Diagnosis, Treatment and Rehabilitation of Knee Injuries

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Goals

- The goals for this course are to present a literature based approach for rehabilitation.
- Take the evidence based information and implement it into daily practice.
- Use your assessment skills to specifically create a rehabilitation protocol for each patient.

Knee Injuries

- Patello femoral injuries
- ACL injuries
- Ligament Injuries
- Meniscus injuries

Patellofemoral Pain

- Numerous authors have linked frontal and transverse plane motion of the hip and knee with patellofemoral joint contact stress.
- (Fuchs, Schutte and Witte,1999, Powers et al 2003, Ramappa et al 2006, Salsich and Perman 2007, Wilson et al 2008, Souza RB. et al 2009, Powers et al 2009)

- PFP (Patellofemoral Pain) results from irritation of innervated structures of the patellofemoral joint (ex., inflamed synovial and fat pad tissues) as a result of excessive joint loading.
- This theory has led to the identification of factors that can lead to increased patellofemoral joint loading, such as (1) altered lower extremity kinematics and kinetics, (2) increased muscle strength and neuromuscular recruitment, (3)faulty structural alignment, and reduced flexibility
- Dye SF et al Clin Orthop Relat Res. 2005, Bolgla LA et al Journal of Athletic Training 2018,

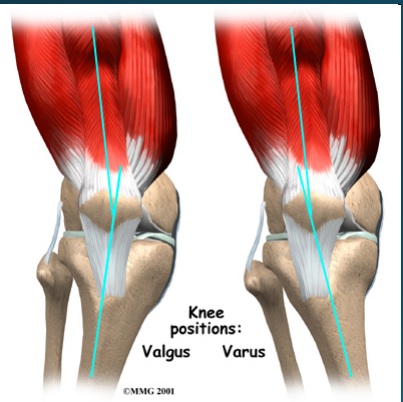
Patellofemoral Pain Syndrome

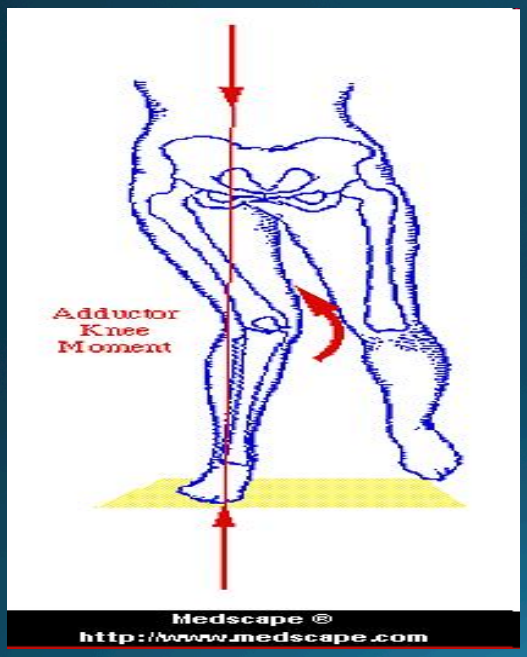
Patellofemoral Pain

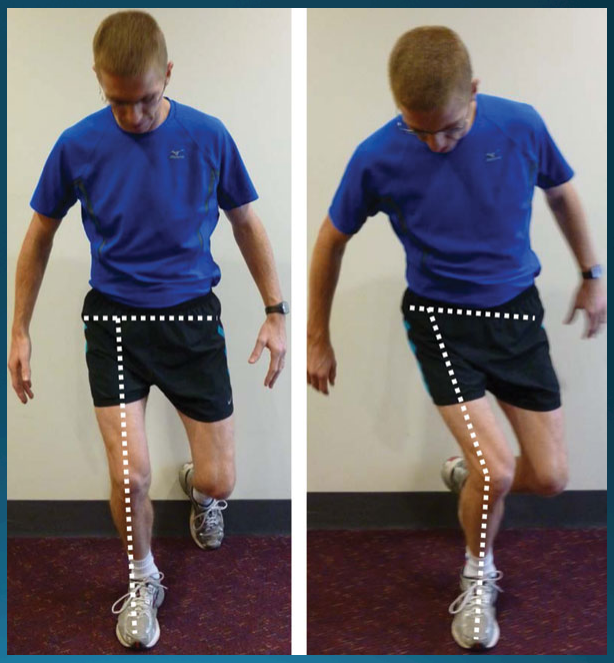
- Changes in the dynamic alignment of the lower limb creates pain and pathology in patellofemoral area.

Patellofemoral Pain

- Ipsilateral trunk lean and contralateral pelvic drop
- Increased hip adduction, hip medial rotation, hip flexion and knee valgus during weight bearing results in elevated joint stresses at the patellofemoral joint.
- Nakagawa T, et al 2012

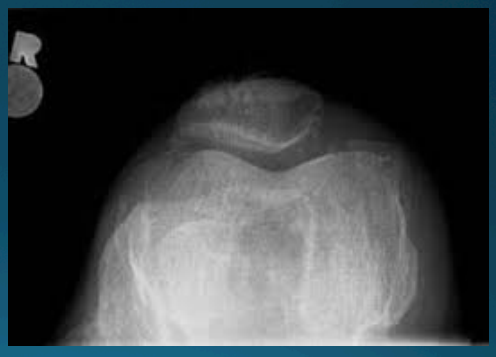






Patellofemoral Pain

- Patella moves laterally while the distal femur goes medial



Patellofemoral Pain

- Powers et al 2003, Souza et al 2010;
- Females with PFP have a significantly greater lateral patellar displacement at 0, 15 and 30 degrees
- Greater medial femoral rotation at 0, 15 and 45 degrees while doing a single limb squat in an MRI.

- Powers CM et al Medicine &Science in Sport 2015
- 9 females with Patellofemoral pain (PFP)
- **MRI** evaluated **loaded** knee flexion at 15 degrees and 45 degrees
- 3D motion analysis standing squat at 15 and 45 degrees of flexion.
- The purpose of this study was to evaluate whether internal rotation of the femur results in elevated patella cartilage stress in females with PFP

Patellofemoral Pain

Patellofemoral Pain

- Powers CM et al Medicine &Science in Sport 2015
- Patella cartilage stress was significantly higher when the femur was internally rotated 5 and 10 degrees 26% and 36% respectively
- Highest cartilage stress along lateral facets occurred at 45 degrees of flexion vs 15 degrees of flexion.

PFPS

- Souza and Powers Am J Sports Med. 2009;
- Found that reduced hip-extension endurance, not isometric strength, was the sole hip-muscle predictor of increased hip internal rotation during running in females with PFP

PFPS

- Neuromuscular Factors:
- Another possible contributor to PFP is a delay in activation of the VMO relative to the VL. The VMO and VL provide dynamic stabilization to the patella as it tracks in the femoral trochlea.

- Therefore, an imbalance in the onset or activity level (or both) of the VMO relative to the VL could lead to patellar malalignment.

- McConnell J. et al Sports Med Arthorsc Rev 2007; Witvrouw E et al Knee Surg Sports Traumatol Arthorsc 2005 Amer J Sports Med 2000; Van Tiggelen D et al Am J Sports Med 2009

PFPS

Davi SM et al J Athl Train 2020

Evaluated patients with PFPS and regional pain syndrome vs control for quadriceps inhibition as a result of pain.

Deficits in spinal-reflex excitability, quadriceps activation, and strength were present in both the PFPS and regional-pain groups.

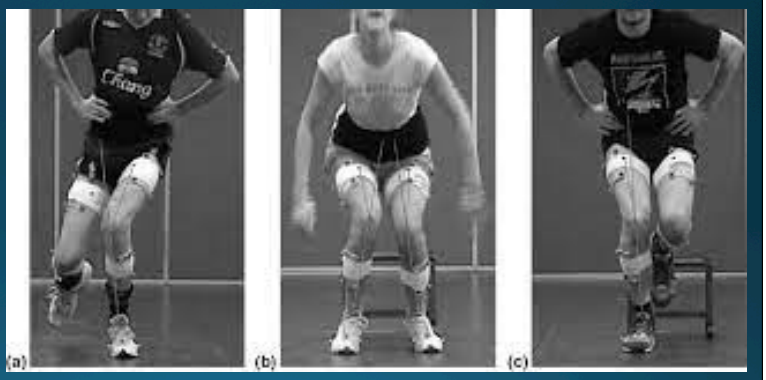
A combination of pain and structural damage appeared to have the greatest negative effect on quadriceps function

Knee pain

- Flaxman TE et al Clin Biomech (Bristol, Avon) 2019
- Evaluated healthy subjects who's strength deficit ratios and individual muscle contribution to experimental torque was computed before and after intramuscular hypertonic (pain inducing) and isotonic (sham) saline was injected to the vastus medialis.
- significant decreases in the knee extensor strength deficit ratio of vastus medialis was observed pre- to post- hypertonic injection. No differences were observed with isotonic injections, confirming the validity of the model.

PFPS

- Myer et al British Journal of Sports Medicine 2015
- Evaluated knee kinetics during a drop-landing task in middle and high school female basketball players before their competitive season.
- Those who developed PFP during the season exhibited greater knee-abduction moments during the initial contact phase of the task



PFPS

- National Athletic Trainers' Association Position Statement: Management of Individuals With Patellofemoral Pain in the Journal of Athletic Training 2018.
- Based on the research evidence with the most consistency and evidence-based strength gave recommendations:

PFPS

- Individuals with PFP (Patellofemoral pain) who complete an 8-week gluteal-strengthening program reported greater improvements in pain and health status 6 months after completing rehabilitation compared with those who completed an 8-week quadriceps-strengthening program.

- Peters JS et al Int J Sports Phys Ther. 2013, Khayambashi K et al Arch
- Phys Med Rehabil. 2014, Ferber R et al J Athl Train. 2015, Bolgla LA et al Journal of Athletic Training 2018,

PFPS

- Clinicians should prescribe interventions that address trunk-muscle (eg, abdominal oblique, rectus abdominis, transversus abdominis, erector spinae, and multifidi) control and capacity in individuals with PFP.

- Peters JS et al Int J Sports Phys Ther. 2013, Khayambashi K et al Arch Phys Med Rehabil. 2014, Earl JE et al Am J Sports Med. 2011, Fukuda TY et al Orthop Sports Phys Ther. 2010, 2012, Baldon Rde M et al J Orthop Sports Phys Ther. 2014,

PFPS

- Movement-retraining programs that incorporate either real-time visual or auditory feedback can benefit individuals with altered lower extremity gait mechanics such as excessive hip adduction or hip internal rotation or increased knee valgus (or a combination of these).

- Napier C et al Br J Sports Med. 2015, Agresta C et al J Orthop
- Sports Phys Ther. 2015, Baldon Rde M et al J Orthop Sports Phys Ther. 2014,

Ligament Injuries

- Zasulak et al 2007 in a 3 year prospective study with 277 collegiate athletes:
- Showed **lateral trunk displacement** was the strongest predictor of ligament injury in women and restricted **ankle dorsiflexion** in men.

Ligament Injuries

- (Zasulak) This study found **trunk displacement, proprioception** changes and **history of low back pain** predicted knee ligament injury with **91% sensitivity** in females.

Rehabilitation

- Henriksen et al; Journal of Biomechanics June 2009
- Inhibited Glut Med via pain and measured loads on the knee during walking.
- They found shutting off the GM did not increase the load on the knee but the **opposite** was true.
- Hip adduction, lateral trunk lean and knee extension were all reduced.

PFPS

- Focus on hip abductor strengthening to decrease knee adductor moment during gait.
- Benell et al 2010, Foroughi et al 2011, Sled et al 2010, Thorp 2010 all found that increasing hip abductor strength with resistance training improved hip abductor strength and reduce symptoms.
- But none of these studies changed the knee adductor moment during gait.

PFPS

- Popovich JM et al 2012 Medicine and Science in Sports and Exercise
- Comparing 2 groups of athletes one weak hip muscles and one strong hip muscles.
- Weaker group on a single leg landing task showed increased **lumbopelvic displacement** in frontal and sagittal planes and increased muscle activity on EMG between the **lumbar erectors and external obliques** except the rectus abdominis

Patellofemoral

- Nakagawa T.H. et al Manual Therapy 2015
- Compared 30 patients with PFPS (20 female and 10 male) with 30 controls (20 female and 10 males) for trunk strength, muscle activation, trunk lean, hip adduction, and knee abduction during a 1 legged squat.
- **PFPS group showed decreased trunk strength in flexion, extension, and rotation in isometric strength testing.**

Patellofemoral

- Nakagawa T.H. et al cont;
- **Ipsilateral trunk lean, hip adduction and knee abduction** was increased during the single leg squat in the PFPS group compared to the control group.
- Lack of lateral core stability in people with PFPS could contributed to the greater **ipsilateral trunk lean** that may have increased the *knee abduction moment* by moving the ground reaction force laterally relative to the knee joint

Patellofemoral Pain

- Teng H, Powers CM Journal of Athletic Training 2016
- In runners hip-extensor strength was correlated positively with trunk-flexion angle and hip-extensor work.
- It was correlated inversely with knee-extensor work
- Runners with hip-extensor weakness used a more upright trunk posture

PFP and increased glut max activation

- Atkins LT et al Physical Therapy and Rehabilitation 2021
- Movement training that Increase gluteus maximus activation, and increased hip extensor moment lead to decreased dynamic hip internal rotation and significantly decreased PFJ pain.
- The movement training was increased forward trunk flexion and increased hip flexion(instructed to sit back into a chair)
- This movement training lead to 3 times increase in hip extensor moment
- Kluger et al 2014 found the same 25 and 50 degree increase in trunk flexion lead to 133 and 211 increase in hip extensor moment in gait

Hip Extensor Moment and PFJ stress

- Farrokhi et al 2008 increased trunk flexion lead to 33% increase hip extensor moment in single leg lunge movement.
- Atkins et al 2021 the increased hip extensor moment in their study resulted in a 25% increase in glut max activation.
- In the Atkins study increased trunk flexion from 13.7 degrees to 59.6, and hip flexion from 36.9 to 78.8
- The increased hip extensor moment lead to a 79% decrease in PFP in this movement training
- Movement training of the glut max in the sagittal plane resulted in kinetic change in the transverse plane

Hip adduction with running

- Powers CM et al Med Sci Sports Exercise 2022
- Evaluated 14 female and 15 male looking for predictors of hip, thigh adduction during running.
- Used 3D camera, EMG, and CT scans of pelvis and hips
- Femoral anteversion was the only significant predictor or peak hip adduction during late swing and stance.
- Found that femoral morphology contributed more to adduction during running than hip abductor strength and activation.

ACL

- Non contact ACL injuries especially in women has been on the rise.
- In the literature it has been proven that if a increased or large valgus movement occurs during running, change of direction, cutting or landing there is an increased stress on the ACL.

ACL

- Hewett et al 2005, Valgus movement and moments during landing predicted noncontact ACL injuries in female athletes 78% sensitivity and 73% specificity, Dingenen B et al Clin Biomech 2015, The Journal of orthopaedic and sports physical therapy 2016;
- Zazulak et al 2007, trunk control and displacement (lateral, and extension) predicted noncontact ACL injuries, 83% sensitivity and 76% specificity, Sugimoto D et al Br J Sports Med 2015; Brunner R et al Br J Sports Med 2019;
- Paterno et al 2010, uninvolved limb hip rotation predicted second ACL injury 77% specificity and 81% sensitivity

ACL

- Orishimo KF et al American Journal of Sports Medicine 2014
- Dance has been shown to have lower number of ACL injuries especially in women compared to team sports
- Dancers don't have the same sex disparity in ACL injuries as team sports do.
- 40 dancers (20 male and 20 female) and 40 team sports athletes (20 male and 20 female)

ACL

- Orishimo KF et al cont;
- All dancers were active in professional ballet or a dance company, all athletes were Div I-III and in jumping sports/cutting sports (basketball, volleyball, soccer, lacrosse, and rugby)
- Each athlete did a 30 cm drop landing with the dominant leg.

ACL

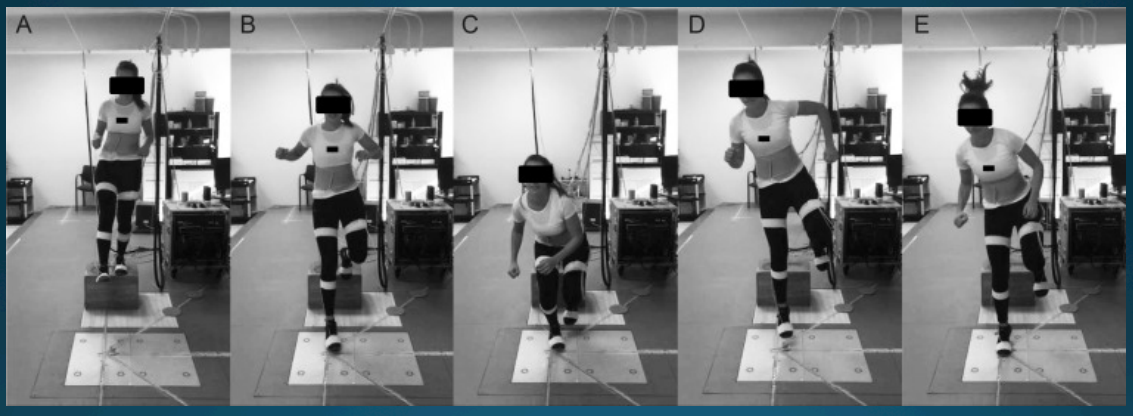
- Orishimo KF et al cont;
- Female dancers land with significantly; less **knee valgus** angle, **hip adduction moment** and **trunk side flexion than females in team sports.**
- Female dancers had a **lower hip adduction moment** that any of the other groups male or female.
- Female dancers had a **lower trunk side flexion** compared to the other groups male and female

ACL

- Hansberger BL et al Journal of Athletic training 2018
- Compared dancers (non professional) with 5 years experience to D1 athletes with at least 5 years experience in soccer or basketball
- Did single leg jump landing to vertical jump
- Female non dance athletes had greater peak ankle eversion, and less peak ankle dorsiflexion (ie, positions associated with greater ACL injury risk) compared with female dancers and male nondancers.
-

ACL

- Hansberger BL et al Journal of Athletic training 2018: cont
- Dancers and male nondancers consistently had higher peak ankle dorsiflexion and inversion, whereas female nondancers maintained a more neutral position with ankle eversion
- Forefoot-first landings result in fewer ground reaction forces than do heel-to-toe landings
- In this study they did not evaluate pelvis or torso position



ACL Injuries

- Female athletes have a 4-6 times higher incidence of non contact ACL injuries compared to men. Agel J et al 2005, Arendt E et al 1995, Numata H. et al 2018, Heebner NR et al. J Athl Train. (2017), Linde LD et al 2018
- Women tend to land with less hip and knee flexion and have greater knee extensor moments, lower hip extensor moments and a higher knee/hip extensor moment ratio. Chapell JD et al 2007, Ford KR et al 2010,Decker MJ et al 2003, Shultz SJ et al 2009, Sigward et al 2011, Heebner NR et al. J Athl Train. (2017), Numata H et al 2018, Linde et al 2018, Sasaki et al 2019

ACL Injuries

- Pollard et al 2010; female athletes who have limited knee and hip flexion landing (Sagittal plane motion) have increased knee abductions angles and increased knee adduction moments.
- These changes put them at significantly increased risk of ACL injury.

ACL Injuries

- Hewett et al; British Journal of Sports Medicine March 2009
- Video analysis of trunk and knee motion at the time of ACL injury in **Men and Women.**
- 12 year period video tapes were evaluated.
- Injured females athletes demonstrated increased lateral trunk motion and increased abduction angle at the knee more than uninjured females and male athletes.

ACL Injuries

- The injured female athletes showed increased abduction during **initial contact-landing sequence.**
- Controls (non-injured females) showed no change in abduction angle on contact.
- Female ACL-injured athletes demonstrated **less forward trunk lean** than female controls.

ACL

- Leppanen M et al Scandinavian Journal of Medicine and Science in Sports 2020
- 258 athletes 12-21 years of age, prospective study
- Recorded non contact low extremity injuries for 12 months.
- Looking for pelvic hiking when doing a single knee lift on contralateral side of injury
- Increased pelvic hike was found to be a risk factor for ACL injuries among female athletes.

ACL

- Improving the utilization of the **hip musculature** during the **deceleration** phase of **landing** and **cutting** maneuvers may decrease the reliance on knee extensors and passive restraints to eccentrically deceleration of the body's center of mass. Powers et al 2006, 2010, Sasaki et al 2019

ACL

- A study demonstrated radiographic evidence of knee osteoarthritis among 42% of female soccer players following ACL reconstruction within 10 years of the injury
- Primary prevention is an effective way to reduce the adverse physical, psychological, and financial outcomes of this traumatic injury
- Approximately 70% of all ACL tears occur with a non-contact mechanism
- Female athletes have a two to eight times higher risk of ACL injury compared to their male counterparts
- Lohmander, L.S. et al Arthritis Rheum. 2004, Swart, E. et al J. Bone Jt. Surg. Am. 2014, Boden, B.P. et al Am. J Acad. Orthop. Surg. 2010, Agel, J.; Olson et al J. Athl. Train. 2007, Mattu AT et al 2022

ACL

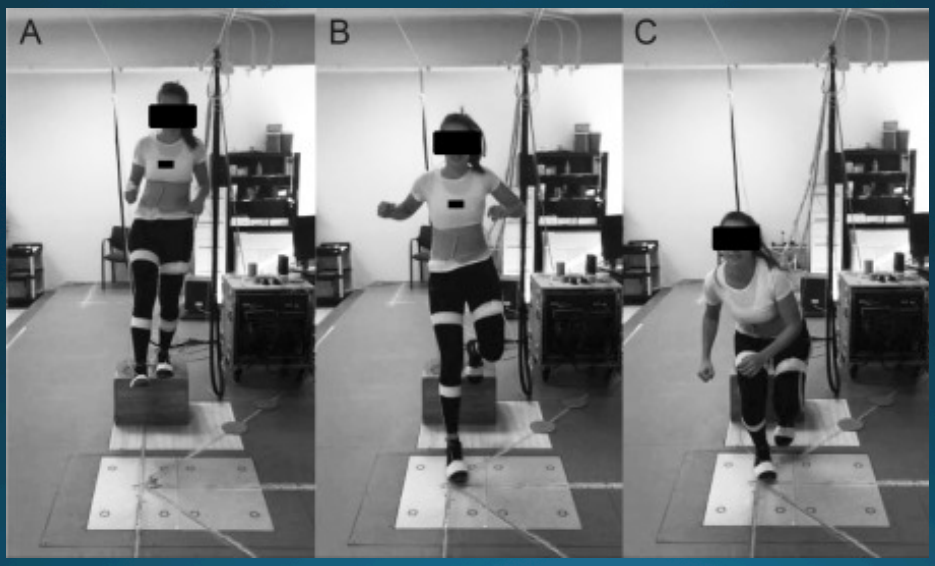
- Specific neuromuscular and biomechanical risk factors for young females include:
- increased knee abduction angles
- reduced knee and hip flexion
- decreased core strength and proprioception
- decreased hamstring strength relative to quadriceps
- increased hip internal rotation, and tibial external rotation with or without pronation of the foot
- Alentorn-Geli et al Knee Surg. Sports Traumatol Arthrosc. 2009, Mattu AT et al 2022

ACL

- The combination of KAM(Knee Abduction Moment), ATS (anterior tibial shear), and ITR (internal rotation torque) increased ACL strain during drop landing simulations
- KAM is the secondary external load that most increases ACL injury risk during landing.
- ITR was the next load that increased ACL injury, when combined significantly increased ACL failure during landing.
- Navacchia A et al J Orthop Res. 2019

ACL

- Larwa J et al 2021:
- Did a systematic review of literature and video analysis of ACL injuries.
- Areas most commonly seen as possible causative mechanics associated with ACL injuries:
- Increased hip flexion esp at strike and through end loading
- Increased hip adduction leading to increased valgus force on knee
- Injured Females had delayed VMO firing compared to males on single leg drop.



ACL

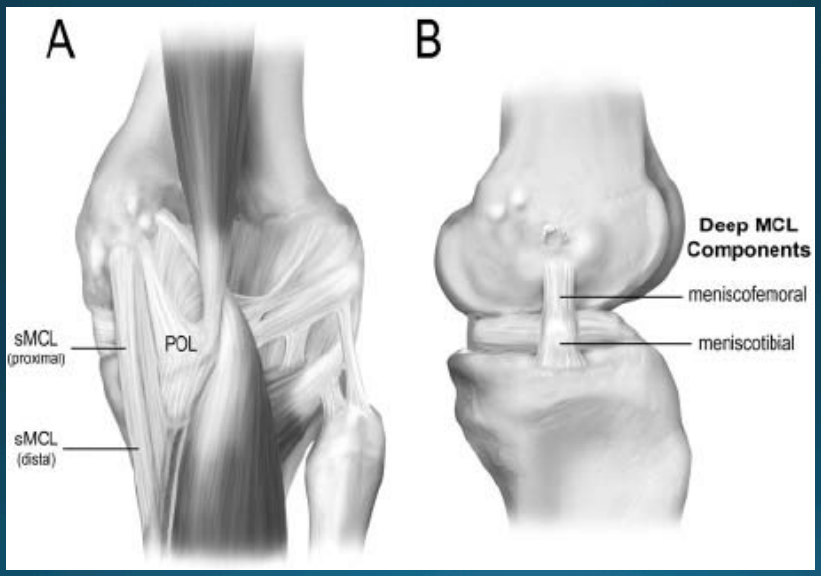
- Larwa J et al 2021: Continued
- Landing in heal strike or flat footed vs more plantarflexion was associated with ACL injured athletes
- Trunk displacement increased lateral trunk displacement, females took longer to stabilize, and were shifted more posterior in relation to center of gravity

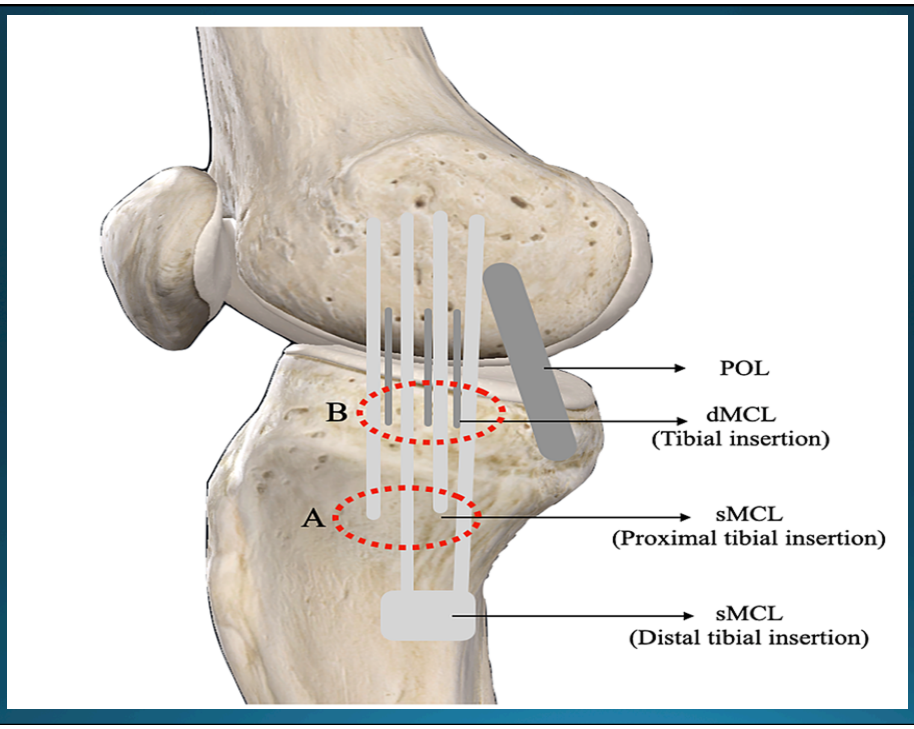
ACL

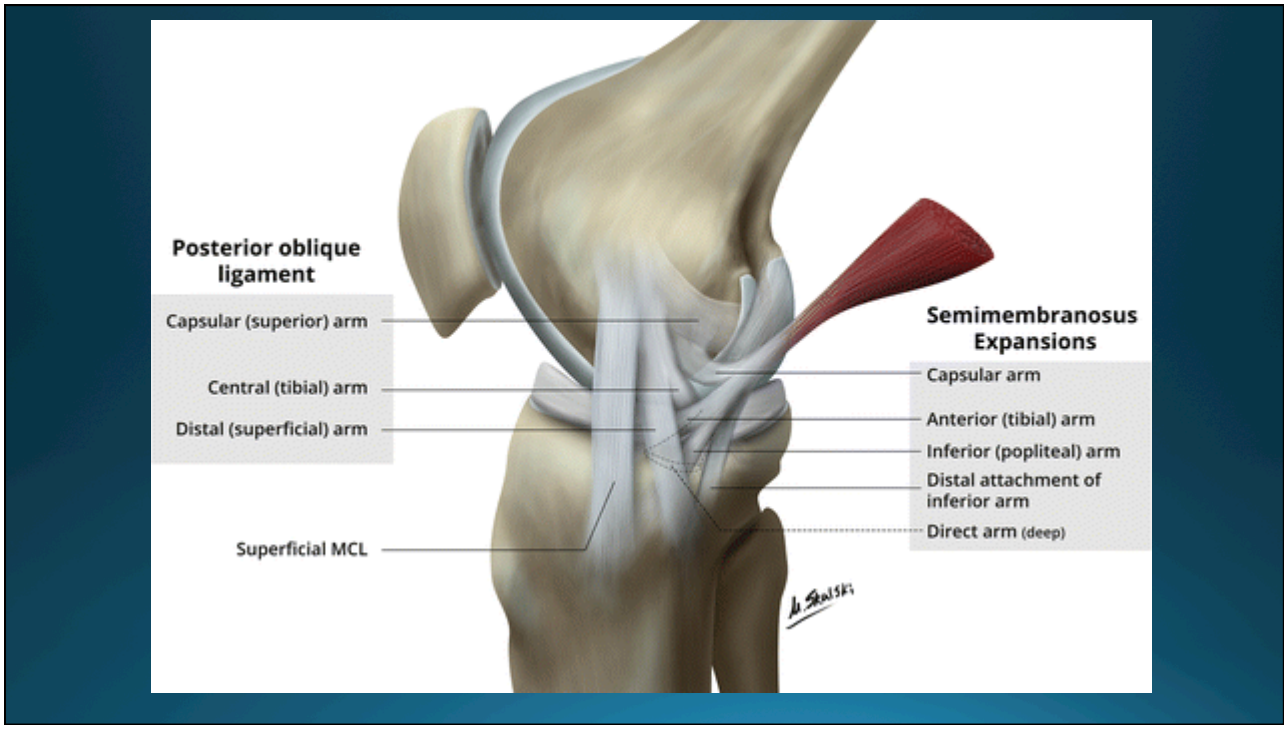
- ACL injury events revealed most (70%) injuries involve minimal to no contact and occur during landing or deceleration maneuvers with a minor perturbation before the injury that may disrupt the neuromuscular system leading to poor body dynamics.
- A series of quantitative videotape studies demonstrated differences in leg and trunk positions at the time of NC-ACLI (noncontact-ACL injury) in comparison to control subjects
- Analysis of the faulty dynamics provoking NC-ACLI, especially the flat-footed landing component, supports the theory that an axial compressive force is the critical factor responsible for NC-ACLI.
- Both a strong eccentric quadriceps contraction and knee abduction moments may increase the compressive force at the joint thereby lowering the axial threshold to injury.
- Boden BP et al Ortho Res 2022

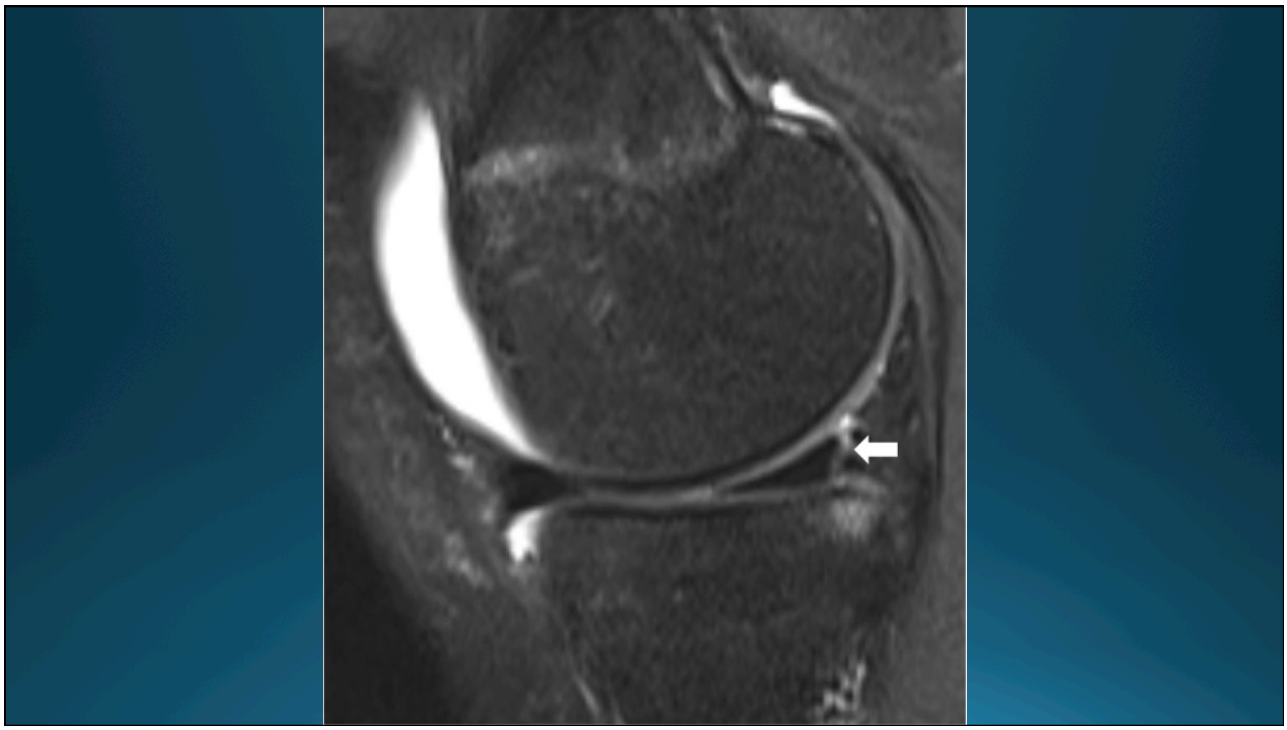
Anteromedial Knee Instability

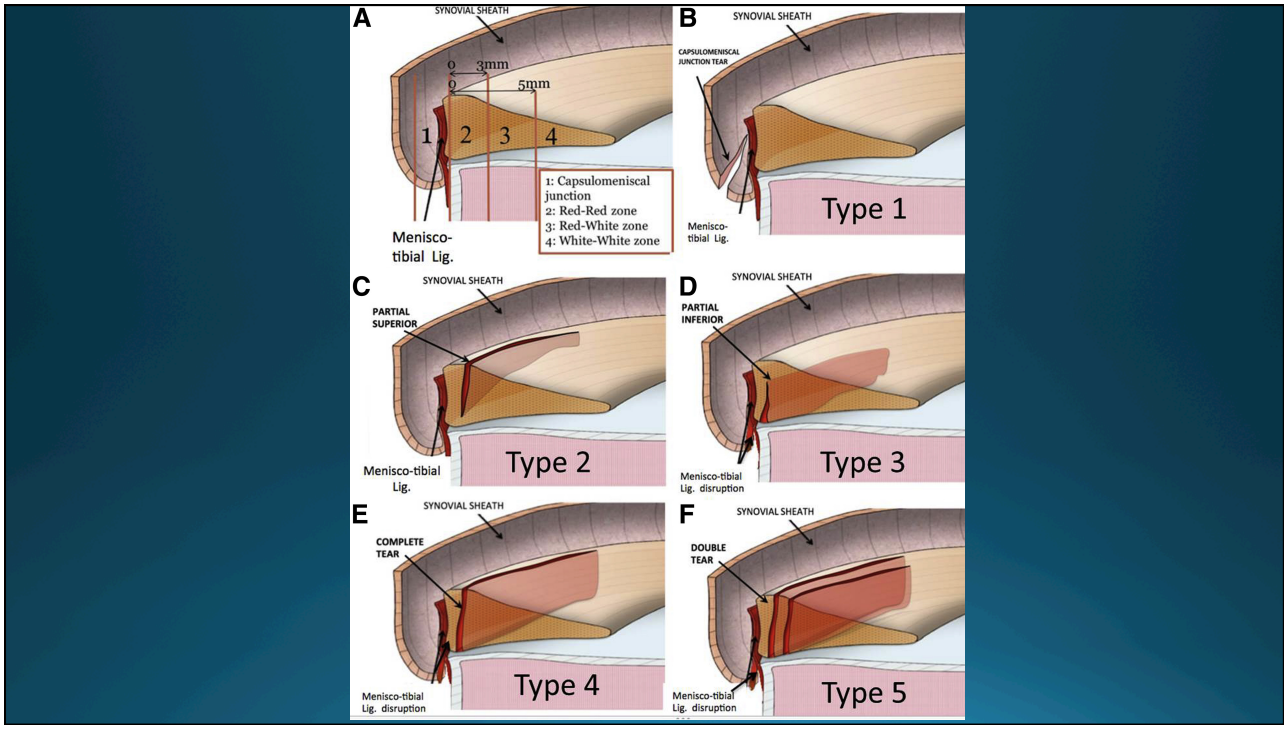
- Anteromedial rotatory instability (AMRI) results from excessive valgus strain with simultaneous external rotation of the knee, leading to pathologic anterior subluxation of the medial tibial plateau relative to the medial femoral condyle.
- AMRI can be caused by injury to the superficial and deep medial collateral ligaments (MCL), posterior capsule, and posterior medial corner (PMC).
- The PMC, which is comprised of the posterior horn of the medial meniscus (ramp lesions), posterior oblique ligament (POL), semimembranosus expansions(post capsule attachment),meniscotibial ligaments, and oblique popliteal ligament,

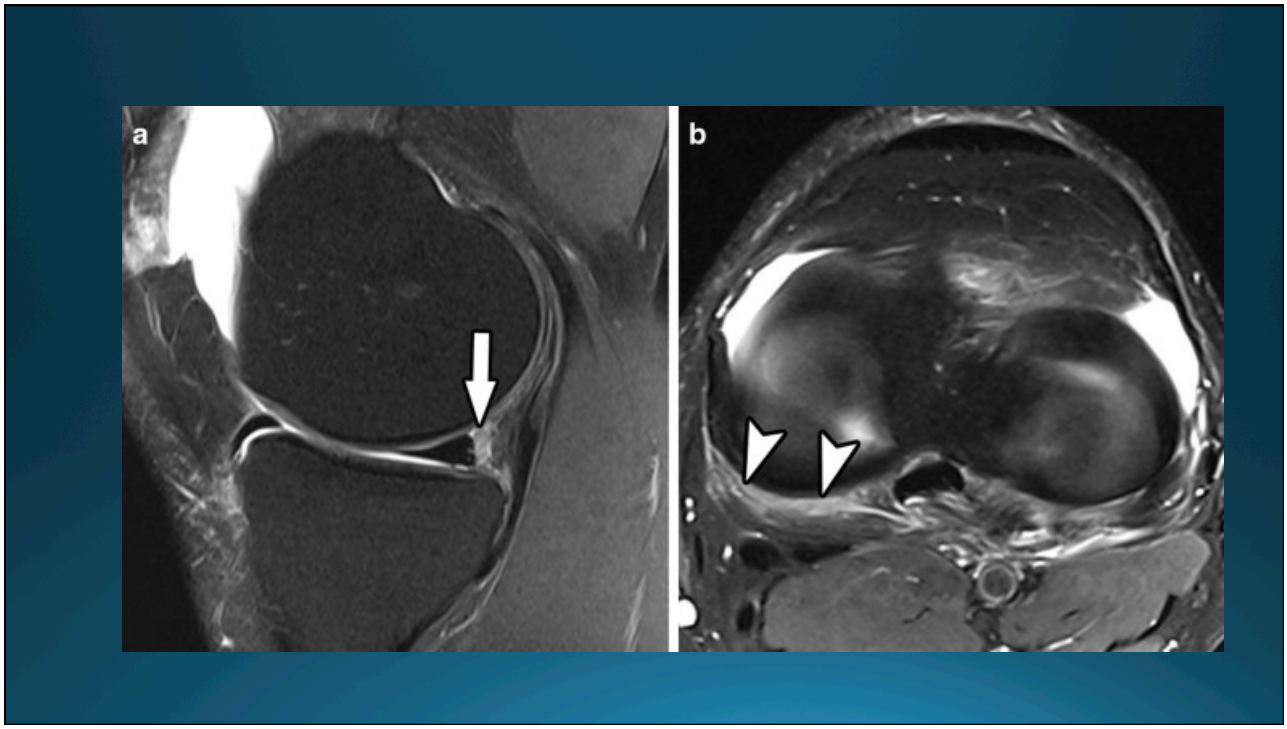

A
B
sMCL
(proximal)
POL
sMCL
(distal)
Deep MCL
Components
meniscofemoral
meriscotibial


POL
B
dMCL
(Tibial insertion)
A
sMCL
(Proximal tibial insertion)
sMCL
(Distal tibial insertion)


Posterior oblique ligament
Capsular (superior) arm
Central (tibial) arm
Distal (superficial) arm
Superficial MCL
Semimembranosus Expansions
Capsular arm
Anterior (tibial) arm
Inferior (popliteal) arm
Distal attachment of inferior arm
Direct arm (deep)




A
SYNOVIAL SHEATH
0
3mm
0
5mm
1
2
3
4
1: Capsulomeniscal junction
2: Red-Red zone
3: Red-White zone
4: White-White zone
Menisco-tibial Lig.
B
SYNOVIAL SHEATH
CAPSULOMENISCAL JUNCTION TEAR
Type 1
Menisco-tibial Lig.
C
SYNOVIAL SHEATH
PARTIAL SUPERIOR
Type 2
Menisco-tibial Lig.
D
SYNOVIAL SHEATH
PARTIAL INFERIOR
Type 3
Menisco-tibial Lig. disruption
E
SYNOVIAL SHEATH
COMPLETE TEAR
Type 4
Menisco-tibial Lig. disruption
F
SYNOVIAL SHEATH
DOUBLE TEAR
Type 5
Menisco-tibial Lig. disruption


a
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Ramp Lesion

- Posterior meniscal anatomy
- Ramp lesions **occur in the peripheral zone of the medial meniscus (red-red area), where meniscocapsular and meniscotibial structures attach to the posterior horn.**
- Ramp lesions can occur during traumatic acute ACL injury or increased tibial translation in chronic ACL-deficient knee

AMRI

- Physical examination findings of pain in the medial and posteromedial aspects of the knee.
- Testing:
- Laxity with valgus stress applied at 30 degrees of knee flexion
- Anterior rotatory subluxation of the medial tibial plateau relative to the femoral condyle
- Anterior drawer test with the knee in 15 degrees of external rotation; + if increased anterior and lateral displacement of the tibia
- A positive dial test, consisting of increased external rotation at 30 and 90 degrees of knee flexion with anterior subluxation of the medial tibial plateau

Posterior Lateral Corner (PLC)

- The patient may demonstrate a varus thrust and stance phase knee hyperextension during gait
- Increased posterior tibial translation at 30 degrees of knee flexion is indicative of an isolated posterolateral corner (PLC) injury, while increased laxity at 30 and 90 degrees of knee flexion is indicative of concomitant PLC and PCL injury
- Lateral compartment widening under varus stress applied with gentle internal rotation of the tibia at 0 and 30 degrees of knee flexion occurs in combined LCL and PLC injuries

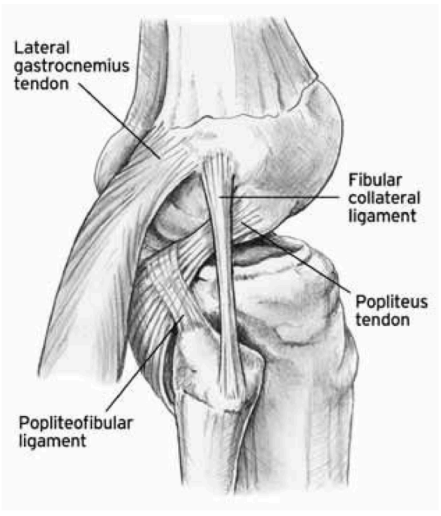
Posterior Lateral Corner (PLC)

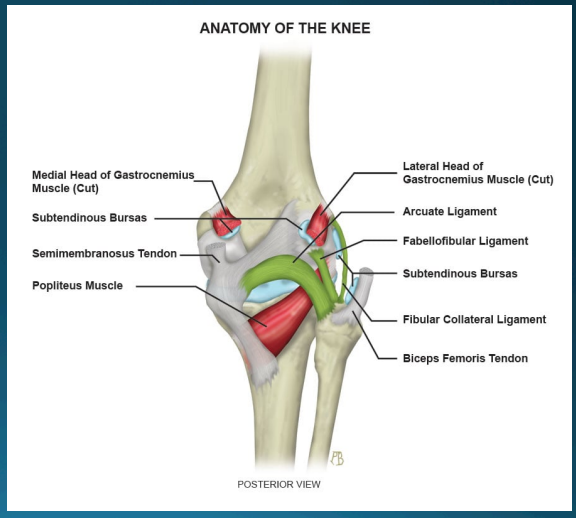
- There are multiple types of rotary instability:
- The majority of research focuses on the impact of the structures in the posterolateral corner and their influence on rotary instability.
- Injuries to the Posterolateral Corner (PLC) can result in posterolateral rotatory instability (PLRI) of the knee
- A pathological instability that is caused by posterolateral tibial subluxation when an external rotational force is applied to the knee joint, or a direct blow to the anteromedial knee

Posterior Lateral Corner (PLC)

- The PLC unit has complex anatomy.
- It includes the lateral (fibular) collateral ligament (LCL) and the popliteus complex, which contain the popliteus muscle tendon, popliteofibular ligament, the fabellofibular ligament (in approximately 48%), and the popliteomeniscal fibers.
- These structures are essential for varus and rotational stability of the knee
- The LCL plays the greatest role in resisting varus stress
- The other components of the PLC play a larger role in resisting external rotation of the lateral side of the tibia on the femur.
- Sajjadi,MM et al Arthrosc Tech. 2022

PLC





PCL

- Presentation:
- Patients with knee rotatory instability will often present with joint line tenderness accompanied by swelling in the posterolateral corner of the knee.
- Many patients with knee rotary instability report episodes of giving way or knee buckling during the stance phase of gate and pivoting or twisting movements.
- Some patients present with an unpredictable giving way of the knee without provocation or simply when just standing.

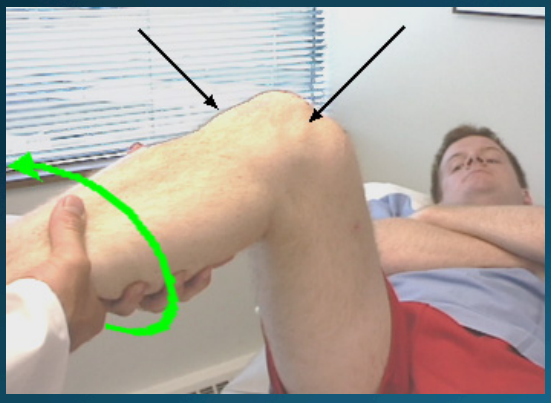
PLC

- Function
- Popliteus works synergistically with the PCL (Posterior Cruciate Ligament to control external tibial rotation, varus, and posterior tibial translation.
- Popliteus and popliteofibular ligament function maximally in knee flexion to resist external rotation
- LCL is primary restraint to varus stress at 5° (55%) and 25° (69%) of knee flexion.

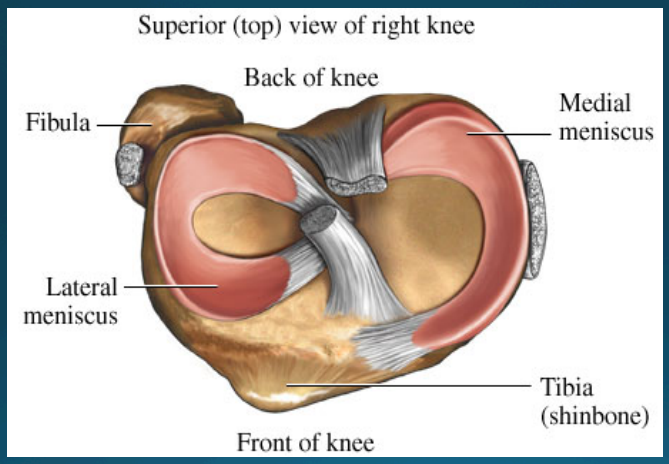
Posterior Lateral Corner (PLC)

- Dial Test: test for PLRI more than 10 degrees of external rotation + test for possible PLRI at 30 degrees of knee flexion. If posterolateral subluxation of the lateral tibial plateau occurs at both 30 and 90 degrees, concomitant Posterior Cruciate Lig injury should be suspected.

Posterior Lateral Corner (PLC)



- A reverse pivot shift test consists of applying a valgus load with the tibia in external rotation while bringing the knee from flexion to extension.
- A positive test includes a palpable shift or jerk as the posteriorly subluxated medial tibia reduces, indicating possible PLRI

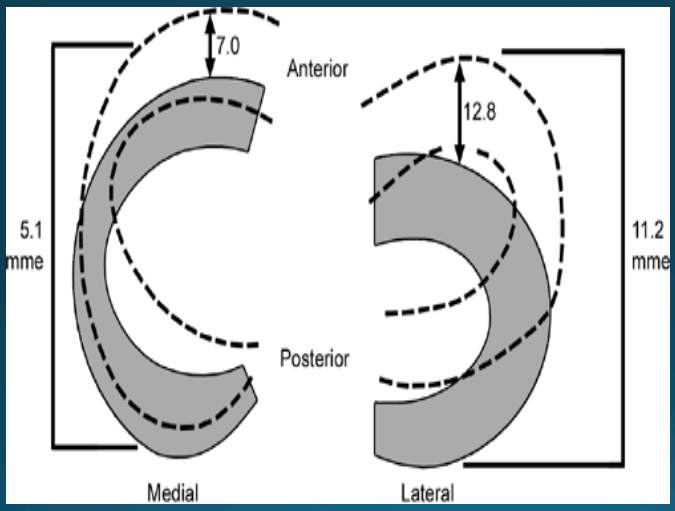


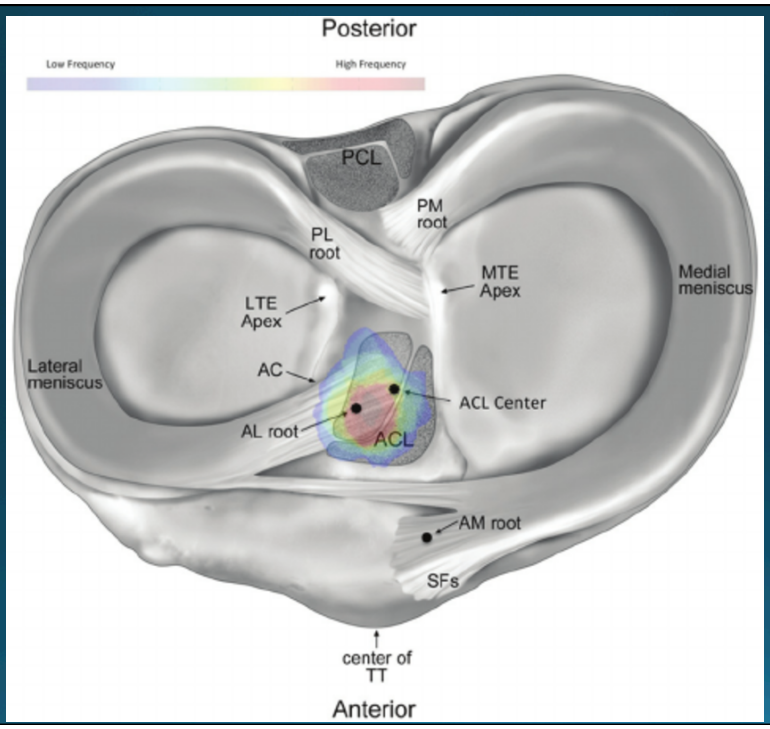
Meniscus

- Posterior translation of the menisci (lateral greater than medial) during knee flexion has been demonstrated in magnetic resonance imaging (MRI) studies
- The anterior and posterior translation of the menisci during flexion and extension is hypothesized to protect the articular surfaces from injury

Meniscus

- A classic study demonstrated that from 0 degrees to 120 degrees of knee flexion the mean meniscal excursion (defined as the average anteroposterior displacement of the anterior and posterior meniscal horns along the tibial plateau in the midcondylar, parasagittal plane) of the **medial meniscus was 5.1** (±0.96) mm while that of the **lateral meniscus was 11.2** (±3.27) mm





Meniscus

- In addition to their anterior-posterior translation, the menisci deform to remain in constant congruity with the tibial and femoral articular surfaces throughout the full range of joint motion.
- Radial tears of the lateral meniscus cause greater loss of the meniscus to absorb stress and transfer it along the entirety of the meniscus via hoop stress.

- Bedi A et al Journal of Bone and Joint surgery Am 2010, Arthorscopy 2012, Messner K et al Journal of anatomy 1998, Tachibana Y et al Knee Surg Sports Traumatol Arthrosc 2017,

Meniscus

- The function of the meniscus is to deepen the tibial plateau, transmit load through the joint, provide shock absorption, and increase joint stability. (Kean CO et al 2017, Shimomura K et al 2018,Pereira H et al 2019)
- The femoral surface is concave to match the femur, the bottom is flat to match the tibial surface. It will optimize the joint contact areas between the convex femoral condyle and flat tibial condyle. It elasticity allows it to act like a shock absorber. (LaPrade RF et al 2021)
- The meniscus act like a secondary stabilizers the medial helps with A-P translation, the lateral helps to resist rotary motion. (LaPrade RF et al 2021)

Meniscus Injuries

- Jiang, Wei et al 2012
- Evaluated meniscus injuries, 0-30 degrees compression is the largest force. **Anterior horn** under the most load.
- 30-60 degrees the **body** of the meniscus had the most compressive load.
- 60-90 degrees of flexion the **posterior horn** under the most compressive load

Meniscus

- Biomechanical studies have demonstrated that at least 50% of the compressive load of the knee joint is transmitted through the meniscus in extension, and approximately 85% of the load is transmitted in 90 degrees of flexion

Meniscus

- 70% of load is transferred to the lateral meniscus compared to 50% to the medial meniscus due to the larger role of the lateral meniscus in joint congruency. (Walker P.S. et al 1975, Mameri ES et al 2022)
- The ligamentous attachments of the meniscus to the tibia and femur are anchor the meniscus to convert axial loads into hoop stresses and prevent extrusion during joint loading. (LaPrade RF et al 2021)
- Radial tears and root tears are equivalent to total meniscectomy. These 2 types of tears leave the meniscus unable to convert axial loads into hoop stresses. (Cinque ME et al 2018,LaPrade RF et al 2021,)

Meniscus

- Acute tears come from a combination of compressive, shear, and rotational forces from the femoral condyles across the tibial plateau.
- Degenerative tears are more often in the posterior horn of the medial meniscus and are horizontal-cleavage or flap tears
- Extrusion of the meniscus can be the result of root tears or radial tears more commonly in degenerative lesions in OA.
- (Kenny C et al 1997,Rauscher I et al 2008, Hunter DJ et al 2008, Jacob G et al 2019)

Meniscus

- The anterior and posterior roots anchor the meniscus to the medial tibial plateau, while the posterior root along with the meniscotibial ligament aids in attaching the meniscus to the adjacent joint capsule and tibia

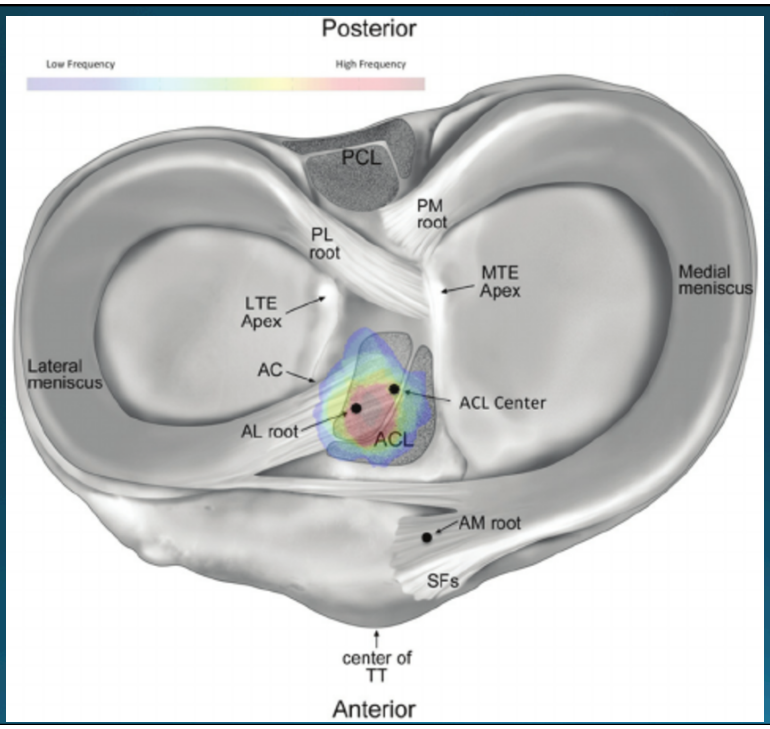
- Because the posterior meniscal root assists in anchoring
- the medial meniscus to the joint capsule and tibia

- The medial meniscus is less mobile compared with the lateral meniscus, which in turn increases its susceptibility to injury.

- This is particularly true during valgus strain or rotational trauma, which places increased pressure specifically on the posterior horn and its meniscocapsular junction

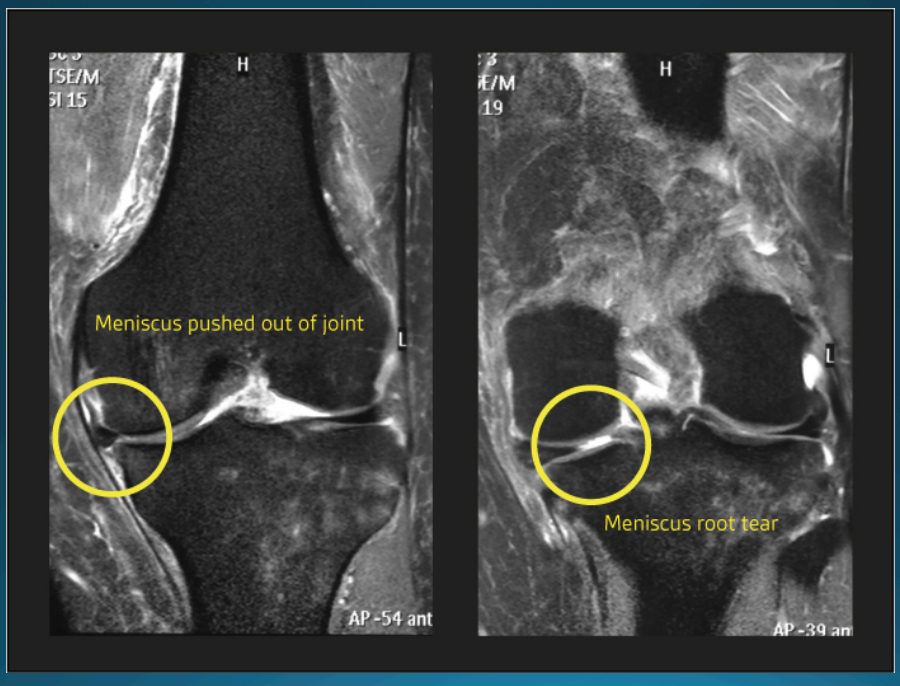
- Vedi V, et al. Meniscal movement.. J Bone Joint Surg Br. 1999; JohannsenAM, et al.Am J Sports Med. 2012;Grief D.N et al Skeletal radiology 2020

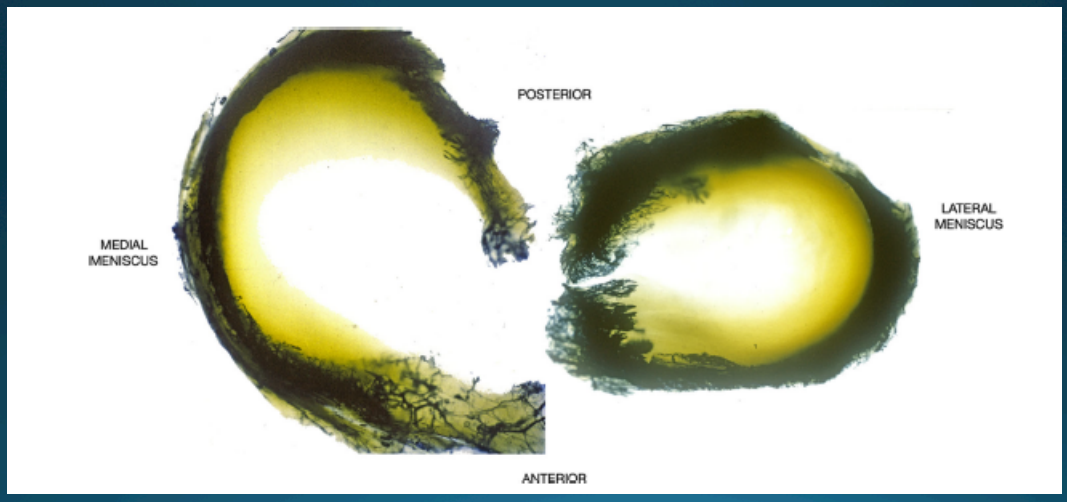
Medial Meniscus



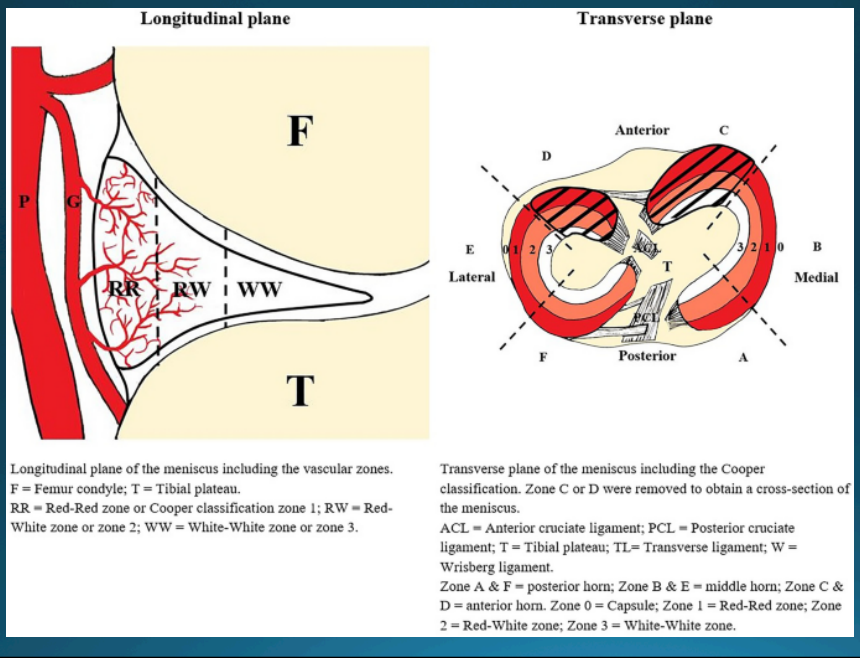
Lateral meniscus

- Lateral meniscus injuries are worse when they are closer to the root attachments.
- If the meniscofemoral ligament is involved worse outcome because the meniscus looses its anchor in this case the Femur.
- Radial tears of the lateral meniscus cause greater loss of the meniscus to absorb stress and transfer it along the entirety of the meniscus via hoop stress.
- Bedi A et al Journal of Bone and Joint surgery Am 2010, Arthorscopy 2012, Messner K et al Journal of anatomy 1998, Tachibana Y et al Knee Surg Sports Traumatol Arthrosc 2017,





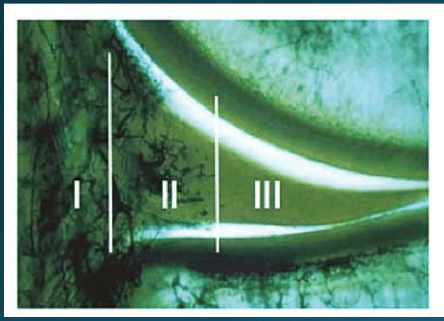
Microvasculature of the meniscus stained

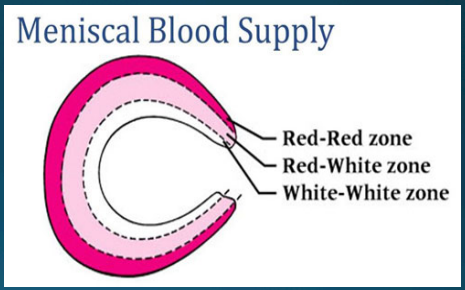


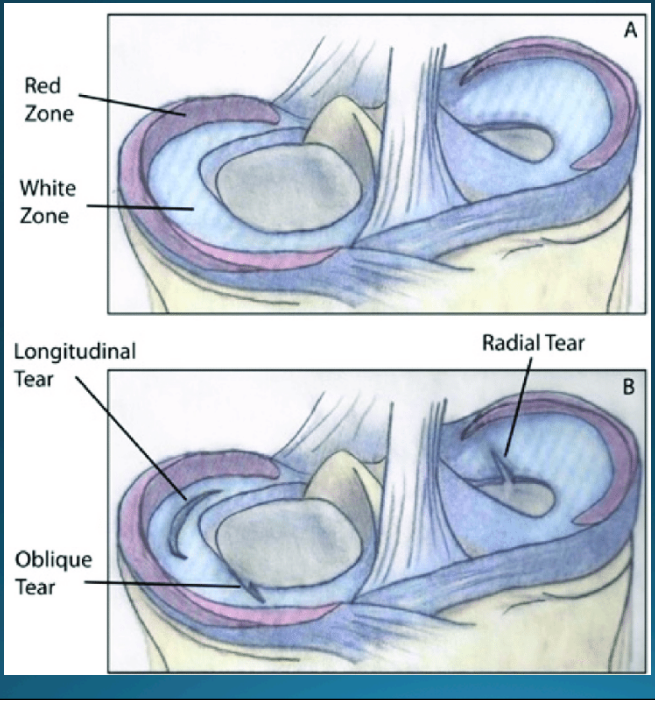
Longitudinal plane of the meniscus including the vascular zones.
F = Femur condyle; T = Tibial plateau.
RR = Red-Red zone or Cooper classification zone 1; RW = Red-White zone or zone 2; WW = White-White zone or zone 3.

Transverse plane of the meniscus including the Cooper classification. Zone C or D were removed to obtain a cross-section of the meniscus.
ACL = Anterior cruciate ligament; PCL = Posterior cruciate ligament; T = Tibial plateau; TL= Transverse ligament; W = Wrisberg ligament.
Zone A & F = posterior horn; Zone B & E = middle horn; Zone C & D = anterior horn. Zone 0 = Capsule; Zone 1 = Red-Red zone; Zone 2 = Red-White zone; Zone 3 = White-White zone.

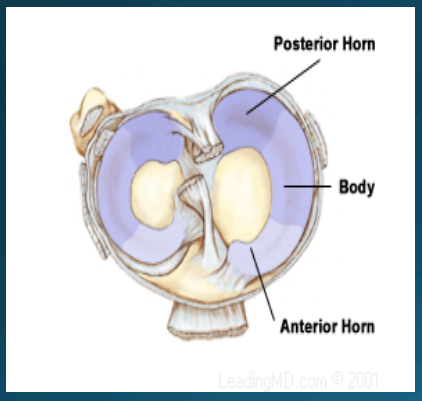
Meniscal blood supply

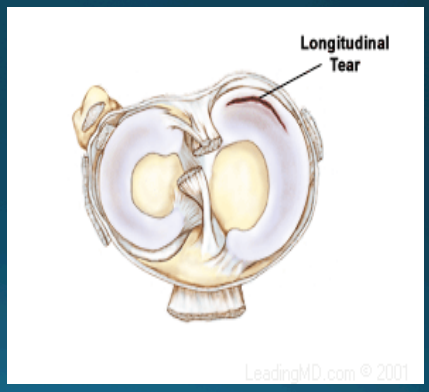






Meniscus injuries





Me

Knee injuries

- Like all of the other knee injuries we have discussed if you have a loss of neuromuscular control this will lead to increase movements in other planes of motion. The more transverse plane or frontal plane movement in the torso or pelvis more stress on the knee.

Treatment

- Perform a Lumbar examination: looking for signs of low back dysfunction, pelvic dysfunction, neurologic signs etc…
- Perform a hip examination looking for Impingement syndrome, labral injuries, bursitis, tendonitis, restricted hip flexion, internal rotation etc…
- Look for hyperpronation syndrome in the foot specifically one side more than the other
- Look for restricted motion in the tibia, internal and external rotation, often associated with hyperpronation.

Treatment

- Normalize torso, low back, pelvis, and hip motion restrictions.
- Normalize tibial rotation restrictions
- Soft tissue to restricted areas consider that many of the injuries to the knee come from a frontal plane movement. Some of the injuries described today have a valgus defect associated with their onset.
- If stability is needed use of specific braces or taping to unload the injured tissue.

Rehabilitation

- Chan MKY et al BMC Musculoskelet Disord. 2017
- Tested hip muscle contraction with bracing vs without bracing during 3 exercises.
- Tested upper glut, lower glut, glut medius and bicep femoris activation during 2 versions of the clam shell and prone hip extension.
- When abdominal bracing was performed increased %MCV occurred of the above musculature vs no bracing

Rehabilitation

- Chan MKY et al BMC Musculoskelet Disord. 2017 cont:
- "The GMed, GMax and BF all have the muscle origin and attachment at various parts of the innominate bone and the femur"
- "These findings indicated that the unwanted pelvic movements, which might contribute to the composite movement during hip exercises, would be minimized with abdominal core activation"

Rehabilitation

- Chan MKY et al BMC Musculoskelet Disord. 2017 cont:
- "The promotion of hip muscles activity in enhanced core condition is independent of the type of hip exercises."
- "The present findings suggest the potential benefit of abdominal core activation in enhancing the strengthening effect of exercises for rehabilitation of the lower limbs."
- "More enhancement in hip activation is correlated to higher physical activity level"

Rehabilitation

- Tsang SMH et al J Electromyogr Kinesiol. 2018
- "Enhanced IO/TrA contraction resulted in significantly greater activity in gluteus maximus, gluteus medius and bicep femoris at various phases of hip extension and clam exercises, single leg sit-to-stand and pelvic drop exercise"
- "These findings indicate the presence of coactivation of the abdominal and hip muscles when performing the free active hip exercises. "

Rehabilitation

- Dierks T et al 2008, Wilson J et al 2009 Snyder K et al 2009, Ferber R et al 2011
- Hip muscle strength appears to have little effect on altered frontal plane mechanics.
- Strengthening hip abductors and internal rotators **did not decrease hip or knee frontal plane peak joint angles** during the stance phase of running and jumping.

Rehabilitation

- Improving the utilization of the **hip musculature** during the **deceleration** phase of **landing** and **cutting** maneuvers may decrease the reliance on knee extensors and passive restraints to eccentrically deceleration of the body's center of mass. Powers et al **2006, 2010**, Sasaki et al 2019

Rehabilitation

- Atkins L et al Physical Therapy and Rehabilitation Journal 2021
- Increased Sagittal plane movement training of the hip and knee with increased utilization of Gluteus Maximus.
- The participants were instructed to increase forward torso lean and sit back into the hips(like sitting into a chair). This increased the hip extensor moment. Increased hip extensor moment decreases knee extensor moment.

Rehabilitation

- Atkins L et al Physical Therapy and Rehabilitation Journal 2021 cont
- Increased training in the Sagittal plane decreases transverse plane movement.
- Increased hip extensor moment training decreased pain in the patellofemoral group. 10 out of 17 participants in the pain group had complete resolution of their pain. Overall 79% reported decreased pain from movement training

Cortico Motor Excitability

- Neurophysiologic feature representing the excitability measured from a peripheral muscle by applying a stimulation from a cortical region. (Rothwell 1997, TMS)
- Early strength gains from training (less than 4-6 weeks) is attributed to increased CME.(Griffin & Cafarelli 2007a, Weier et al 2012)
- Increased CME seen in increased muscle strength of tibialis anterior, soleus, rectus femoris (Beck et al 2007,Griffin & Cafarelli 2007a, Weier et al 2012)
- Increased CME activity seen in increased muscle strength in Glut Max (Yani et al 2018)

Hip Rehabilitation

- Powers et al 2010, 2020,Jenson et al 2005,
- Motor skill training that emphasizes functional use of hip extensors can result in experience-dependent neuroplasiticity
- Non skill training such as muscle strengthening has been reported to have no to minimal cortical motor excitability(CME)
- Strengthening will increase movement capacity motor skill training would be required to make use of such capacity through the facilitation of CME

Hip Rehabilitation

- Powers et al 2020 cont
- Higher descending neural drive of Gluteus maximus(GM) was found to associated with greater functional use of the hip.
- Specifically CME of GM was predictive of the average hip extensor moment and peak hip flexion during sport specific task. (one leg drop and jump)

CME

- Shih Yo et al 2021 Human Movement and Science
- Tested CME of Glut Max in healthy females vs males, they found females had less CME of Glut Max and less hip extensor torque compared to males.
- CME was a good predictor of hip extensor torque and strength for males and females.
- CME plays a role in the muscles ability to generate maximal torque

CME

- Shih Yo et al 2021 Human Movement and Science cont;
- Found that CME of the Glut Max was not dependent on the sex, male vs female
- Higher CME in males was due to greater efficiency of the corticomotor pathway. This is trainable!!!
- Exercise related neuroplasticity following long term use of a muscle was found in ballet dancers compared to non dancers (Saito et al 2014 in ankle flexors)