stress the knee and surrounding soft tissues. Both camps are wide of the mark in my opinion. The way in which float permits a rider to adopt the biomechanical patterning optimal for their muscles and joints must surely allow them to generate more power than is lost by trying to stabilise in compensation for a few degrees of float – if indeed they have to do that at all.

At the same time experience tells me that, while the idea of sharing the load sounds like a persuasive theory, it probably isn't the reason float works. This is because riders who move to a clipless pedal system with adjustable float (such as Speedplay zeros), usually start with the maximum degree of float available and over time dial the float in, removing what they don't need. The float allows them to find the position they are most happy in on the pedal and then the few degrees remaining after they have removed the extraneous float will allow natural biomechanical lower limb patterning to take place.

Foot pedal side to side

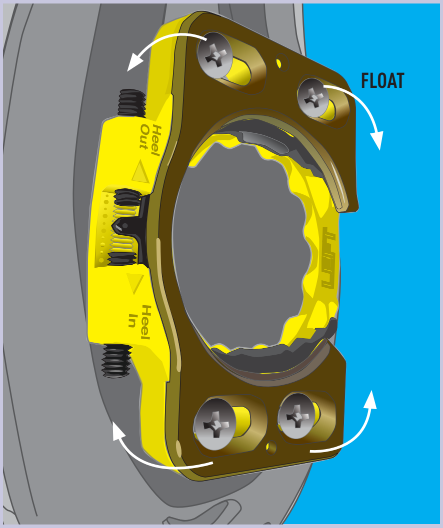
The side-to-side position of the cleats, in terms of how far left or right they sit on the shoe, affects the effective stance width of the bike, that is, the distance between your feet. By positioning the cleat towards the outside or the inside of the shoe you position the foot closer to or further away from the crank arm. Hence people with narrow hips trying to align hip/knee/foot may well move their cleats to the outside of their shoes, therefore narrowing their stance and helping to align the hips with the knee and foot. Wider-hipped riders will employ the opposite to gain alignment.

TOE FLOAT VARUS

TOE FLOAT VERSUS CENTRED FLOAT AND SPRING-CENTRED PEDALS

Most of the pedal systems available use cleat systems that lock in from the front of the shoe. In other words the float is centred at the front or toe end of the cleat. Speedplay pedals provide centred rotation (see the illustration to the right).

A lot of the pedal systems also employ springs that return the cleat and shoe to the middle position where possible – Shimano Dura Ace for example. Others use friction that increases as it gets further from the midline. Both give the sensation of centring the foot on the pedal when the forces allow it. As I mentioned on p. 58, when one famous company changed the springs in their top end pedal to a higher resistance without telling anyone we noticed a sharp spike in knee niggles and pain, as the system had effectively locked down the position if the rider wasn't strong enough to overcome the stronger spring.



Source: courtesy of bikefit.com © BikeFit LLC

Different pedals offer different amounts of adjustability when it comes to stance width. Speedplay have up to 4mm either side of centre making a total 8mm of adjustability. Some pedal systems offer different sized pedal spindles to people wanting to optimise their stance width. Speedplay offer four different sizes of spindle, for example, and other manufacturers make longer spindle widths for the pro riders in the peloton (the group of riders bunched together in a race), although these are not available commercially.

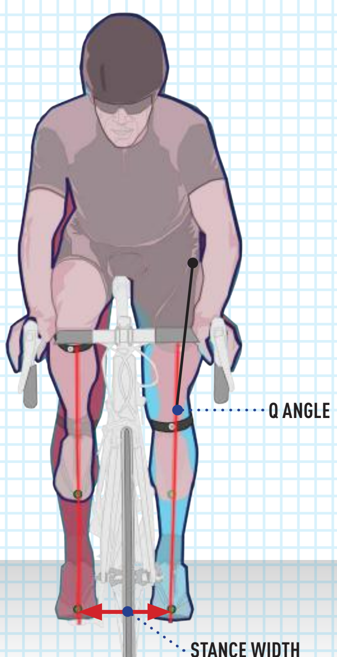
STANCE WIDTH

Of all the parameters that are adjustable on a bike, stance width is the most overlooked in my opinion. Until relatively recently, stance width was pretty much set by the width of the bottom bracket on the bike because pedal spindles were almost universally the same length. This one-size-fits-all approach has always baffled me. People's pelvises and therefore hip widths are obviously different – and achieving a hip, knee, foot alignment that delivers a Q angle a rider can cope with is obviously dependent on stance width.

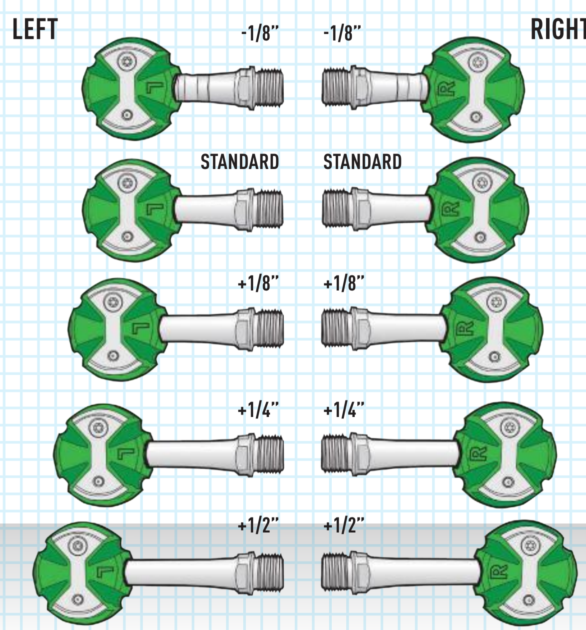
Q FACTOR AND Q ANGLE

The terms Q factor and Q angle are confusing because they are often used interchangeably. Q angle in cycling refers to the angle formed by the quadriceps as it meets the patella tendon. Women have a larger Q angle than men in general due to having wider hips. Q Factor is the distance between the two pedal cranks, which is a measure of stance width and therefore affects the Q angle. I have decided to use the term stance width instead of Q factor to avoid this confusion. I've found that manipulation of the Q angle through stance width has resolved many riders' knee issues.

STANCE WIDTH



DIFFERENT **SPINDLE** WIDTHS



Source (for both figures): courtesy of bikefit.com © BikeFit LLC

SO WHAT FRAME SIZE AM I?

Despite all of what I've just said about the complications of bike fit and sizing some of you will still be asking this question. We have discussed the shortcomings of various quick methods – formulae and the like – but I understand many of you won't want to drop £200–£300 pounds on a dynamic bike fit, which is the easy answer. The best way to find your frame size cheaply is to not rely on any one single measure. If you're outside the middle area of normal distribution, as discussed earlier, you could end up in trouble. So line up lots of evidence for what frame size you're likely to be and you will have a better chance of getting it right.

I would suggest you do all of these to increase the chances of success:

1. Check with the manufacturer. If you know the make of bike you want, check online. Many manufacturers have websites that give you a guide as to what size you may be. The simplest being your height related to the top tube length. For example, I'm 6'4" tall, and for this height most would recommend a 60cm top tube size bike. Others go into more depth.
2. Use the Lemond method. Measure your inseam and multiple by 0.833 to give you saddle height. If you take this information to a bike shop they will be able to work which size frame you need.
3. Use online sizing apps. Many have sprung up – some linked to major manufacturers – and normally involve measuring a few body parts. For instance, at the time of writing, the ebicycles.com site had a good 'Road Bike Size Calculator'.
4. If you have a bike already – measure that – saddle height and reach and drop. This info will help online and in the shop to place you on the right frame.

Remember, this is sizing not fitting. Sizing is working out what size bike should work for you, fitting is just that – fitting the bike to you.

RETÜL RECOMMENDED **NORMAL** RANGES

MEASUREMENT TITLE	NOTES	ROAD	MTB	TT	Tri
Knee angle flexion	–	108–112	110–115	110–115	110–115
Knee angle extension	–	35–40	35–40	37–42	37–42
Back angle	on hoods for road	45	50	20	25
Armpit angle to elbow	–	–	–	75–80	70–75
Armprit angle to wrist	–	90	75–80	–	–
Elbow angle	–	150–170	150–170	90–100	90–100
Foream angle	–	–	–	varies	varies
Ankling range	–	15–30	15–30	15–30	15–30
Ankle angle max (plantar flexion)	near top of pedal stroke	95–105	95–105	95–105	95–105
Ankle angle min (dorsi flexion)	near bottom of pedal stoke	70–80	70–80	70–80	70–80
Hip angle closed	look for bilateral differences	55–65	60–80	35–45	45–55
Hip angle open	look for crank length too	–	–	–	–
Knee forward of foot		(-10) – 0	(-20) – (-10)	(+50) – (+100)	(+50) – (+100)
Hip vertical travel		40–60	40–60	40–60	40–60