Evaluation and Rehabilitation of the Lower Extremity

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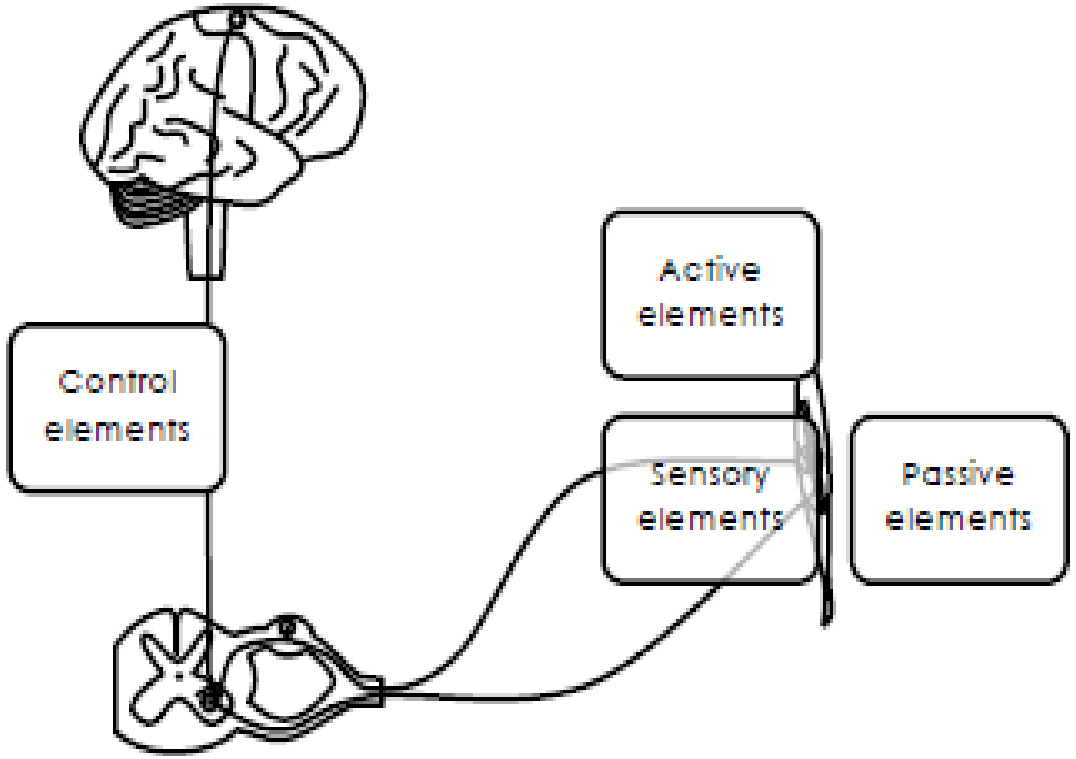
Spine motor control?



Panjabi, 1992 J Spinal Disord

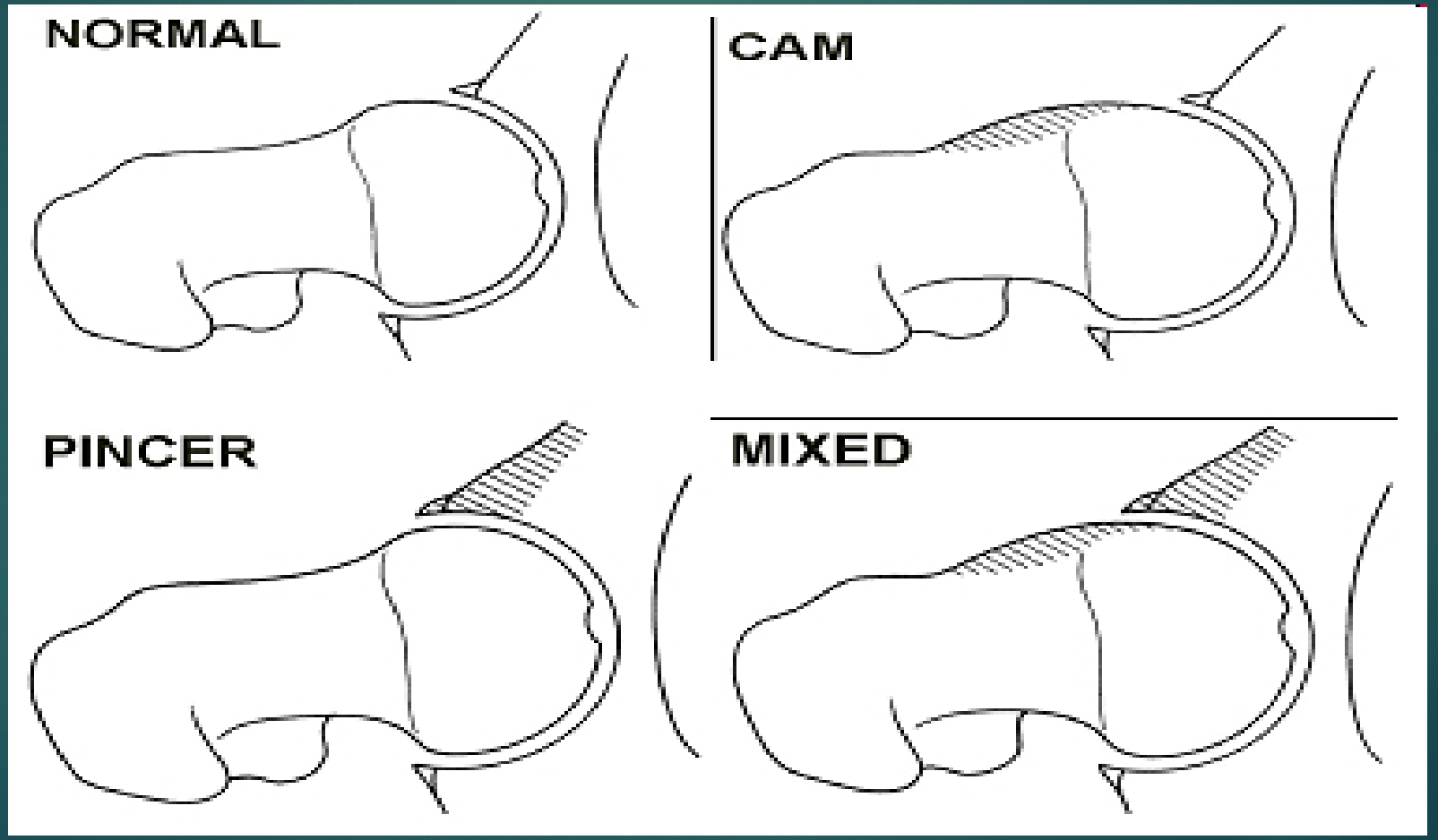
Neuromuscular Control

- Jacobs et al; Experimental Brain Research Sep 2011,
- The pain condition altered muscle activation and altered movement patterns in the torso, low back, and hip.
- Pain also changes the cerebrocortical activity that is associated with postural coordination.

Hip Injuries

- FAI;
- Possible causes:
- Cam Impingement
- Pincer Impingement
- Hyperflexion
- Hyperextension
- Circumduction

Femoral Acetabular Impingement Syndrome

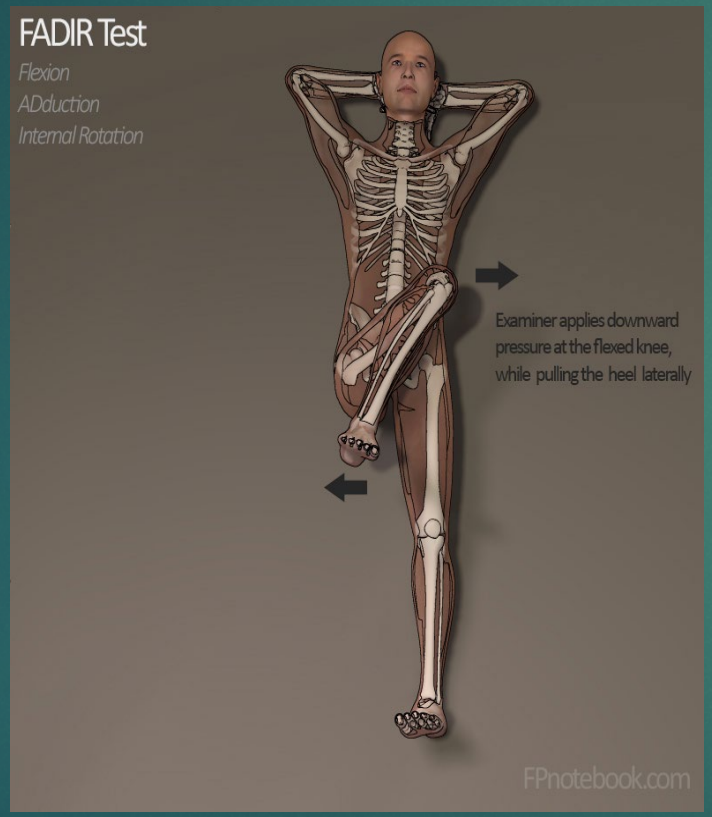


FAI Diagnosis

- Reiman M.P. et al Br Journal of Sports Medicine 2014

- Meta-analysis 21 accepted papers
- Femoral Acetabular Impingement Test:
- FADIR and Flexion with internal rotation most accurate physical examination test with the highest sensitivity and specificity.

FAI test


FADIR Test
Flexion
ADduction
Internal Rotation
Examiner applies downward pressure at the flexed knee, while pulling the heel laterally
FPnotebook.com

Orthopedic test

- Tijssen M et al Scandenavian Journal of Medicine and Science in Sports 2016
- Used 3 test for FAI to determine sensitivity and specificity(FABERE, FADDIR, Fitzgerald)
- Sensitivity range for the three test were high 72-91%
- When **all three** were positive for groin/hip pain sensitivity went up to **97%**
- FADIR and FABERE together were the most sensitive.

Orthopedic Test

- Fitzgerald test:
- The leg begins in flexion internal rotation like FADIR then it is externally rotated, abducted (FABERE) and straightened

FAI and Labral tear

- Impingement and labral tears area being increasingly recognized as a cause of hip pain after trauma as result of sporting activity.
- This diagnosis is easily missed as a source of hip pain in younger athletes who do not have a history of dysplasia and often do not recall a history of trauma.
- Age range that it is being reported in is 17-48, with the average being 30.5

FAI and Labral Tear

- Presentation:
- Usually no clear history of trauma, may be a history of a twisting and stretching.

- Increased incidence in runners as the mileage increases over 10 miles per week.

- The patient may complain of groin pain and painful clicking in the hip in up to 64%.

FAI and Labral Tear

- Mechanism of injury:
- It is not clear if there is one accepted mechanism of injury.
- The majority of authors believe that it is a hyperflexion injury that compresses the anterior superior labrum (femoroacetabuar impingement).
- So patients who's activities require extreme repetitive hip flexion such as ballet dancers, hurdlers, gymnast may be at higher risk.

FAI and Labral Tear

- To date most of these injuries have been seen in football players, hockey players, soccer players, ballet dancers essentially sports that have flexion, and repetitive twisting maneuvers.

FAI and Labral Tear

- In a study done in the Journal of Arthroscopic and Related Surgery May 2005 a population of runners was studied who presented with hip pain.

- Eight high level runners were seen for complaints of increasing hip pain with running with out any history of macrotrauma.

FAI and Labral Tear

- All of the patients had either run several marathons(4), were triathletes (1), Olympic middle distance runners (1), or had run more than 10 miles per week for longer than 5 years.

- 6 of these patients had a chondral injury of the acetabular cartilage underlying the labral tear. 3 had ligamentum teres disruption.

FAI and Labral Tear

- Mc Carthy and Lee postulated reproduction of groin pain with hip extension rather than flexion and internal rotation.
- The mechanism being hyperextension and torsional forces acting on the labrum and the articular cartilage.

FAI and Labral Tear

- In addition mild instability with a possible hyperextension in the stride phase may be a source of recurrent subluxation and attritional tearing of the labrum.


TIGERS

Acetabular labral injuries

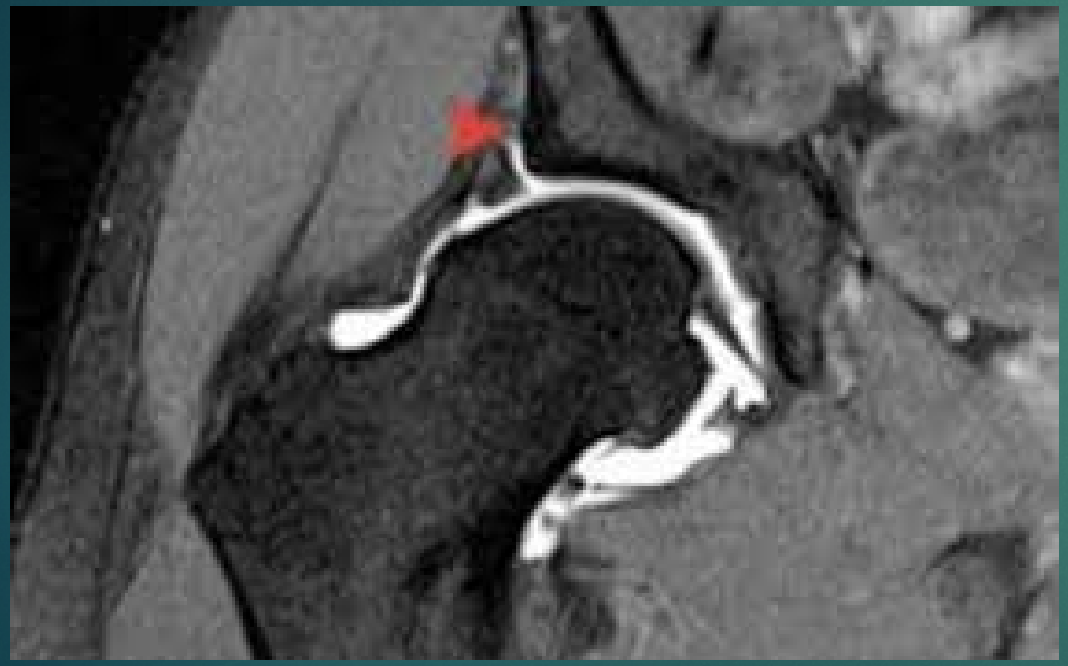
- Nepple et al Journal of Bone and Joint Surgery 2014
- 50 male and female subjects undergoing hip surgery for FAI. FAI subtype was classified based on clinical diagnosis and radiographic evaluation
- Females 31.4 (16-49 YO) Males 28.7 (14-49 YO)
- Anterior groin pain was present in females 86% of the time and 94% of the time in males. Females had pain radiate beyond the anterior hip to lateral hip 19% compared to males 10%.
  Duncan et al Clinical Orthopaedics and Related Research 2014

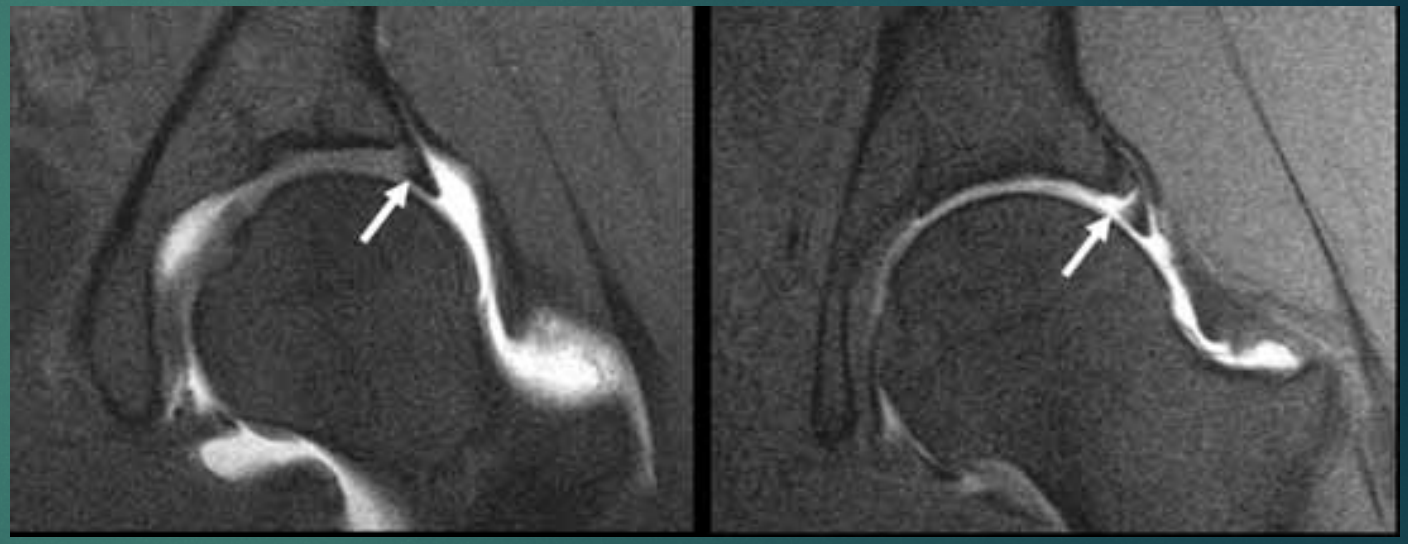
Acetabular Injuries

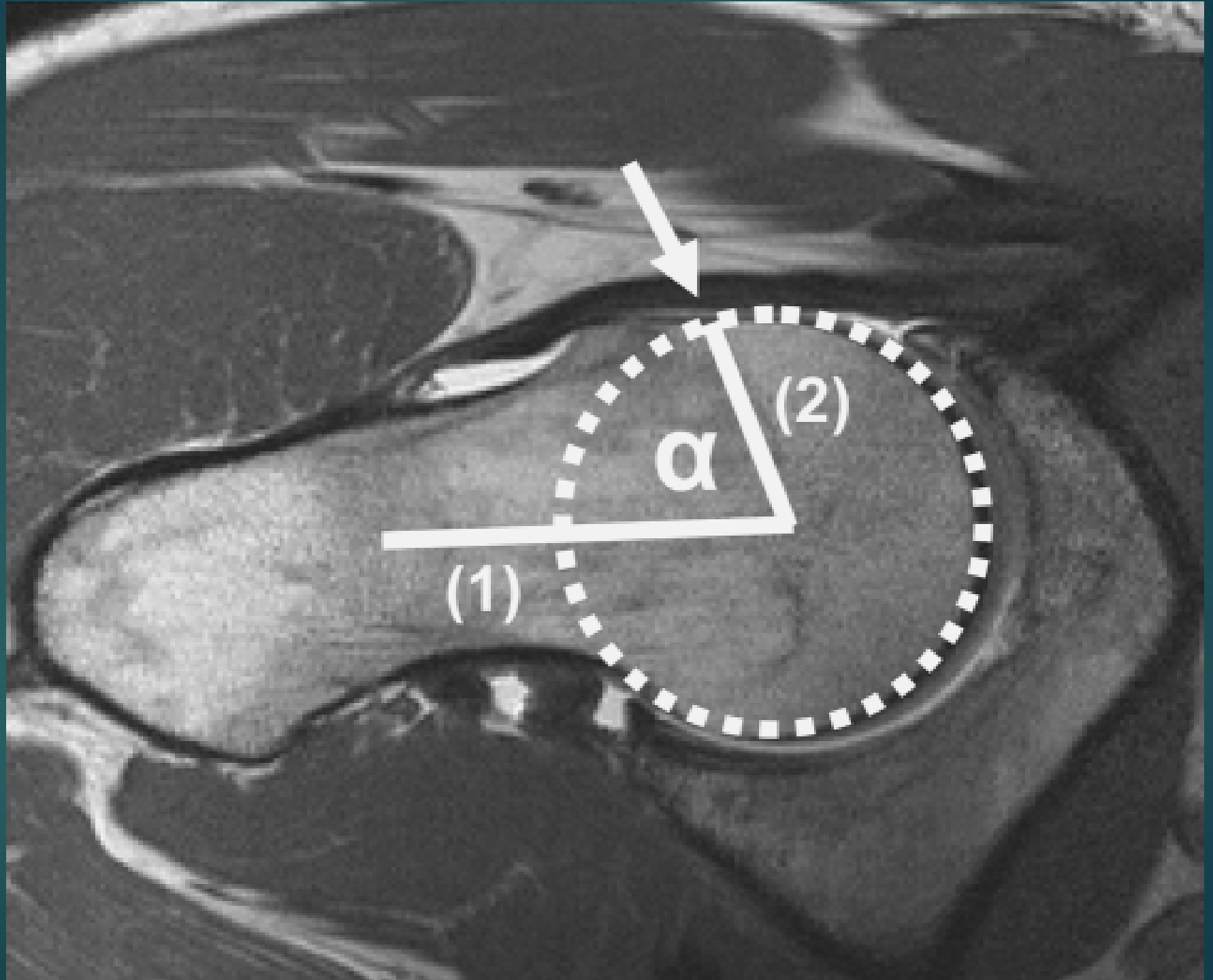
- Nepple et al cont:
- Females had more **cartilage changes malacia and debonding** (70% vs 44%). Males had more **advanced cartilage cleavage and defect** (56% vs 24%)
- **Clinically all men had a cam type deformity** No isolated pincer type alone. Radiographically males 56% also showed signs of pincer, females 48% showed cam, 41% combined.
- Female patients presented with more disability than males but with less severe deformities and intra-articular disease. Females also had lower UCLA activity score. Duncan et al Clinical Orthopaedics and Related Research 2014
- .

Acetabular injuries

- Nepple et al cont:
- Females presented with greater internal, external rotation and flexion than males. Duncan et al Clinical Orthopaedics and Related Research 2014
- Smaller alpha angle in females 57.6 degrees vs 70.8 degrees in males. Duncan et al Clinical Orthopaedics and Related Research 2014
- Cam deformity in 88% of females and 100% of males radiographically and clinically(surgical repair). Duncan et al Clinical Orthopaedics and Related Research 2014



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Cam Impingement

- Cordelia W. et al Journal of Pediatric Orthopaedics 2014
- 17 adolescent patients (24hips) age 12-16 yo who had undergone a surgical procedure for symptomatic FAI in a 4 year period 2006-2010. **7 boys 10 girls** average age 14.6 years
- Sports these athletes participated in were soccer, dance, ice hockey, swimming, and football

Cam Impingement

- Cordelia W et al cont;
- All of these participants had **cam impingement** and over half of the hips had a intra-articular injuries. 12 had labral tear and 2 had a chondral flap.
- MRI's with 3D volumetric acquisition were evaluated for all patients in this study.

Cam Impingement

- Agricola R. et al American Journal of Sport Medicine 2014
- Evaluated 63 elite soccer players mean age 14 years old and did a follow up 2.4 years later.
- A-P and frog leg lateral radiographs were taken, a angles were measured, neck shaft angle and hip ranges of motion were measured.

Cam Impingement

- Agricola R et al cont;
- Of the soccer players 12-13 yo at base line 84% had a normal head neck junction, no prominence.
- At the follow up 2.4 years later only 43% were still normal
- A smaller neck shaft angle along with a decrease in internal rotation at baseline in the this study was a predictor of development of cam deformity.

Pediatric

- Stracciolini A et al Journal of Pediatric Orthopedics 2016
- Performed a retrospective study over 10 years of pediatric hip injuries children 5-17 years of age.
- 2178 charts were evaluated

Pediatric

- Stracciolini A et al Journal of Pediatric Orthopedics 2016
- 59% of hip injuries in females were labral tears. 15% were tendonitis and 6% were snapping hip syndrome
- 23% of hip injuries in males were labral tears. 12% were avulsion fractures and 12% slipped capital femoral epiphysis, 8% were tendonitis

FAI

- Kakaty et 2010, Tannast et al 2012,Troelsen et al 2010, van Bosse et al 2011, Wan et al 2009
- All showed acetabular orientation changed with anterior or posterior pelvic tilt (inclination/reclination) and with pelvic rotation right and left
- SI dysfunction can alter pelvic tilt and rotation
- (Cibulka, Delitto, and Koldehoff 1988; Mitchell, Moran and Pruzo 1979)

FAI

- The unique feature that develops in SI dysfunction is the **asymmetry** between right and left innominate bones which alters normal tilt and rotation of the pelvis (Cibulka, Delitto, and Koldehoff 1988; Mitchell, Moran and Pruzo 1979)
- Shi et at 2013 found patients with SI disorders had a greater difference in right to left iliac crest width suggesting rotation differences in patients with SIJD

FAI

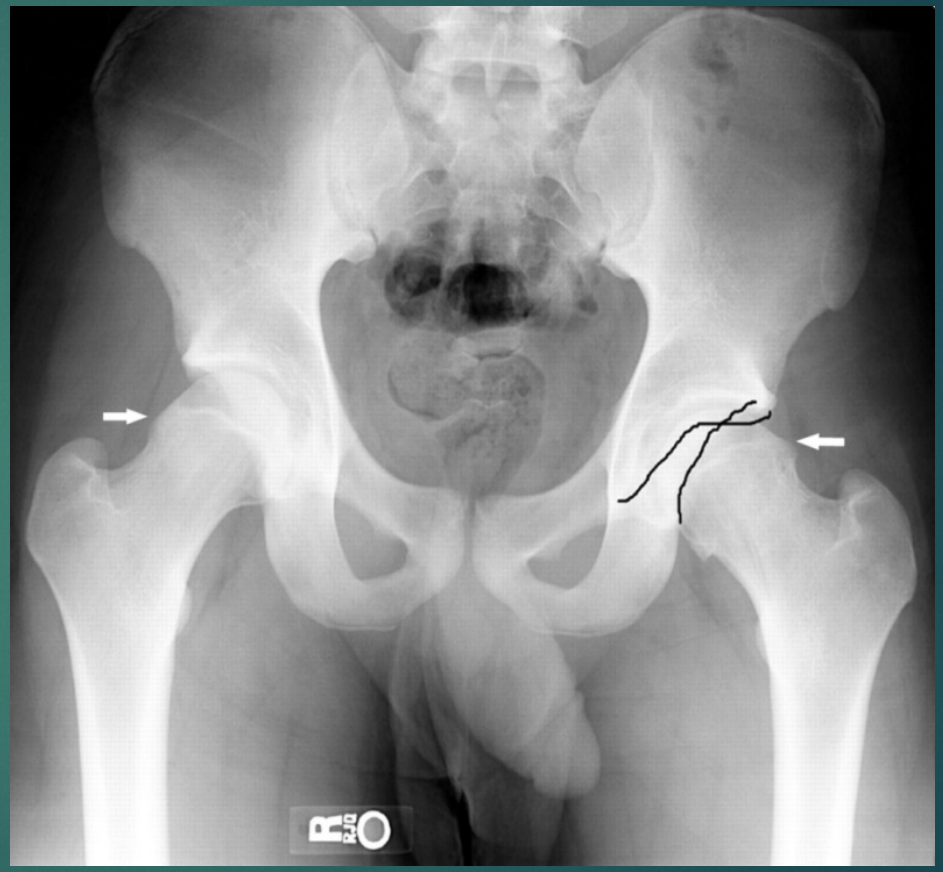
- Acetabular retroversion has been long thought to be a hyperplastic growth of the anterior acetabulum or hypoplastic growth of the posterior wall of the acetabulum.

- Kalberer et al 2008, Werner 2010 Kakaty et al 2010, Tannast et al 2012,; showed acetabular retroversion occurred in outward or external rotation of the innominant.

FAI

- When Cross Over Sign (COS) or Ischial Spine Sign (ISS) is present suggest acetabular retroversion develops from outward or external rotation of the entire hemipelvis.

COS



FAI

- Tannast et al 2012;
- Wider ilium is often found on the side of acetabular retroversion and the thinner ilium is found on the opposite side non retroverted.
- A unilateral ISS, COS, wider pelvis are all found on the side of the acetabular retroversion suggesting the pelvis is rotated.

FAI

- Cibulka et al Physiotherapy Theory and Practice 2014
- Presents **a rotational movement model** like in SI dysfunction AS/PI
- This group showed in **pincer** FAI the **posterior orientation** of the acetabulum increases the coverage to the anterior femoral head while decreasing the coverage of the posterior femoral head

FAI

- Cibulka et al cont;
- **Posterior** innominant is characterized by a backward or posterior and **outward** tilt or rotation of the whole innominant on the sacrum. It will appear **wider** on A-P x-ray

- **Anterior** innominant is characterized by a forward or anterior and **inward** tilt or rotation of the whole innominant on the sacrum. It will appear **thinner** on A-P x-ray.

- In patients with SI dysfunction the innominants are rotated/tilted in **opposite directions** vs the same direction as in the normal pelvic tilt.

Causes of FAI

- Musielak B et al BMC Musculoskeletal Disorders 2016
- Retrospectively evaluated 31 male patients who had surgery for FAI and using 3D CT scan
- The purpose of the study was to evaluate the movement of a hemipelvis in FAI

Causes of FAI

- Musielak B et al BMC Musculoskeletal Disorders 2016 cont:
- As the hemipelvis moves anterior and laterally the acetabulum faces more caudally.
- **This movement of the hemipelvis creates an increase in anteversion of acetabulum**.
- Possible reasons to increase coverage posteriorly to prevent dislocation and prevent dynamic conflict with the femoral head anteriorly.

FAI

- Ross et al American Journal of Sports Medicine 2014
- Retrospective study of 48 patients (50 hips) with symptomatic FAI who all underwent arthroscopic surgical procedures from June to August 2012.
- Pre-surgical CT scans had been performed.

FAI

- Ross et al cont;

- Static and dynamic radiographic CT evaluations were done in 3 pelvic positions: 10° anterior tilt, 0° native tilt, and 10° posterior tilt

- A simulated 10° anterior tilt significantly **increased** the relative **acetabular retroversion.**

- Crossover sign in native was 48% vs 84% in anterior tilt, Posterior wall 38% in native vs 74% in anterior tilt, prominent ischial spine 28% in native vs 68% in anterior tilt.

FAI

- Ross et al cont;
- A simulated 10° posterior tilt resulted in a significantly **increased** relative **acetabular anteversion.**
- Crossover sign 48% in native 14% in posterior tilt, posterior wall sign 38% in native and 14% in posterior tilt, prominent ischial spine 28% in native and 0% in posterior tilt

FAI

- Ross et al cont;
- "Rehabilitation for patient with FAI should include attempts to improve dynamic muscular control of the pelvis with resultant changes in pelvic tilt."
- In this study "the radiographic appearance of the anterior and posterior acetabular rims is significantly affected by the amount of pelvic tilt."

FAI

- FAI patients exhibit differences in all 3 planes of motion during gait.

- **Treatment of FAI must address the restrictions in range of motion, neuromuscular and strength retraining in all three planes of motion.**

FAI

- Bryson et al Journal of Gait and Posture 2013; Samaan MA et al 2019
- Evaluated the effects of FAI surgery on lower extremity joint mechanics pre and post operatively and a healthy control group.
- 10 patients who had unilateral cam FAI who underwent surgical intervention using an open or combined technique to correct the femoral head-neck offset vs 13 healthy control.

FAI

- Bryson et al. Samaan MA cont
- Follow up testing approximately 1 year later, all surgical patients received rehab focused on increasing strength and restoring hip ROM.
- Postoperatively significant improvement in reduction of hip pain, but not hip stiffness or function.
- The surgical group had reduced hip frontal plane and sagittal plane range of motion pre and post compared to the control group.

FAI

- Bryson et al cont;
- Post operatively there was a decrease in frontal and sagittal plane ROM compared to pre surgically.
- The ranges effected were hip flexion and adduction

FAI

- Bryson et al cont;
- They also proposed hip surgery patients adopt a pelvic stabilization technique to reduce frontal plane motion to decrease the frontal plane moment caused by the shift of there center of mass.
- Soft tissue restrictions from the surgery may create biomechanical hip impairments.

Causes of FAI

Bagwell et al., 2016a; Lamontagne et al., 2009 2017; Ng et al., 2015,

Decreased ability of persons with FAIS to posteriorly tilt the pelvis during motions requiring large ranges of hip flexion, such as a deep squat

Causes of FAI

Azevedo et al., 2016; Lewis et al., 2018a; Lewis et al., 2018b; Rylander et al., 2013, Yin Qf et al 2021

Persons with FAIS have been reported to assume a relatively more anteriorly tilted pelvis compared to healthy controls

Most of the time, the pelvis has a synergetic tilt backward while hip flexing, which could prevent the contact cam lesion of the femoral head and acetabular rim.

Causes of FAI

Bagwell JJ et al Clinical Biomechanics 2019

Evaluated posterior pelvic tilt during a squat and non weight bearing hip flexion in patient with FAI vs non FAI

Patients with FAI decreased posterior pelvic tilt during the squat and non weight bearing hip flexion vs controls

Causes of FAI

Bagwella JJ et al Clinical Biomechanics 2019

We speculate that a lack of lumbopelvic mobility or hip joint capsular tightness is a potential cause of overall reduced pelvis motion.

Limited lumbopelvic mobility could be the result of tightness of soft tissues

Change in pelvic incidence via changes in lumbopelvic mobility directly effects the hip joint, acetabular and femoral head.

Femoral Acetabular Impingement (FAI) Symptoms

- Diamond L.E. et al British Journal of Sports Medicine 2016, 2019

- Systematic review of literature 16 studies out of 1724 articles to determine physical impairments of people with FAI.

- Hip range of motion **flexion** and **internal rotation** was decreased in patients with FAI

Femoral Acetabular Impingement (FAI) Symptoms

- Diamond L.E. et al British Journal of Sports Medicine 2016, 2019 cont;
- Patients with FAI showed **weakness** of hip flexors and adductors (75% reduction vs control)
- Limitation in walking and stair climbing (hip flexion)
- Bagwell et al., 2016a; Diamond et al., 2017; Diamond et al.,2018; Fader et al., 2018; Hammond et al., 2017; King et al., 2018;

Femoral Acetabular Impingement (FAI) Symptoms

- **Diamond L.E. et al British Journal of Sports Medicine 2016,2019 cont;**

- Following surgery to repair the labrum hip ROM in **flexion** improved but not **internal rotation** during gait, and **both** did not improve with **stair climbing**.

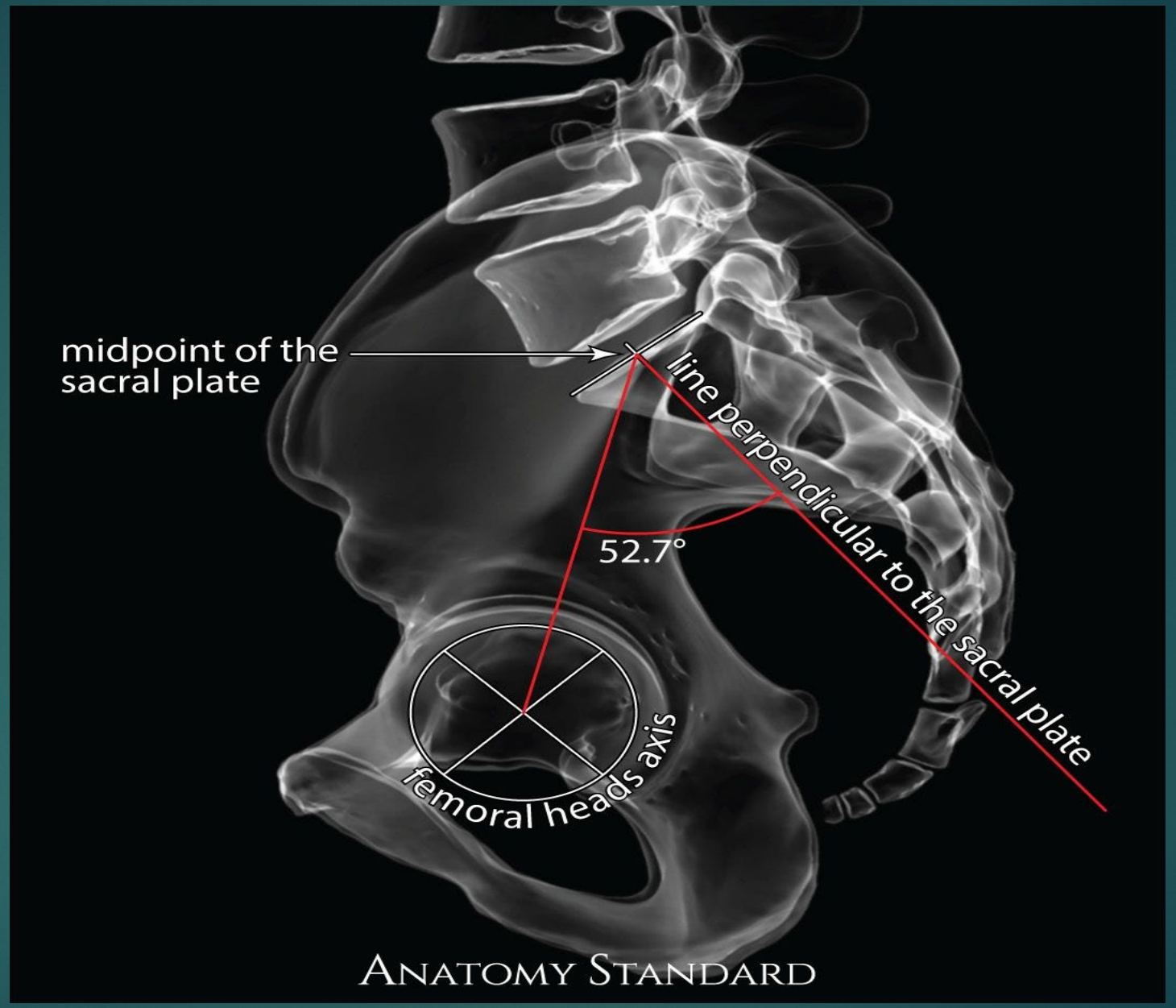
- Arthroscopy may improve some, but not all, impairments in ROM

Causes of FAI

Yin Qf et al 2021 Orthopedic Surgery, Fader RR et al 2018

- Patients who complain of sitting pain have a decreased Pelvic Incidence(PI) and demonstrate less capability of pelvic tilting backward during sitting down compared to these without sitting pain complaint.

- Insufficient pelvic tilting backward could be an aggravating factor for pain in symptomatic cam-type FAI patients.


midpoint of the sacral plate
line perpendicular to the sacral plate
52.7°
femoral heads axis
ANATOMY STANDARD

Hip Restriction

- Camp C.L. et al Journal of American Academy of Orthopedic Surgery 2018

- In baseball players 129 pitchers and 129 position players evaluated preseason from 2010 -2015 for hip range of motion restrictions.

- Players who developed abdominal injuries and low back injuries had decreased hip internal rotation. **Injury risk increases 35-60% for every 5 degree decrease in internal rotation of the hip**.

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. "

Hip Restriction

- Chang BF et al Journal of Sport Medicine and Physical Fitness 2018
- Evaluated adolescent tennis players experience vs beginners for hip and shoulder range of motion
- In the experienced players they had decreased hip internal rotation and increased shoulder external rotation.
- Conclusion was to evaluate the younger athletes to monitor changes in hip and shoulder range of motion for prevention of injury

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)

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

Knee 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)

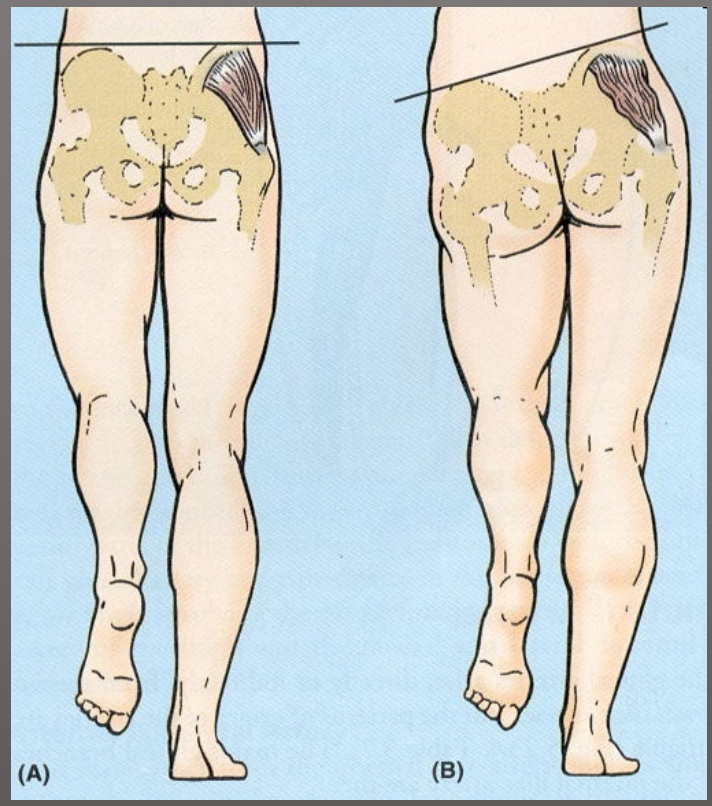
Patellofemoral Pain Syndrome

- PFP (Patellofemoral Pain) results from irritation of innervated structures of the patellofemoral joint (eg, 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,

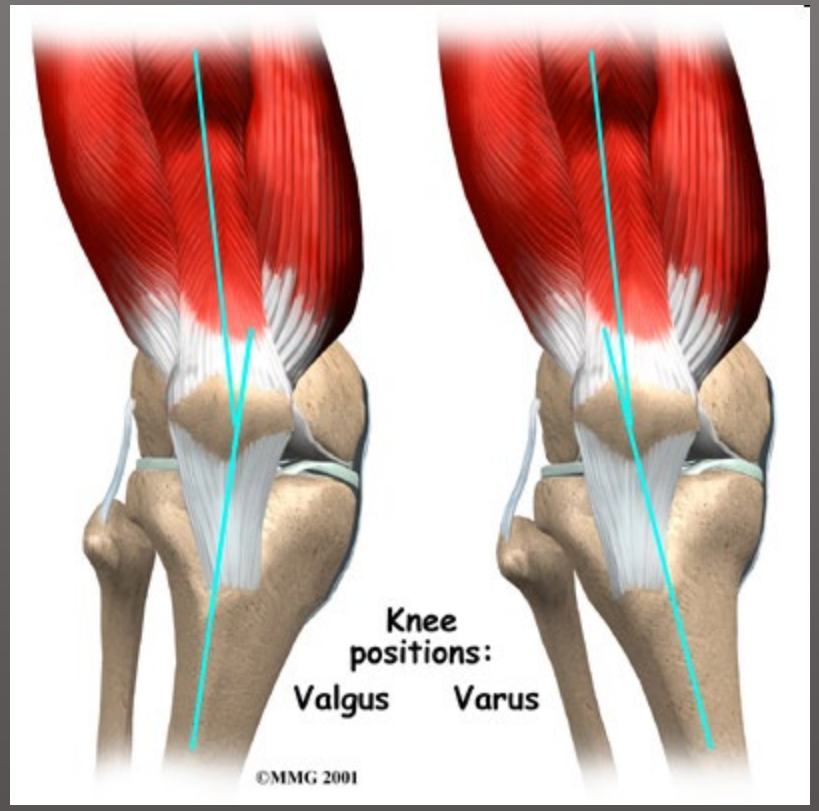
Patellofemoral Pain

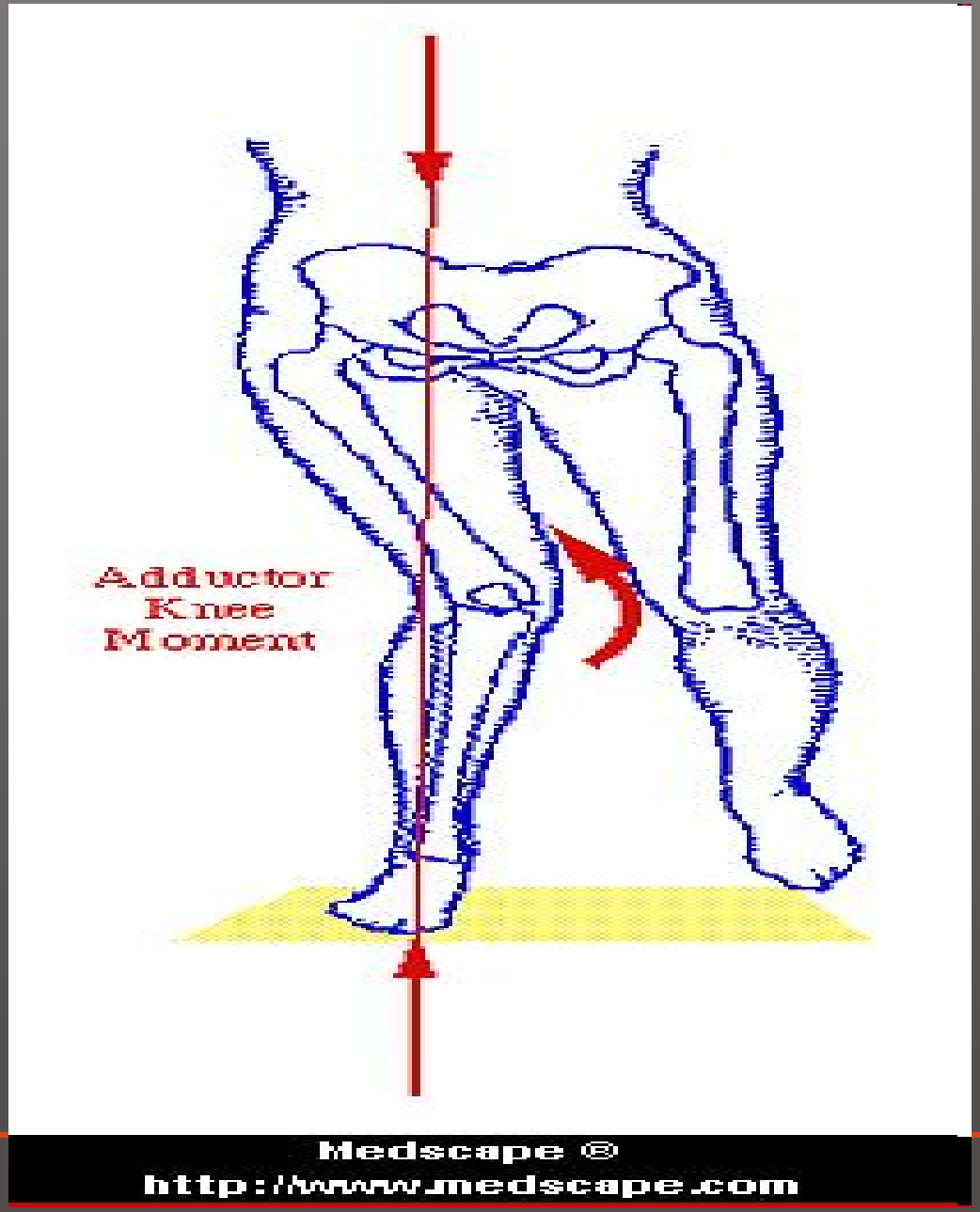
- Changes in the dynamic alignment of the lower limb creates pain and pathology in patellofemoral area.



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

Patellofemoral Pain


Knee
positions:
Valgus
Varus
©MMG 2001


Adductor
Knee
Moment
Medscape ®
http://www.medscape.com

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.

Patellofemoral Pain

- 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

- 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.

Patellofemoral Pain

- 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

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

- 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.

Knee pain

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 these 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,

- 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,

PFPS

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.

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

Ligament Injuries

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 runneers 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


BOLT


1479

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.

- 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

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.

- 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

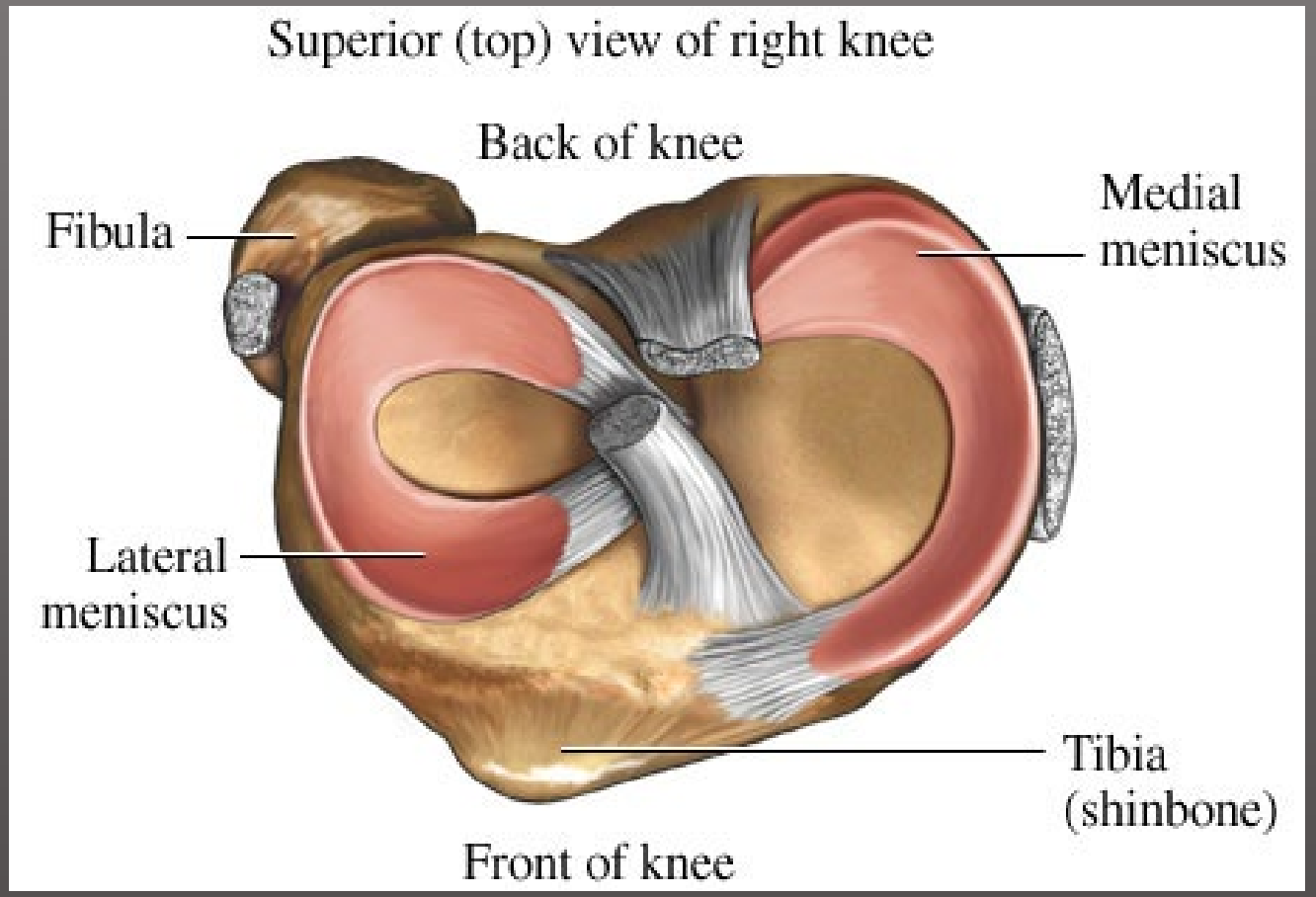
Rehabilitation

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

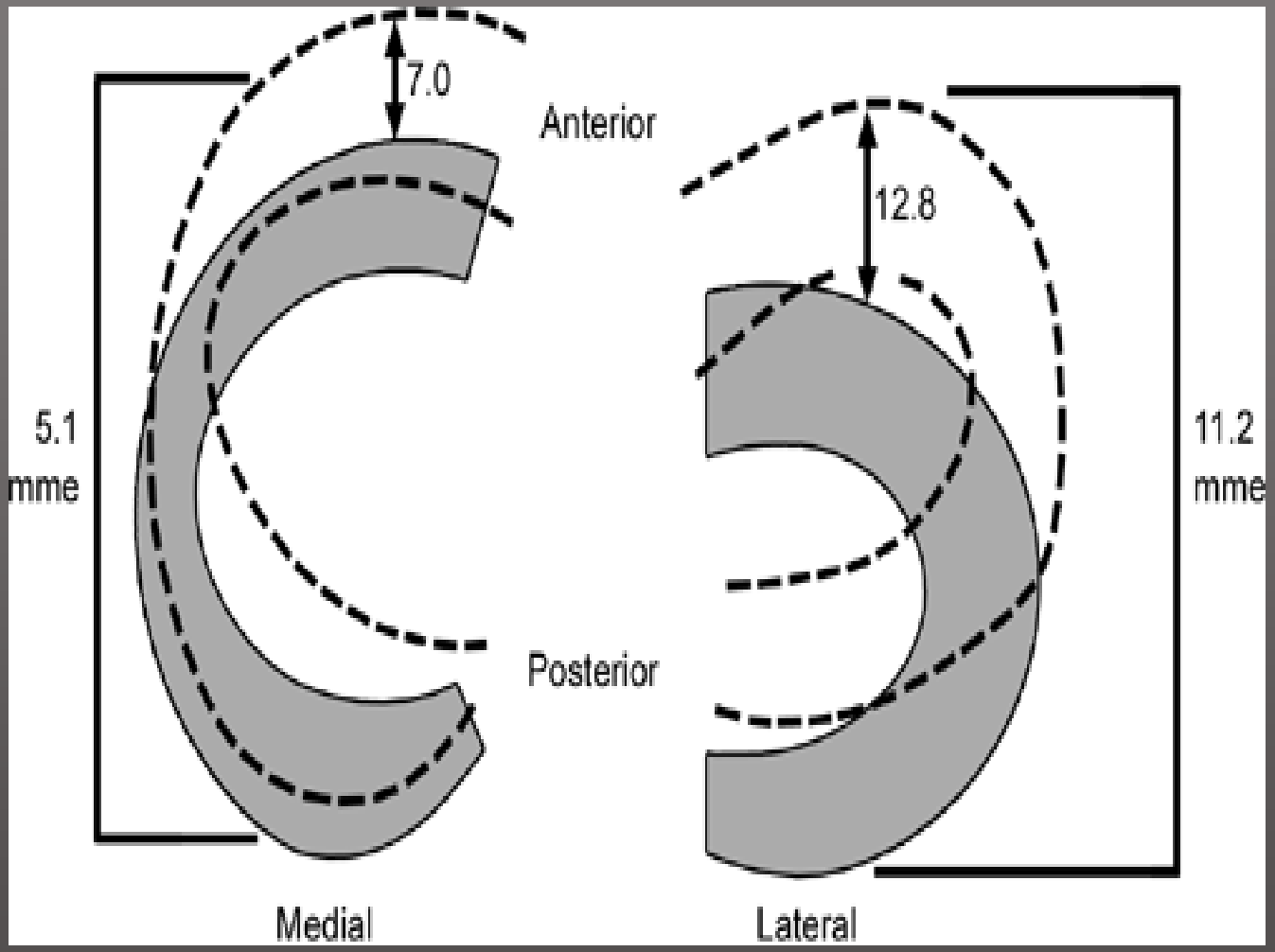

Superior (top) view of right knee
Back of knee
Fibula
Medial meniscus
Lateral meniscus
Tibia (shinbone)
Front of knee

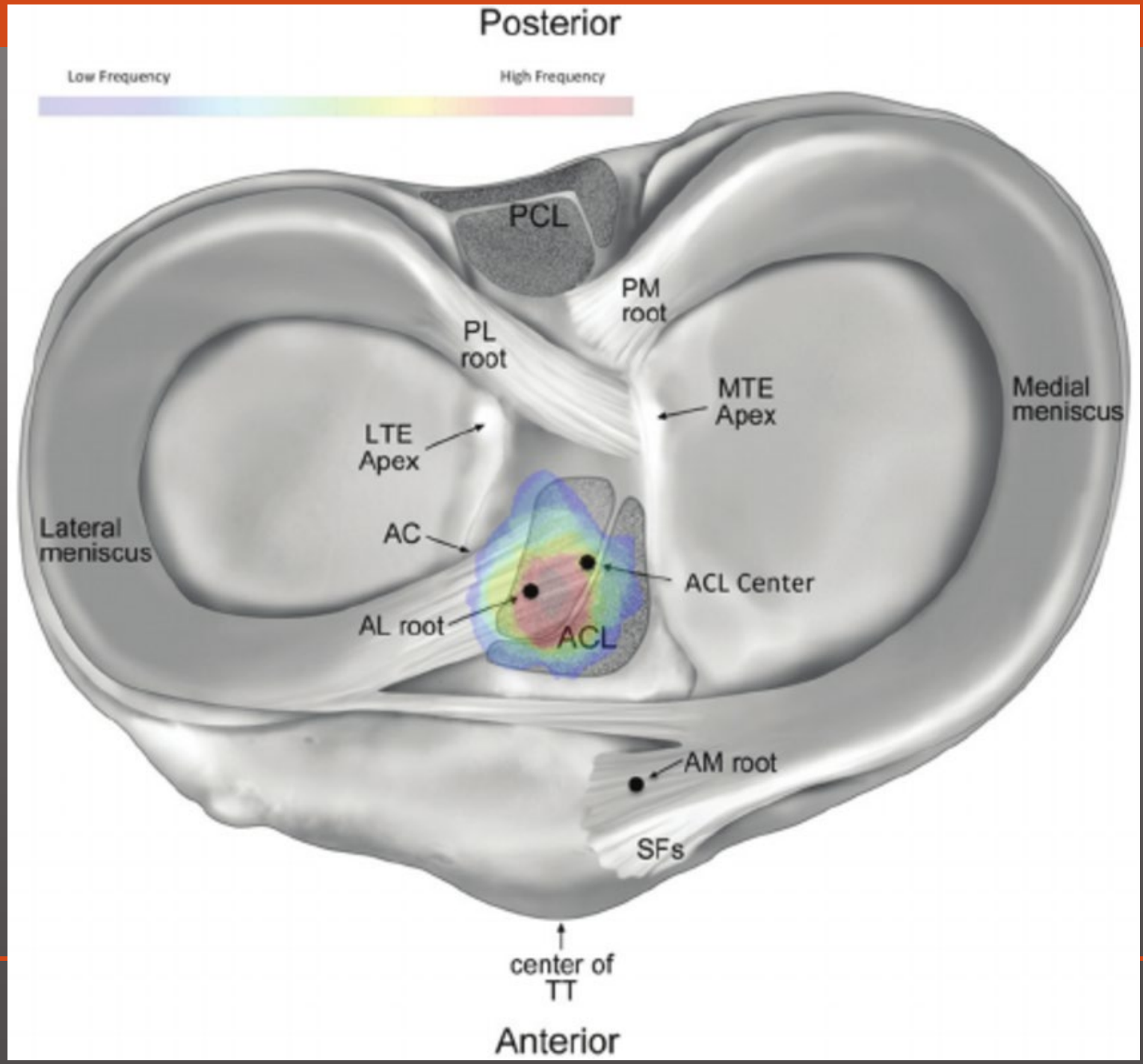
Meniscus

- 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

- 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


7.0
Anterior
12.8
5.1
mme
11.2
mme
Posterior
Medial
Lateral

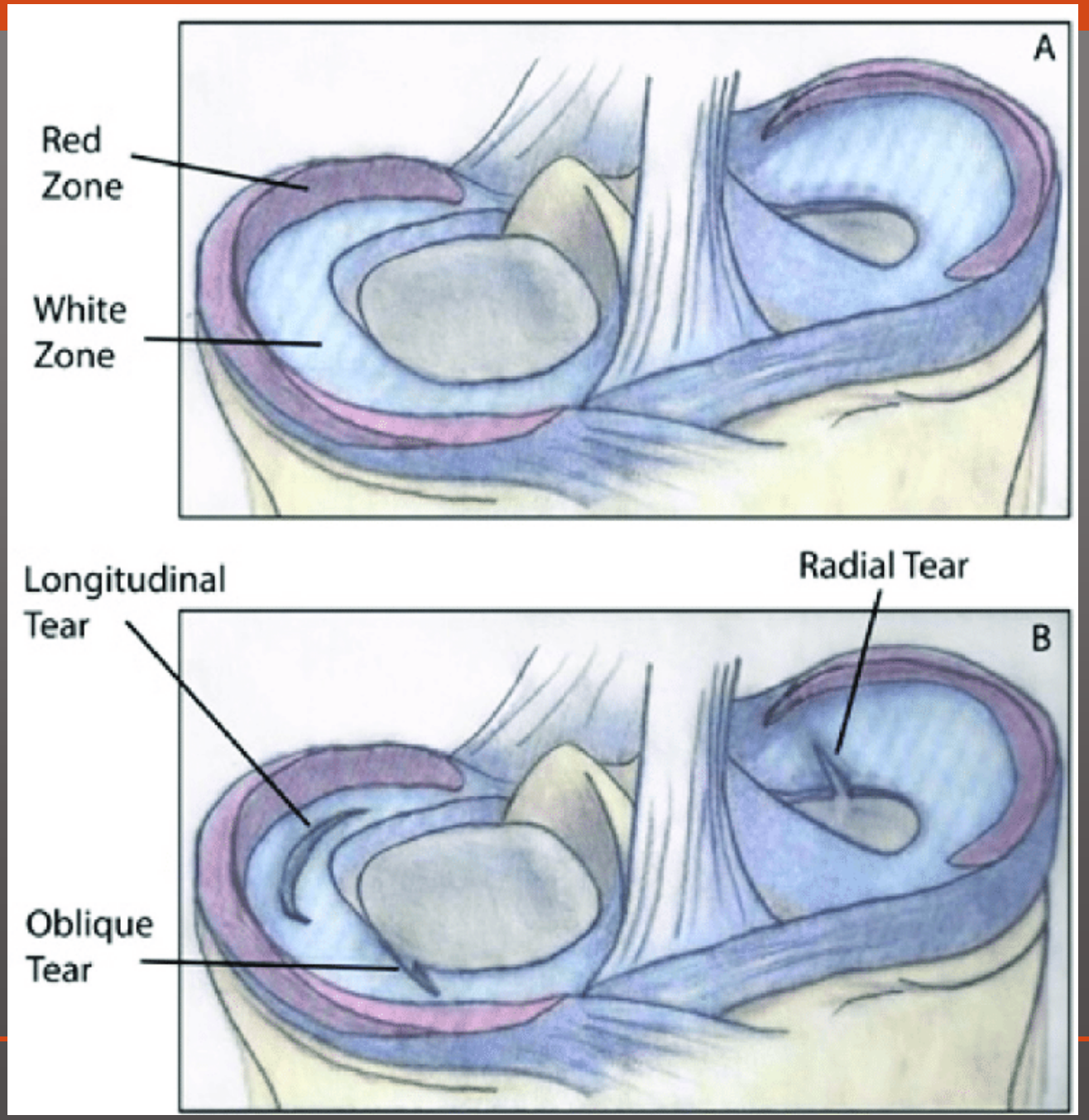

Posterior
Low Frequency
High Frequency
PCL
PM root
PL root
MTE Apex
Medial meniscus
LTE Apex
AC
Lateral meniscus
ACL Center
AL root
ACL
AM root
SFs
center of TT
Anterior

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. This allows the meniscus to provide additional joint stability

- 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,


A
Red
Zone
White
Zone
Longitudinal
Tear
Radial Tear
B
Oblique
Tear

- 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. This allows the meniscus to provide additional joint stability

Meniscus

Meniscus Injuries

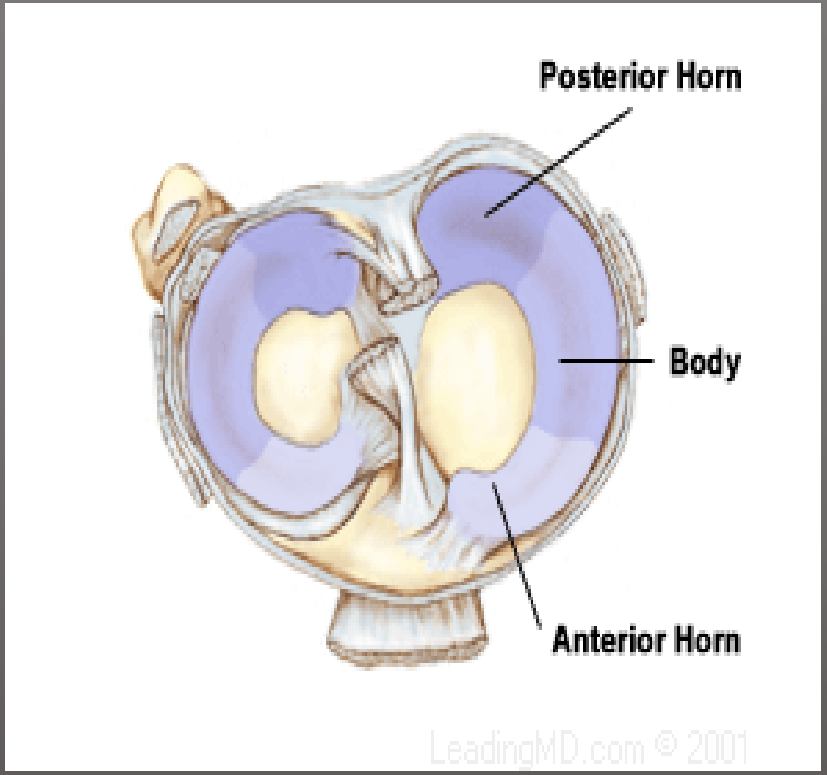
- Jiang, Wei et al 2012
- Evaluated meniscus injuries, 0-30 degrees compression is the largest force. **Anterior horn** under the most load.

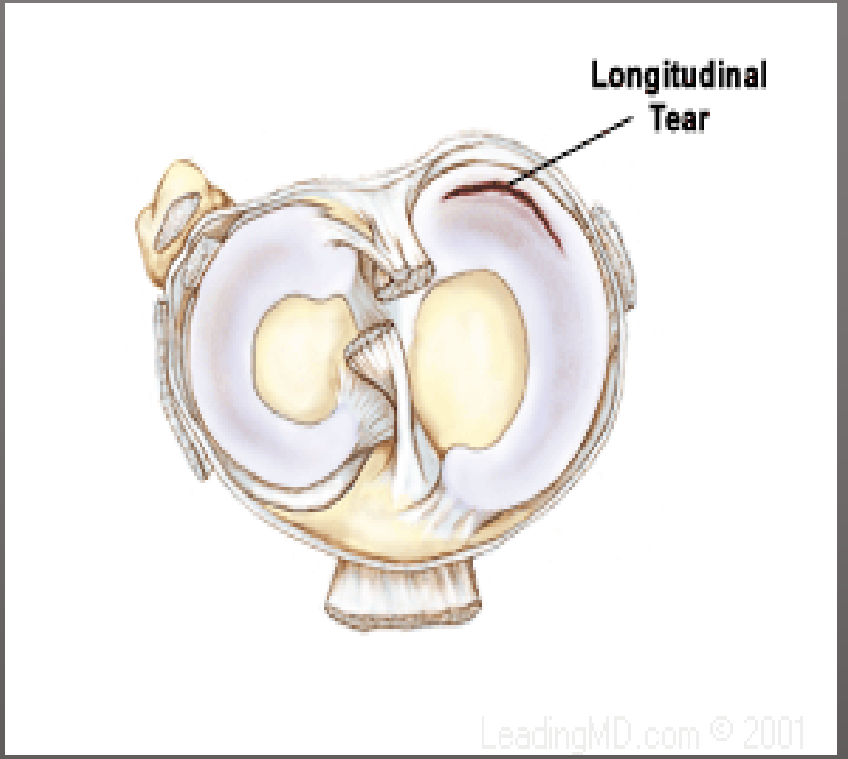
- 30-60 degrees the **body** of the meniscus had the most compressive load.

- 60-90 degrees of flexion the **posterior horn** under the most compressive load

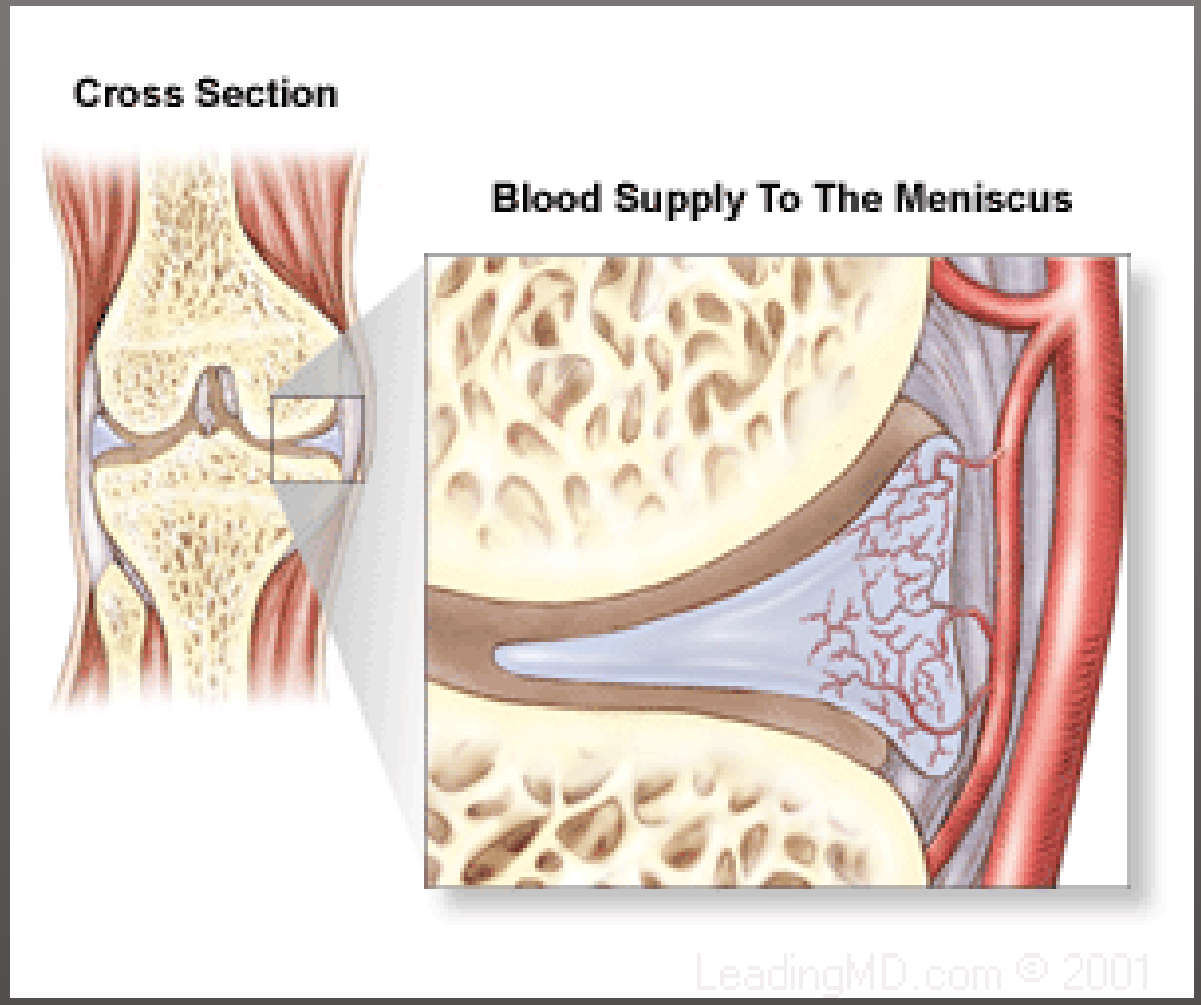
- Yim J-H et al 2013 The American Journal of Sports Medicine
- 102 patients with MRI findings of posterior horn horizontal (longitudinal tear) degenerative tears.
- Average age 53.8 years old
- 50 of the patients underwent arthroscopic meniscetomy and 52 non operative treatment
- At 2 year follow up satisfaction and functional improvement were the same.

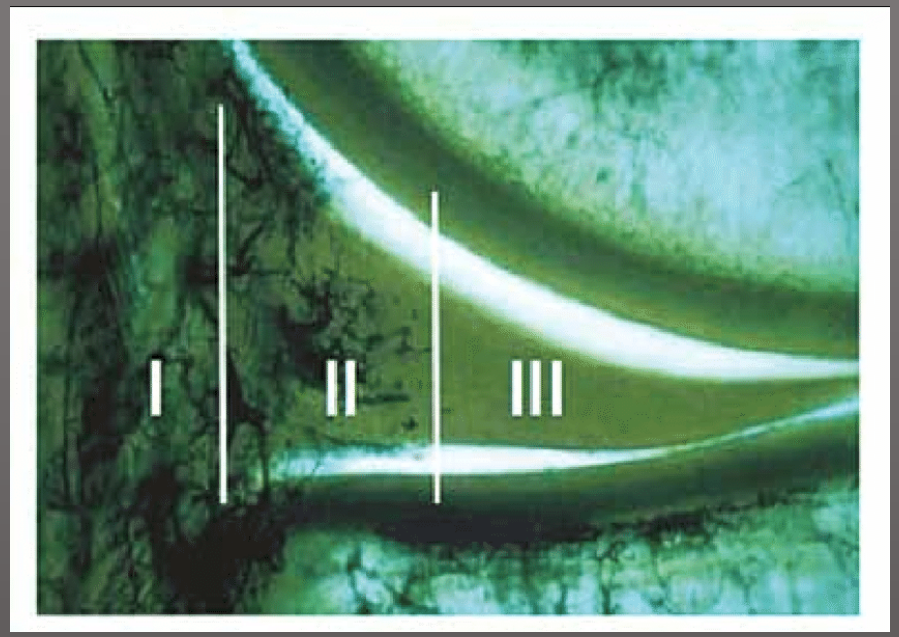
Meniscus Injuries

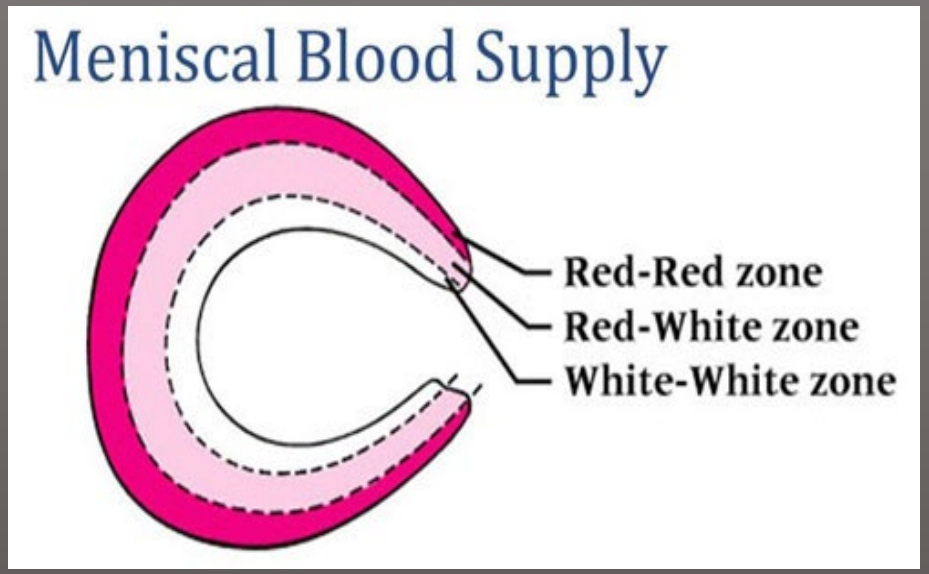




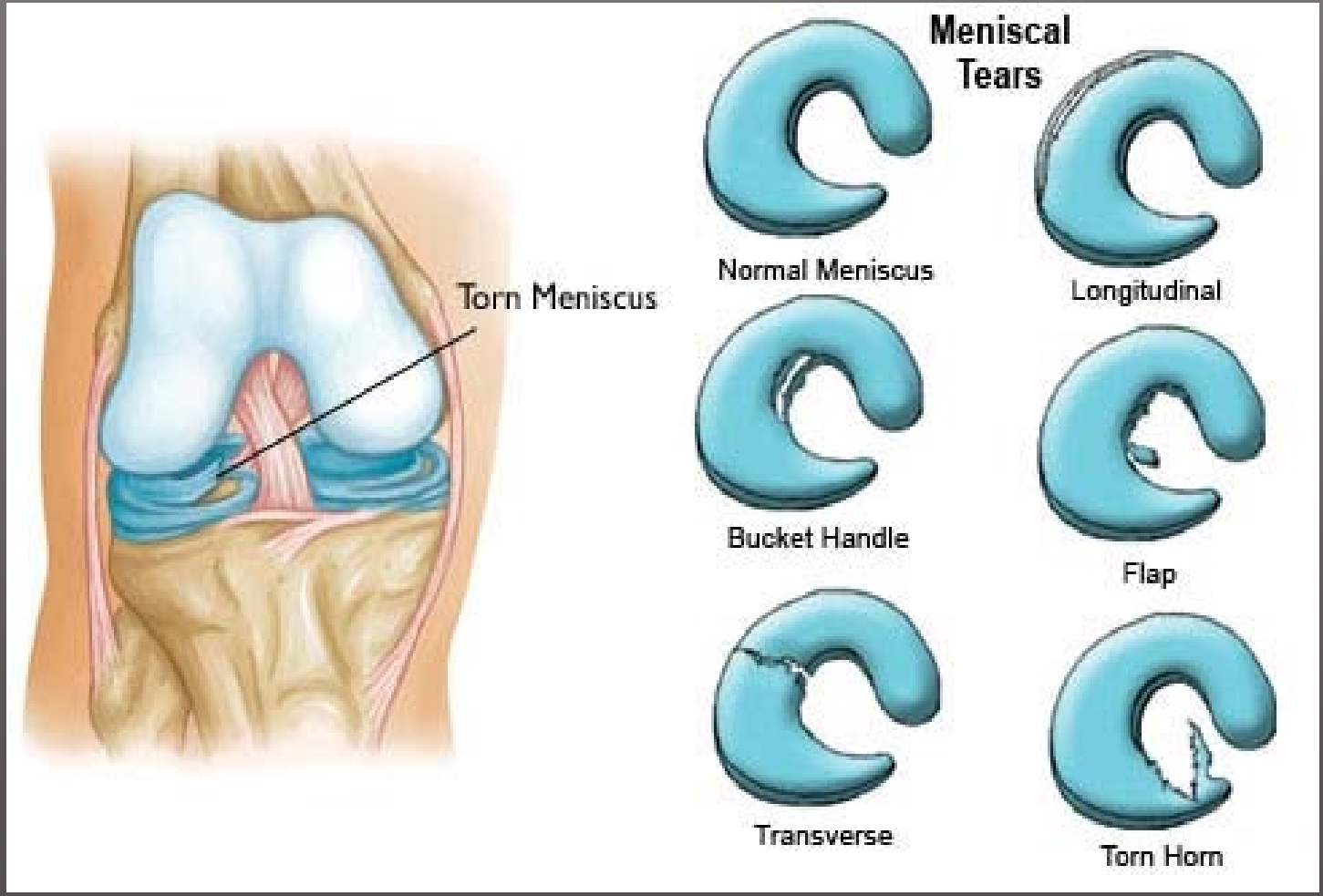
Meniscus injuries


Cross Section
Blood Supply To The Meniscus
LeadingMD.com © 2001





Meniscal blood supply


Torn Meniscus
Meniscal Tears
Normal Meniscus
Longitudinal
Bucket Handle
Flap
Transverse
Torn Horn

Meniscus

- 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.

Knee injuries