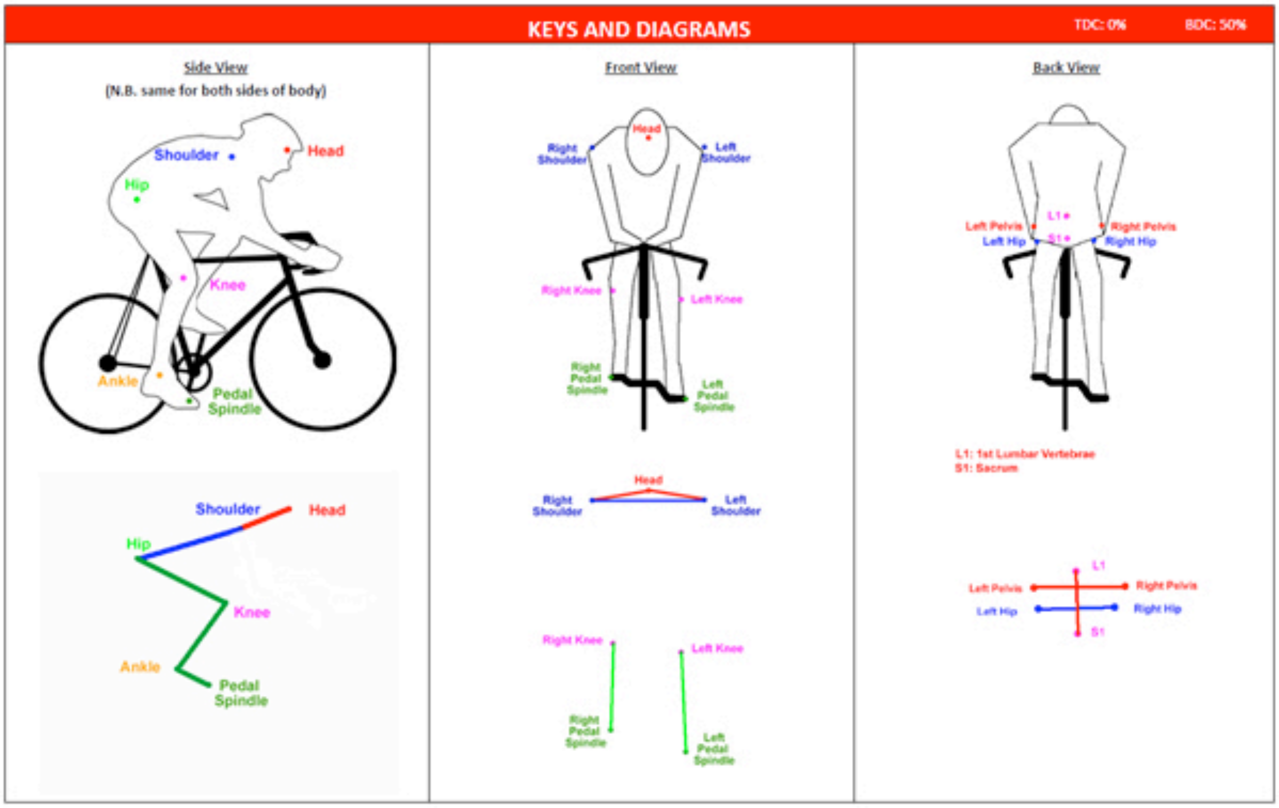
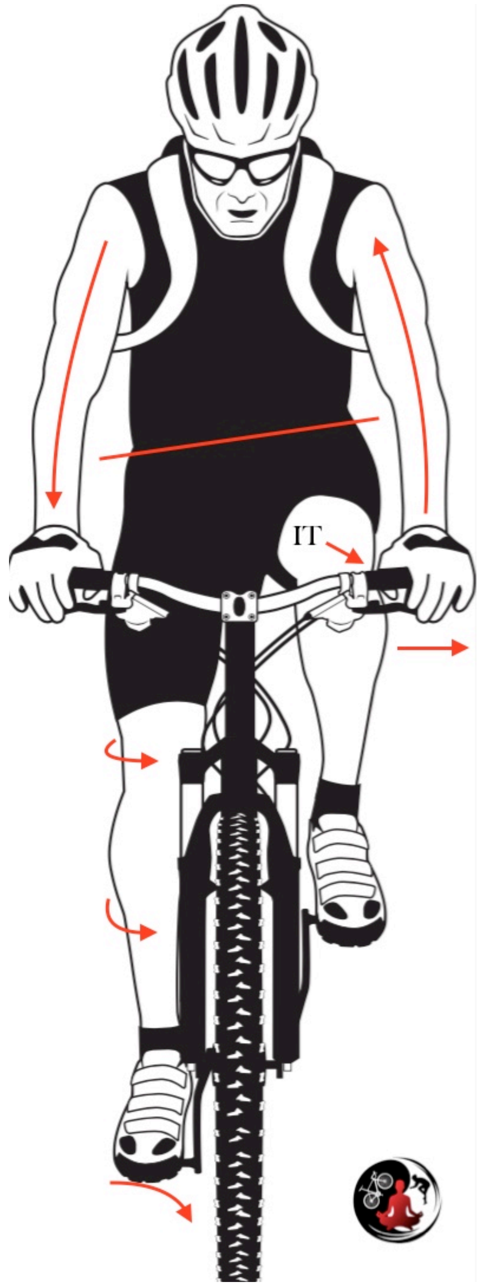
Biomechanical Considerations
Of
Increased Q-Factor and Pedaling Base



Cycling is a pure example of the kinetic chain in biomechanics, where modifying the orientation of a contact point can produce a somewhat predictable "chain" of events throughout the body and other contact points.

To illustrate this concept, the possible implications of a unilateral pronation scenario are illustrated below. A dropped arch at the right pedal can effectively shorten the same leg, increasing right hand pressure and causing the left-leg to appear "wind-swept" relative to the bicycle's midline – right-hip drop/left-hip rise. The resulting increased left-leg reach tends to lengthen the tensor fascia and increase iliotibial tract tension, which can produce symptoms from gliding over the now more prominent (wind-swept) lateral femoral condyle.

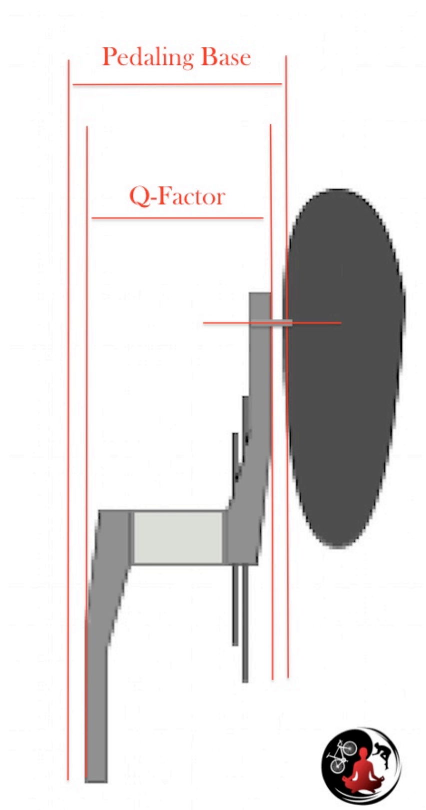


Each adjustment to a bicycle, shoes and/or cleats impacts the entire kinetic chain when cycling. The objective of each quality bike fitting is to ensure that all body parts are arranged in a fashion that function optimally in a variety of conditions.

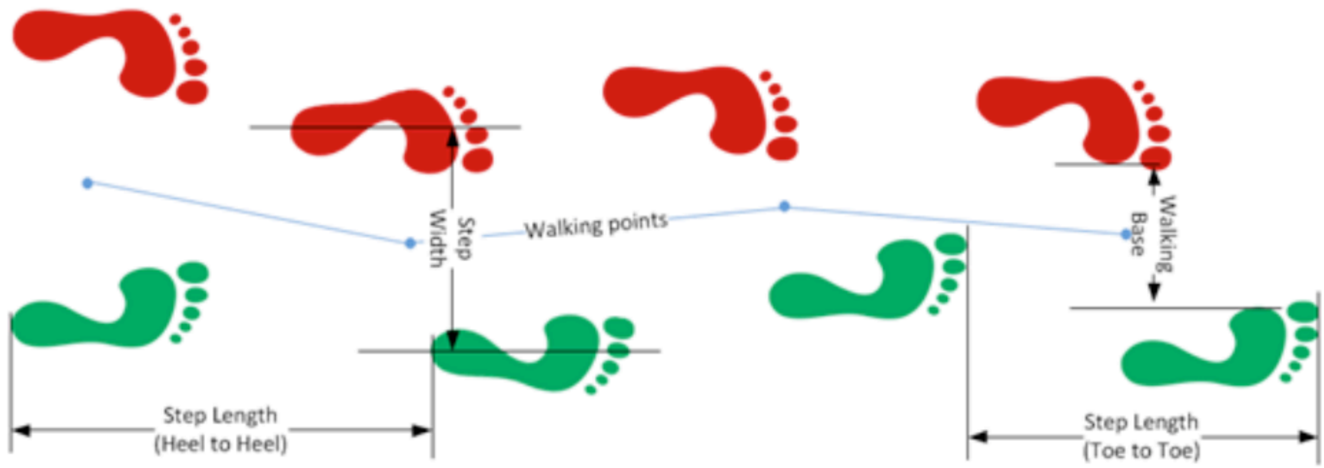
If a person is relatively symmetrical, with effective glute and ankle stability, owning relatively “normal” varus/valgus knee angles we assume that she/he should be capable of riding a bike without knee pain. The strength of this assumption is strong so long as a bike’s contact points, shoes and cleats are adjusted within the range of an individual’s biomechanical needs.

Pedaling base is a component of these adjustments, which I have defined as the lateral distance between feet in the coronal/frontal plane – adapted from "walking base" in gait analysis.

Pedaling Base

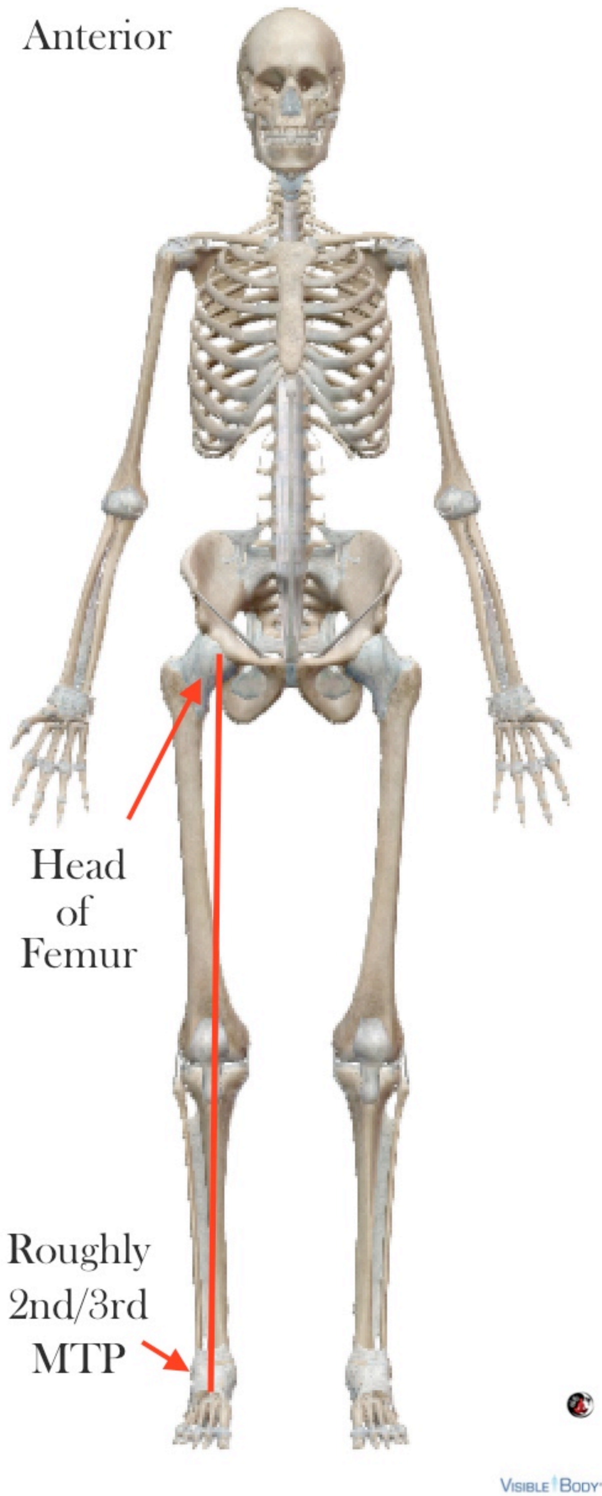


Walking Base



The common protocol for determining appropriate pedaling base is to estimate a coronal plane vertical axis intersecting the center of the femoral head, tibial plateau and distal tibia, modified to accommodate balanced internal and external tibiofemoral rotation (arthrokinematics).

We can illustrate this alignment in the simplest terms by projecting a vertical laser (assuming perpendicular alignment of the bike relative to floor) along the middle-thigh (upper) and roughly the 2nd and 3rd MTP's (toe-knuckles).



Numerous factors impact the reliability of this approach, but practice supports a strong correlation between statue and pedaling base. Big people with large bones (not just pelvis) tend to appreciate an increased lateral-offset at the pedal, with a medial offset for smaller riders.

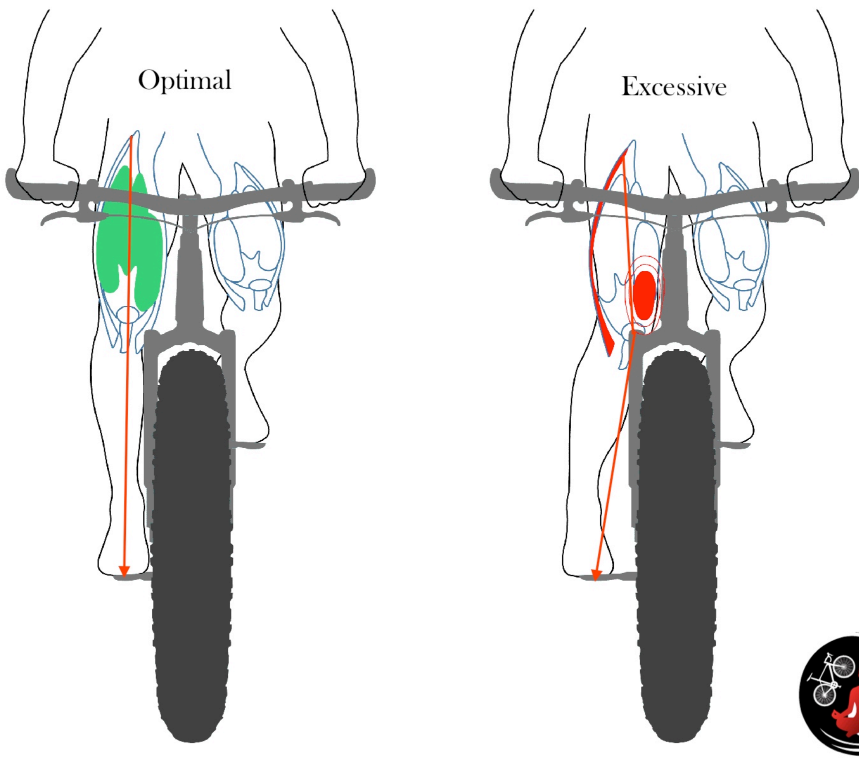
Exceeding Optimal Pedaling Base

Congruency and stability of the knee are contingent on the relative function and orientation of adjacent joints. In other words, the ankle, foot and pelvis are directly responsible for what happens at the knee. Symmetrical pelvic obliquity and rotation contribute to proper knee function, but may be compromised by improper ankle and/or foot biomechanics. Foot and ankle biomechanics are impacted by many factors, including vertical axis proximity to the femur in the frontal plane, and may impact knee and hip function.

Assuming optimal pelvis, ankle and foot orientations and function, bi-lateral medial knee pain typically accompanies an excessively wide pedaling base with similar features laterally when too narrow. Of course there are many exceptions to this rule, including people who demonstrate abnormal kinematics without symptoms, but we are speaking in general terms.

Based on these findings, I expected fat biking to host an epidemic of medial knee problems. In truth, the incidence of knee related issues for fat bike clients is higher, but not sufficient for predictive value. I expect this is due to the dynamic features of fat biking and reduced pedaling torque necessary to maintain traction riding off-road and in snowy-conditions.

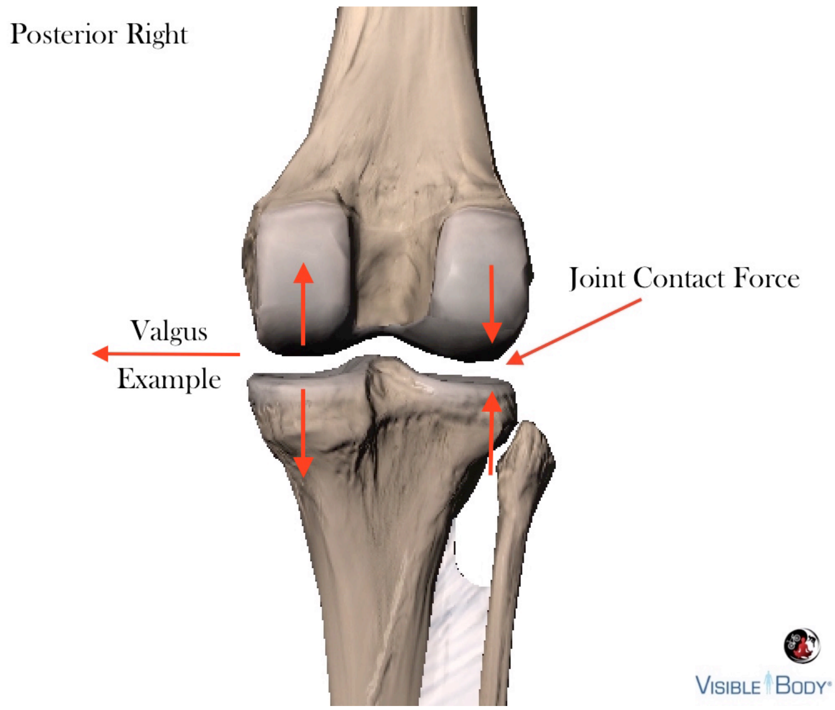
Regardless of symptoms, compromised biomechanics that can increase the risk for injury or have cumulative negative effects on knee integrity.



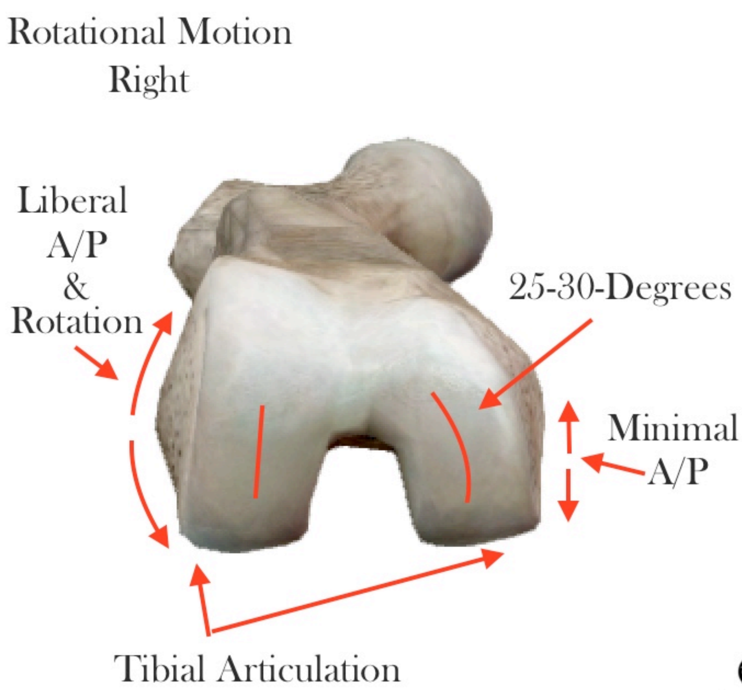
Biomechanics of a Wide Pedaling Base

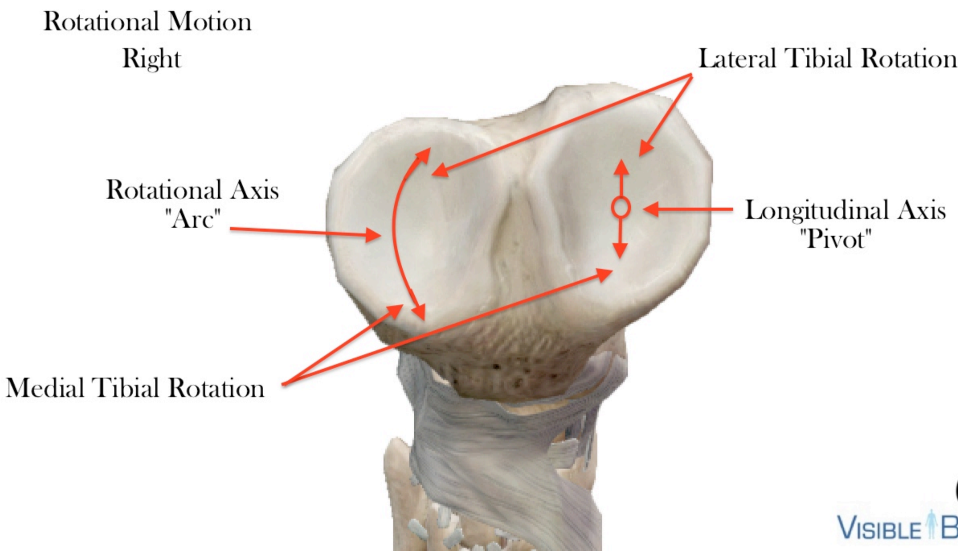
Joint Forces

Flexion and compressive tibiofemoral loads are very low when cycling, and patellofemoral compression has more to do with saddle height/setback than pedaling stance. Contrary to the medial condyle loading accompanying adduction moments in ground reaction force in gait, a lateral shift in pedal reaction force tends to distract the medial condyle and increase lateral compression.



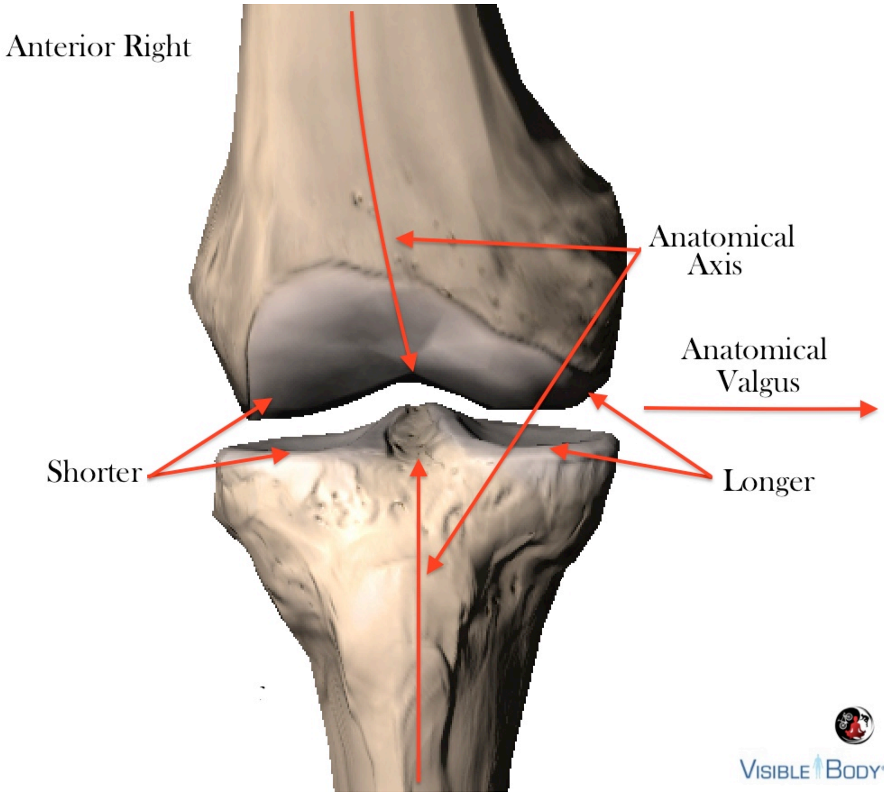
Rotational stress is contingent on the distribution and direction of femoral on tibial rotation inherent to the combined open/closed chain characteristics of pedaling. Coupled internal femoral and tibial rotation patterns imposed by an excessive pedaling base can disrupt menisci and Intracapsular ligament integrities.





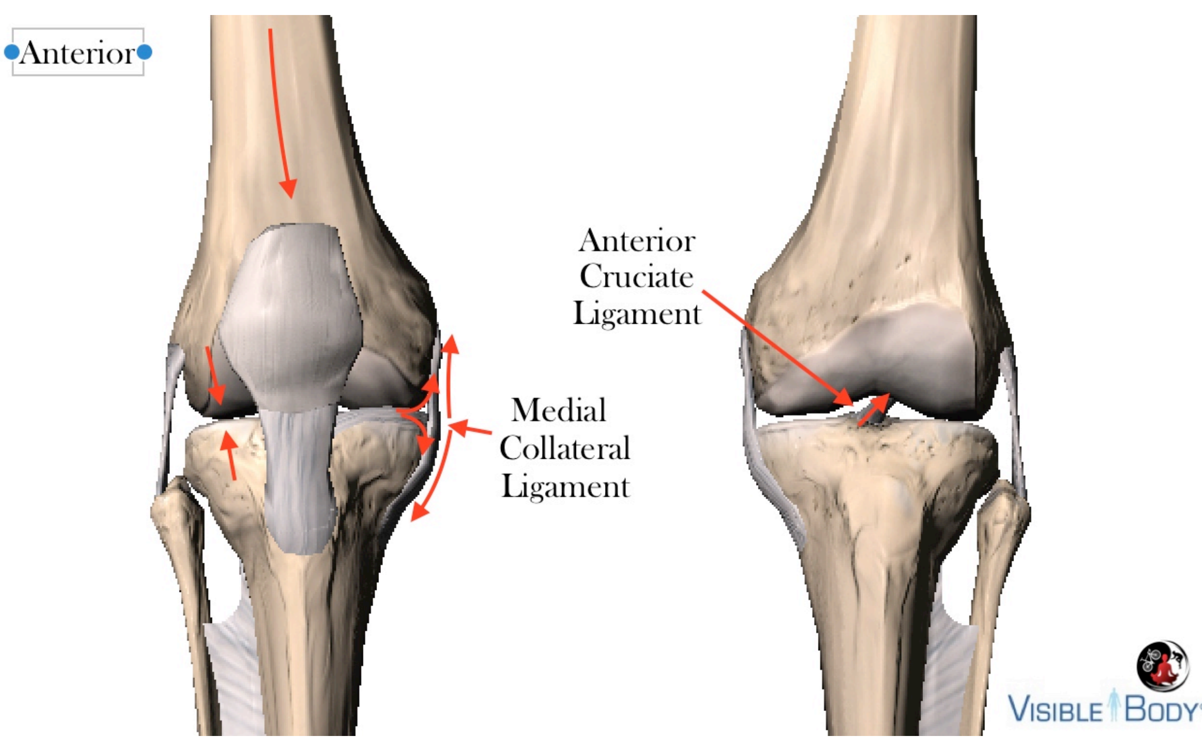
Ligament Forces

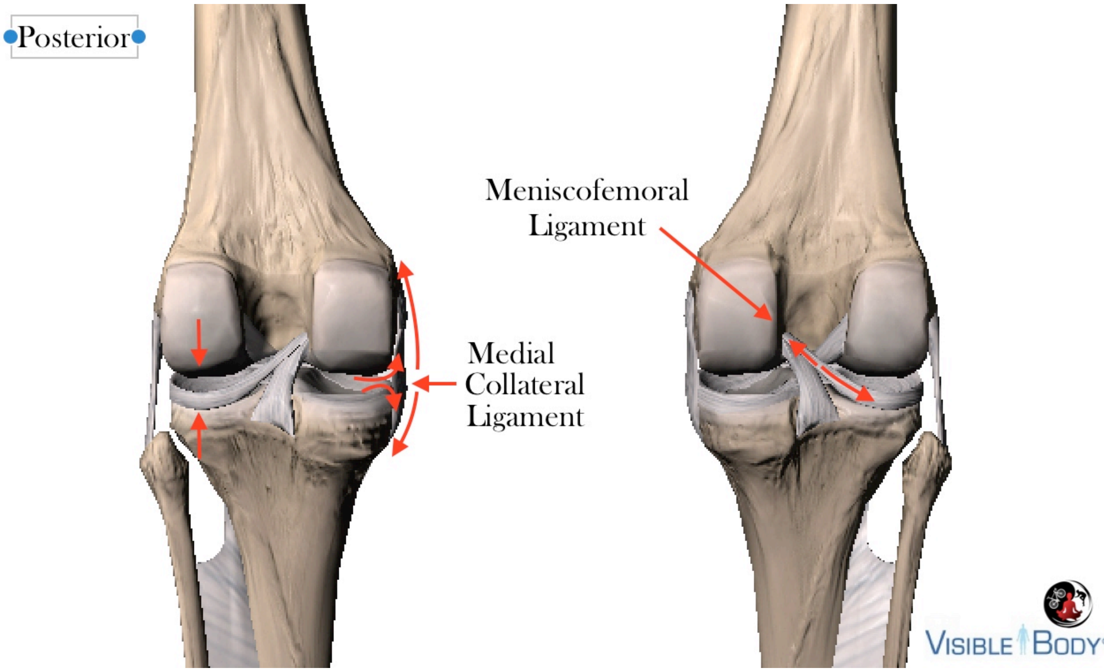
Exceeding the “normal” tibiofemoral valgus orientation in knee extension is a risk factor for medial ligament injury when riding a wide pedaling base.



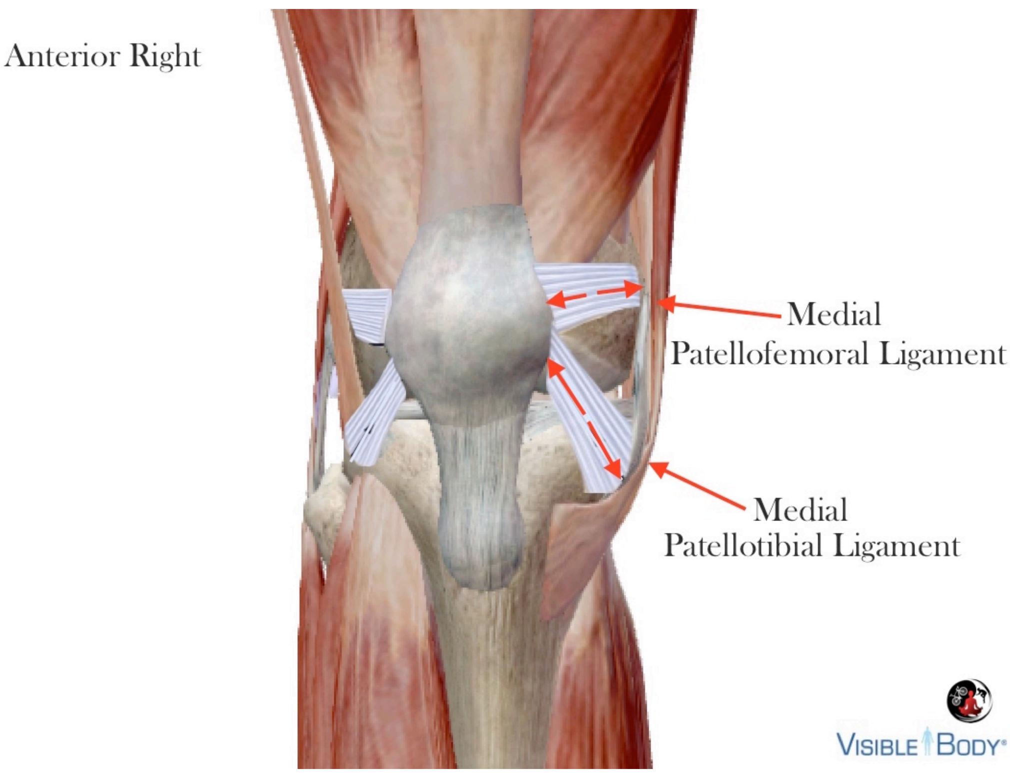
The medial collateral ligament contains superficial and deep portions that are intimate to the joint capsule and medial meniscus providing first-line resistance for knee adduction. Imposing additional torque on this ligament can strain/injure the ligament, menisci or both.

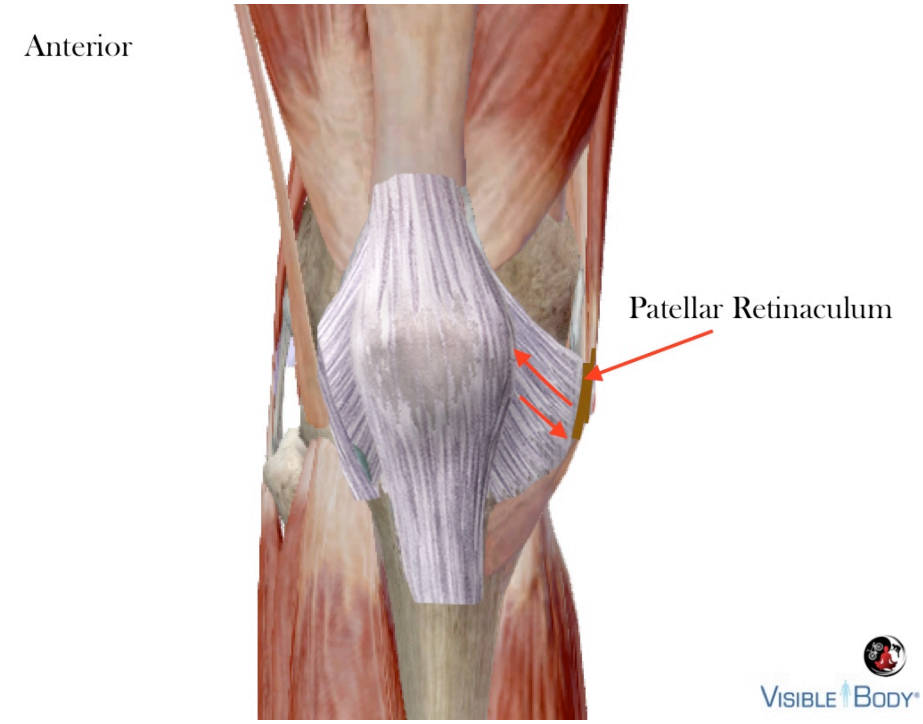
Less common issues involve the meniscofemoral, anterior and posterior cruciate ligaments, though we'd expect compromised integrity accompanying excessive coupled anterior tibial translation and internal rotation.



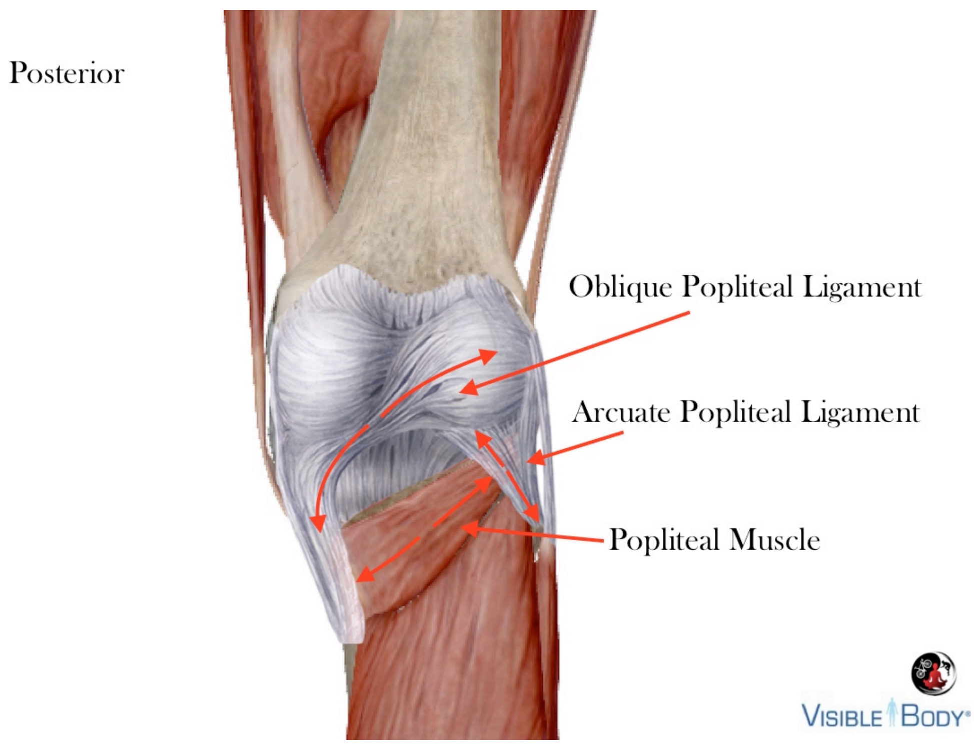


The patellofemoral, patellotibial, and retinaculum are subject to increased tension/strain relative to abnormal valgus moments, increasing the risk for patellar tracking errors and associated symptoms.





Posterior capsular supporting ligaments including the oblique and arcuate popliteal ligaments are impacted by increased adductor moments, though rarely symptomatic.



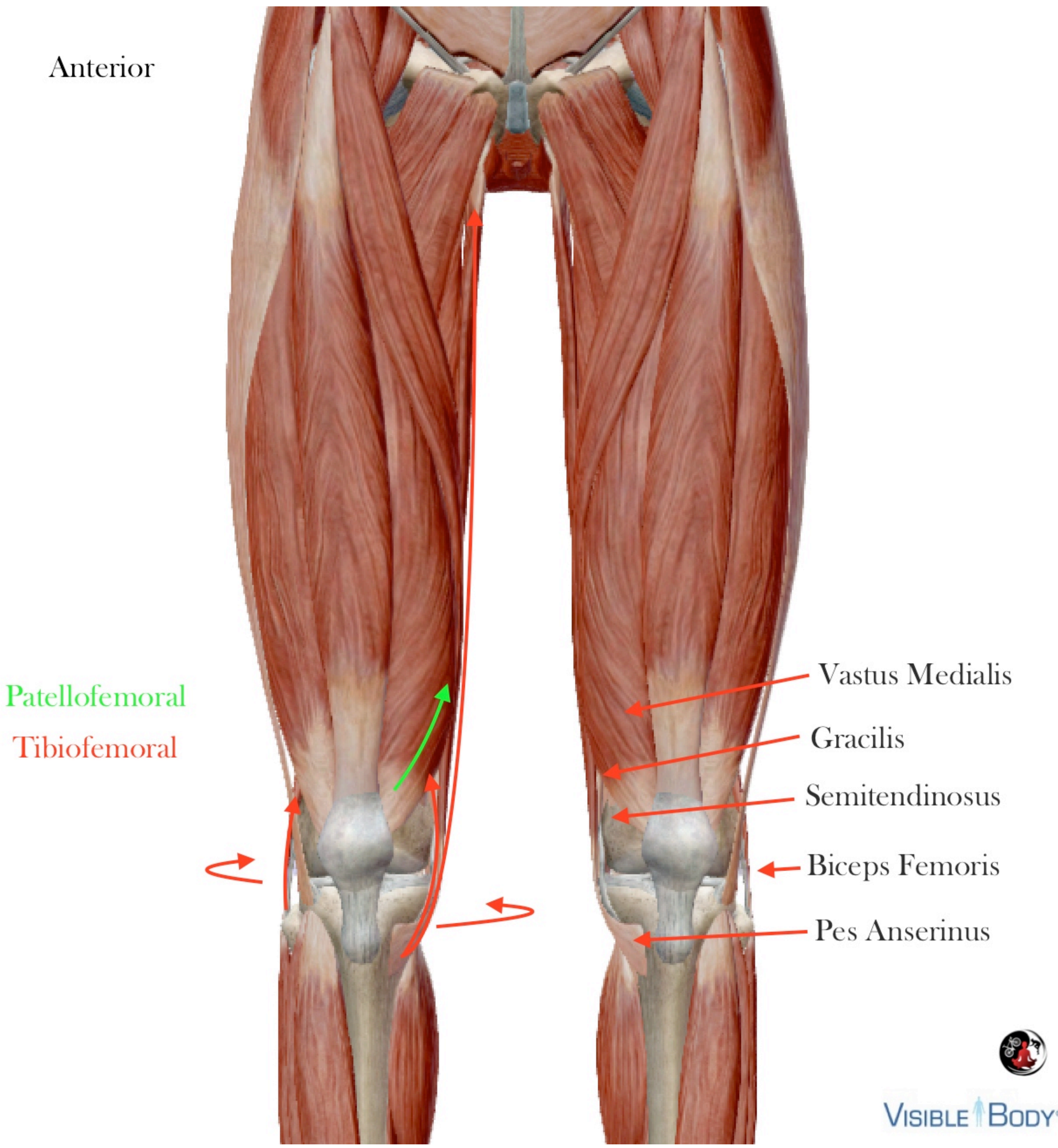
Muscle Forces

Muscle recruitment is impacted by muscle tension. The force-length concept suggests that force is greatest when contraction is initiated relative to a muscle's natural resting length, with significant reductions if activated in a pre- stretched or shortened condition.

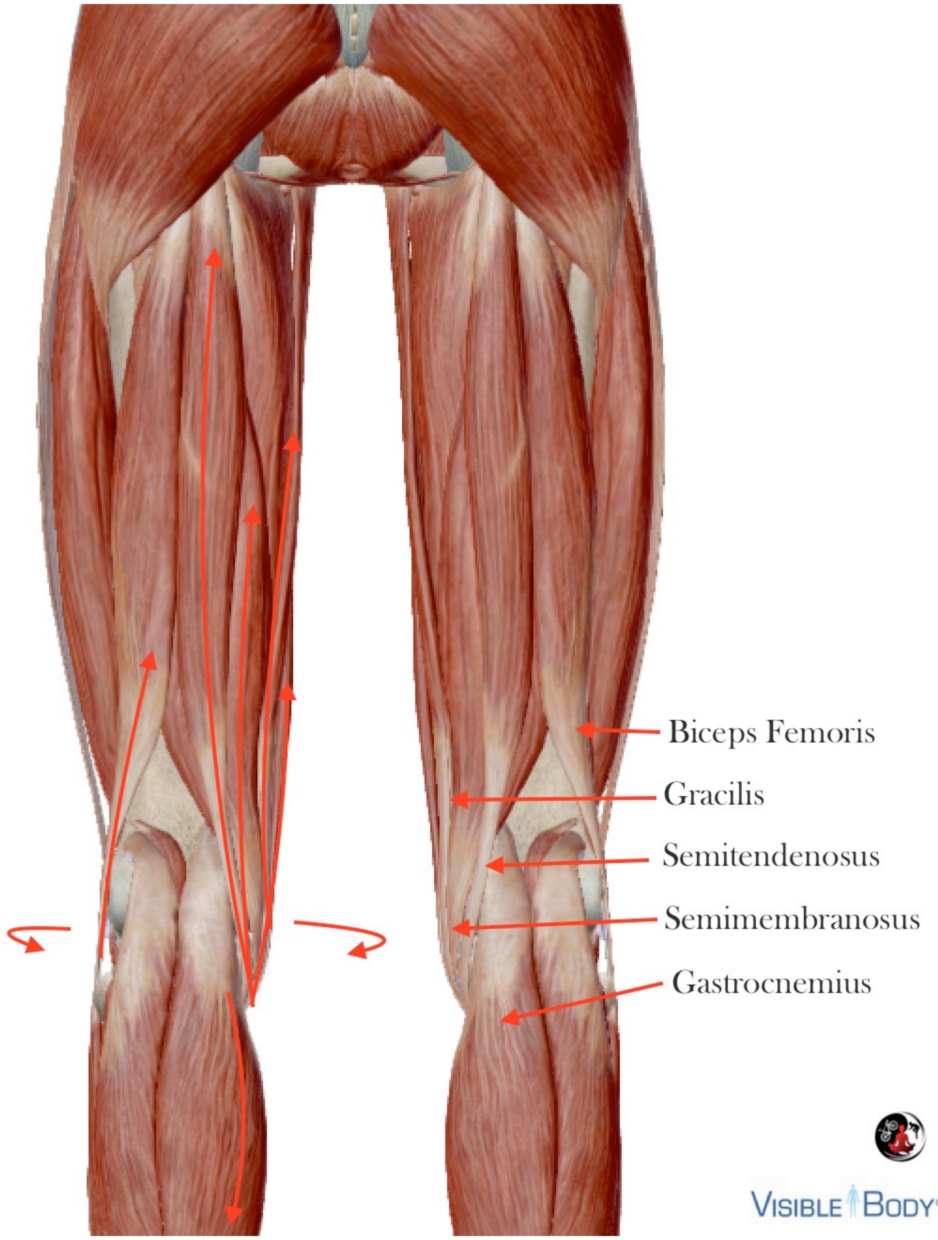
Exceeding pedaling base can increase muscle length/tension in the knee (and hip) adductors and internal rotators accompanied by reduced length/tension in knee (and hip) abductors and external rotators

Accompanying kinematic features include but are not limited to increased valgus knee orientation and internal tibial rotation, impacting muscles at the pes anserinus, semimembranosus, and popliteus

The same condition accompanied by optimal foot and ankle stability might increase the distance between origin and insertion of the biceps femoris – especially if this stability reduces valgus knee orientation.



Posterior


Biceps Femoris
Gracilis
Semitendenosus
Semimembranosus
Gastrocnemius
VISIBLE BODY