PRINCIPLES OF BIKE FITTING: WHAT FACTORS MAKE FOR AN OPTIMAL FIT

RANDY ICE PT, CCS
SCOR PRODUCTIONS
FALLBROOK, CALFORNIA

RANDOLPH ICE PT, CCS – MY BIO

- CARDIOPULMONARY PHYSICAL THERAPIST X 40 YEARS
- RIDE DIRECTOR SOLVANG CENTURY (30 YEARS) AND SOLVANG PRELUDE (22 YEARS)
- CLINICAL COORDINATOR, VINTAGE MEDICAL GROUP (BIO-ID HORMONE REPLACEMENT PROGRAM) MURRIETA, CALIF.
- INVENTED KNEESAVERS PEDAL EXTENDERS/PEDAL ADAPTERS - 1986
- INVENTED SPIZ, THE ONLY NUTRITONALLY COMPLETE MEAL REPLACEMENT ENERGY DRINK – 1986 ULTRA ENERGY, 1994 – SPIZ

MY BIO

- CO-OWNER TIFFANY'S HAIR STUDIO & SKIN CARE, MURRIETA, CALIFORNIA
- INSTRUCTOR, USC SCHOOL OF PHYSICAL THERAPY AND MOUNT ST. MARY'S PHYSICAL THERAPY SCHOOL
- PHYSIOLOGICAL MAXIMAL EXERCISE TESTING X 38 YEARS
- BIKE FITTING SERVICES (PRO BIKE FIT I AND PRO BIKE FIT II) X 25 YEARS
- NUTRITIONAL CONSULTANT X 35 YEARS
- CYCLIST, WEIGHTLIFTER AND GOLFER

DIRECTOR OF CARDIOPULMONARY REHABILITATION – RANCHO P.T.

CARDIAC REHABILIATION X-MAS PARTY

MEDICAL CARE IN USA - DOA

MY FAMILY

MY GIRLFRIEND - DANIELLE

SOLVANG CENTURY, METRIC AND HALF CENTURY – SCOR CARDIAC CYCLISTS CLUB

ANATOMY

Bones and Landmarks, Pelvis and Leg

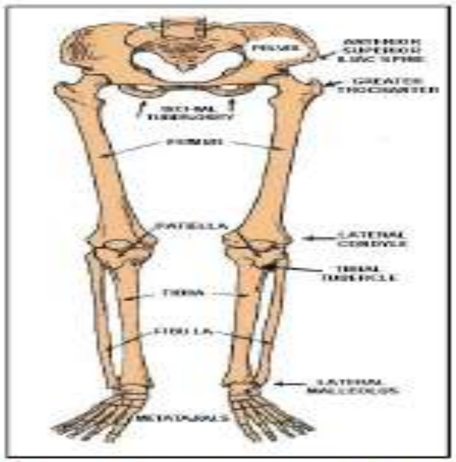


Figure 84. Selected lower limb bones and landmarks. For the shoulders, see Figure 35 on page 60.

ASIS—The anterior superior iliac spine, a landmark on the anterior pelvis.

Femur—The thigh bone. The largest bone in the body; runs from the hip to the knee.

Fibula—The minor bone running from the knee to the ankle.

Greater Trochanter Femur—A landmark at the junction of the neck and upper body of the femur.

Greater Tubercle Humerus—A landmark at the lateral head of the humerus.

Humerus—Upper arm bone.

Ischial Tuberosity—The sit bone.

Patella—The kneecap. Part of the knee's extensor mechanism. Serves as a pulley for the quadriceps muscles. The patella slides in a groove in the femur. Tracking of the patella is related to the Q-angle: the quadriceps-pull angle. The Q-angle is the angle formed by a line drawn from the ASIS to the central patella and a second line drawn from the central patella to the tibial tubercle.

Pelvis—Bony structure at the base of the spine. Each os coxae (hipbone) comprises three bones: the ilium, ischium, and the pubis. The ilium is the largest and upper most part, the ischium is the posterior-inferior (back-lower) part, and the pubis is the anterior (front) part of the hipbone. The two hipbones are joined anteriorly at the symphysis pubis and posteriorly to the sacrum.

Tibial Tubercle (Tibial Tuberosity)—The bony knob just below the patella. An attachment point of the patellar tendon.

ANATOMY – LOWER EXTREMITY MUSCLES

Muscles, Hip and Leg

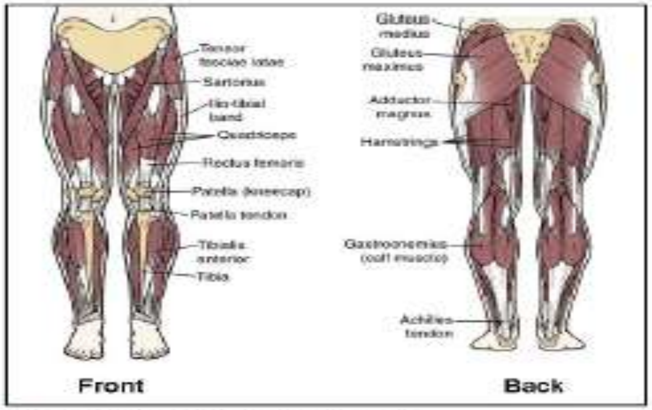


Figure 85. Selected lower limb muscles.

Gastrocnemius—Calf muscle that extends the ankle. Minor role: flex the knee.

Gluteals—Buttock muscles that extend the hip. Minor role: outwardly rotate hip and extend the trunk. Comprised of the gluteus maximus, gluteus minimus, and gluteus medius. The gluteus maximus is the largest and most powerful.

Hamstrings—Upper leg (posterior thigh) muscles that flex the knee. Minor role: extend the hip. Comprised of the biceps femoris on the lateral side of the leg, and the semitendinosus and semimembranosus on the medial side.

Sitting in a chair, you can easily feel the two sets of hamstring tendons.

Hip Flexors—Group of muscles that flex the femur onto the pelvis. The muscles contribute to flexing the lower back onto the pelvis when the pelvis is fixed, or flexing the pelvis onto the lower back when the lower back is fixed.

The hip flexors include: Tensor fasciae latae, sartorius, pectineus, adductor longus, adductor brevis, rectus femoris (part of the quadriceps), and the iliopsoas.

Quadriceps—Upper leg (anterior thigh) muscles that extend the knee. Minor role: flex the hip. The largest, most powerful group of muscles. The quadriceps, more fully named the quadriceps femoris group, comprised of the vastus lateralis, vastus intermedius, rectus femoris, and vastus medialis. The anterior thigh sartorius muscle is not part of the quadriceps group.

Soleus—Lower leg (posterior) muscle that plantar flexes the ankle. Underneath the gastrocnemius.

TERMINOLOGY

Directions, Movements, and Planes

Anterior—Towards the front of the body (or the front-most portion or structure).

Posterior—Towards the rear of the body (or the rear-most portion or structure).

Medial—Toward to the centerline of the body.

Lateral—Away from the centerline of the body.

Abduction—Movement away from the midline or centerline.

Adduction—Movement towards the midline or centerline.

Flexion—Bending movement that decreases the angle between parts.

Extension—Bending movement that increases the angle between parts.

Valgus—Bent (or bending, or force) inwards. Knock-knees = genu valgum.

Varus—Bent (or bending, or force) outwards. Bow-legs = genu varum.

Sagittal Plane—Plane splitting the body into left and right sides. Most bicycling movements have been traditionally studied in the sagittal plane.

Coronal (Frontal) Plane—Plane splitting the body into front and rear sides.

Transverse (Axial) Plane—Plane splitting the body into top and bottom sides.

CYCLISTS- COME IN VARIOUS SIZES AND SHAPES

CYCLISTS – OLD VS YOUNG COMFORT VS SPEED

UNICYCLE – FITTING ISSUES?

WIDE VARIETY OF BICYCLES

PROFESSIONAL CYCLISTS AT 2009 ATOC

TEAM OUCH VIP TENT – 2009 ATOC

BIKE FITTING GOALS/RULES

- RELIEVE CYCLING-RELATED PAIN SYNDROME
- IMPROVE ON-THE-BIKE COMFORT
- IMPROVE CYCLING BIOMECHANICS AND POWER OUTPUT/SPEED
- DETERMINE OPTIMAL BIKE POSITIONING ON A CLIENT'S OWN BIKE TO MEET THE CYCLIST'S GOALS (MORE POWER, MORE SPEED, MORE COMFORTABLE, PREVENT REPETITIVE MOTION PAIN SYNDROMES)
- FITTING "RULES OF THUMB"

PRINCIPLES OF BIKE FITTING

- **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 im-

BIOMECHANICS OF CYCLING "THRESHOLD EFFECT" – REPETITIVE MOTION MAGNIFIES BIOMECHANICAL ERRORS

- **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.

ALBERTO BLANCO – 4TH PLACE 2011 RAAM

2011RACE ACROSS AMERICA – ALBERTO BLANCO

- WON ROOKIE OF THE YEAR – 9 DAYS, 7 HOURS
- CALLED TWO MONTHS BEFORE THE RACE FOR NUTRITION ADVICE & RIGHT KNEE PAIN
- BIKE FIT IN LATE MAY 2011
- KNEESAVER INSTALLED ON RIGHT CRANKARM
- PAIN FREE RIGHT KNEE DURING 2011 RAAM (APPROXIMATELY 1 MILLION REVOLUTIONS)

2011 RACE ACROSS AMERICA – BLANCO SUPPORT TEAM

MOST COMMON CYCLING-RELATED PAIN SYNDROMES (USUALLY UNILATERAL)

- KNEE – IT BAND SYNDROME, PATELLAR TENDONITIS, PATELLO-FEMORAL PAIN SYNDROME, QUADRICEPS TENDONITIS, RETINACULUM INFLAMATION
- LOW BACK – M/S PAIN, DEGENERATIVE DISC DISEASE
- FOREFOOT – BURNING, NUMBNESS, PAIN
- NECK/SHOULDERS – PAIN, TIGHTNESS, HEADACHES, MUSCLE SPASM
- FINGER NUMBNESS/PAIN
- SADDLE ISSUES

RETUL BIKE FITTING SYSTEM

Book Standard Fit | Book Retül Fit

Retul: Bicycle Fitting for the Digital Age!
The Retul motion capture system was developed with professional racers and the best bike fitters in the world and now we bring this revolutionary fitting tool to you! With Retul's 3-dimensional motion capture technology, we can dial in your bike fit to sub-millimeter tolerances. By allowing you to continuously pedal your bike in a trainer, the Retül system lets us see exactly what you're doing as you ride. Retül makes our bike fitting process faster and more precise so you can be riding at your best, sooner!

Why is a Retül Bike Fit Superior?
Every rider has unique biomechanics and therefore there are no generalizations that apply when truly fitting a rider to a bike. The Retül system provides sub-millimeter accurate measurements of every moving angle of the body while riding at different workloads - thus providing the fit specialist with the information needed to fit you to the bike and realistically mimic your ride on the road. Retül helps the fitter optimize the biomechanics of the rider while taking each rider's goals into consideration.

We place eight markers atop anatomical landmarks (see illustration), along one side of your body that will be used to analyze your full body movements while riding your bike. The small Retül wiring harness is then attached to these markers and information about your riding is sent to the computer. The harness uses tiny LED lights that flash 42 times per second to send data to the sensor. The Retül software then processes all of that data in seconds, synchronizing the eight data points and tracking them across longitudinal, vertical and horizontal planes.

Book Retül Fit

The fitter gains a wealth of information from the system. For instance, we can see all of the different knee angles throughout your pedal stroke. And the sensor is able to capture tiny lateral movements, such as knee wobble, that tells us how your body is moving in three dimensions. We repeat this process on the other side of your body to find any asymmetries between sides.

GURU DYNAMIC BIKE FITTING UNIT (DFU)

The machine itself is an amazing piece of engineering. Below is a picture of the unit without the various computer screens and ancillary equipment that are also part of the complete package:

The fitting machine can be set up to exactly replicate all dimensions of your current bicycle for those who bring in a bicycle for a fitting. Even the exact seat tube angle can be programmed into the machine. The fitter has a large array of popular seats and pedals; hence when you climb on the machine, you are literally sitting on what feels to be your exact bike. For those who start with no bike, the initial setup is determined by an extensive set of measurements taken of the subject's body and a thorough interview dealing with any medical issues, injuries, goals, current level, etc., that precedes the measurement-taking session. The ultimate goal of my particular fitting was to make me as fast as possible on my time trial bike, and ideally enabling me to be as comfortable as possible in an aggressive, aerodynamic position.

GURU DYNAMIC FIT UNIT

Guru Dynamic Fit Unit - DFU™

After two years of testing and engineering, GURU Cycles Inc. has finalized the development of the first computerized robotic assisted bicycle fitting system. With our patented drivetrain, motors, actuators and proprietary software; Guru has revolutionized the fit process by drastically increasing efficiency and by creating an interactive experience for the client.

The DFU™, manipulates the rider's position while he or she is pedaling. The software, based on the client's body morphology, suggests a starting position for the fitter in using XY coordinates. The Guru trained fitter then adjusts the fit down to the millimetre in order to achieve a perfect fit, which is optimized for power, cadence, position and most of all, comfort

At no point does the instructor or fitter ever have to ask the rider to disembark from the unit to change positions of handlebars, pedals or seat position. The actuators take care of all of these actions automatically

BIKE TRAINER & TOOL BOX

BIKE FITTING TOOLS

SEQUENCE OF FITTING EVENTS

- BIKING HISTORY, WEEKLY TRAINING MILEAGE, OTHER SPORTS PARTICIPATION , WEIGHT TRAINING
- NATURE OF THEIR CYCLING PAIN SYNROME - WHAT BODYPART, FOR HOW LONG, HOW MUCH PAIN, MILEAGE THRESHOLD, WHAT DOES OR DOES NOT RELIEVE PAIN
- MEDICAL HISTORY – ACUTE OR CHRONIC ILLNESSES/DISEASES, OLD OR RECENT INJURIES (SPORTS OR TRAUMATIC)
- PHARMACEUTICAL USE – WHAT DRUGS?, WHAT DOSE?
- STATINS: CAUSE MUSCLE AND JOINT PAIN!!
- HOW MANY OF YOU TAKE A STATIN DRUG?
- SUPPLEMENT USE – WHICH ONES? WHAT DOSE?
- HOW MANY OF YOU TAKE A SUPPLEMENT(S)?

OUR SICKNESS CARE SYSTEM

SEQUENCE OF FITTING EVENTS - STATIC

- PHYSICAL EXAMINATION – LEG LENGTH MEASUREMENTS, CHECK ROM MOTION IN ANKLES, KNEES, HIPS
- FOOT EXAMINATION – FOOT STRUCTURE, CALLUS LOCATION ON SOLES
- HAMSTRING TIGHTNESS ASSESSED VIA STRAIGHT LEG TEST
- HAMSTRINGS ARE "TWO JOINT MUSLES" – TIGHT HAMSTRINGS REDUCE CYCLING EFFICIENCY, CAN CONTRIBUTE TO KNEE PAIN

START IN SUPINE POSITION

FOOT EXAMINATION

STRAIGHT LEG RAISE TEST – GOAL = 90 DEGREES

LEG LENGTH MEASUREMENTS

Leg Length—Anatomical and bicycle fit dimension.

(1) Anatomic: from the anterior superior iliac spine (ASIS) to the medial malleolus (ankle bone).

(2) Bicycle fit: Greater trochanteric. Standing, from the greater trochanter to the floor.

(3) Bicycle fit: Inseam. Standing, from the crotch to the floor.

For a discussion about leg length discrepancy, see page 87.

MEASURING LEG LENGTHS – ASIS TO MEDIAL MALLEOLUS

CORRECTING LEG LENGTH DIFFERENCES - OPTIONS

Many riders change the angle of the knee when they stop pedaling by changing their ankle position. Measuring knee angles while the rider pedals with an electronic goniometer or by computer algorithm from video imaging gives information that is more accurate.

Correcting Leg-Length Discrepancy

Simplest method: Set the seat height for the longer leg. Shim the exterior sole or cleat of the shoe on the shorter leg to nearly equalize knee angles.

The body partially adapts to leg-length differences. In general, femoral (upper-leg) differences require about one-third correction, tibial (lower-leg) differences about one-half.

For example, a femoral leg-length discrepancy of 6 mm requires about a 2-mm shim. A tibial leg-length discrepancy of 6 mm requires about a 3-mm shim.

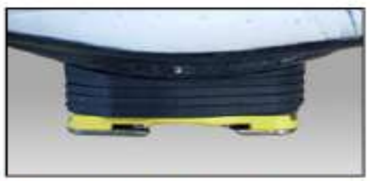


Figure 61. Shims between the cleat and shoe sole.

Simplistically, the femur moves the knee fore and aft; the tibia moves the knee up and down. Since I usually set cleat fore-aft as rearward as commonly-drilled shoes allow, with this model, femoral differences can be accommodated by offsetting the cleat of the shorter leg forward (cycling more on the toes).

Differences of several cm or inches, generally due to medical disease or traumatic injury, can be managed with commercially available crank shorteners, drop pedal devices, or different length cranks. Crank shorteners are commonly marketed by tandem-parts suppliers as child stoker conversion parts. For an example of a drop pedal device, see Figure 81 on page 106.

Other Methods

Small differences are sometimes shimmed with an insole. This often crowds the interior of the shoe and is not ideal. The insole of the shoe of the longer leg is sometimes removed as an easy fix for small differences. Again, a comfortable fit may now not be possible. Different-size shoes to accommodate different thicknesses of insoles are an unusual alternative.

Some practitioners correct leg-length differences with eccentric chainrings, concentrically machined but off-center mounted chainrings. I do not endorse this approach.

CORRECTING LEG LENGTH DIFFERENCES – SOLE BUILDUP

Answers to FAQ: Shimming Cleats

Q: When should I shim a cleat?

If you have a leg-length inequality (LLI) of 3 mm or greater accompanied by back pain, it's important to heed the following advice.

For walking or running, most orthopedists won't adjust for a LLI until the difference between legs is 6 mm or more.

In cycling, if the LLI is less than 6 mm, I don't use a shim. Instead, I move the cleat on the short-leg side forward on the shoe sole 1-2 mm. You can move the cleat on the long-leg foot backward to get the same affect. Rarely do you have to compensate for the full amount of the LLI.

These techniques have the effect of making the short-leg foot slightly longer to compensate for the leg length difference. If the LLI is over 6 mm, it requires a shim.

Q: How do I shim my cleat?

The shim goes between the shoe sole and the cleat (photo). Look and Look-compatible road cleats are the easiest to shim, while Shimano SPD cleats (both road and off-road) are slightly harder. Other brands vary from fairly easy to difficult. Several makes of high-end road cleats are impossible to shim.

Shoe repair and prosthetic-device shops can shim your cleats if you explain what you want. Or, you can do it yourself. Here's how:

1. Choose a material to use as a shim. Neolite, available in shoe repair shops, works well for Look road cleats. Fairly hard plastic or aluminum bar stock is often used for Shimano SPD cleats. The material should be hard enough to resist compression but soft enough for the serrated bottom of the cleat to make an impression. You don't want the cleat to slide when the bolts are tightened or when it's entering or exiting the pedal.
2. The shim should generally be half the amount of your leg-length inequality. Why? Because your body has already adjusted for much of the LLI via various physical compensations. Adjusting for the entire amount would be overkill. So, if your LLI is 8 mm, the shim should be 3-4 mm thick.
3. Obtain longer bolts to accommodate the added thickness of the shim. Take one of the stock bolts to a hardware store.
4. Cut the shim material in the shape of the cleat.
5. Drill bolt holes.

SEQUENCE OF FITTING EVENTS – STATIC & DYNAMIC

- STANDING STANCE (BAREFOOT) – FOOT, ANKLE, TIBIA AND FEMUR ALIGNMENT
- KNOCK-KNEED OR BOWLEGGED
- PRONATED OR SUPINATED FEET, HIGH OR LOW LONGITUDINAL ARCH,
- MORTON'S FOOT (LONG SECOND METATARSAL BONE)
- GAIT ANALYSIS – TOE OUT, PIGEON-TOED, FOOT PRONATION OR SUPINATION, RIGHT VS LEFT LOWER EXTREMITY DIFFERENCES

COMPARE ONE LEG AND FOOT TO THE OTHER LEG AND FOOT

POSTERIOR STANCE VIEW

GAIT ANALYSIS - BAREFOOT

GAIT ANALYSIS – REAR VIEW

STANDING STANCE – FEET PARALLEL ONE FOOT APART

NATURAL FOOT POSITION STANDING

GAIT ANALYSIS – TOE OUT

GAIT ANALYSIS – RIGHT FOOT POSITION WITH WEIGHT BEARING

GAIT ANALYSIS – LEFT FOOT WEIGHGT BEARING POSITION

GAIT ANALYSIS – POSTERIOR VIEW

FRAME SIZING

Other Methods

When you stand over a road bicycle in stocking feet there should be 0 to 1 inch of clearance from the top tube to your crotch, and about 1 to 2 inches when you are wearing shoes. If your crotch touches the top tube, the bicycle is certainly too big.

If you are sizing a mountain bike, you will need at least another inch of clearance over the top tube.

Figure 2. Road bicycle frame size. Left: Allow at least 1 inch of clearance between the top tube and your crotch. Right: Compact road frames, like mountain bikes, will allow even more room.

CRANKARM LENGTH

- IN GENERAL, SHORT PEOPLE AND/OR "SPINNERS" NEED A SHORTER CRANKARM (165- 170 MM)
- TALLER PEOPLE AND/OR "BIG GEAR MASHERS" NEED A LONGER CRANKARM (172.5 – 180 MM)
- CRANKARM LENGTH IS GENERALLY NOT A CONTRIBUTING FACTOR TO KNEE PAIN

STATIC BIKE FITTING ANALYSIS

BIKE-ON- TRAINER FITTING ANALYSIS

- START AT THE FOOT
- WORK UP THE "BIOMECHANICAL TREE" FROM DISTAL (FOOT) TO PROXIMAL (HEAD)
- FOOT FORE/AFT OVER PEDAL SPINDLE (CLEAT POSITION, FIXED VS PEDAL FLOAT, FREE FLOAT VS "SORTA" FLOATS, DEGREES OF FLOAT
- "KOPS" (SADDLE FORE/AFT POSITION) WITH CRANKARM PARALLEL TO GROUND POSITION
- SADDLE HEIGHT
- ANTERIOR-POSTERIOR ANALYSIS – DYNAMIC PRONATION OR SUPINATION ASSESSMENT, TOE-IN, TOE-OUT POSITIONING, FOOT/KNEE/HIP ALIGNMENT, Q FACTOR DISTANCE

FOREFOOT FORCES DURING CYCLING

Consider that until relatively recently, most bike fitters used formulas based on leg length or inseam to set seat height.

If the cleats are moved rearward without a change in seat height, such a change may result in more power for general riding.

However, such a forward position may limit leg speed and the ability to produce the high cadence (rpm > 140 rpm) often required in sprinting. Sprinters, who require high cadences, may therefore prefer to have their feet back on the pedals a little more and be more on their toes.

However, if knee angles are used to set seat height, as I advocate, riders who move their cleats rearward will lower their saddle. In this case, there is no evidence that power or high-cadence performance will change. For details, see the discussion in *Seat Height* on page 34.)

Limited Scientific Theory

With traditional cleat placement, in transmitting force to the shoe and pedal, the first metatarsal head is the structure that provides the greatest contact surface area.

If maximizing aerobic power is the goal, it is logical that aligning the maximum forces over the pedal spindle makes biomechanical sense.

Sanderson and Cavanaugh[35] measured forces on a specially designed insole with 256 discrete force-measuring elements. Using three-dimensional computer modeling, they showed that at a power level of 400 watts and at a cadence of 90 rpm, the highest pressure occurred *behind* the first metatarsal head. They used a platform pedal with the first metatarsal head positioned slightly rearward of the pedal spindle.

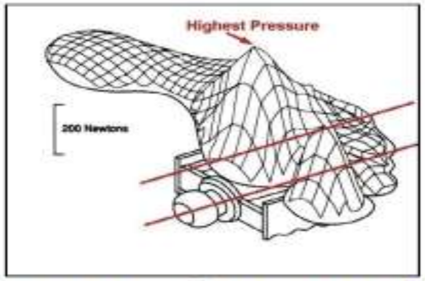


Figure 25. 3D image contour of peak pressure on the bottom of the foot during cycling. Red diagonals run through the ball of the foot and the pedal spindle. Adapted from Sanderson.[36]

35 Sanderson, DJ, et al. *An investigation of the in-shoe pressure distribution during cycling in cycling or running shoes*. Proceedings of the 12th International Congress of Biomechanics. Umeå, Sweden. 903-907. (1985).

36 Illustration adapted from Cycling, Nike. *Sport Research Review*. Advertising Section. May/June (1990).

OPTIMAL PEDAL FORE/AFT POSITION

Rule of Thumb

Position cleat so that ball of the foot lies between the center and the front of the pedal spindle.

From a practical point of view, considering the current drillings of most shoes, this is often the most rearward cleat position the shoe allows.

Discussion

Position the cleat so that the ball of the foot is *over* the center of the pedal spindle or up to 10 mm (1 cm, ½ inch) *in front* of the spindle.

Since pedal spindles are up to 20 mm in diameter, positioning the ball of the foot over the *front* of the pedal spindle amounts to a distance up to 10 mm forward of center.

It is easiest to assess this in the power position: with the crankarm in the 3 or 9 o'clock position (for the right or left foot respectively) and the foot horizontal.

The ball of the foot is the knuckle of the first metatarsal head and big toe. This corresponds to the bump that sticks out at the base of your big toe—where some people get bunions.

To adjust the shoe forward, move the cleat rearward. For most riders, for most shoes and pedal systems, I position the cleat at its most rearward position on the shoe.

Traditionally, the ball of the foot is positioned *over* the center of the pedal spindle.

This traditional position is the most rearward shoe position (most forward cleat position) I generally advocate.

Figure 23. Yellow circle: First metatarsal head.

Figure 24. Foot fore-aft, looking down. Left foot, 9 o'clock position. Yellow oval: Edge of the first metatarsal head, just in front of the pedal spindle.

PEDAL FLOAT – ESSENTIAL!

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.

DEGREE AND FREEDOM OF PEDAL FLOAT

Foot/Pedal Float

Rule of Thumb

For most riders, float is a good idea.

Discussion

Most current pedal/cleat systems allow some rotation on the horizontal plane of the pedal. Nine degrees of float is enough for most riders.

My experience suggests that overuse injuries, especially iliotibial band syndrome, are more common in riders who pedal without float.

Too much float causes some riders to develop a hamstring overuse injury. However, hamstring overuse injuries are among the least common knee overuse injuries I see.

Best viewed from behind, riders who are unable to stabilize the foot, whether due to general weakness or ride-specific fatigue, may wiggle their heels while pedaling, especially at the bottom return of the pedal stroke.

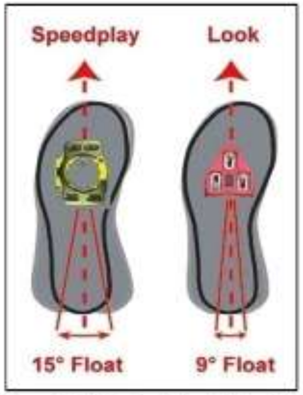


Figure 29. Both Speedplay (15°) and Look (9°) pedals have appreciable float.

Background and Theory

Traditionally, old-style pedals with toeclips allowed a few degrees of float. It was not that the float was planned, but it happened.

Traditionally, riders were positioned with their feet pointing straight ahead, and those with overuse injuries relocated their fixed cleats pointing their toes toward the side that hurt—to shorten the path of the tendon on the injured side.

ADVANTAGES OF SPEEDPLAY PEDALS – MORE FREEDOM AND DEGREE OF PEDAL FLOAT

KNEE OVER PEDAL SPINDLE

Figure 21. Traditional method of establishing seat position fore-aft. A plumb line dropped from the tibial tubercle bisects the pedal spindle with the crank horizontal. The figure demonstrates a common fitting error: The crank is not quite horizontal.

31 For example, Bontrager, K. *The myth of KOPS, updated*. (1998). Linked and accessed Jan 1, 2008.

OPTIMAL SADDLE FORE/AFT POSITION – POWER VS COMFORT

Rule of Thumb

Set saddle position fore-aft so that a straightedge placed against front of kneecap and the front of pedal spindle is vertical.

Discussion

If seat height is the holy grail of power, *seat fore-aft is the holy grail of balance*: (1) control for descending and cornering, and (2) weight distribution for the prevention or treatment of upper extremity overuse injuries.

My approach to seat positioning fore-aft is a variation of the classic *Knee-Over-Pedal-Spindle* or KOPS method—described in more detail on page 43.

Seat position fore-aft is adjusted to optimize bicycle balance and align the legs over the bottom bracket to best produce power and minimize overuse injury.

Do not change fore-aft position to set torso angle or reach. Adjust the stem or choose a bicycle with different geometry.

When the cranks and shoes are horizontal, a plumb line from the front of the knee should fall flush in front of the pedal spindle.

The knee may also be up to 2.5 cm (1 inch) behind this plane for taller or long-distance riders. Sprinters, track pursuiters, time trialists, and triathletes sometimes come forward.

Figure 19. Seat position fore-aft. Side view. With the crank forward and horizontal, a straightedge placed against the front of the knee and the front of the pedal spindle is vertical.

SADDLE FORWARD - MORE POWER, MORE KNEE STRESS

In order to achieve a flat back and to meet UCI equipment and position requirements, time trialists often require a negative stem in order to ride with their elbows 6 inches or so below the height of the saddles. For UCI rules, see page 122.

Figure 56. World Champion and US Record Holder Mari Holden (left) may be one of the fastest women time trialists ever. Notice how Holden rides on the nose of her saddle, opening her hip angle to obtain more power. Her position is not as slippery as Chris Boardman's (right), the world hour record holder. Boardman is flatter and less cramped. Chris Boardman rode 56.3759-kilometers full aero.

Fore-aft is sometimes adjusted so that the knee is as much as two inches in front of the pedal spindle. This allows the hip angle to open with small torso angles. Time trialists therefore often choose bicycles with steep seat tube angles.

Racers governed by UCI regulations are generally not allowed to assume such forward positions. In order to keep their hip angles open, they ride with higher torso positions.

I do not advocate changing crank arm length for time trialing.

Although longer crankarms have been traditionally favored for time trialing, studies have shown that they change pedal force, not torque or power—they require the rider to pedal a larger circle. Longer crankarms mean that the knees rise higher, and hence closer to the chest—which may result in *worse* biomechanical function. The rider may close the hip angle, *reducing* power. Breaking tradition, National time-trial champion and frame builder Glen Swann uses *shorter* cranks, 165 mm, when he time trials.

To narrow their profile, time trialists choose narrow handlebars—both in overall width and in the position of their forearm pads.

Project 96 (USA Cycling's Olympic program) data showed that a narrow pedal stance (narrow bottom bracket) with a knees-in pedaling style was more aerodynamic and more powerful.

OPTIMAL SEAT HEIGHT IS 145 – 150 DEGREES OF FEMUR TO TIBIA ANGLE

Seat height is the most important bicycle-position setting.

Seat height is the holy grail of power.

Many non seat-height bike-positioning recommendations are often work-arounds to mitigate a suboptimal seat height.[14]

After seat height is initially set, it may need to be adjusted if cleat fore-aft, seat fore-aft, cleat thickness, pedal height, crankarm length, shoes, or saddle are changed.

Rule of Thumb

Set the seat height so that the knee is flexed about 30° at the bottom of the pedal stroke. Power riders may set the saddle higher. Beginners may set the saddle lower.[15]

Figure 12. Seat height. A seat height that results in 30° of knee flexion is a good compromise for many riders. Red dotted anatomical landmarks, from the top: Greater trochanter of hip, lateral condyle of knee, lateral malleolus of ankle. Racers may prefer a higher position. Beginners may prefer a lower position.

SADDLE HEIGHT

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

SADDLE COMFORT

Figure 22. Saddle angle. The saddle is level.

Those with genital numbness may find that having the noses of their saddles slightly down improves the problem. (Genital numbness is also associated with a saddle that is too high.)

A slightly down saddle nose often helps with crotch discomfort in women or with the use of aerobars (a specialty type of handlebar that allows a low, aerodynamic profile).

Be cautious: too far down results in more pressure on your shoulders, arms, and hands.

Background and Theory

Saddle discomfort is a nearly universal complaint. Traditionally made out of leather, saddles used to require a break-in period. Rituals of soaking saddles or riding in the rain, or applying leather-softening greases to the saddle were customary practices.

Beginners often have trouble finding a comfortable saddle—for at least two reasons: (1) their tissues are not adapted to riding, and (2) their legs do not push as hard—and so they sit heavier on the saddle.

It is for this second reason that experienced riders are most likely to experience saddle discomfort on long, easy days.

MY BIKE: DAVIDSON STEEL FRAME
-BROOKS LEATHER SADDLE
-SEAT SHIFTER
-ADJUSTABLE STEM AT 45 DEGREE ANGLE

TV WATCHING SHORTENS LIFE

DYNAMIC ANALYSIS IN SAGITAL PLANE - FOOT, KNEE & HIP ALIGNMENT

Discussion

Some authorities advocate trying to align the hip, knee, and foot in a vertical (sagittal) plane while riding. The anatomical landmarks used are the hip (head of the femur), knee (mid patella), and foot (second toe).

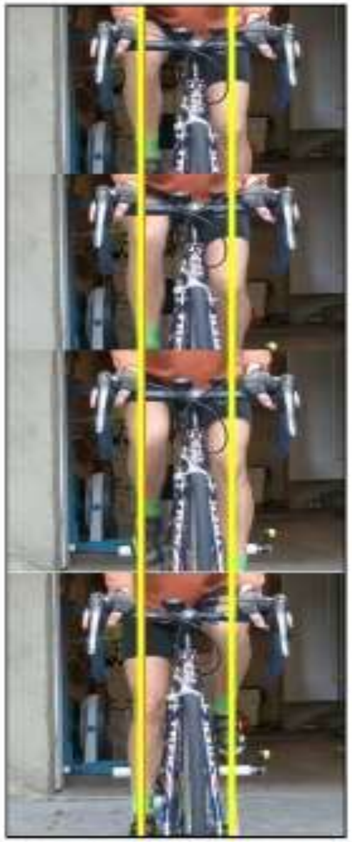


Figure 63. As the vertical yellow lines show in this composite of four photographs, this rider's knees stay well aligned during up and down of pedal stroke.

POSTERIOR VIEW – BIKE TRAINER

FOOT POSITION ON PEDAL - TOE IN, NEUTRAL, TOE OUT

Foot/Pedal Rotation Angle

Rule of Thumb

Set fixed cleats or the mid-point of floating cleats/pedals to point the toes the same way you walk. (Read about pedal float on page 54. Read about pedal stance width and stack height on page 104.)

Discussion

Riders may walk with their feet pointing straight ahead, outward (duck-footed) or inward (pigeon-toed).

Nowhere in bike fit is it more important to "adapt the bike to the rider, not the rider to the bike."[43]

Figure 26. Rider walks and pedals with toes straight ahead.

Figure 27. Duck-footed rider walks and pedals with toes pointing out.

Figure 28. Pigeon-toed rider walks and pedals with toes pointing in.

Q FACTOR – DISTANCE BETWEEN FEET ON PEDALS(STANCE WIDTH)

Q-Factor—Stance Width

In bicycling, Q-factor refers to stance width. Bicycle Q-factor relates to bottom bracket axle width, crankarm offset, pedal spindle length, and cleat position.

Pedals have different length spindles, or distances from the crankarm to the center of the pedal platform.

The same manufacturer may produce pedals with different spindle lengths. Bowlegged riders generally need pedals with long spindles.

Cornering clearance is improved as the Q-factor decreases.

Figure 70. Pedal spindle length. Left: Speedplay X-1 titanium pedal top. 50 mm from crank face to center of pedal. Right: Crank Bros Egg Beater. 57 mm from crank face top center of pedal.

Placing the cleat inward, toward the bike, also widens the stance.

Longer bottom brackets or crankarms with more offset may also increase stance width. Note: Mountain bikes and tandems often have longer bottom brackets than road bicycles. Bicycles with triple chainrings often have longer bottom brackets than bikes with double chainrings.

Pedal/stance spacers (see Figure 74 on page 101) that increase the distance to the crank reduce the tendency to pedal bow-legged.

Pedal/stance spacers usually help knees-out riders. Washers 2 mm thick are usually safe. Spacing more than 2 mm may not leave enough threads on the pedal to safely engage the crank.

Pedal axle extenders are an alternative.

A 20-mm spacer, threaded male at one end and female at the other, is commercially available under the brand name Kneesavers. Unfortunately, this amount of spacing overcorrects knee-out style for many riders. 25-mm and 30-mm extenders are also available.

Increasing the distance between the feet with pedal/stance spacers can be especially helpful for obese riders who frequently pedal with their knees splayed out during the downstroke power phase of the pedal stroke.

PEDAL Q FACTOR ADJUSTMENTS

Pedal Stance Width

Pedals differ in their stance width or Q-factor. Some have an adjustable Q-factor in the pedal. Some cleats can be adjusted side-to-side (cleat Q-factor). Some manufacturers make the same pedal platform with different lengths of spindle (axle).

Figure 77. The Speedplay pedal has an adjustable cleat Q-factor. It adjusts 4 mm to each side of center for a total of 8 mm.

Figure 78. The center of the Look CX6 pedal may be between 50 mm and 60 mm from the crankarm. It has an adjustable pedal Q-factor of 10 mm.

Although riders may adjust cleats to one extreme or another to optimize stance width, in a perfect world the center of shoe pressure should be centered over the pedal. In a perfect world, stance distance would be accomplished through bicycle frame design, bottom-bracket length, crank offset, and pedal-spindle length rather than moving the shoe side-to-side on the pedal.

BOWLEGGED CYCLING – TOO NARROW Q FACTOR

Knees-Out Style

Bow-legged or knees-out from the top tube pedaling is rarely an advantageous style.

Most riders who pedal this way are either obese or have hip or knee problems. Riders who bow only one leg may do so if that leg is longer than the other one is, or if they have hip or knee problems.

Riders who pedal knees out are usually more comfortable if this style is reduced or corrected to a vertical style.

The best way to reduce or correct this style of pedaling is to increase stance width (see below).

Figure 69. Exaggeration of knees-out pedaling style.

BOWLEGGED “V8” CYCLING POSITIONING

BOWLEGGED CYCLING

WIDING THE Q FACTOR

Figure 74. Pedal/stance spacer. This aluminum washer has a 14-mm inside diameter, a 22-mm outside diameter and is 2 mm thick.

Figure 75. Pedal axle extender. This steel extender effectively lengthens the axle 20 mm.

Specialty pedal axle extenders, often 20 mm to 30 mm long, are available through a

WIDEN Q FACTOR WITH KNEESAVER PEDAL EXTENSIONS

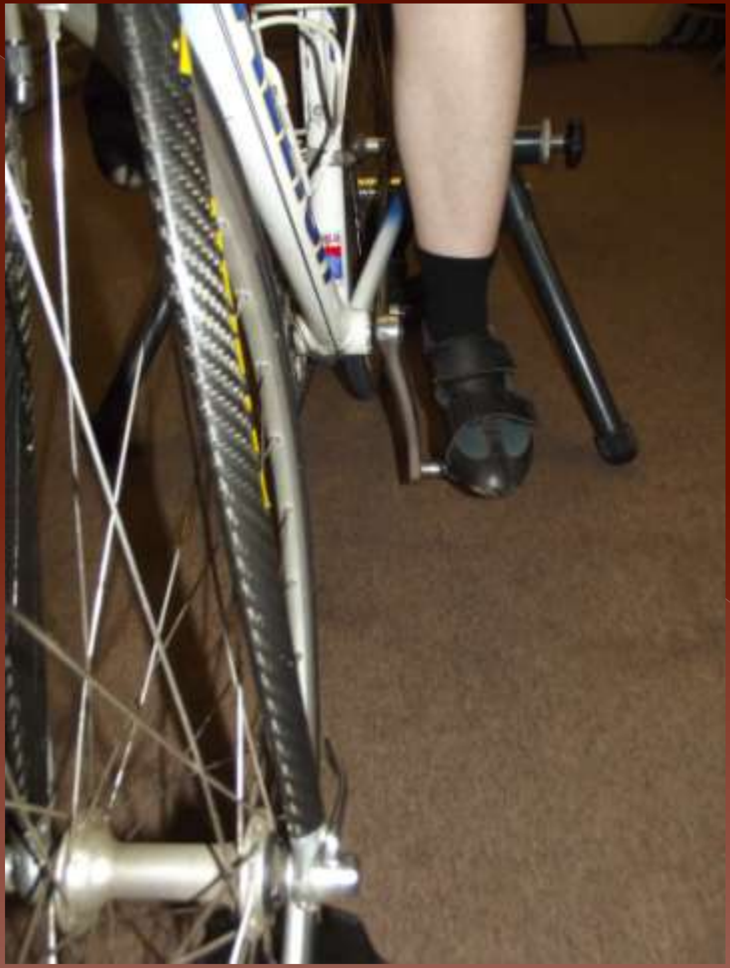
SHORT STOCKY CYCLISTS NEED WIDER Q FACTOR

MOUNTAIN BIKE FITTING

MOUNTAIN BIKE FIT – WIDER BOTTOM BRACKET/CRANKARMS CREATES A WIDER Q FACTOR

RIGHT SIDE – NO ASYMETRY, NO TOE-OUT

LEFT SIDE -TOE OUT ACCOMODATED WITH KNEESAVER



CORRECT "WATERFALLING" BY INCREASING THE Q FACTOR

Waterfalling

Too much unsupported pressure on the outside of the foot results in waterfalling.

In this situation, the outside of the shoe falls over the sole; or the outside of the shoe and sole falls outward over the cleat and pedal.

This may occur when a heavy or powerful rider positions the cleat inward (so that the shoe is farther from the crank) and breaks down the shoe material.

Riders commonly set their cleats inward when using pedals with short spindles or pedals with small Q-factors to avoid hitting the crankarm with their shoe.

Riders with a knees-out pedaling style—for example riders with wide pelvises or overweight riders—waterfall their shoes more often than those with a knees-in style.

Waterfalling may be improved by using pedals with longer axles, increasing the Q-factor for pedals that have this feature, or using pedal/stance spacers.

Figure 71. Waterfalling shoes. The outsides of the shoes fall over their soles. The plane of the sole (red-arrowed line) is not horizontal (blue-arrowed line).

KNEESAVERS PEDAL EXTENDERS - OPTIONS

- STEEL KNEESAVERS
- 20, 25 or 30 MM WIDTHS (9/16" THREADS)

- STATIONARY BIKES
- 20 OR 30 MM WIDTHS (1/2" THREADS)

- TITANIUM
- 20 MM WIDTHS (9/16" THREADS)

- PEDAL ADAPTERS FOR SPIN TRAINERS OR STATIONARY BIKES
- 20 MM WITH (1/2" MALE END, 9/16" FEMALE END)

KNEESAVERS – 25 MM WIDTH

KNEESAVERS – 30 MM WIDTH

RETAIL KNEESAVERS ONLINE AT KNEESAVER.NET

KNEESAVERS CAVEAT

- KNEESAVERS PEDAL EXTENDERS CREATE A LONGER LEVER ARM
- THE "WEAK LINK" IN TERMS OF FORCE ON THE PEDAL BECOMES THE CRANKARM
- STEEL OR ALUMINUM CRANKARMS ARE NOT A PROBLEM
- NOT ADVISED FOR CARBON FIBER CRANKARMS IN THOSE > 200 POUNDS (UPRIGHT CYCLING). RECUMBENT BIKES – NO BODYWEIGHT LIMIT

CUSTOM MADE KNEESAVERS

THREADING PROBLEMS – THE PEDAL NOT THE KNEESAVER

ALLEN WRENCH PEDAL SYSTEMS

KNEE JOINT ROTATION DURING CYCLING - NEED FOR PEDAL FLOAT

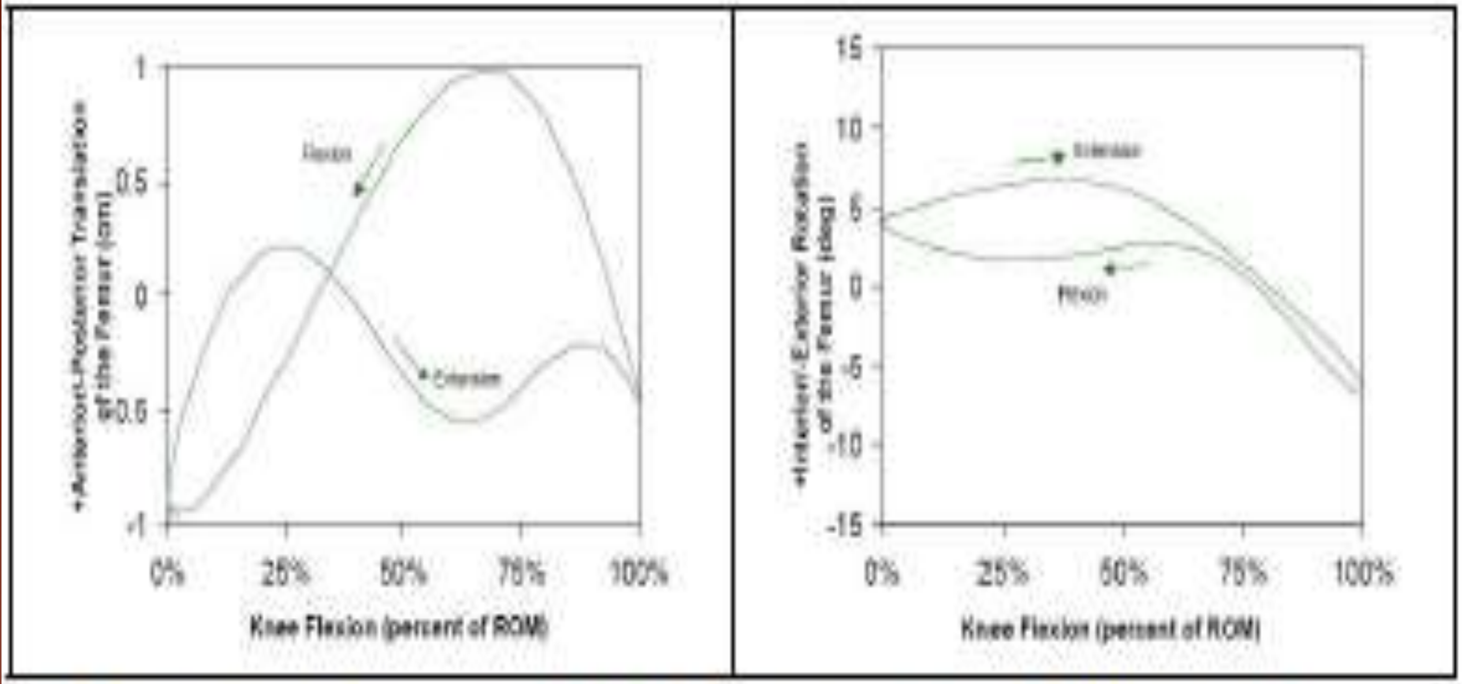


Figure 67. As the knee flexes and extends (bends and straightens) during cycling, the tibia and femur move forward and backward (left), and twist (right) relative to each other. From Chaudhari.

THE KNEE IS NOT A "HINGE JOINT" – 15 DEGREES OF TIBIA/FEMUR ROTATION

Although a straight-ahead no-float position may be (perversely) aesthetically pleasing to some, it is misguided. The knee has more than a hinge motion of flexion and extension (bending and straightening). It has a relevant twisting motion.

During the pedal stroke, the lower leg (tibia) twists about 15° relative to the upper leg (femur).

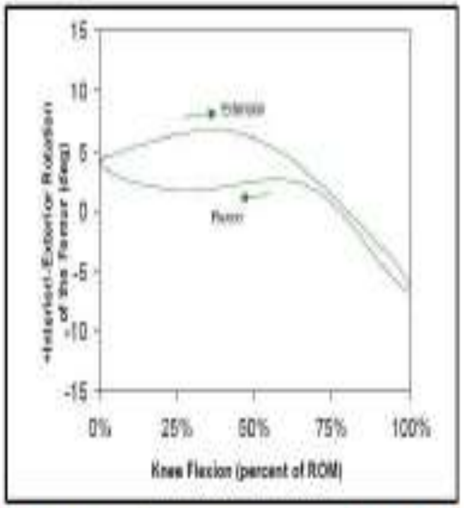


Figure 30. As the knee flexes and extends (bends and straightens) during cycling, the tibia and femur twist relative to each other. From Chaudhari. For more details, see page 94.

KNOCK-KNEED CYCLING - WITH OR WITHOUT TOE IN

Knees-In Style

Some authorities have ascribed a knees-in style to forefoot varus.

Most riders have a neutral foot position in which the big toe is higher than the small toe. As riders apply power to the ball of the foot, the foot and knee may move medially, toward the center of the body.[51]

Figure 64. Knees-in pedaling style.

In general, medial wedges or varus-canted shoes reduce the common forefoot varus, or turning in of the front of the foot, and help straighten the alignment of those who pedal knock-kneed—with their knees toward the top tube.[52]

If forefoot varus is present in about 80% of the population, as a couple of studies have suggested, some have argued that bicycle shoes should incorporate this tilt in their

CORRECTING MEDIAL KNEE VALGUS AND TIBIAL TORSION DUE TO FOOT PRONATION

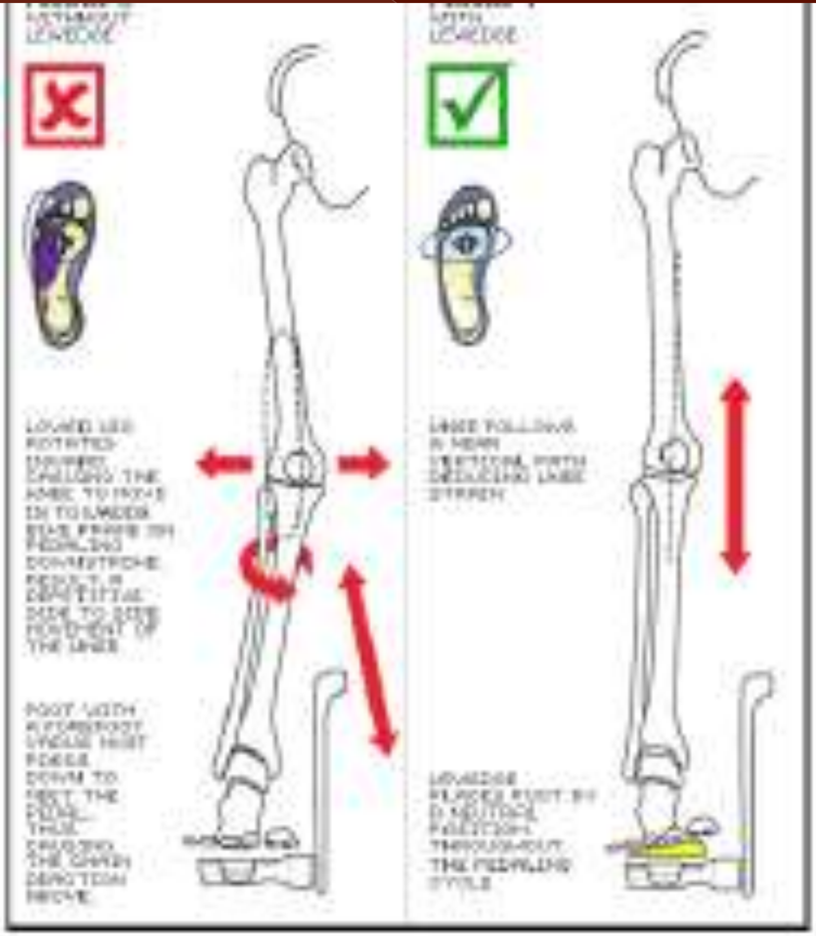


Figure 66. Medial wedges change a knees-in pedaling style to a vertical up and down style.[67]

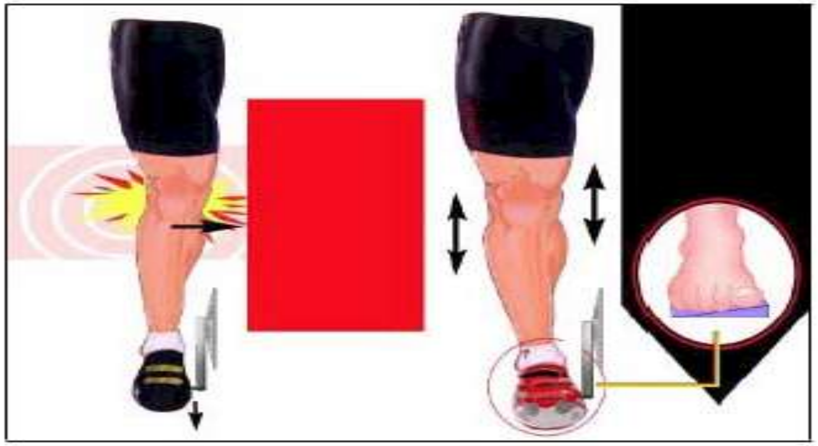
FOREFOOT PRONATION (VARUS)- KNEE PAIN

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

16



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.

PRONATION, NEUTRAL, SUPINATED FOOT STRUCTURE

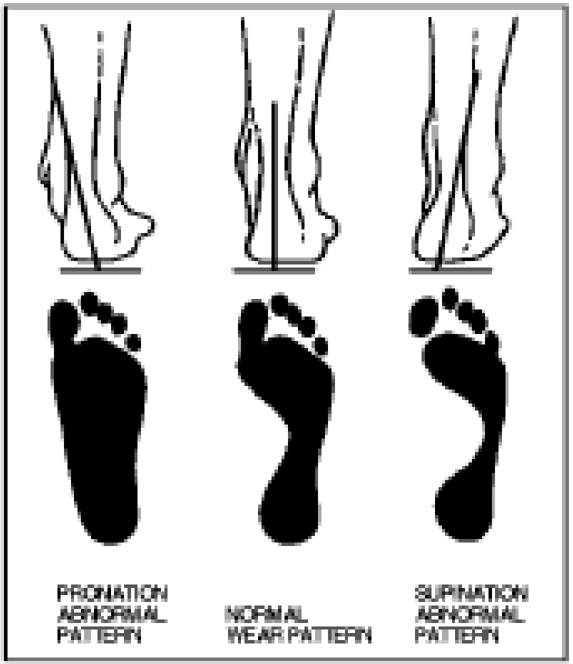


Figure 76. Midfoot patterns.

If you have chronic foot, knee, hip, or leg pain or problems, and your patterns are abnormal, it is possible an orthotic may help.

CORRECTING FOREFOOT PRONATION WITH WEDGES

Part 6: Wedges, Shims, Pedal Spacers & Extenders, Orthotics, & Custom Shoes

Wedges and Shims

If performing bike fits for many riders, a variety of shoe-pedal wedges and pedal/stance spacers will be useful.

As discussed throughout this book, these devices can be useful to help correct leg-length discrepancy, to cant the foot, and to increase stance width in knees-out (bow-legged) pedaling riders.

Commercial wedges are readily available for standard 3-hole, Speedplay, and SPD-type cleats. Alternatively, washers can be used. When wedges are alternated with the thicker side toward and away from the crank (medially and laterally) they function as shims.

Longer cleat-fixing bolts may be required.

Some bike fitters wedge most riders, believing the common forefoot varus is responsible for a knees-in pedaling style that should be corrected. As discussed on page 92, this opinion is far from universal.

Although some coaches and other cycling experts quote a 1997 study by Van Zyl showing that medial wedges help patellofemoral pain, this same study showed that raising the seat height a couple of millimeters was equally effective.[60]

A more recent study by Gregersen found theoretical reasons why medial wedges might prevent or treat patellofemoral pain.[61]

Figure 73. Look-style shims. The four held shims are 4 mm thicker on the side away from the fingers.

CORRECTING FOREFOOT PRONATION WITH WEDGES

Figure 65. Medial wedge inserted between shoe outsole and pedal cleat.

56 Y/O WOMAN WITH LATERAL KNEE PAIN >15 MILES

LEFT KNEE PAIN ONLY – UNILATERAL PROBLEM

STANDING STRUCTURE – MILD KNOCKNEED

STANDING PRONATION

LEFT >RIGHT FOOT PRONATION

ORTHOTIC MEASUREMENTS

MEASURING AND CORRECTING EXCESSIVE FOREFOOT PRONATION

Forefoot alignment can be measured with standard or specific forefoot goniometers.[39]
A 1-mm wedge will correct roughly 5° of forefoot varus (twist).

Figure 72. Specific forefoot goniometer. Courtesy LeMond Fitness.

ORTHOTIC PLASTER OF PARIS CASTINGS

"SLIPPER CAST" MOLDS FOR CUSTOM MADE ORTHOTICS

CUSTOM MADE CYCLING ORTHOTICS

ORTHOTICS – KEY TO SUCCESS IS FOREFOOT POSTING

UPPER BODY - BIKE FIT ANALYSIS IN CORONAL PLANE

- SADDLE COMFORT
- ASSESS STEM HEIGHT
- ASSESS STEM LENGTH AND ANGLE
- HAND POSITIONING & COMFORT
- DEGREE OF ELBOW BEND
- TRUNK ANGLE AT PREFERRED POSITION

- AERODYNAMICS VERSUS COMFORT!

HANDLE BAR WIDTH

Handlebar Width

It is best and easiest to evaluate shoulder width with the rider on the bicycle.

The anatomical landmarks are the lateral shoulders and the first web spaces (the space between the thumbs and index fingers). With hands on the brake hoods, a vertical line from the lateral shoulder will pass through the middle of the elbow and the first webspace (see Figure 32, Figure 33, and Figure 34).

Road handlebars are commonly 42 cm wide.

Mountain bikers place their hands horizontally on a bar generally 20 to 24 inches wide (about 50 to 60 cm). Note that although the handlebar is wider, a line from lateral shoulder will still generally pass through the elbow and first webspace.

Figure 32. Standard-bars. Vertical yellow lines from the shoulder edges pass through the drops of the handlebars.

Figure 33. Wider bars. Men and women with shoulder widths less than 40 cm (16 inches) often prefer standard 40-cm handlebars that give them better bicycle control for general road riding.

Figure 34. Mountain bike Pro and NORBA Champion Jimena Florit prefers the control that this wider-than-shoulder width handlebar provides.

Shoulder width can be measured off the bicycle. When measured off the bicycle with shoulders back and square, shoulder width is the distance from acromion to acromion. The acromion is a forward projection of bone from the shoulder blade. It is found just to the outside of the collarbone (see Figure 35).

As riders round their shoulders on the bicycle, effectively narrowing their width, these two measurements are about the same.

Too wide a hand placement is tiring, especially when riding in a bent-over aerodynamic position.

OPTIMAL STEM HEIGHT

Handlebar/Stem Height

Rule of Thumb

Set stem height so the handlebar tops are between zero and a fist width below a horizontal straightedge from the saddle.

Discussion

The stem is generally from zero to four inches below the height of the saddle.

At one extreme, beginners and recreational riders are often more comfortable with their stem height level with their saddles.

Figure 45. A horizontal straightedge from the saddle is between zero and a fist width above the handlebar.

At the other extreme, performance time trialists may rest their forearms on pads six or more inches below the height of their saddles.

In general, the higher your stem, the more power you can produce and the better you will climb.

The lower your stem, the more aerodynamic you will be. In fast-paced solo riding on level ground, aerodynamics may more than compensate for the loss of power.

If your stem is too low, you may be uncomfortable—especially in your lower back or neck—or lose power.

Other Methods

Racer mechanics often set stem height too low for their beginner and recreational customers.

As discussed above, these riders will have a more uncomfortable and less powerful ride. Many of them rarely take advantage of the drop position of their handlebars because their handlebars are already too low.

AERODYNAMIC, BUT NOT COMFORTABLE BIKE POSITION

Beginners ride better and enjoy riding more with shorter, higher stems and a more upright position. Climbers are also often able to develop more power this way.

Figure 53. Two traditional older methods of setting stem extension: With the hands in the drops and the elbows comfortably bent about 20°, (1) the top of the handle-bar should just hide the front hub; (2) there should be just a little clearance between the elbow and the knee. Recreational riders do better with shorter, higher stems.

OPTIMAL UPPER BODY ANGLE & ARM REACH

Torso Angle / Reach

If seat height is the holy grail of power, and seat fore-aft the holy grail of balance, *torso angle is the holy grail of aerodynamics*.

Rule of Thumb

Combine stem extension, stem height, and stem rise to set a comfortable torso angle.

Discussion

Top tube length, stem extension, stem height, stem rise, and saddle fore-aft are the major contributors to torso angle. Minor contributors include handlebar and brake lever shape.

Standard torso angle is measured on a level bicycle with the rider positioned with the hands on the hoods.

It is the angle formed by the shoulder (greater tubercle of the humerus), hip (greater trochanter of the femur), and a horizontal.

Figure 46. Torso angle of 40° in an experienced recreational rider.

Riders vary greatly in their preferred torso angle.

Torso angle affects aerodynamics, power, and comfort.

Lower torso positions are generally more aerodynamic; they require back and hamstring flexibility. Higher torso positions are generally more comfortable and allow for more power production.

Experienced recreational riders are comfortable and do well riding with a torso angle of about 45°.

Beginners and obese riders prefer to sit more upright, perhaps with an angle of 60°.

OPTIMAL STEM LENGTH

Aerodynamics

Torso angle is the holy grail of aerodynamics.

As speeds increase, an increasing percentage of work is used to overcome wind resistance.

As riders reduce torso angle, they lessen their frontal area and reduce wind resistance. Other things being equal, they travel faster.

Power

At torso angles smaller than 30°, riders commonly experience loss of (1) economy[47] and (2) power associated with the closure of the hip angle. For strategies dealing with this loss of power, see *Time Trialing* on page 76.

Reach

Once you know how stretched out you like to be, measure the distance from the tip of your saddle to your brake hood. Use this measurement as a reference to help you set up different or new bicycles.

(Traditionally, reach is measured from the tip of the saddle to the handlebar tops at the stem. Shimano and Campagnolo brake hoods were elongated, becoming more ergonomic, around 2004. Since most riders now spend most of their riding time on the brake hoods, it makes most sense to now measure reach to the brake hoods—to where one reaches.)

Figure 48. Bicycle reach. Tip of saddle to brake hood.

STEM HEIGHT AND LENGTH

Extension Arc

As stated above, stem extension, stem height, and stem rise combine to determine torso angle. Various combinations will result in the same torso angle, as illustrated in Figure 49, Figure 50, and Figure 51.

The longer the stem for the same extension arc, the more the arms are weight is forward.

Choose the right combination by considering weight distribution, discussed also on page 41, and shoulder angle, discussed next.

Figure 49. Any combination of stem extension, stem height, and stem rise along the yellow arc will combine to set the same torso angle.

Figure 50. Yellow line marks a 60-mm long stem with a 90-degree angle from the steering axis, 2-1/4 inches above the headset.

Figure 51. Computer generated image rotating around the shoulder. The torso angle is unchanged. Now the stem would be about 130 mm long with a 100-degree angle from the steering axis, about 4 inches above the headset. Although the torso angle is the same, the shoulder angle and handling characteristics of the bicycle have changed. This position is not recommended. See the text.

OPTIMAL STEM HEIGHT/STEM LENGTH - LEAST NECK AND SHOULDER DISCOMFORT/PAIN

Shoulder Angle

Rule of Thumb

Shoulder angle should be about 90° with the hands on the hoods and the elbows bent about 15°.

Discussion

The anatomical landmarks are the hip (greater trochanter of the femur), the shoulder (greater tubercle of the humerus), and elbow (lateral epicondyl of the humerus).

Figure 52. The shoulder should be bent about 90°.

Although road racers and time trialists may have greater angles, if the shoulder is bent much more than 90°, it is uncomfortable and tiring to hold position. Bicycle handling is adversely affected.

Although mountain bikers may sit more upright, if the shoulder is bent much less than 90°, the rider tends to be cramped, overlap the legs and arms, and be more jarred by road shocks. Handling is also adversely affected.

Time trialing with forearm-supported bars is an exception. The bars support the forearms and a more extended shoulder may be well tolerated. Even so, many time trialists drop the forearm supports to six or more inches below the height of the saddle so that the shoulder angle remains around 90°.

Other Methods

A well-known rule of thumb for racers is that with the hands in the drops, the top of the bars obscures the front axle when looking down. This rule applies less often to current frames and forks than it used to apply to traditional diamond design frames and standard raked forks.

Another popular rule for racers on road bicycles is that when the hands are in the drops and the elbows bent about 25°, there should be scant clearance between the elbows and the knees.

ARM POSITIONING AND AERODYNAMICS

Positioning the arms inside of the shoulders or legs, rolling the shoulders inward, having the forearms slightly up to shield the face (and balance the forward sliding from a slightly down saddle nose), and riding with a knees-in style all improve aerodynamics.

For a time-trial tandem photograph, see Figure 58 on page 82.

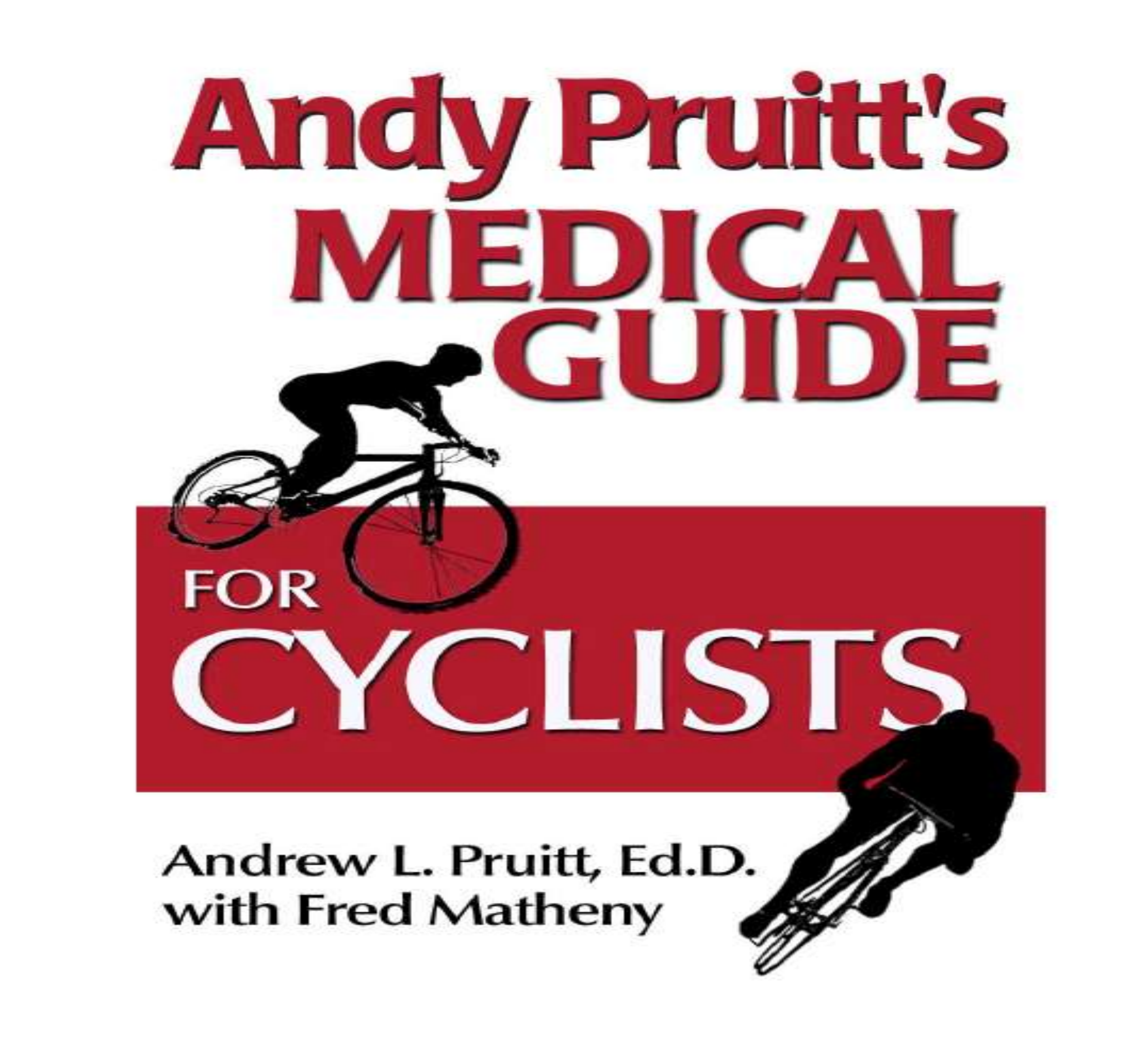
Bar Angle Down 20°	Drag, Grams
Wind Angle 0°	2779
Wind Angle 15°	2566
Wind Angle 25°	2568

Bar Angle Horizontal	Drag, Grams
Wind Angle 0°	2756
Wind Angle 15°	2470
Wind Angle 25°	2413

Bar Angle Up 20°	Drag, Grams
Wind Angle 0°	2741
Wind Angle 15°	2456
Wind Angle 25°	2377

Figure 57. Arms up helps Floyd Landis. The expected time savings of an arms-up position was less than Floyd's winning margin in the Tour of California, Tour of Georgia, and Tour de France 2006. Assume 10 grams drag savings equates to 3 seconds in an hour, and figure a 15° effective wind angle: Bars horizontal saves about 30 seconds an hour over bars down, and bars up 20° saves another 5 seconds an hour. Allied Aerospace LSWT, San Diego, January 2005.

REFERENCES



Andy Pruitt's
MEDICAL
GUIDE
FOR
CYCLISTS
Andrew L. Pruitt, Ed.D.
with Fred Matheny

FRED,ANDY AND CHRIS

Andy Pruitt is flanked by two of his patients—co-author Fred Matheny (left) and coach Chris Carmichael.

REFERENCES


4TH EDITION
Bike Fit
Arnie Baker, MD
http://arniebakercycling.com

PRINCIPLES OF 'BENT' FITTING

- SADDLE POSITION
- HANDLEBAR POSITION
- PEDAL FLOAT
- CLEAT POSITION
- CRANKARM LENGTH
- Q FACTOR!
- TEST: STAND UP! WHERE ARE YOUR KNEES?
- SITDOWN! WHERE ARE YOUR KNEES NOW?

RECUMBENT BIKE FITTING

Recumbent Bike Fitting - The Perfect Bent Bike For You

The following information is provided as a summarized view of proper fit and set up for your Bacchetta Recumbent Bicycle. For more detailed information and to learn how to make the necessary recumbent bicycle adjustments, please refer to your Bacchetta Owner's Manual (also available on our web site) or visit your authorized Bacchetta recumbent bike dealer.

A. FRAME SIZE

Your Bacchetta dealer is well qualified to assess and adjust the fit of your new recumbent bicycle, starting with the proper frame size. Choosing the correct frame size can be the single most important element in guaranteeing the proper fit and ride of your new recumbent bike. Below is a listing of our available models and frame sizes:

The following is a listing of our available models and frame sizes for our full line of recumbents

Cafe	Bellandare	Agio	Bella	Giro 20	Giro 26	Strada	Corsa	Carbon Aero
Standard	Standard	Standard	Small 37.5"	Small 11.5"				
			Medium 41.5"	Medium 14"	Medium 13"	Medium 13"	Medium 12.5"	Medium 12.5"
				Large 14"	Large 15"	Large 15"	Large 14"	Large 14"

The above numbers are the length of the boom on each of the individual frame sizes of our recumbents. You can check the frame size of your Bacchetta recumbent bike by measuring the boom from the center of the head tube (the area where the fork comes up through the frame) to the center of the bottom bracket (or center of your crank set).

RECUMBENT BIKE FITTING – FRAME SIZE

To determine the correct recumbent frame size, it is important that you take an X-Seam measurement. Different from the inseam measurement used on traditional road bikes, an X-Seam uses a measurement based on the entire length of your leg, which is a necessary measurement when purchasing a recumbent bicycle. Following are the steps, along with an illustration, of the correct method of taking an x-seam measurement.

1. Remove your shoes and sit on the floor with your back against the wall.
2. Make an effort to push your glutes (butt) as far as possible into the angle where the floor and the wall meet.
3. Extend your legs in front of you with your toes pointing upward (do not point toes out).
4. Have someone measure from the wall to your heel. This is your X-Seam measurement, which will be used to choose a proper size for your new Bacchetta bent bike.

We recommend that you have your Bacchetta recumbent bike dealer take your X-Seam measurement before riding!

After taking an accurate X-Seam measurement, your bike dealer can help you determine the correct frame size.

RECUMBENT BIKE FITTING ARTICLE

AUSTIN EASY STREET RECUMBENTS

Easy Street Recumbents

« Off-Road Adventure on a KMX Kart   Trike Cornering »

Comfort for the Long Haul: Fitting a Recumbent

June 17th, 2010. Written by Sam Placette

Recumbents, being comfortable and efficient, are a natural fit for long distance riding. Many upright bike riders find themselves limited in distance by pains that are unique to upright bicycles, localized to their wrists, arms, back, neck, and butt. When those riders discover recumbent bikes and trikes, they may increase their distance dramatically over the course of several months.

However, once riders extend the duration of their riding by several hours, they will find new aches and pains that kick in from repetitive use of certain key muscles and joints. The good

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RECUMBENT BIKE FITTING

The reference model for fitting a Bacchetta high racer.
Courtesy Bacchetta Bikes.

I used digital graphics software to measure the angles on the Bacchetta reference model and compare them to my own photo, below. I saw that the Bacchetta reference had roughly a 20 degree bend at the hip, 25 degree bend at the knee, the upper arm angled 20 degrees below horizontal, and the elbow bent at 30 degrees. Measuring my own photo, I saw that my knee had a much sharper bend, at a full 40 degrees, and that my upper arms were more extended than they needed to be.

Knee bent at 40 degree angle, and arms overextended.

RECUMBENT BIKE FITTING

Knee now bent at 30 degree angle.

Reducing the knee bend by ten degrees was a significant improvement, but I really wanted to bring the angle closer to the Bacchetta reference model. I moved the seat back again, by just 1 centimeter this time, and did another round of photography and analysis. This time the knee bend was somewhere between 25 and 30 degrees.