

Cycling Biomechanics

Cycling Biomechanics and the Knee

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The aim of this vignette is to highlight the possible causes of knee pain in cycling and to suggest potential corrective actions.

For full anatomical detail of the knee go here - <http://en.wikipedia.org/wiki/Knee>

For the purposes of bike fitting I would like to highlight certain characteristics of the knee. The knee is a hinge joint (permits flexion and extension) and it rotates both medially and laterally to a small degree. The knee is also a synovial joint which basically means that the joint is surrounded by synovial fluid which works to reduce friction during movement. The patella (knee cap) connects the femur (thigh bone) to the tibia (shin bone) via the quadriceps tendon and patellar tendon. The quadriceps tendon together with the patella is called the quadriceps mechanism. The main role of the patella is to extend (straighten) the knee. As it does so the patella slides over the femur in the femoral groove. This exerts pressure between the patella and the femur. The patella tracking along the femoral groove is stabilized by the important vastus medialis muscle of the quadriceps (this is the tear drop shaped muscle to the inside or medial side of the thigh).

When performed correctly, cycling is good for the knees as it promotes the movement of synovial fluid around the knee joint and exercises and strengthens the muscles that support the entire kinetic chain from the hip through the knee to the ankle and feet. The converse is also true. Incorrect range of movement will cause discomfort and pain at the very least or can lead to overuse injury and degradation of the articulation surfaces of the knee joint. The majority of the menisci and cartilage in the knee joint does not have a blood supply and is therefore not able to heal itself. A cyclist cycling for an hour at a fairly easy 12 mph has an average cadence of 60 rpm which is extending both knees 4500 times in just one hour.

Balanced biomechanics is not just about getting a bike fit. Ensuring that the various muscle groups are strengthened through correct exercise and maintaining muscle flexibility are essential throughout your cycling career. Although cycling closely resembles our walking gait as humans we are not designed to spend hours on a bike. During the pedal stroke a cyclist will activate the hips, quadriceps, hamstrings and ankle dorsiflexors at various phases of the pedal stroke. The knee does not only act as a hinge constantly flexing and extending along the vertical plain, but also twists laterally and medially at the same time. During the pedal stroke, Chaudhari et al has showed that the tibia twists about 15 degrees relative to the femur. While pedalling in the saddle a cyclist will never fully extend the leg, therefore the various muscle groups develop at a different rate over thousands of pedal revolutions. Many serious cyclists who do no exercise other than cycling will have muscle imbalance with strong outer (lateral) quadriceps muscles (vastus lateralis, rectus femoris and vastus

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intermedius) and weak inner (medial) quadriceps muscle namely the vastus medialis. Because patella tracking is stabilised via the vastus medialis this can lead to Patella Femoral Syndrome and if not treated ultimately to Chondromalacia patella.

The two most common knee conditions in cyclists are

Patellofemoral pain syndrome (PFPS) is a pain or discomfort originating from the contact of the posterior surface of the patella with the femur.

Chondromalacia patellae (also known as **CMP**) is an irritation of the undersurface of the patella. The undersurface of the patella is covered with a layer of smooth cartilage. This cartilage normally glides effortlessly across the knee during bending of the joint. However, in some individuals, the kneecap tends to rub against one side of the knee joint, and the cartilage surface becomes irritated, and knee pain is the result

Functional vs. Anatomical knee biomechanics

Some cyclists have abnormal knee function due to injury or recovering from injury either in the knee joint or elsewhere in the kinetic chain. These functional discrepancies will need to be taken into account during the bike fit. Anatomical discrepancies also need to be considered. Everyone is different and not everyone has perfectly aligned joints. Below are some examples of anatomical abnormalities specific to the knee which cyclists may encounter and the medically accepted bike fit recommendations.

Trochlear Dysplasia or an unstable patella.

Patella Alta or a high riding patella

Patella Subluxation is when the patella is pulled laterally as the knee joint is flexed

I believe that these conditions are more common than most people realize. I have suffered all three of the above dysfunctions and have had tibial tubercle osteotomy surgical procedures to correct the condition in both my knees.

If you suspect that you may have a knee abnormality or a knee injury that rest and recuperation is not resolving make an appointment to see a knee specialist. Most orthopaedic surgeons now days have experience with sport injuries. Always take medical advice from the appropriate experienced medical professional before attempting any form of exercise.

If you know or suspect that you have any of the conditions mentioned, tell your bike fitter before the fit.

Condition	Effect during pedaling	Bike fit Recommendation
Trochlear Dysplasia	Patella not tracking evenly within the femoral groove	Raise saddle Ensure Q factor correct Correct for lateral knee tracking Increase cadence/low (easy) gears
Patella Alta	Increased pressure on articular cartilage Increased articular cartilage wear	Raise saddle Increase cadence/low gears
Patella Subluxation	Increased pressure on lateral Condyle Increased articular cartilage wear	Raise saddle Ensure Q factor correct Correct for lateral knee tracking Increase cadence/low gears

Q Factor – distance between cyclists feet

Below is a table to help diagnose potential knee issues. Please note the table is not intended to replace a professional bike fit

Problem Location	Possible Cause	Possible Solution
Pain in front of knee (Anterior)	Saddle too low Saddle too far forward Crank too Long Climbing/High gears	Raise saddle Move Saddle Back Shorten Cranks Increase cadence
Pain at back of knee (Posterior)	Saddle too high Saddle too far back Pedals with too much float	Lower saddle Move saddle forward Limit Float in pedals
Pain inside the knee (Medial)	Saddle too low Hi Q Factor (feet too far apart) Riding toes out	Raise saddle Adjust cleats to shorten dist. Adjust to more neutral pos.
Pain outside the knee (Lateral)	Saddle too high Low Q Factor (feet too close) Riding Toes inwards	Lower saddle Adjust cleats to increase dist. Adjust to more Neutral pos.

References:

Chaudhari, AM et al. Dynamic changes in anterior/posterior translation and internal/external rotation of the knee during cycling. Stanford Biomotion Laboratory, Stanford University. (2001)