PART 1

Bike Fit

Chapter 1: Bike Fit Rules

Cyclists are often obsessed with bike fit. The more experienced they become, the more they worry about the subtle differences that a couple of millimeters can make.

Eddy Merckx, probably the greatest cyclist who ever lived, carried a 5-mm allen key in his jersey pocket. He was famous for making slight adjustments in saddle height, often several times a day. Sometimes he raised or lowered his saddle while on the bike during races.

It's often said that Merckx was persnickety about bike fit because he suffered nagging pain from injuries in a crash. But he also had an undetected physical abnormality that gave him problems during his whole career.

A few years ago, Eddy brought his son Axel to my office. (Axel now rides for the Domo-Farm Frites team and is an excellent pro in his own right.) I examined the young rider and found a significant leg-length inequality, primarily in his femur.

Incredibly, Eddy has the same problem.

When I diagnosed this, Eddy knew why he had been so uncomfortable on the bike despite his great success. At the thought of all the pain he had suffered—pain that could have been alleviated with a properly shimmed and adjusted cleat—he remarked, with his characteristic rueful grin, "Where were you when I was riding?"

Merckx's constant fiddling with bike fit points up what all cyclists know. First, if you're uncomfortable, riding is no fun. And because bike fit is so closely allied to power production, no one wants to squander even one watt of hard-earned power due to a poor position on the bike.

Fortunately, it isn't hard to find your ideal riding position.

- **Rule 1: Bike fit is a marriage between bike and rider.**

If the two are incompatible, the marriage will fail. Just as married couples must adjust to each other, so must a bike and rider.

There's an important qualifier to this analogy. The bike can be adjusted to the rider's anatomy in multiple ways, such as moving the saddle up or down or changing the stem. But the body can be adjusted only in minor ways—with a carefully designed stretching program and by adapting to progressively longer rides. So the second rule is:

- **Rule 2: Make the bike fit your body; don't make your body fit the bike.**

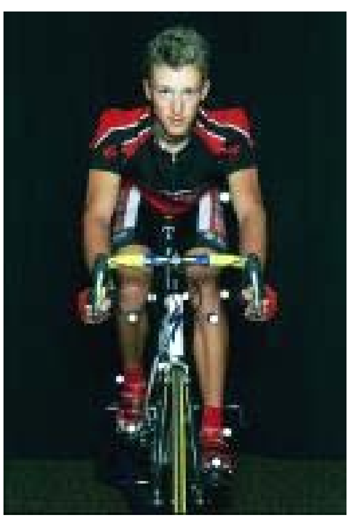
It's easy to adjust the bike but difficult to stretch or contort your body into some pre-conceived "ideal" position.

If you have long legs coupled with a short torso and arms, your bike needs a relatively short top tube/stem combination (often called "reach"). If you have stubby legs and most of your height is in your torso, you need a long top tube and stem.

Forget what your favorite pro rider's bike looks like unless your body is a carbon copy of his. Make your bike look like you, not like your hero.

- **Rule 3: Dynamic bike fit is better than static bike fit.**

Most bike fit systems are static. They are done with a rider sitting motionless on a trainer or from a set of formulas using body-part measurements. Static and numerical formulas are an important starting point, from which we can move to dynamic fit.



A pedaling rider is constantly moving on the bike. As you pedal, you actually rise or levitate slightly from the saddle. So ideal saddle height is different when you're pedaling compared to when you're just sitting motionless.

At the Boulder Center for Sports Medicine, we use a dynamic system to determine bike fit variables such as saddle height. First, we attach reflective markers to specific anatomical landmarks on the rider's knee, ankle and hip (**photo**). Then we put him on the trainer and have him pedal.

We videotape the pedaling rider. A computer converts him into a 3-D stick figure. From that data we can determine exact and functional fit for saddle height, saddle fore/aft and reach to the bar.

Again, there's nothing wrong with static bike fit and mathematical formulas as a starting place. In fact, in this eBook I'll suggest a number of ways to find ballpark figures for these important measurements. For 95 percent of riders, this eBook's information will enable powerful and pain-free cycling.

But if you're constantly uncomfortable on the bike or beset with nagging injuries, there's no substitute for an anatomical dynamic bike fit done while you're actually pedaling.

- **Rule 4: Cycling is a sport of repetition.**

At a cadence of 90 revolutions per minute, a 6-hour century ride requires 32,400 iterations of the pedal stroke for each leg. That's a lot of repetition!

Worse, each pedal stroke is almost identical—your knee tracks in the same plane when observed from the front, and it bends the same amount at the top of each stroke.

As a result, a minor misfit (for instance, the saddle too low by several millimeters or a leg-length inequality of 5 mm) can lead to major problems over time. That's why fit is so important.

Chapter 2: Saddle Position

Saddle position is the key fit variable and the most important measurement to get right.

A low saddle often leads to problems in the front of the knee because the knee is bent excessively at the top of the pedal stroke where power production begins. There's too much shearing force on the back of the *patella* (kneecap) where it tracks in a groove in the *femur* (thighbone).

A saddle set too high can cause pain behind the knee because you have to reach for the pedals, excessively stretching the hamstrings.

A high saddle also compromises power production. This is because the patella acts like a fulcrum in the leg's lever system. As the leg straightens, it's less effective until the patella loses contact with the femur entirely at a knee bend of about 15 degrees. Inappropriately high saddles mean you lose power because the patella is no longer an effective fulcrum.

A saddle also can be positioned by sliding it fore or aft along its rails on the seatpost. This is an important fit variable because it controls where you sit in relation to the bike's bottom bracket (center of crank rotation).

Finally, a saddle can be tilted up or down or be completely level.

Saddle Height for Road Bikes

To find a close approximation of your ideal saddle height, the simplest method is often the best:

With the bike on a trainer, pedal for five minutes in a medium gear until your muscles are loose and you're positioned on the saddle where you normally sit.
Unclip and place both heels on the pedals.

Pedal slowly. Your knees should reach full extension at the bottom of each stroke. Your heels should almost, but not quite, lose contact with the pedals as they go around the bottom (**photo**). Your pelvis should remain level with no hip rocking.

When you clip back into the pedals with the ball of your feet over the pedal axles, the length of your feet makes your legs longer. The result is the appropriate amount of knee bend at the bottom of the stroke.

The LeMond Method

Another commonly used method was popularized by three-time Tour de France winner Greg LeMond. It's an approach that Greg learned from his French coach, Cyrille Guimard.

In bare feet and wearing cycling shorts, stand with your back against a wall. Have your feet about six inches apart.

Put a carpenter's square between your legs so that one side is flush against the wall. The other side should project in front of you from between your legs. (The idea is to have a measuring device that is level with the floor. A large thin book or record album—remember those?—can work, too.) Pull up on whatever you use until you feel pressure against your crotch equal to what a saddle produces when you're pedaling easily.

Have someone measure from the top of the horizontal edge of the carpenter's square to the floor. Record this crotch-to-floor distance precisely in centimeters.

Saddle height, as measured from the center of the bottom bracket axle to the top of the saddle along the seat tube, should equal 0.883 times your crotch-to-floor distance. For instance, if your crotch-to-floor measurement is 87 cm, your saddle height is 0.883 x 87 or 76.8 cm.

There are five important qualifiers to this formula.

- It was developed in the early 1980s when equipment was different. Cycling shoes had thicker soles, and pedals with toe clips positioned the foot higher above the axle than modern clipless pedals do. These factors mean that the 0.883 multiplier may be too high when you're using modern equipment. Still, it's a good starting point for ballparking saddle height.

- Riders with long feet for their height may find that this formula produces a saddle that's too low. Long feet have the effect of lengthening legs beyond standard proportions.

- Cyclists with excessive soft tissue over their sit bones may find the saddle too low. After sitting on the saddle for a while, the soft tissue compresses.

- Adding thickness to your shoes—in the form of thicker insoles or cycling-specific orthotics that extend under the ball of the foot—has the effect of lengthening your legs. This requires a higher saddle.

- Adding thickness between your crotch and the saddle, like when you wear thick winter cycling tights, effectively shortens your legs and requires a slightly lower saddle.

Saddle Height for Mountain Bikes

Determine saddle height for a mountain bike using the road bike guidelines.

There's one exception. If your ATB's crankarms are longer than your road bike's, you should lower the saddle an amount equal to the difference in crankarm length. This is necessary to give you the correct amount of bend in your knee at the bottom of the stroke.

For example, if you run 170-mm crankarms on your road bike but 175-mm on your mountain bike, lower your mountain bike's saddle 5 mm.

Frame Size

LeMond's crotch-to-floor measurement will help you find your frame size, too.

Simply multiply your measurement by 0.65. For example, if your crotch-to-floor distance is 87 cm, then 87 x 0.65 = 56.5 cm. This means you should ride a frame that measures 56 to 57 cm from the center of the bottom bracket to the top of the top tube, measured along the seat tube.

However, many current frames don't have the traditional diamond shape with a top tube parallel to the ground. It's hard to find their center-to-top measurement. Most manufacturers give a "virtual seat tube height" measurement when their bikes are designed with angled top tubes. This makes it easier to get the correct frame size.

Some riders need a larger frame than this method suggests.

For example, if you need your handlebar fairly high compared to the saddle, you may want to use 0.7 as a multiplier. The same holds if you have a relatively long torso or arms and need a frame with a longer top tube. As seat tubes lengthen, so do top tubes.

Saddle Setback

This important measurement involves the fore/aft location of the saddle and is contingent on the length of your *femur* (thighbone). It has nothing to do with a frame's seat tube angle.

The saddle setback should put your knee's center of rotation directly over the pedal axle of the forward crankarm when it's horizontal.

Correct setback is important for two reasons:

1. It positions your knee so that your power can be driven directly into the pedal at the point in the crank circle where it does the most good.
2. It means that your hips are neither too far forward nor too far behind the bottom bracket. Either of these extremes can cause injury or chronic pain as you pedal.

The center of the knee's rotation must be directly over the ball of the foot (and therefore the center of the pedal axle) at the time of maximum power production. Of course, some riders may not have their cleats directly under the ball of their feet (I'll discuss this later), but this rule holds for everyone else.

To determine saddle setback, you need a plumb line that you can make from a piece of string with a heavy washer or nut tied to one end. You also need a friend to help.

1. Put your bike on a trainer. If the surface isn't level, shim the trainer's legs until it is. Pedal for five minutes to warm up and find the place on the saddle where you normally ride.

2. Stop pedaling so the crankarms are horizontal (parallel to the floor) and your right foot is forward. Take care that you don't raise or lower your heel when you stop pedaling. Have your friend watch to be sure it's in the same position as when you're turning the crank.
3. Your friend should drop the plumb line from the front of your right leg's kneecap (**photo**). The line should touch the end of the crankarm. If the line is in front or behind the end, loosen the seatpost bolts and slide the saddle forward or backward on the rails to get it right.
4. Pedal for a minute to re-establish your normal position on the saddle, then recheck with the plumb line and readjust the setback, if necessary. Keep at it until you get it right. Be patient—this is an important measurement.

5. Now check the left leg. If the line doesn't touch the end of the crankarm like on the right side, it means you might have an inequality in femur length. If so, adjust the saddle setback to split the difference.

Changing the saddle's fore/aft position can change its height. If you had to slide the saddle a considerable distance to achieve proper setback, recheck saddle height. If it needs to be changed, do it and then recheck setback.

Some authorities say that the plumb line should be dropped from the bony bump below your kneecap (called the *tibial tuberosity*). The line should then bisect the pedal axle when setback is right.

I prefer to use the front of the kneecap because it's an easier anatomical landmark to find. Also, the bony bump varies in thickness and location among individuals, making it less precise.

Finally, it's easier to see if the plumb line touches the end of the crankarm than it is to judge its relationship to the pedal axle. The end results are very close.

> **CAUTION! It's a fashion statement in some cycling circles to have the saddle jammed as far back on the seatpost as possible so the rider can sport what he considers a "pro" position. But this setback is right only for riders with long femurs coupled with a flexible low back and hamstrings.**
>
> **EXAMPLE! Greg LeMond has extremely long femurs. His kneecaps seem to be only slightly above his ankles! So for him, a bike with a slack seat tube angle, a long top tube and the saddle jammed all the way back is appropriate. Such a position puts his knee over the pedal axle or just slightly behind it.**
>
> **But most people aren't built Greg's way. Former pro Ron Kiefel, a seven-time Tour de France competitor, once moved his saddle back when a famous rider he admired told him he'd be faster if he did. Ron didn't get faster. Instead, he developed severe back pain and missed several weeks of racing.**
>
> **The moral of this story: Let your femur length, not your hero, determine your saddle position.**

Saddle Tilt

When I go to mass-participation cycling events like centuries or Ride the Rockies, I'm amazed at the variations in saddle tilt. Some riders have the nose pointed down at extreme angles—as much as 30 degrees. Other riders tilt the nose so high that their saddle looks like a jumbo jet taking off. It's painful to look at.

Here's the rule: If you're a recreational or touring cyclist and you have the nose of your saddle pointing up or down, your bike doesn't fit. It's probably the reach to the handlebar (see below) that's incorrect. Other points:

- In general, your saddle should be positioned level with the ground. It should not be angled up or down. Check with a carpenter's level or a yardstick placed lengthwise on the saddle and compared to something horizontal like a tabletop or windowsill.
- If the nose of the saddle is down, you'll have too much weight on your arms and hands as you try to stop your body from sliding forward. The result may be arm fatigue and numbness in your fingers.
- Downward sloping saddles also put too much of your weight on the front wheel. This degrades bike handling.
- Tilting the saddle down doesn't solve crotch problems like numbness or excessive saddle sores. Instead, it can make them worse. When you're constantly sliding down the saddle and then pushing yourself back, crotch irritation results.
- If the nose of the saddle points up, it will push against the soft tissue, blood vessels and nerves in your crotch. This leads to saddle sores, numbness and the risk of erection difficulties (for males).
- When the nose points up, it also has ramifications for the lower back. The normal curvature is changed, often resulting in pain.

Despite these risks, there are two exceptions to the level-saddle rule:

1. People with unusual pelvic tilts or lumbar postures (swayback, for instance) sometimes require a slight upward tilt (1 to 3 degrees) so they can get their weight on their sit bones rather than on soft tissue.

   Posture irregularities don't have to be so pronounced that people notice. For example, you could have a very subtle swayback syndrome that tilts your pelvis forward as you lean over to hold the handlebar. But usually a simple adjustment—raising the handlebar slightly—will let you level the saddle and still get the pressure off the pudendal nerves in your crotch.
2. In rare instances, the saddle should be tilted down slightly. This is appropriate mainly when in a low time trial position with aero bars.

Chapter 3: Handlebar Position

Reach is the combination of top tube and stem length with some input from saddle fore/aft position.

Reach to the handlebar determines the angle of your torso in relation to the ground. The shorter the reach, the greater the angle. Tourists sit relatively upright while time trialists want their backs to be almost parallel to the ground. Your best torso angle will depend on the way you ride, your goals in cycling, your body's limitations and your comfort.

Other contributors to reach are the type of brake levers you have and the handlebar shape. Some bars are longer from front to back, enlarging the reach. Some have a deeper drop. The shape of the levers' bend can affect where you grip the lever hoods, changing the reach.

Reach is the most individual part of bike fit. It depends on a wide range of factors including hamstring and low-back flexibility, low-back strength, posture, arm and torso length, and shoulder strength.

Each of these factors also plays a role in the height of the bar in relation to the saddle.

Age is part of the equation, too. As we get older, we often lose flexibility regardless of how much stretching we do. The handlebar has to come up, and often the reach must be reduced.

In the days of conventional quill stems and threaded steerer tubes, adjusting handlebar height was relatively easy—just raise the stem. But with the acceptance of threadless headsets, handlebar height adjustments are more complicated.

> **TIP! If you're considering a new or custom bike, don't let the shop cut the steerer tube until you're sure the fit is right.**

Reach to a Drop Bar

Use the following advice to approximate correct reach to the handlebar and set your saddle/handlebar height differential. This advice is for a drop (downturned) road handlebar unless otherwise noted.

> **CAUTION! Be sure your saddle height and setback are correct before you adjust the handlebar.**

These are only guidelines, but they're useful starting points:

- An old Italian wives' tale says to determine reach, put your elbow against the tip of the saddle and extend your open hand toward the handlebar. The end of your middle finger should come within an inch or so of the bar.
- To get a ballpark figure for the relationship of handlebar height to saddle height, measure your fist across the knuckles from little finger to index finger. Then use a stem height that makes the difference between the bar top and saddle top equal to your fist measurement. Take several rides, then make adjustments based on feedback from your body.

CAUTION! These anatomical approximations assume that all of your body parts are in proportion. Is there a relationship between the size of your fist and the length

of your upper body? Or the flexibility of your low back? Sometimes—and sometimes not. Still, these approximations are a useable starting point.

Another formula says that your reach to the handlebar should be such that 40 percent of your weight is on the front wheel and 60 percent on the rear. There's no good way to determine those percentages, however.

One suggestion is to put the bike's rear wheel on one bathroom scale and the front wheel on another. Then sit on the bike and see if 40 percent of the combined weight registers on the front scale. This is a rough approach at best because it's done while you're stationary rather than pedaling.

> **CAUTION! Flexibility matters. If you can't stand with locked knees and bend over to touch your toes after only a minimal warmup, none of the static bike fit formulas will work for you. None of them! You'll need a higher handlebar, set closer to the saddle.**
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> **EXAMPLE! At the Boulder Center for Sports Medicine, we recently diagnosed a young pro with a congenital back ailment. He has since raised his handlebar almost 3 inches. He went from a 12-cm bar/saddle differential to about 5 cm. He still looks like a pro on the bike and he's amazed at the increased comfort.**

Bike shops fit customers to bikes. In good shops, the employees have extensive training and experience. But because of all the variables, it's beyond even the best bike fitter's skills to get reach right on the first try. This dimension is just too personal.

As a result, shop employees shouldn't be upset when customers come back and want a stem change after they've ridden several hundred miles.

Still, I've heard shop people complain: "I spent two hours fitting this guy, and he had the nerve to come back and want a different stem!"

You bet he had the nerve—literally. The nerves in his hands or neck hurt after he'd ridden several hours. Something wasn't right. It's a precarious balance and bike shops need to realize this.

Reach to a Flat Handlebar

Some road riders like to install a flat bar, especially on a commuting bike so they can sit upright on busy streets. It's easy to duplicate your drop-bar reach when you convert to a flat bar, or if you want to set up a mountain bike.

1. Put some blue carpenter's chalk on the web between your thumb and index finger.
2. Pedal your properly adjusted road bike on the trainer for several minutes, then measure the distance from the tip of the saddle to the blue chalk mark you left on the brake hoods.

3. Without washing your hands, ride your bike with the flat bar and note where the blue mark appears on the grips.
4. The distance from the tip of the saddle to the chalk marks should be the same on both bikes.

Handlebar Width

Handlebars come in several widths. Some manufacturers measure drop bars from the center of the bar ends, while others measure from the outside of these openings. Generally, the bar on your road bike should equal the width of your shoulders.

To determine your shoulder width, have a friend measure from one *acromio-clavicular joint* to another. The A-C joint is the prominent bump on top and about two inches from the outside of each shoulder. If the distance is 42 cm, that's the width of the bar you should use

Criterium specialists may prefer a narrower bar so they can squeeze through tiny openings in the pack.

Distance riders usually like wider bars for more comfort and steering stability. Wider bars aren't a panacea, however, because they can create their own set of physical problems. Women usually have narrower shoulders and less upper-body strength to help them cope with ill-fitting bars.

Brake Lever Placement

A drop bar should be nearly level when looked at from the side. This will be the case if the bar is positioned so that the flat lower portion points to the bike's rear brake.

Once the bar is set, here's how to position the brake levers:

1. Hold a straightedge under the flat part of the drop so that it projects forward (**photo**).
2. Move the lever on the bar till the tip just touches the straightedge.
3. Anatomical handlebars with flat sections in the bends for hand comfort may affect Step 2. If you have this type of bar, go with this general rule: You should be able to reach the levers equally well from atop the hoods or in the drops.

Touring or long distance cyclists may want to rotate the bar in the stem so the drops point at the rear hub rather than the brake. This raises the top of the lever hoods, putting them closer to the saddle to create a more upright position.

Compared to Campagnolo brake levers, Shimano models have a more abrupt transition from the lever body to the handlebar. Some riders find one brand or the other to be more comfortable.

If you're updating from brake-only levers to combination brake/shift levers, remember that the new levers have bodies about 1 cm longer to accommodate all the internal mechanisms. As a result, you need a stem 1 cm shorter.

It's fine to position one brake lever slightly different than the other. Remember, the bike should look like you. Some riders have one arm that's slightly shorter than the other thanks to a broken bone or congenital factors. A broken collarbone can cause the same effect. In these cases, you'll want to have the brake lever higher on the short-arm side.

> **TIP! One signal that you need an asymmetrical reach is a stabbing pain behind one shoulder blade or on one side of your neck. Check by riding a trainer. Have a friend look from the front and from behind to see if your shoulders are level. Adjust your brake levers until they are.**

Hand Positions on Drop Bar

The shape of drop handlebars has remained basically the same for a hundred years. There's good reason for this apparent lack of innovation—the standard downturned shape is best suited for comfort and control. It provides a number of hand positions, too. This is crucial because leaving your hands in one place guarantees numb and tingling fingers.

> **TIP! Your wrist should be in a neutral, handshake position as much as possible. If your wrist angles toward the thumb or little finger, you'll experience numbing nerve pressure.**

There are three primary hand positions on a drop bar:

> **1. On the lever hoods**. Place the web of your hand atop the brake lever hood with the thumb to the inside and the four fingers to the outside. Curl your index finger across the top of the lever. Be sure your wrist is straight. From this position, it's easy to brake with one or two fingers and shift if you have combined brake/shift levers. This is also the standard position for out-of-saddle climbing.
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> One useful variation on this position (assuming you have levers with concealed cables) is to put the middle of your palm on the tip of the hood as if you were resting your hand on the end of a cane. This stretches you out slightly and aids aerodynamics. When the reach is correct, your forearms will touch the top of the handlebar, providing support, comfort and aerodynamics.
>
> **CAUTION! You may see some roadies try to get more aero by resting their forearms on top of the bar. They grasp the cable coming from the side of each**

Shimano brake/shift lever. This is extremely dangerous! The cables provide only a flimsy grip, so hitting a bump can cause loss of control and a nasty crash.

2. On the tops near the stem. Place both hands, palms down, on the bar beside the stem. Some riders prefer to move farther out, near where the bar begins to curve forward, for added stability.

This is the standard climbing position. It allows you to sit more upright for added power and easier breathing. Many riders also use it for easy cruising because of the upright position.

If you need to ride one-handed (while drinking from your bottle, for instance), hold the bar with the other hand near the stem. If you hit a bump or are jostled from the side, you're less likely to swerve. This works because the closer to the bar you put your hand, the less leverage you have for steering. A bump isn't likely to make you jerk the bar.

CAUTION! You'll sometimes see a racer reach back to grab a teammate's hand and sling him forward on a climb or into a better position for a sprint. They'll hold their bars near the stem for better stability. Don't try this move unless you know exactly what you're doing. It's an easy way to tangle the bikes and take your friend down with you.

3. On the drops. Grip the bar's low section near the curves ("hooks") for descending or fast, flat riding. This is the most aerodynamic position on a drop handlebar. It also produces the most powerful braking because you can pull on the levers with several fingers while opposing the force with your thumb wrapped around the bar.

Some riders defy conventional wisdom and grip the drops during out-of-saddle climbing. They argue that this provides more leverage to let them get their upper body into the pedal stroke. Climbing in the drops used to be discouraged on the grounds that the bent-over posture makes breathing difficult and aerodynamics doesn't matter going uphill. But now that top climbers like Marco Pantani are seen on the drops more often than not, more riders are trying it. And they do seem to be going faster.

TIP! No matter which grip you use, remember to change it frequently. If your bike fits properly, holding the bar tops will be as comfortable as riding in the drops. If you are comfortable only with your hands in one location, it's a sign that your reach to the handlebar is incorrect.

CAUTION! Some riders install a long stem with the bar much lower than the saddle. They think this makes them look like a pro. But the reach is often so excessive that they have to ride most of the time on the tops with their hands next to the stem. Then they have to move their hands each time they want to brake or shift.

Modern brake/shift levers are designed to reward riding with the hands on the lever hoods, where both shifting and braking are readily accessible. This is, to use a computer term, the default position. Still, you need to change your grip every few minutes to avoid hand numbness.

Aero Bar Position

Aero bars can be attached to most drop handlebars. They aid comfort and improve aerodynamic efficiency. But they also can be quite dangerous if you use them in a group or paceline. Your bike control isn't as sharp, and your hands are a long way from the brake levers.

As a result, there are only two reasons to install aero bars on your road bike:

- For long-distance cycling when many miles are ridden solo or with just a couple of other riders. Install the aero bars so when you're on them, a plumb line dropped from the front of your shoulder exits at the back of your elbow. In other words, your upper arm should be nearly vertical with the elbow slightly ahead of the shoulder.
- For time trialing when getting low is less important than getting narrow. Adjust the armrests so your arms are within the width of your hips when viewed from the front. Use a mirror or have a friend check. Also, slide the saddle forward 1-2 cm depending on comfort and power production.

  A pure time trialing position has a plumb line from the front of the forward knee falling 2 cm in front of the end of the crankarm when it's horizontal. Adjust the saddle's fore/aft position and its height, then adjust the aero bars as just described.

Chapter 4: Pedals and Cleats

Modern clipless pedals are a significant innovation compared to the clips, straps and slotted cleats of just a few years ago.

With clipless pedals, there's no pressure from toe straps across the instep or from toe clips digging into the end of your toes. Clipless pedals are easy to enter and exit. In a crash, your feet automatically disengage so you aren't attached to the bike as you fall.

Clipless pedal systems have, however, made bike fit more important.

With slotted cleats, if one leg was slightly longer than the other, the short leg's cleat would rise slightly off the pedal rail at the bottom of the stroke. This compensated for the inequality. The slight play in toe straps, even when pulled fairly tight, also helped.

But with clipless pedals, your foot is locked in and no compensation is possible. Over many repetitions of the pedal stroke, this can lead to problems such as low-back pain.

Also, the first clipless pedals didn't have *float*, the ability to let the foot rotate a few degrees outward or inward as you pedal. (Slotted cleats wore with time, so they allowed float even though it wasn't intended.) Today, nearly all clipless pedals permit float. This has lessened the injuries that were associated with the original rigid models.

Still, adjusting pedals and cleats is supremely important. Here's how.

Fore/aft Foot Position

In general, the ball of your foot should be directly over the centerline of the pedal axle. Here are pointers for obtaining this so-called "neutral" position.

- The ball of the foot is the first *metatarsal phalange joint*—directly behind the big toe. Feel it with your finger, then mark the side of your shoe. Align the mark with the center of the pedal axle. Slide your cleats forward or back until you get it right.
- This placement works best for men's size 9 feet (Euro size 41-42). Riders with longer feet will do well to move the cleats rearward on the shoe to put more of the foot in front of the pedal axle. In contrast, riders with shorter feet may move their cleats toward the front of the shoe so they are pedaling more "on their toes." The reason is that longer feet want stability and shorter feet want more lever length.
- Your shoe model will determine where your cleats can be placed. Each shoe manufacturer drills the same hole pattern for several sizes. If you're at the extremes for the hole pattern (because you have long or short feet), it may limit your ability to put the cleats in the optimum position.
- Long-distance riders often find that they can avoid painful numbness and "hot foot" by sliding their cleats all the way back. This puts the ball of their feet as far ahead of direct pedal pressure as possible. In fact, some ultramarathon riders go so far as to drill the shoe soles so they can move their cleats even farther to the rear. (For another solution to the hot foot problem, see the section on *metatarsal buttons*.)

EXAMPLE! Race Across America legend Lon Haldeman's business is taking riders across the U.S. on his PAC Tours—transcontinental rides that average well over 100 miles a day (www.pactour.com).

Sometimes a rider will develop such extreme foot discomfort that it's hard to continue. When this happens, Haldeman drills their shoes and moves their cleats as much as 2 cm farther back. This usually provides an instant cure, with pain-free pedaling the rest of the tour.

Many ultramarathon riders claim that this modification doesn't diminish the power or suppleness of their pedal stroke, so they ride with their cleats rearward all the time. However, this contention has yet to be tested in the lab.

CAUTION! Drilling shoe soles is a last resort. Don't try it until you've exhausted the other "hot foot" remedies in this eBook. Drilling can ruin expensive shoes unless you know exactly what you're doing. Putting additional holes in

some soles can weaken them. Also, moving cleats far to the rear may reduce "hot foot" symptoms but create other physical problems as the body copes with the extreme change in position.

Rotational Cleat Position

In addition to the fore/aft setting, cleats can be rotated to accommodate foot postures that point in or out from the centerline of the bike. Even with pedals that provide some amount of free rotation (*float*), it's important to set your cleats properly.

The goal is for your feet to automatically be in the center of the cleat's rotational arc, no matter what angle they naturally assume. This allows them to move one way or another from your "neutral" center.

To find the correct angle to mount your cleats, sit on the edge of a table or counter and let your feet dangle. Your hips, knees and ankles should all be at 90-degree angles.

Let your feet hang where they want to—don't force them to toe in or out. Just accept what you get. But remember to keep your ankles flexed at 90 degrees.

Now look down to see the angles your feet are making. Those are the angles you want to reproduce when you set your cleats. Have someone help you by looking at your feet dangling off the table and again when you mount the cleats and sit on the bike.

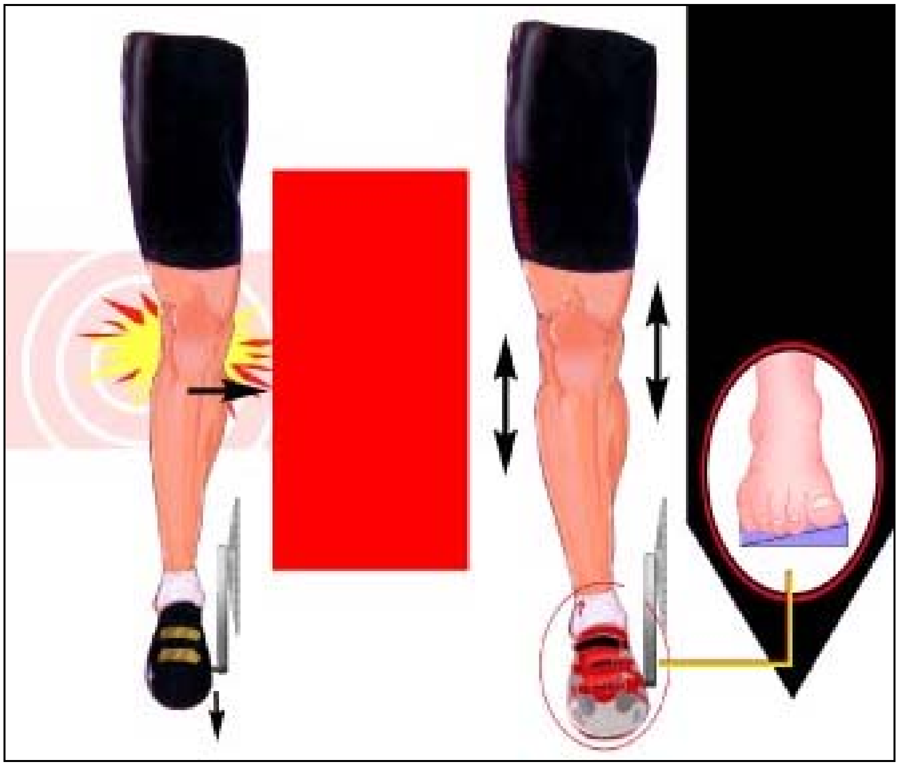
Two caveats:

- Most people's feet don't toe in or out at the same angle. Be prepared to set your cleats at different angles depending on how each foot behaves.
- When some people bend forward, the angle of their feet changes due to internal rotation at the hips. So, bend forward on the table the same amount you do to reach the handlebar on your bike. If your foot angle changes, use the angle created when you lean forward.

Forefoot Varus

As many as 87 percent of all feet have *forefoot varus*. Varus is when the ball of the foot at mid stance is raised off a level plane for your normal walking gait.

In cycling, varus causes us to internally rotate the shin. This, in turn, drives the knee toward the top tube. This creates a significant loss of power and is the most common cause of anterior medial knee injuries



Uncorrected forefoot varus (left) can injure knees and steal pedaling power. The solution (right) is to use shoes, orthotics or other devices that neutralize varus.
(Courtesy of Specialized)

Forefoot varus can be neutralized by custom orthotics, wedges made by Bicycle Fitting Systems, Inc., and anatomic shoes such as the Body Geometry models from Specialized.

Pedal Float

Most riders get along fine with only 3 to 6 degrees of rotation by the cleat before it snaps free from the pedal. On rare occasions, a rider might need a pedal system that provides more than 9 degrees.

The less float you have, the more power you can produce because your leg muscles aren't working so hard to stabilize your foot rotationally on the pedal.

There's an endpoint to the transfer of power to the pedal (much like in walking). Some extremely duck-footed riders need pedals with more float but only so they can achieve their normal foot posture on the pedal.

Of course, your anklebones shouldn't hit the crankarms and your heels shouldn't hit the chainstays. If they do, you need orthotic arch supports and/or forefoot varus correction.