# Basic Cycling Biomechanics- The Bike Side

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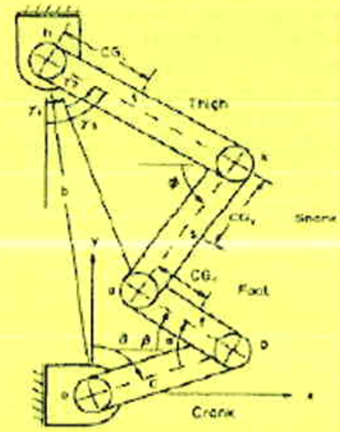


*As an competitive cyclist Michael was mentored by Dave Brinton, Eileen Olsen, and Dr Massimo Testa. In 2004 he left the sport of cycling to pursue his second passion- education. The sport of cycling was his drive to acquire the knowledge through college and experience in the field of exercise science to help athletes achieve optimal performance. He has a bachelors in 2006 at California State University of Dominguez Hill in Kinesiology. While at Dominguez Hills he received the Ronald E McNairs Scholarship to pursue research and education.*

*In June of 2006 he went to University of Northern Colorado to pursure a Master degree in Exercise Science emphasis in Biomechanics. While at UNC he did research on exercises training. After the research was completed he then was accepted to attend the Chris Carmichael Coaching residency program. After the residency was complete he was offered a job by the National Academy of Sports Medicine where he is now the Education Content Developer. He currently owns his own coaching company Kinetic Loop Training System.*

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In the last two decades, applied biomechanics has advanced the sport of cycling by changing how athletes train and by improving body position on the bicycle. The sport of cycling has evolved due to bike frame geometry changes and expanded the racing venues from simple roadways to a variety of roads and trails. Scientific knowledge has altered cycling performances with the successful athletes utilizing such information gained by wind tunnel testing, power meters, and the geometry changes in seat tube angles.

**Definition of Biomechanics**

Biomechanics is the study of motion and the effects of forces relative to the human body; a field that combines discipline of physiology and engineering mechanics, which utilizes tools of physics, mathematics, and engineering to describe the properties of physiology.

**Cycling Biomechanics**

Since we just defined biomechanics we can know learn and understand how biomechanics is applied to cycling to optimize cycling performance. The bicycle is a fixed object where only certain parts can be change like the stem, cranks, and saddle height. When looking for a bike you need to recognize other biomechanical factors that can't be modified like seat tube angle. As a cycling coach and a biomechanicist the goal is to obtain optimal position for the recreational cyclists or competitive athlete's that provides comfort and efficiency to improve their performance. Having the optimal position allows the cyclist to produce optimal force in cycling, which is known as power output. The goal is to position the cyclist where he/she will have the lowest amount of oxygen consumption while maintaining optimal power production which is known as efficiency. As a biomechanicist you want the cyclist to be able to apply pedaling forces effectively to obtain optimal performance and avoid injury. This article considers some variables of rider positioning and equipment set up that are important to all cyclists.

**Saddle height**

Saddle height is the most important component of properly fitting a cyclist. If pedal placement, crank arm length, and fore-aft position are off then saddle height may be slightly off. If a saddle height is off by being too high this can cause anterior knee pain and having a saddle too low can cause posterior knee pain. Changing the saddle height alters a number of variables in cycling including joint angles, muscle lengths and the force output muscles can produce. Research has reported the optimal seat height corresponding to trochanteric height which is known as the sum of the crank arm length and the seat height should be adjusted to 97-98%. Trochanteric height is measured from greater trochanter to the ground when standing erect in cycling shoes (Figure 1). The other method used to address saddle height is using the preventive injury method of 25 to 35 degree knee angle. Both of these heights are considered efficient however, the 98% of trochanteric height and 25 degree knee angle produce the highest mean anaerobic power on a Wingate test according to research literature.

*Figure 1 trochanteric height*

**Crank Arm Length**

Crank arm length has been a controversial topic. Some coaches and cyclists think longer cranks are better. This is the same mentality of the small guy in the big truck. I believe this comes back as an ego thing. As you increase your crank arm length from 0.170m for the average 5'9 cycling the pedaling rate or cadence is affected [4]. A taller cyclist requires greater kinematic joint moments than a person of average height, thus enabling the taller person to move the crank due to increased mass and moments of inertia of his/her lower limb segments. The optimal crank arm length increases as the stature of the rider increases. Once crank arm length increases from the standard 0.170m, the result is a decrease in cadence[4]. A resulting benefit of the longer crank arm length is a lower demand of pedal forces, however, it requires more motion from leg segments resulting in increased kinematic moment. The sensitivity of pedaling rate is due to the change in crank arm length. A big concern is that most bikes come stocked with the wrong size cranks.

**Saddle Position (Fore-Aft and angle)**

When looking at saddle position there are two factors that need to be addressed the fore and aft position, which refers to the location of the nose of the saddle behind a vertical line drawn to the centre of the crank axle. The other factor is the angle of the saddle nose either pointing up, down, or neutral. The optimal position of the saddle in respect to fore aft position allows you to use a plumb line dropped from the patella to bisect the pedal axle when the crank is aligned parallel to the ground (Figure 2). In respect to the angle of the saddle it should be in neutral position. If your saddle is in a negative angle or tilted downwards your hips will slide forward which can lead to knee pain. Just the opposite having a positive tilt or tilted upwards has shown to cause lumbar pain. By keeping the saddle at a neutral angle and keeping the knee aligned with the pedal shaft you can optimize your performance being more efficient at utilizing the quadriceps, gluteus maximus, gluteus medius, soleus, gastrocnemius, and hamstrings muscles.

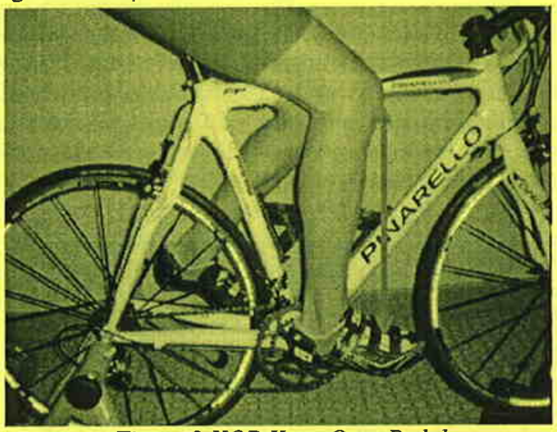


*Figure 2 KOP Knee Over Pedal*

**Shoe and Pedal Position**

The optimal position for shoe and pedal position is when the ball of the foot (metatarsophalangeal joint) (MTP) is directly over the pedal. Depending on the pedals you need to look at the cleat interface. An example is the Speed Play pedals which are a great pedal to use, but are commonly poorly fitted on the shoe. Because the cleat surface is shaped different than other cleats you need to look at the groove in the cleat where the pedal spindle bisects the cleat. If this bisect is positioned directly at the ball of the foot you will have achieved the optimal position.

**Seat Tube Angle**

Seat tube angle is defined as "position of the seat relative to the crank". A tall rider would benefit from shifting their hips backwards relative to the crank axis, while a shorter rider would benefit from shifting his/her hips forward relative to the crank axis. A research article by Gonzalez and Hull concluded that an optimal seat tube angle varied on cadence and leg length. The significance of their study was in finding that while cyclist stature increases from the average rider of 5feet 9inches, the optimal seat tube angle decreased from 78 to 73 degrees. Research has shown that steeper seat tube angles produced significantly higher aerobic power efficiency and lower mean VO2. Price and Donne noted that optimal seat height is the height which produces the lowest VO2 at a fixed power output and cadence. These angles are especially important when looking for a mountain bike, which commonly has a seat tube angle that decreases performance.

**Shim or Not to Shim**

I believe coaches and doctors are too quick to shim athletes back to normal technique. Today coaches see products to shim your cleats, your shoes, and even your pedals. In some cases an athlete might need a shim due to him/her born with a leg length discrepancy. Although majority of the problems are from altered muscle length-tension relationships, altered force-couple relationships, altered arthrokinematics, which causes altered movement. In simple terms there is an overactive and under active muscle that can be corrected through a corrective exercise prescription.

**Basic Cycling Biomechanics- Introducing the Human Body Side**

Since we just discussed the position and dynamics of the bike which is a fixed object with some moveable parts it is now time to discuss the human body. When performing a bike fit it is necessary to understand the functional anatomy (adduction, abduction, flexion, extension, pronation, and supination) of the human body to perform a movement assessment. A movement assessment can be as simple as an overhead squat, single leg squat, and or manual muscle test. To learn more on how to correctly perform these types of movement assessments you can go to the National Academy of Sports Medicine and enroll in the Corrective Exercise Specialist credential. There are also some good books like "Athletic Body in Balance" by Gray Cook, "Diagnosis and Treatment of Movement Impairment Syndromes" by Shirley Sahrmann, and the "NASM Essentials of Corrective Exercise" by Mike Clark. Movement represents how the body functions as a unit. The unit is called the kinetic chain, which is made up of the Nervous system, Myofascial system, and the articular system. However, we are just going to focus on the myofascial system, which is all the soft tissue (muscle, ligaments, and tendons, etc). To insure optimal performance you need to make sure each cyclist has established normal length tension relationships. If a muscle is overactive or tight then this muscle can't produce the optimal force. Likewise, if a muscle is under active then the muscle is weak and lengthened and it can't produce optimal force (Figure 3). Here is an example of an over active and underactive muscle on muscle balance in Figure 3

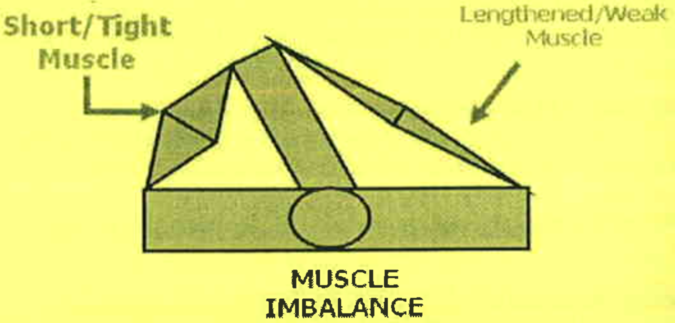


*Figure 3*

There are exercises you can do to increase elasticity in the muscle and improve optimal performance of the endurance athlete through static stretching and SMR self myofascial release (foam rolling). Now that you have the bike side I encourage coaches to look at the other side of cycling biomechanics- the human body. ▢

**More Information Please!** Contact Michael Lovegren at Kinetic Loop Training System (www.kineticloop.org). For a list of references email condpress@aol.com and ask for Basic Cycling Biomechanics-The Bike Side