MMSx AUTHORITY · APPLIED BIOMECHANICS LAB

Knee Rehabilitation

50 Evidence-Based Biomechanics Analyses

50 titles · four analysis slides each · movement analysis, verified research data, decision pathways and APA 7 references

AUTHOR

Dr. Neeraj Mehta, PhD

ORCID 0000-0001-6200-8495

MMSx Authority Institute for Movement Mechanics & Biomechanics Research, Inc.

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BIOMECHANICS IS A FORCE-GOVERNED DECISION SYSTEM — NOT A POSTURE MODEL.

KNEE REHAB CHALLENGE

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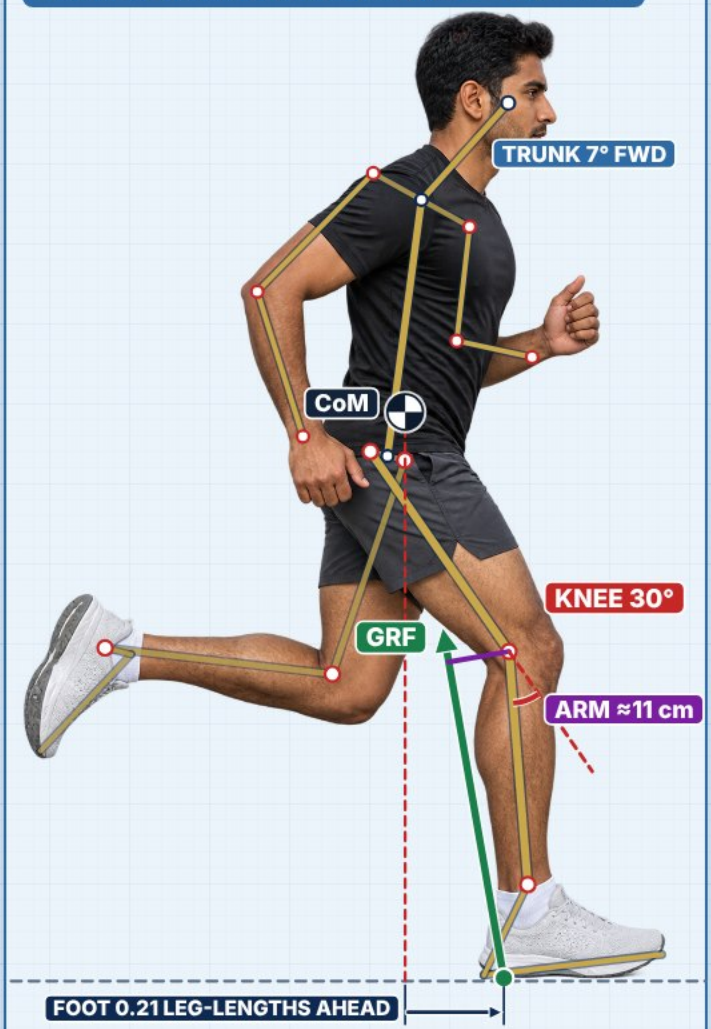
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RUNNER'S KNEE: WHY DOES THE FRONT OF YOUR KNEE HURT?

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FRAME A · RUNNING, EARLY STANCE · SIDE VIEW



Front-of-knee pain is a patellofemoral load problem

Patellofemoral pain (PFP) sits around or behind the kneecap and is provoked by running, stairs and squatting.

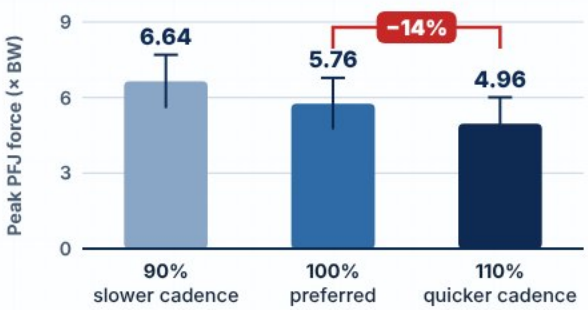
22.7% annual prevalence, general population

28.9% annual prevalence, adolescents

What Frame A shows

- Foot contacts **0.21 leg-lengths ahead** of the centre of mass (CoM): a braking contact.
- The ground reaction force (GRF) passes **≈11 cm behind the knee**, creating an external flexion moment.
- The quadriceps must resist it, and quadriceps tension compresses the patella onto the femur.

Cadence is a load-dose lever



Mean ± SD; 30 runners at 2.81 m/s. Lenhart et al. (2014).

2-D estimates from pose landmarks on an illustrated figure; CoM per de Leva (1996); GRF line approximated contact point → CoM; cm for a 1.70 m adult (Winter, 2009). Prevalence: Smith et al. (2018). Educational, not diagnostic.

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FRAME B · STEP-DOWN · SIDE VIEW



What Frame B shows

- Stance knee flexed **49°**, hip flexed **46°**, trunk **4°** forward.
- The CoM line falls **≈1 cm in front of the knee centre**: hip flexion and the reaching leg hold the CoM over the forefoot, so the hip shares the work.
- Knee further forward at the same depth: longer moment arm, more quadriceps force, more joint load.

Why bending loads the kneecap

Quadriceps and patellar-tendon pulls (navy) sum to the compressive reaction force **R**.

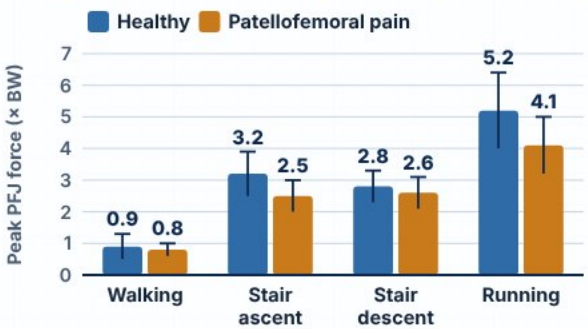


20° flexion	60° flexion	90° flexion
R = 0.35 F	R = 1.00 F	R = 1.41 F

R = 2F·sin(θ/2), equal tendon pulls along the segments (simplified)

PFJ stress = reaction force ÷ contact area.
External knee moment = GRF × moment arm.
Symptoms follow **stress against tissue tolerance** (Powers, 2003).

Everyday tasks load the joint very differently



Pooled peaks were **similar or lower** in people with patellofemoral pain. Pain reflects load against tolerance, not simply a higher force.

Mean ± SD, pooled. Hart et al. (2022).

2-D estimates from pose landmarks on an illustrated figure; quasi-static GRF assumed vertical through the CoM; CoM per de Leva (1996); cm for a 1.70 m adult (Winter, 2009). The kneecap schematic is a simplified planar model, not subject data. Educational, not diagnostic.

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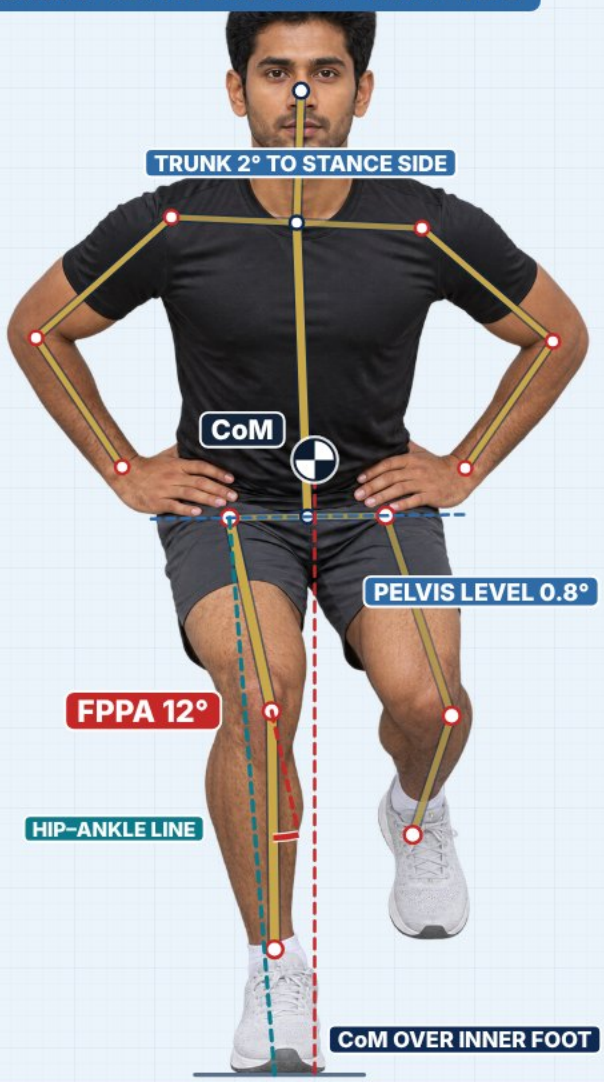
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FRAME C · SINGLE-LEG SQUAT · FRONT VIEW



Reading the "knee-in" pattern

- Frontal-plane projection angle (**FPPA**) ≈ **12°**: the knee sits medial to the hip–ankle line.
- The pelvis is level and the trunk near vertical, so the deviation here is mainly **femoral adduction**, not pelvic drop.
- Hip adduction with femoral internal rotation can shift patellar contact laterally and **shrink contact area, raising joint stress** (Powers, 2003).

What predicts future PFP? Prospective data



Weaker quadriceps predicted PFP in recruits; **weaker hips did not**. A knee-in pattern is a loading cue, not proof of hip weakness.

18 prospective studies, 4,818 people. Pooled hip SMDs shown as a range (CIs not in abstract). Neal et al. (2019).

Decision: test quadriceps and hip capacity, and film the single-leg squat. Treat the person's numbers, not the picture.

FPPA, pelvic and trunk angles are 2-D estimates from pose landmarks on an illustrated figure; surface hip landmarks can overstate femoral adduction. CoM per de Leva (1996). Educational, not diagnostic.

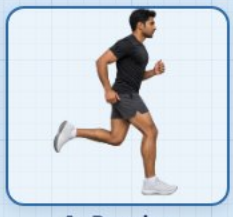
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A · Running
Foot lands ahead of CoM

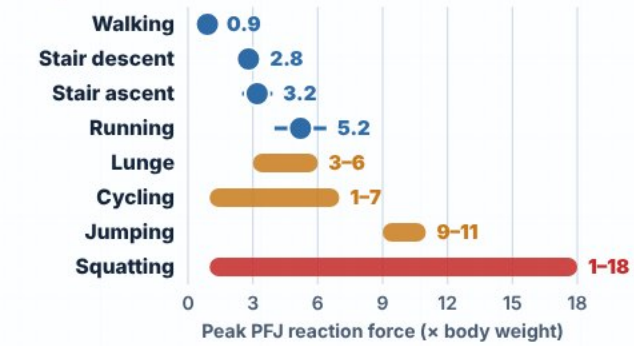


B · Step-down
Knee 49°, hip-shared



C · Single-leg squat
FPPA 12°, pelvis level

The patellofemoral load ladder



Dots: pooled mean ± SD (healthy). Bars: ranges across single studies; squat load rises with depth and external load. Hart et al. (2022).

Decision pathway

1. **SETTLE**
   Lower the dose, keep moving. Use tasks lower on the ladder until symptoms settle, and explain joint load to the person.
2. **BUILD**
   Hip- and knee-targeted exercise is the core treatment. Taping or prefabricated foot orthoses may help short term, alongside exercise.
3. **RETURN**
   Climb the ladder again: stairs, then running, then jumping. Runners can add gait retraining, such as a modest step-rate increase.

NOT RECOMMENDED (Willy et al., 2019)

Knee braces or sleeves, dry needling, biophysical agents, and joint mobilisation used on its own.

SEEK ASSESSMENT IF

Swelling, locking or giving way, pain after a fall or twist, night pain, or a hot, red knee.

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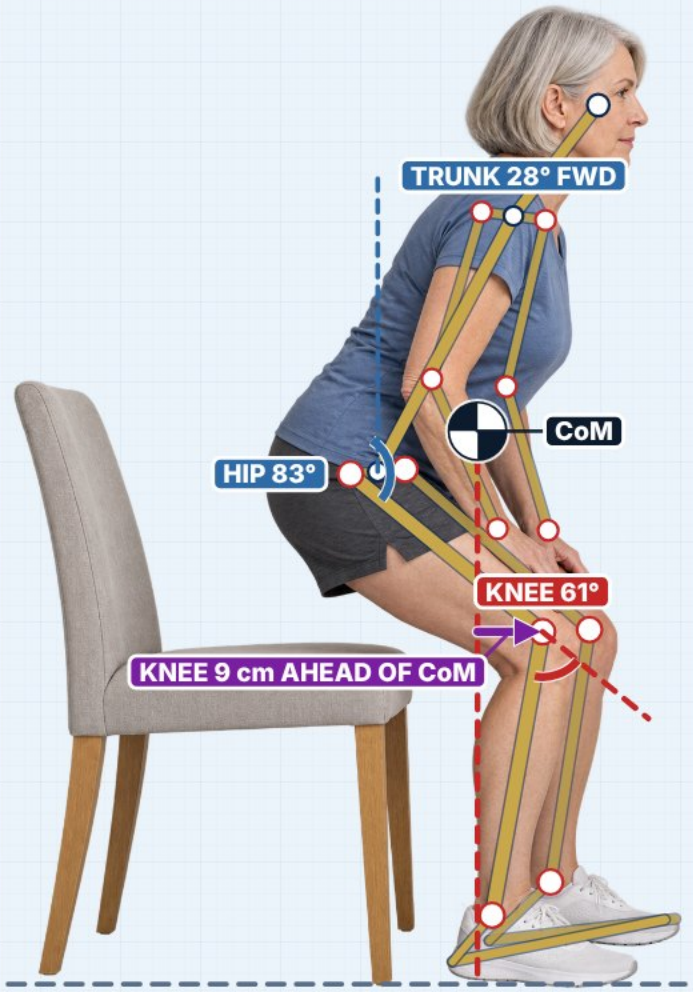
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KNEE OSTEOARTHRITIS: WHY EVERYDAY MOVEMENTS BECOME DIFFICULT

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FRAME A · SIT-TO-STAND · SIDE VIEW



Knee OA: a whole-joint condition, common after 40

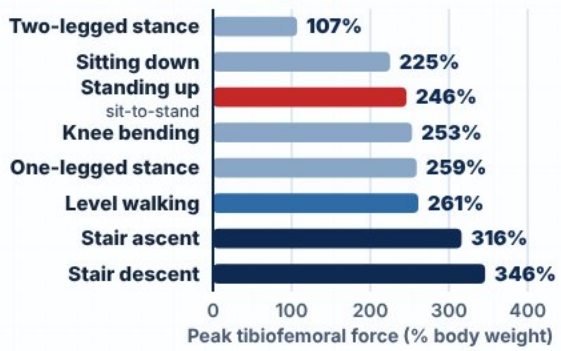
22.9%
knee OA prevalence, adults aged ≥40

654.5 M
people aged ≥40 with knee OA, 2020

What Frame A shows

- Knee flexed **61°**, hip **83°**, trunk **28°** forward to bring the CoM toward the feet.
- The CoM line still falls **≈9 cm behind the knee**, so the quadriceps must create a large extensor moment to rise.
- Hands pushing on the thighs share the work, a common strategy when the knee is painful or weak.

Peak knee force in daily tasks



Instrumented knee replacements, 5 people; no SD reported. Kutzner et al. (2010). Prevalence: Cui et al. (2020).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Educational, not diagnostic.

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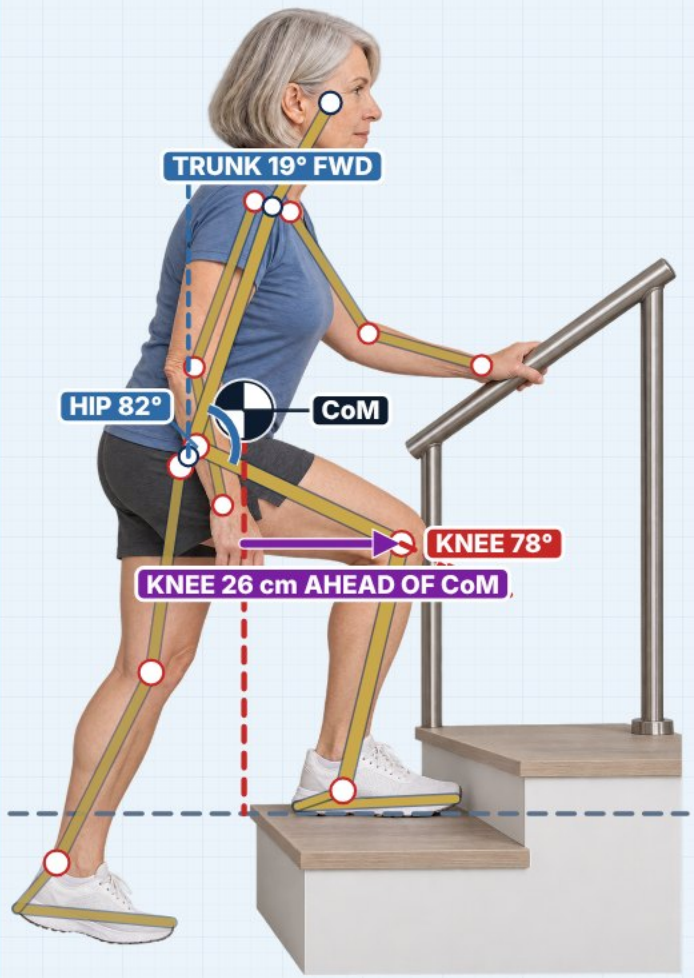
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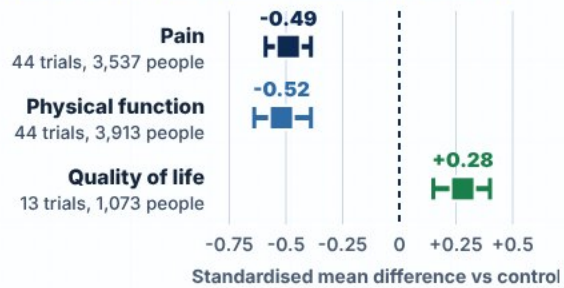
FRAME B · STAIR ASCENT WITH RAIL · SIDE VIEW



Stairs: deep knee flexion under full body weight

- Leading knee flexed **78°** and sitting **≈26 cm ahead of the CoM line**: a long lever the quadriceps must overcome.
- Trunk **19°** forward and the handrail move the CoM toward the step and share the effort.
- Measured inside replaced knees, stair ascent peaks at **316%** of body weight versus 261% for level walking.

Exercise therapy works — Cochrane review



Negative = less pain / better function. Straight after treatment: about **12/100 less pain** and **10/100 better function**.

Immediately post-treatment; 54 studies in total. Fransen et al. (2015). Stair loads: Kutzner et al. (2010).

Decision: build the capacity the task demands — strength for the stair, not avoidance of the stair.

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Educational, not diagnostic.

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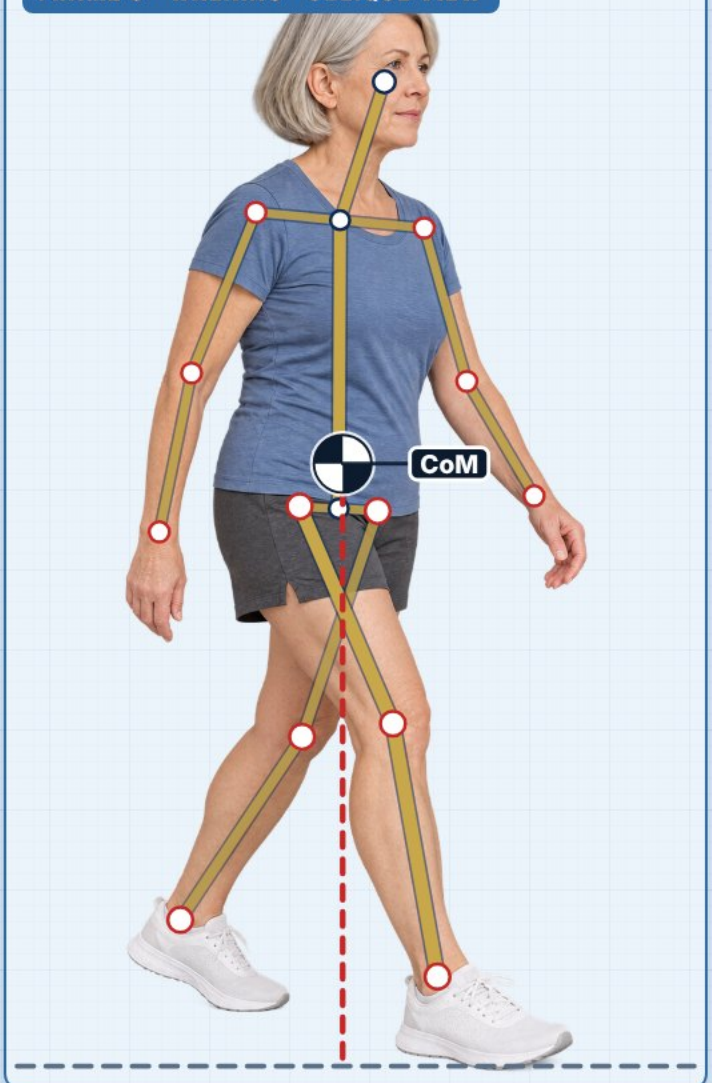
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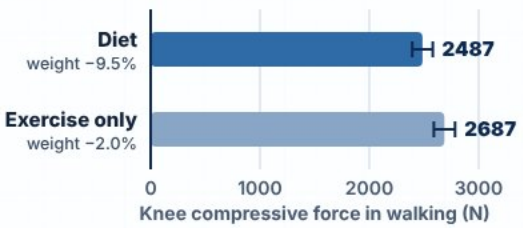
FRAME C · WALKING · OBLIQUE VIEW



Walking: the load repeated thousands of times

- Oblique view, so joint angles are not measured here; the CoM sits between the feet as weight transfers.
- In instrumented knee replacements, each walking step peaks at about **2.6× body weight** (261%).
- In medial knee OA, a 1% higher baseline peak **knee adduction moment** was linked to a **6.46-fold** higher risk of radiographic progression over 6 years.

Weight loss lowers walking load



Diet + exercise (−11.4% weight) gave the best pain and function scores at 18 months.

Means with 95% CI; IDEA trial, 454 adults, 18 months. Messier et al. (2013). Progression: Miyazaki et al. (2002). Walking load: Kutzner et al. (2010).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Frame C is oblique: no angles reported. Educational, not diagnostic.

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A · Sit-to-stand
Knee 61°, trunk 28°

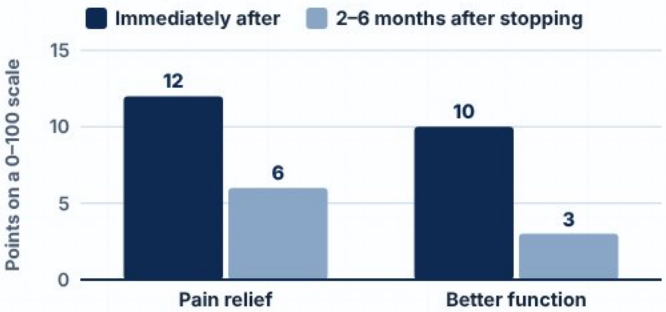


B · Stair ascent
Knee 78°, rail-assisted



C · Walking
Repeated daily load

Exercise helps while it continues



Average benefit vs control. Fransen et al. (2015).

Decision pathway

1. **DIAGNOSE**
   Clinically: age ≥45, activity-related pain, morning stiffness ≤30 min. Routine imaging is not needed (NICE, 2022).
2. **BUILD**
   Therapeutic exercise for everyone: strengthening plus aerobic fitness, supervised where possible. If overweight, any weight loss helps; 10% beats 5%.
3. **KEEP GOING**
   Practise the hard tasks — sit-to-stand and stairs — progressing height and repetitions. Benefits fade when exercise stops.

NOT RECOMMENDED

Arthroscopic lavage or debridement, acupuncture, electrotherapy, routine paracetamol or weak opioids, glucosamine (NICE, 2022; Kolasinski et al., 2020).

SEEK ASSESSMENT IF

Hot, red, swollen knee or fever; trauma with inability to bear weight; rapidly worsening pain or deformity; morning stiffness over 30 min.

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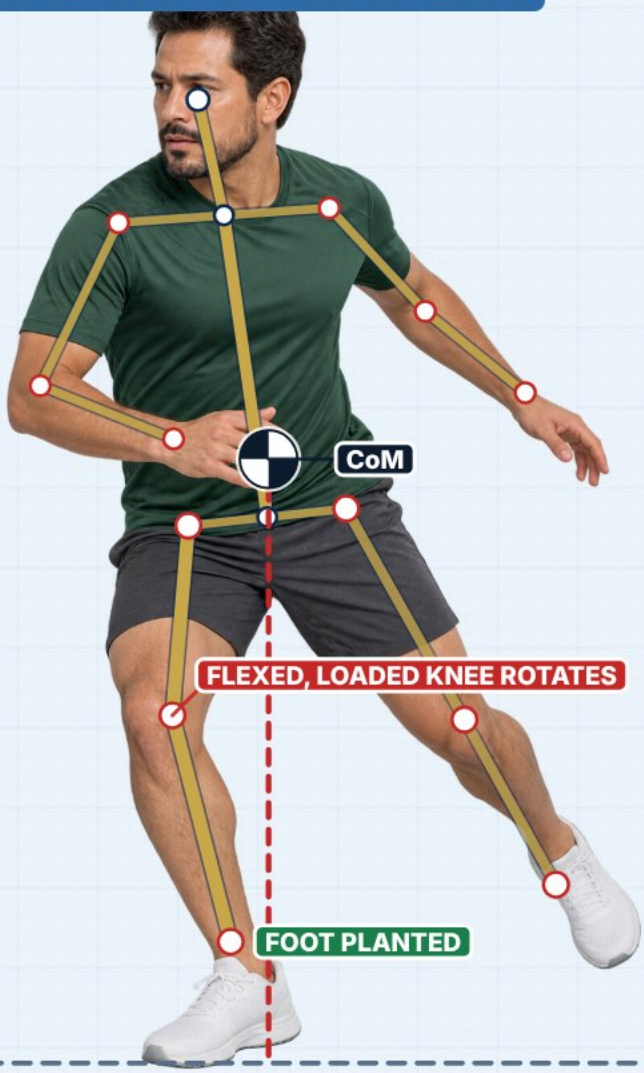
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MENISCUS INJURY: KNEE PAIN WHEN TWISTING OR TURNING

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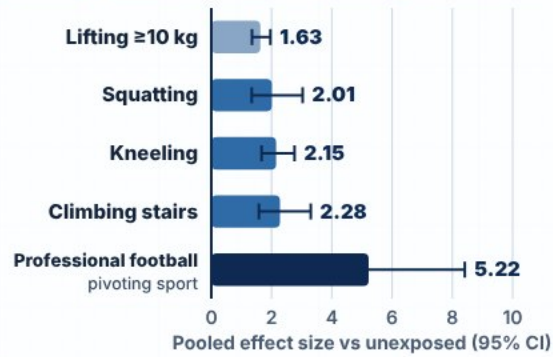
FRAME A · PLANTED-FOOT TURN · OBLIQUE



Twisting on a flexed, loaded knee

- The foot is planted while the body turns: the femur rotates on a fixed tibia, **shearing the menisci** between them.
- The menisci spread compressive load; flexion plus rotation concentrates it on the posterior horns.
- In younger, active people tears are usually traumatic; after 50 they are often **degenerative** and part of early osteoarthritis.

Loading patterns linked to meniscal lesions



Observational data: associations, not proof of cause.

22 studies in the review; 9 in the meta-analysis. Bahns et al. (2021).

Decision: a twisting pain is a load-and-rotation problem first; train capacity before thinking about surgery.

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Frame A is oblique: no angles reported. Educational, not diagnostic.

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INTEGRATING PERFORMANCE & REHABILITATION HEALTHCARE PATHWAYS.

MENISCUS INJURY: KNEE PAIN WHEN TWISTING OR TURNING

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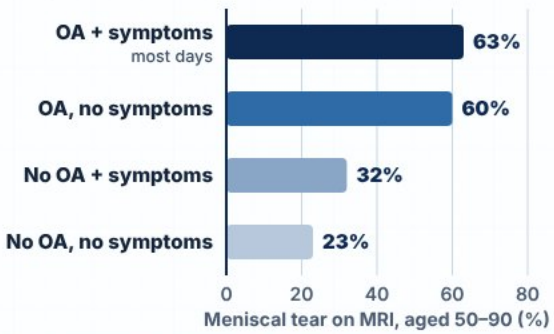
FRAME B · GETTING OUT OF A CAR · OBLIQUE



Getting out of a car: flexion plus rotation

- Oblique view, so angles are not measured. Both knees are flexed while the trunk turns toward the door.
- Sitting low and swinging the legs out rotates the tibia under a flexed knee: a common pinch point for a sore meniscus.
- Turning the whole body first, then standing, reduces the twist on the loaded knee.

Tears are common, even in knees that do not hurt



61% of people with a tear had no knee pain, aching or stiffness in the previous month.

Population sample, n = 991. Englund et al. (2008).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Frame B is oblique: no angles reported. Educational, not diagnostic.

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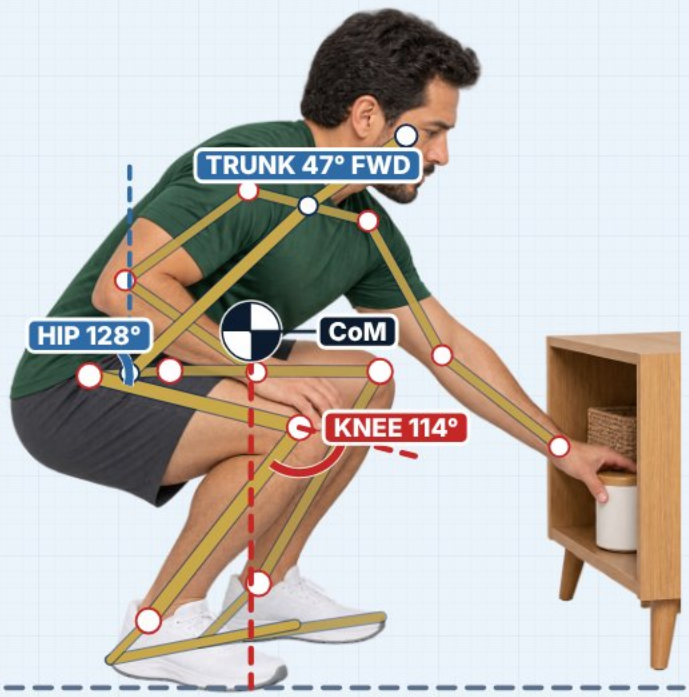
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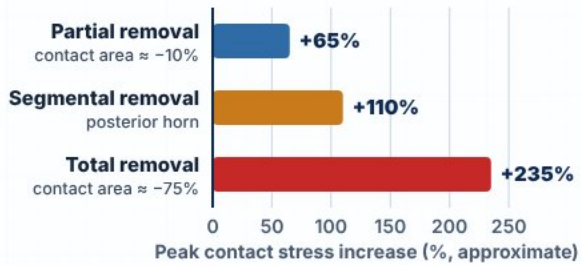
FRAME C · DEEP SQUAT TO A LOW SHELF · SIDE VIEW



Deep squat: the posterior horns take the load

- Knee flexed **114°**, hip **128°**, trunk **47°** forward to reach the low shelf.
- In deep flexion the femoral condyles roll back onto the **posterior horns** of the menisci.
- Occupational squatting and kneeling were each linked to about twice the risk of meniscal lesions.

Why preserving meniscus matters (cadaver knees)



Removing tissue shrinks the contact area and concentrates stress on cartilage.

Human cadaver knees under axial load; small samples; values approximate. Baratz et al. (1986).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Educational, not diagnostic.

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A · Planted turn
Rotation on a fixed foot

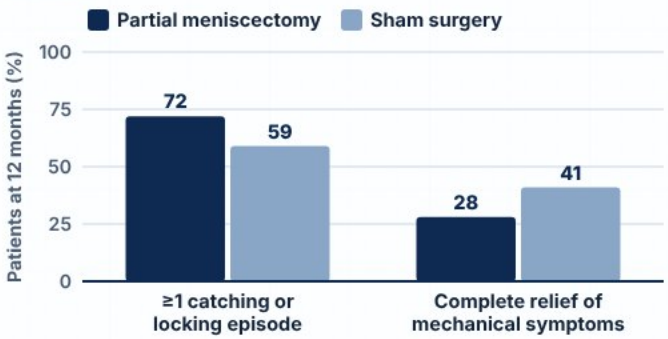


B · Car exit
Flexion + twist



C · Deep squat
Knee 114°

Catching and locking: surgery was no better than sham



n = 69 with mechanical symptoms; no CIs available. Sihvonen et al. (2016).

Decision pathway

1. **TRIAGE**
A knee that **cannot fully straighten** after a twist, or swells within hours, needs a prompt surgical opinion; repair is preferred over removal where possible.

2. **EXERCISE FIRST**
Degenerative tear: 12 weeks of supervised exercise matched partial meniscectomy at 2 years and built more thigh strength (Kise et al., 2016).

3. **REBUILD**
Progress squat depth, load and pivoting gradually; turn the body before the knee when getting out of a car.

NOT RECOMMENDED

Arthroscopic surgery for degenerative knee disease, even with clicking or catching (Siemieniuk et al., 2017).

SEEK ASSESSMENT IF

Knee locked and unable to straighten, rapid swelling after a twist, inability to bear weight, giving way, or a hot swollen knee with fever.

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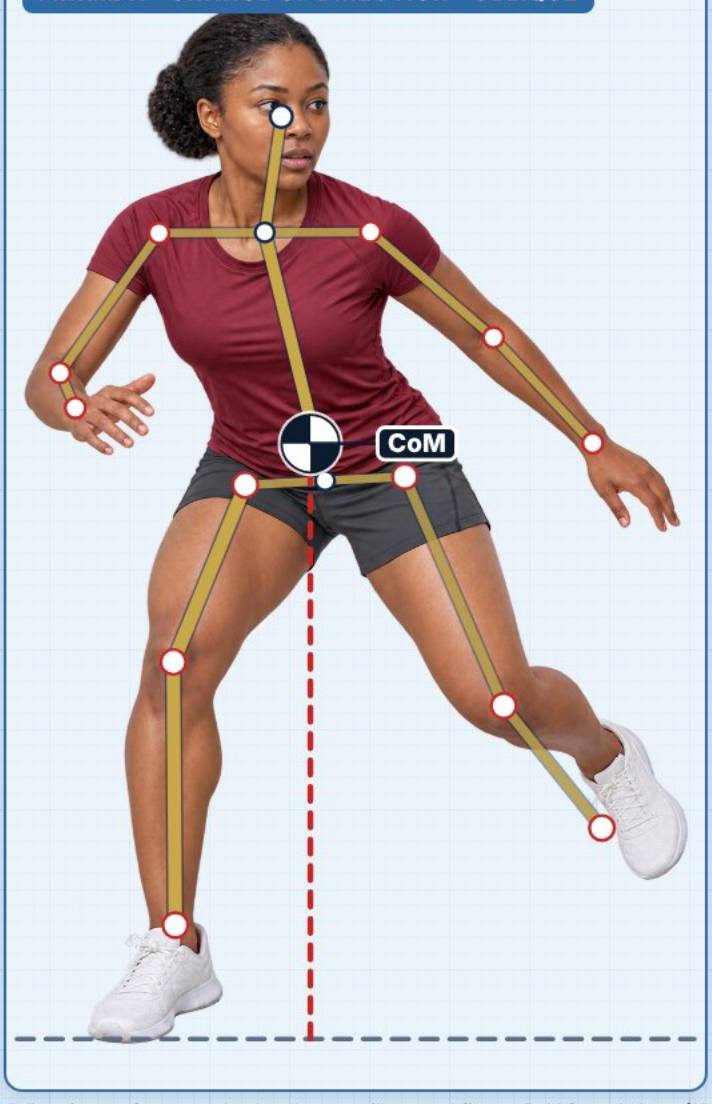
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ACL INJURY: WHAT HAPPENS DURING CUTTING AND LANDING?

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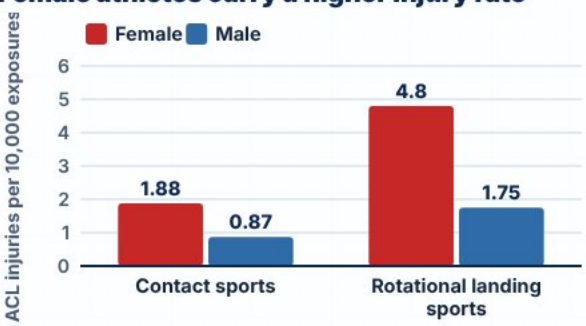
FRAME A · CHANGE OF DIRECTION · OBLIQUE



Most sport ACL tears happen without contact

- The ACL resists forward shift and rotation of the tibia under the femur.
- Injuries cluster in **cutting, landing and sudden deceleration**: a planted foot with the body moving over and past it.
- Oblique view, so angles are not measured; the overlay shows the planted base and the CoM moving away from it.

Female athletes carry a higher injury rate



Incidence rate ratios: 3.00 (contact) and 5.51 (rotational landing sports).

No CIs in abstract. Montalvo et al. (2019).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Frame A is oblique: no angles reported. Educational, not diagnostic.

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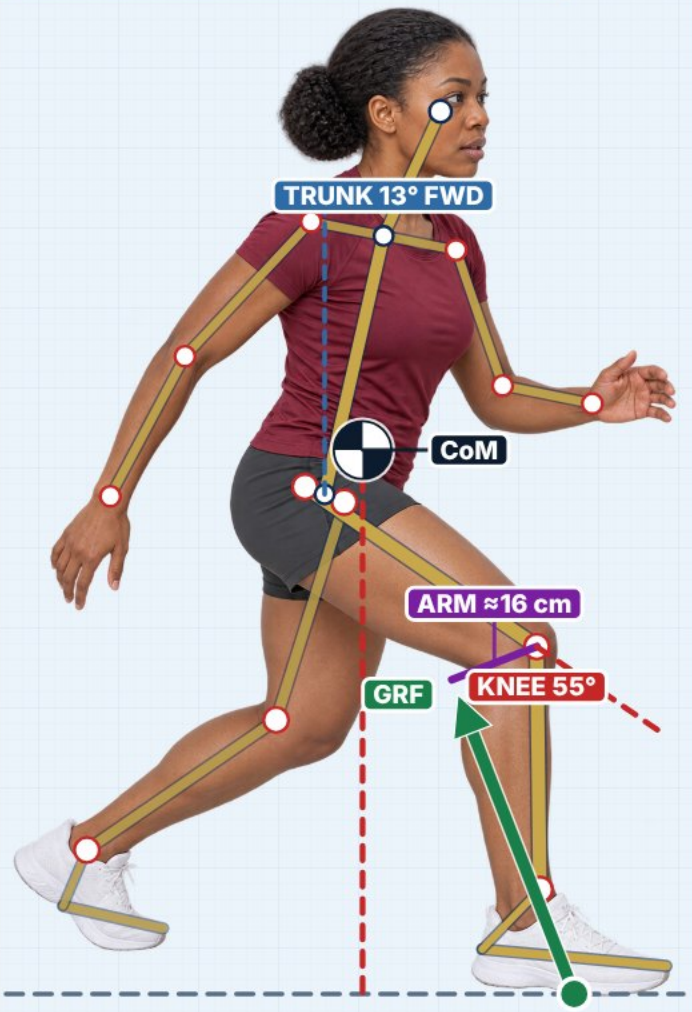
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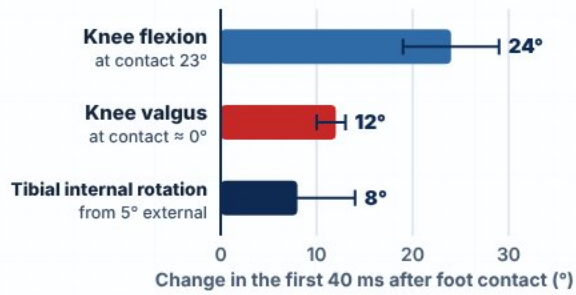
FRAME B · DECELERATION STEP · SIDE VIEW



Deceleration: braking far in front of the body

- Front knee flexed **55°**, trunk **13°** forward; the foot lands well ahead of the CoM.
- The ground force passes **≈16 cm behind the knee**: a large flexion moment the quadriceps must brake, pulling the tibia forward.
- In real injuries peak vertical force reached **3.2× body weight** about 40 ms after contact.

The first 40 ms of real ACL injuries



Injury happens faster than a voluntary correction, so preparation matters.

Mean (95% CI); video analysis of 10 non-contact injuries. Koga et al. (2010).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). GRF line drawn from contact to CoM. Educational, not diagnostic.

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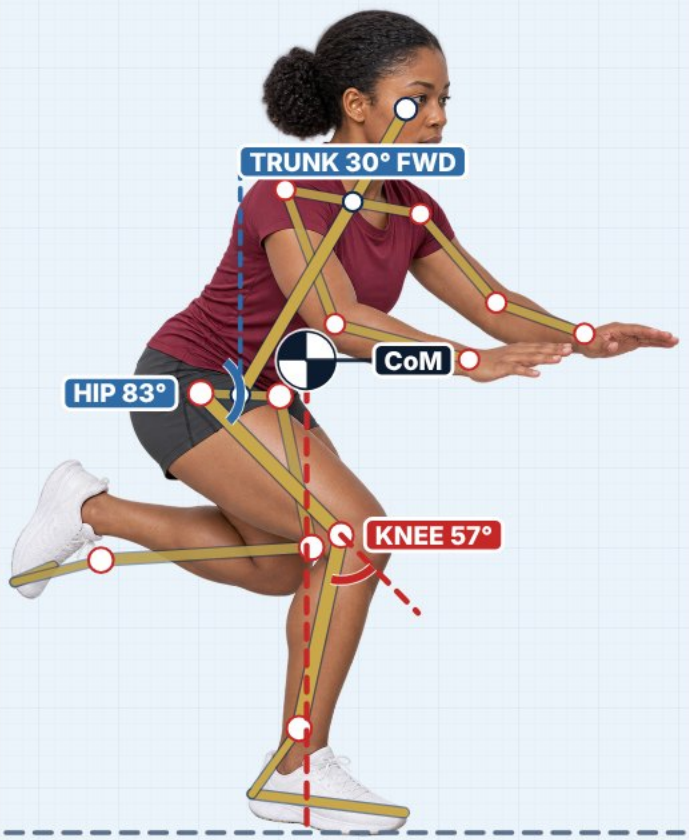
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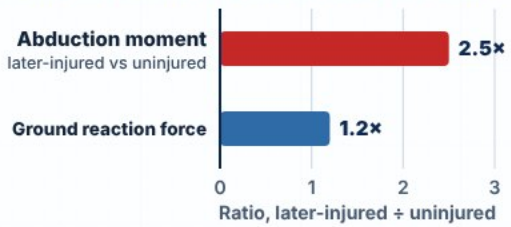
FRAME C · SINGLE-LEG LANDING · SIDE VIEW



Single-leg landing: one knee absorbs it all

- Landing knee flexed **57°**, hip **83°**, trunk **30°** forward: a flexed, hip-led landing.
- Landings that stay stiff and let the knee fall inward increase **knee abduction (valgus) moment**.
- But in 710 elite players, the drop-jump screen predicted injury poorly (AUC ≈ 0.6) (Krosshaug et al., 2016).

Landing in 9 athletes who later tore their ACL



Knee abduction angle at landing was also **8° greater**; stance time 16% shorter.

205 female athletes screened; 9 later injured. Hewett et al. (2005).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Educational, not diagnostic.

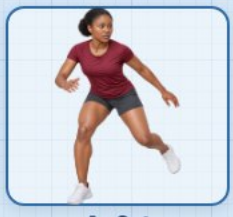
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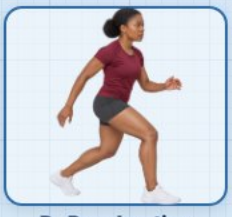
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A · Cut
Planted foot, body turning

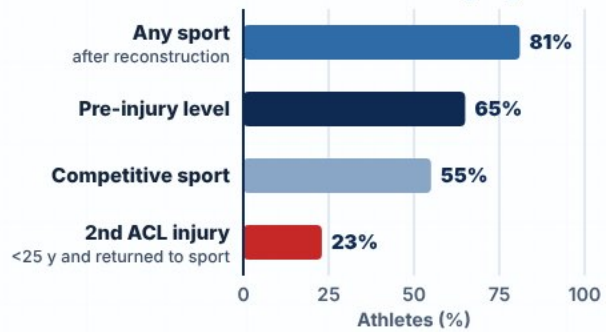


B · Deceleration
Arm ≈16 cm



C · Single-leg landing
Knee 57°

After reconstruction: return and re-injury



Return: 69 studies, 7,556 people (Ardern et al., 2014). Second injury: Wiggins et al. (2016).

Decision pathway

1. **PREVENT**
   Neuromuscular warm-ups (landing, balance, strength, plyometrics) roughly halve ACL injuries: OR 0.50; in females non-contact OR 0.33 (Webster & Hewett, 2018).
2. **TRAIN THE TASK**
   Practise soft, flexed landings and controlled deceleration steps; build hip and quadriceps strength.
3. **RETURN BY CRITERIA**
   Clear return on hop symmetry, strength and psychological readiness, not time alone. Young athletes face a high second-injury risk.

NOT RECOMMENDED

Using a single landing screen to clear or exclude an athlete (Krosshaug et al., 2016).

SEEK ASSESSMENT IF

A pop during a pivot or landing, swelling within hours, inability to keep playing, giving way, or a knee that cannot straighten.

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JUMPER'S KNEE: PAIN JUST BELOW THE KNEECAP

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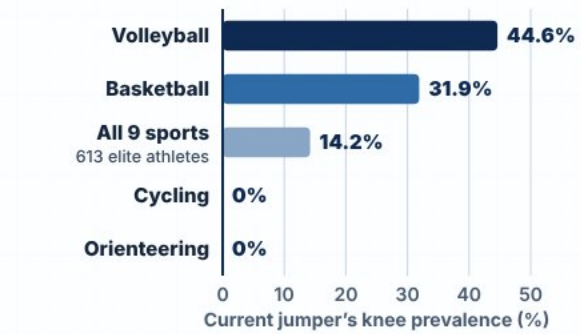
FRAME A · JUMP TAKE-OFF · SIDE VIEW



A tendon that stores and releases energy

- Pain sits at the **lower pole of the kneecap**, where the patellar tendon attaches.
- At take-off the knee is nearly extended (≈15°) after a rapid countermovement: the tendon has just loaded and recoiled.
- Energy-storage tasks — jumping, landing, cutting — provoke it; pain rises with load.

Jumping sports, not endurance sports



Symptoms had lasted **32 ± 25 months** on average.

Norwegian national-team athletes, 9 sports. Lian et al. (2005).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Educational, not diagnostic.

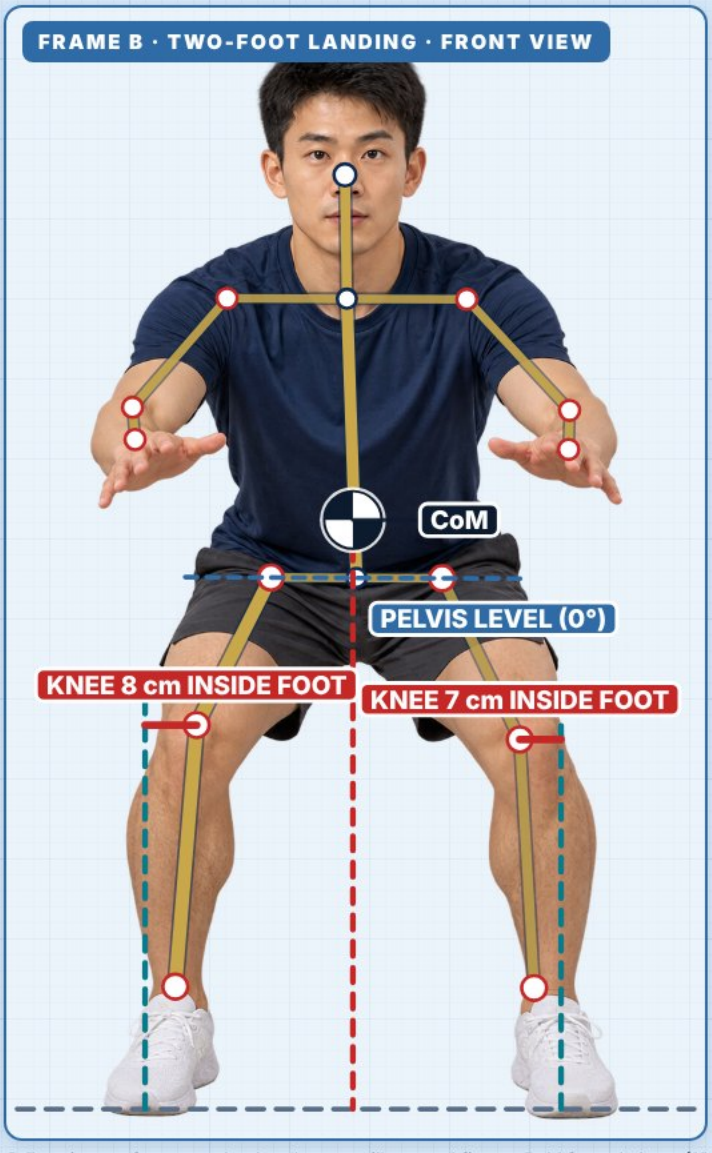
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Two-foot landing: the tendon brakes the body

- Both knees track **≈8 cm inside the feet**; pelvis level (0°).
- The quadriceps and patellar tendon work eccentrically to absorb the landing.
- Exercise choice is a **dose decision**: tendon load varies about fourfold across common tasks.

Which tasks load the patellar tendon most?



Composite of peak, rate and impulse of tendon load, healthy adults; 8 of 18 reported tasks. CMJ = countermovement jump. Scattone Silva et al. (2024).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Knee tracking distance is horizontal, knee centre to foot centre. Educational, not diagnostic.

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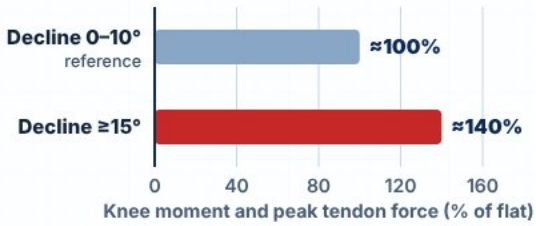
FRAME C · DECLINE SQUAT · SIDE VIEW



Decline squat: shifting load onto the knee

- Knee flexed **95°**, trunk **12°** forward; the knee sits **≈21 cm ahead of the CoM line.**
- The slope removes ankle work, so the knee extensors and tendon take a larger share.
- Hip and ankle moments fell as the decline steepened; adding 10 kg at 25° raised knee moment a further 23%.

Steeper board, more knee load



Single-leg eccentric squats, n = 5; per-angle values not reported. Zwerver et al. (2007).

Decision: the decline squat is the top-tier tendon load here — earn it, do not start with it.

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Educational, not diagnostic.

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A · Take-off
Energy release

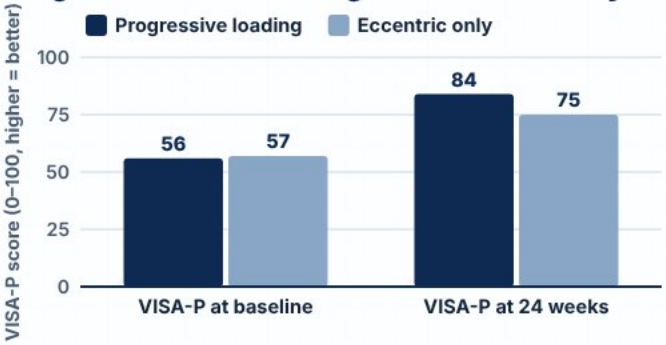


B · Landing
Eccentric braking



C · Decline squat
Knee 95°, top tier

Progressive tendon loading beat eccentric-only



76 athletes; adjusted difference 9 points (95% CI 1–16). Breda et al. (2021).

Decision pathway

1. **SETTLE**
   Keep training, lower the dose: drop the highest-index tasks; use isometric holds for short-term pain relief.
2. **LOAD**
   Progress isometric → heavy slow strength → energy storage (jumps, landings) → sport, using the loading-index ladder.
3. **RETURN**
   Re-introduce jumping volume gradually and track pain the next morning. Rest alone rarely resolves it.

NOT RECOMMENDED

Relying on rest or passive treatment alone; starting rehab with decline squats.

SEEK ASSESSMENT IF

A pop with inability to straighten the knee against gravity, marked joint swelling or locking, or tibial-tubercle pain in a growing child.

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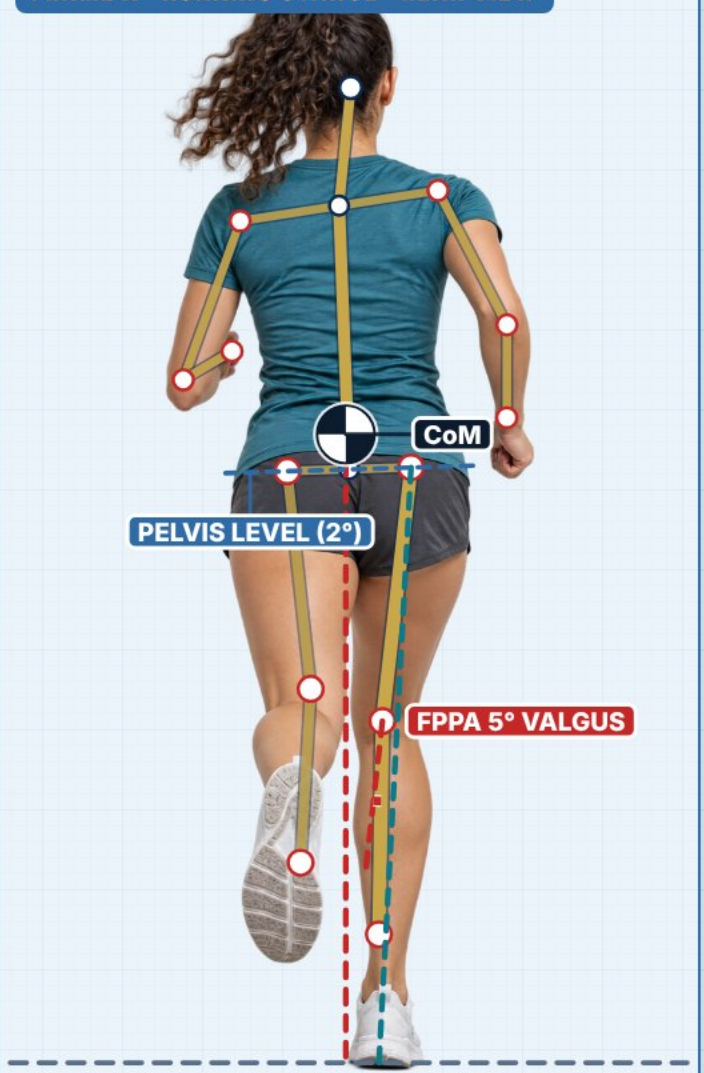
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INTEGRATING PERFORMANCE & REHABILITATION HEALTHCARE PATHWAYS.

IT BAND SYNDROME: PAIN ON THE OUTSIDE OF THE KNEE

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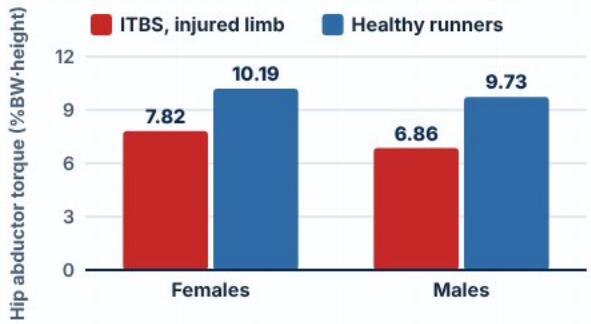
FRAME A · RUNNING STANCE · REAR VIEW



Lateral knee pain from repeated bending

- Sharp or burning pain over the **lateral femoral epicondyle**, provoked by repetitive flexion–extension in running or cycling.
- Rear view, stance leg: pelvis level (2°), knee 5° inside the hip–ankle line.
- The only prospective study found more **hip adduction and knee internal rotation** in runners who went on to develop ITBS (Noehren et al., 2007).

Weaker hip abductors on the painful side



After 6 weeks of hip abductor training, 22 of 24 returned to pain-free running (uncontrolled).

24 runners with ITBS vs 30 controls. Fredericson et al. (2000).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Frontal angle from the rear view. Educational, not diagnostic.

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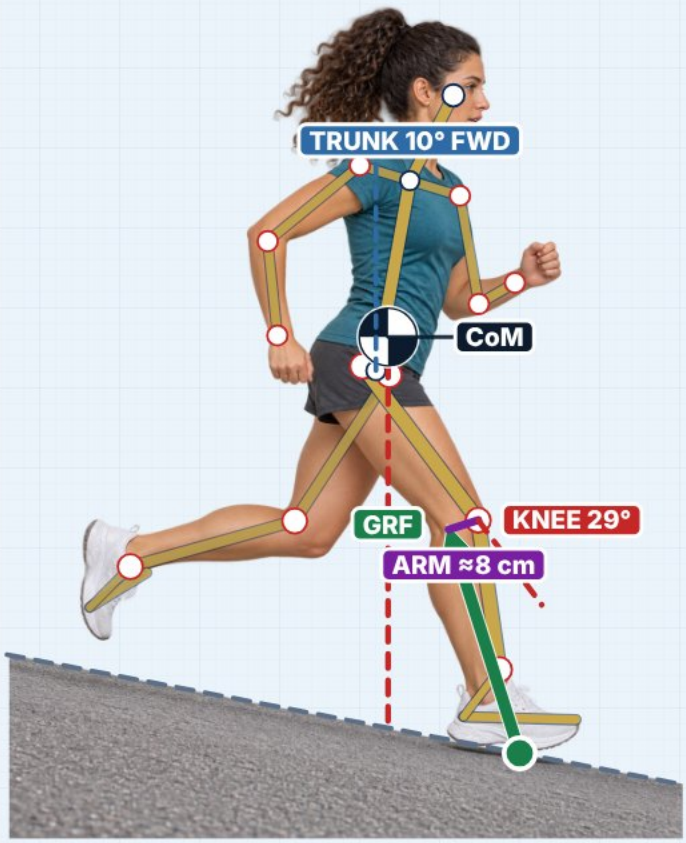
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FRAME B · DOWNHILL RUNNING · SIDE VIEW



Downhill: the knee lands straighter

- Stance knee **29°** at this frame, ground force ≈8 cm behind the knee.
- The band is thought to compress over the epicondyle near **20–30° of flexion**; injured runners touched down at **21.4° ± 4.3°** (Orchard et al., 1996).
- Landing straighter on slopes means early stance passes through that zone under load.

Steeper downhill, straighter landing



Means of 6 trained runners. Sundström et al. (2021).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). GRF line from contact to CoM; ground drawn along the slope. Educational, not diagnostic.

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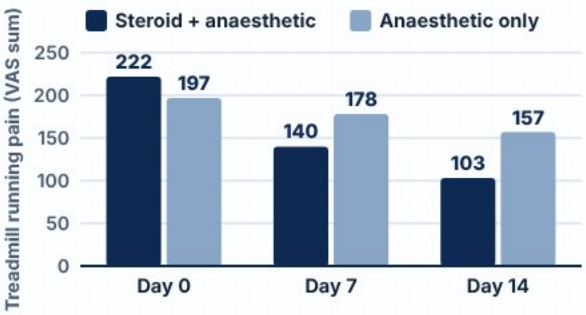
FRAME C · STATIONARY CYCLING · SIDE VIEW



Cycling: thousands of cycles through the zone

- Knees at **73°** and **78°** mid-stroke; each revolution sweeps the knee through the 20–30° range near the bottom.
- Saddle height sets the bottom-of-stroke angle: a **5% change altered knee kinematics by 35%** and knee moments by 16% (Bini et al., 2011).
- Set the saddle so the knee is flexed about **25–30°** at the bottom of the stroke.

A steroid injection helps short term (small trial)



Greater pain drop with steroid from day 7 to 14 ($p = 0.01$).

Recent-onset ITBS, n = 9 per group. Gunter & Schwellnus (2004).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Educational, not diagnostic.

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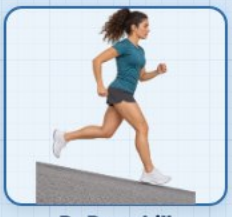
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A · Rear view
Pelvis and knee line



B · Downhill
Knee 29° in stance



C · Cycling
Saddle sets the angle

Where the knee is when it hurts



Downhill running and low saddles keep the knee near this zone

Kinematics of 9 ITBS runners plus 11 cadaver knees. Orchard et al. (1996).

Decision pathway

1. **MODIFY LOAD**
   Cut downhill running and the provoking volume for a while; cyclists check saddle height and cleat set-up.
2. **STRENGTHEN**
   Progressive hip abductor strengthening, then return running on the flat before slopes.
3. **ESCALATE**
   Persistent cases: a corticosteroid injection may ease pain in the first 2 weeks; surgery only for refractory cases.

NOT RECOMMENDED

Promising that "fixing hip alignment" will cure it — kinematic differences are small and inconsistent (Aderem & Louw, 2015).

SEEK ASSESSMENT IF

Joint swelling, locking or giving way, pain after a fall or twist, bony tenderness, or night pain unrelated to activity.

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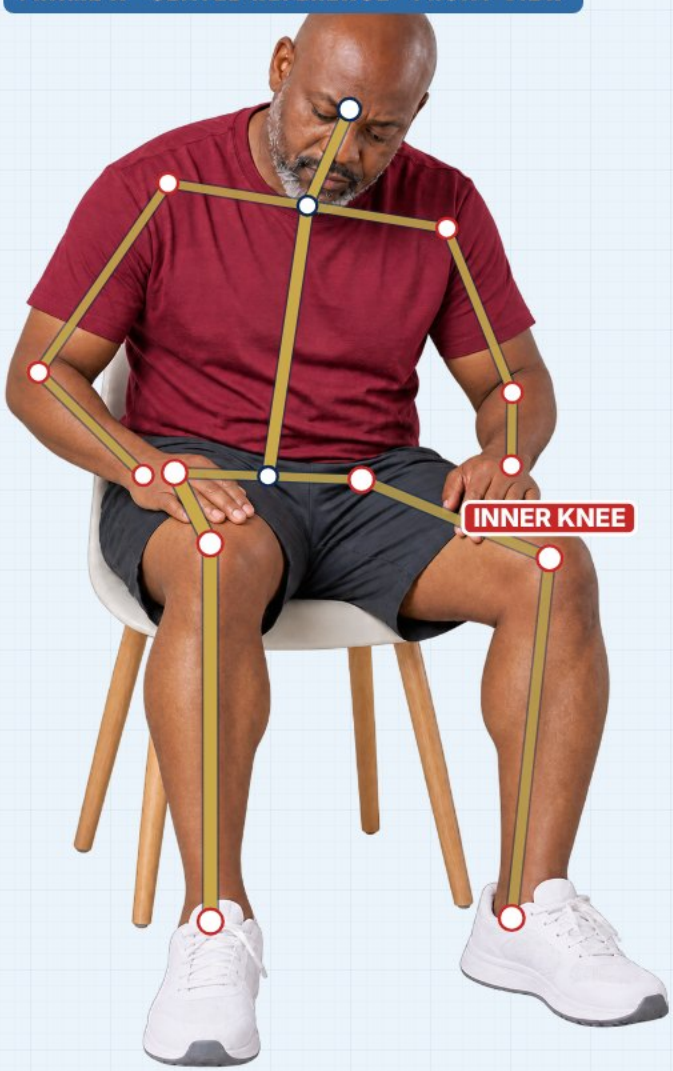
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INNER KNEE PAIN: WHY THE LOCATION MATTERS

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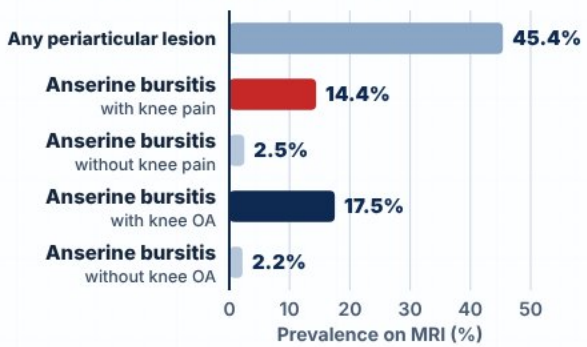
FRAME A · SEATED REFERENCE · FRONT VIEW



A location, not a diagnosis

- Inner knee pain can come from **medial osteoarthritis**, a **medial meniscal tear**, the **MCL**, or **pes anserine** bursitis or tendinopathy.
- Where exactly it hurts (joint line vs just below it on the tibia), how it started (twist vs gradual) and what provokes it narrow the list.
- Seated reference view: the skeleton shows the inner aspect of the knee being palpated.

Not all inner-knee pain is the joint



Population MRI study, n = 348, middle-aged and older adults. Kim et al. (2016).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Frame A is a reference view: no angles reported. Educational, not diagnostic.

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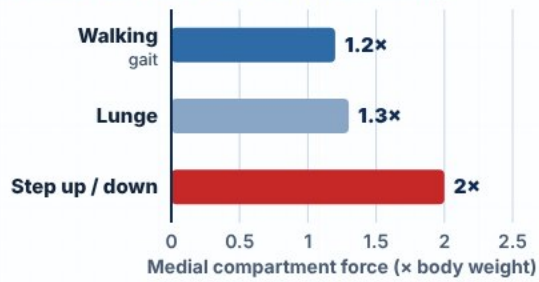
FRAME B · STEP-UP · SIDE VIEW



Step-up: the inner compartment works hardest

- Lead knee flexed **70°** and **≈18 cm ahead of the CoM line**; trunk 13° forward.
- In an instrumented knee the medial side carried **53–60%** of total force at peak load across walking, stepping, kneeling and lunging.
- Step height is a dose dial for medial load.

Medial force: step-up ≈ 1.7× walking



One instrumented knee replacement, at maximum load. Zhao et al. (2007).

Decision: if step-ups provoke medial pain, lower the step before removing the exercise.

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Educational, not diagnostic.

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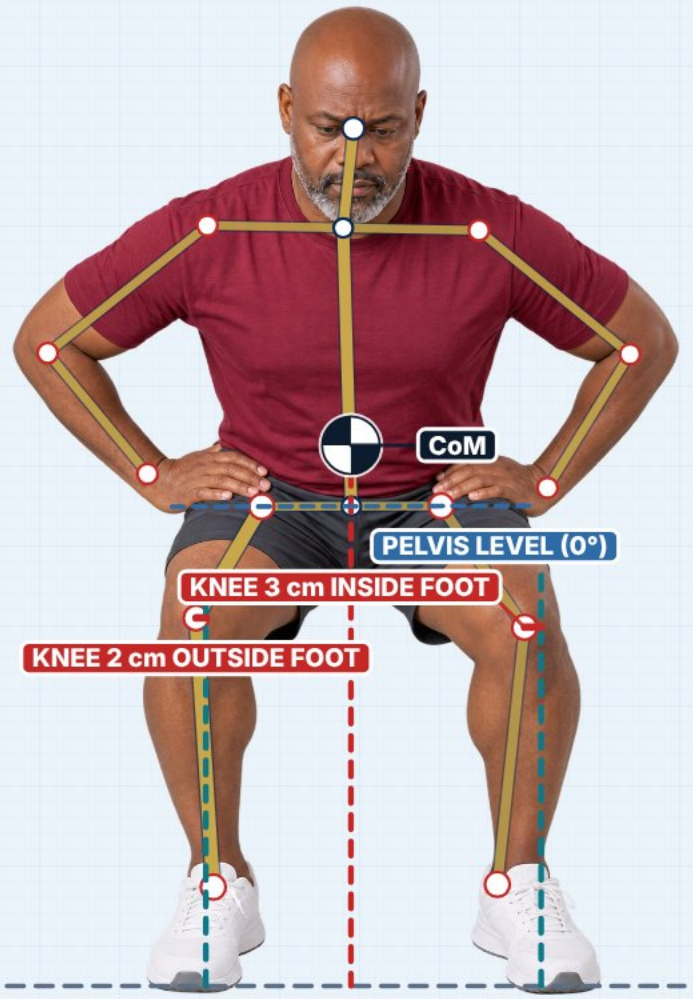
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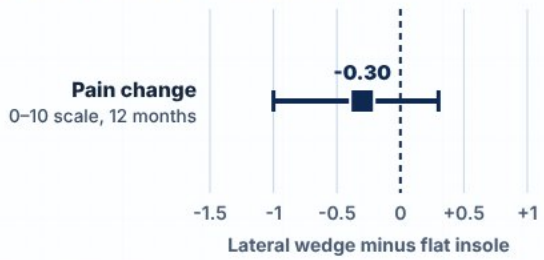
FRAME C · SHALLOW SQUAT · FRONT VIEW



Shallow squat: watch the knee over the foot

- Left knee ≈3 cm inside and right knee ≈2 cm outside the foot centre: near-neutral tracking; pelvis level.
- In medial knee OA, a higher **knee adduction moment** in walking was linked to faster radiographic progression (Miyazaki et al., 2002).
- A lateral wedge insole aims to reduce that moment, but it did not reduce pain over a year.

Wedge insoles: no pain benefit



Confidence interval crosses zero: no meaningful effect.

RCT, 200 people with medial knee OA. Bennell et al. (2011).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Knee tracking distance is horizontal, knee centre to foot centre. Educational, not diagnostic.

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A · Location
Joint line or below?

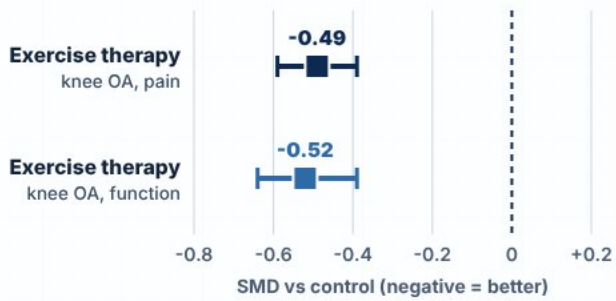


B · Step-up
Medial load 2.0×BW



C · Shallow squat
Knee over foot

Exercise is the first-line treatment



Cochrane review, 44 trials. Fransen et al. (2015).

Decision pathway

1. **LOCATE**
   Joint line pain after a twist suggests meniscus; just below the joint line on the tibia suggests pes anserine; gradual pain with stiffness suggests OA.
2. **MATCH THE PLAN**
   OA: exercise and weight management. Degenerative tear: exercise first (Kise et al., 2016). Pes anserine: load change and progressive strengthening.
3. **DOSE THE TASK**
   Adjust step height, squat depth and volume; progress as symptoms allow.

NOT RECOMMENDED

Lateral wedge insoles for medial OA pain; arthroscopy for degenerative knee disease (Siemieniuk et al., 2017).

SEEK ASSESSMENT IF

Pain after a valgus blow or twist with instability, marked swelling or inability to bear weight; a locked knee; a hot, red, swollen knee or fever.

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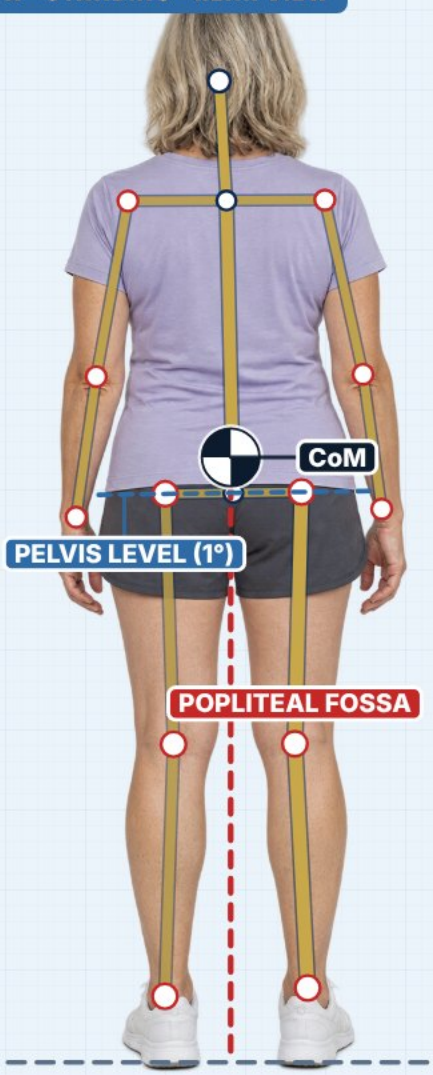
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PAIN BEHIND THE KNEE: COULD IT BE A BAKER'S CYST?

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FRAME A · STANDING · REAR VIEW



A cyst is usually a sign of a joint problem

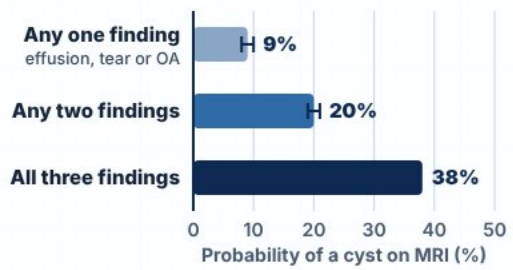
4.7%
had a popliteal cyst on MRI (1,001 knee patients)

94%
of those cysts had another joint lesion, most often meniscal

What Frame A shows

- Quiet standing: both knees straight, pelvis level (1°), CoM centred between the feet.
- A Baker's cyst bulges in the **popliteal fossa**, from the bursa between the medial gastrocnemius and semimembranosus.
- In adults it usually connects with the joint and fills from it, so the cause sits **inside the knee.**

The more the joint is affected, the likelier the cyst



Ranges as reported; 400 knee MRI reports. Miller et al. (1996). Prevalence: Sansone et al. (1995).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Educational, not diagnostic.

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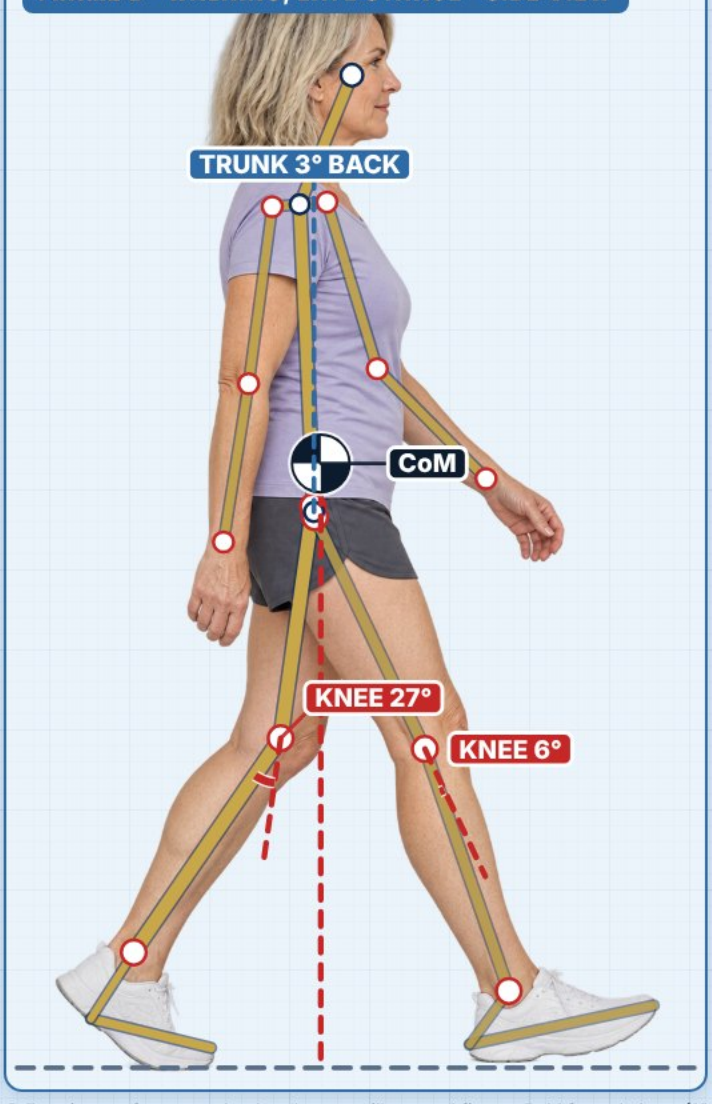
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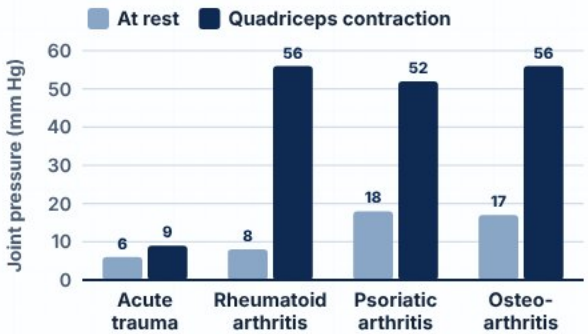
FRAME B · WALKING, LATE STANCE · SIDE VIEW



Walking: extension and flexion cycle the back of the knee

- Front knee nearly straight at contact (**6°**); trailing knee flexed **27°** as it prepares to swing.
- A proposed one-way valve between joint and bursa lets fluid pass in **flexion** and closes in **extension** (Frush & Noyes, 2015).
- With an effusion, quadriceps contraction drives joint pressure up sharply, pushing fluid toward the bursa.

Quadriceps contraction raises pressure in an effused knee



The rise grew with effusion volume (r = 0.45).

Central values; 33 patients with effusions. Jawed et al. (1997).

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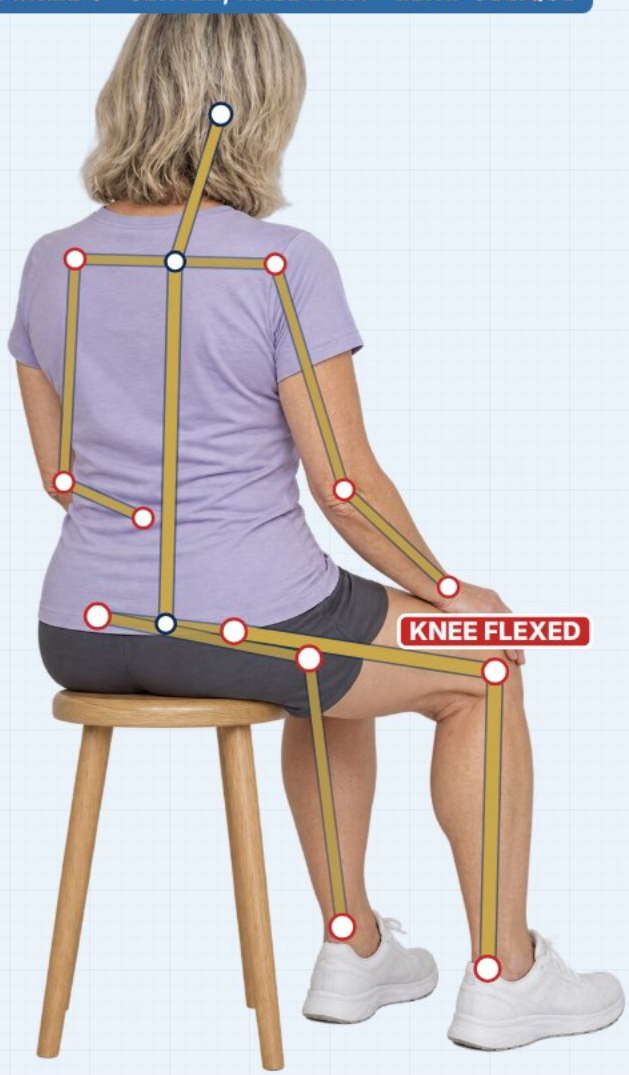
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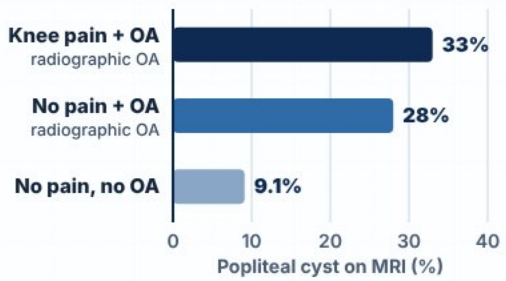
FRAME C · SEATED, KNEE BENT · REAR-OBLIQUE



Sitting with the knee bent: fullness and tightness

- Oblique view, so angles are not measured. Sustained knee flexion is often where people notice fullness behind the knee.
- In older adults, cysts were as common in painless OA knees as in painful ones: the cyst marks **joint disease**, not necessarily the pain source.
- Ultrasound found cysts in **19.8%** of painful knees versus **3.0%** of controls (Labropoulos et al., 2004).

Cysts follow osteoarthritis, with or without pain



Older adults, mean age 67; n = 381 / 52 / 25. Hill et al. (2001).

Decision: find and treat the joint problem; the cyst usually follows it.

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Frame C is oblique: no angles reported. Educational, not diagnostic.

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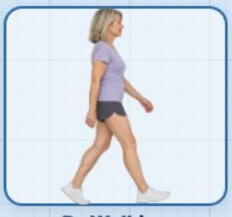
INTEGRATING PERFORMANCE & REHABILITATION HEALTHCARE PATHWAYS.

PAIN BEHIND THE KNEE: COULD IT BE A BAKER'S CYST?

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A · Standing
Popliteal fossa

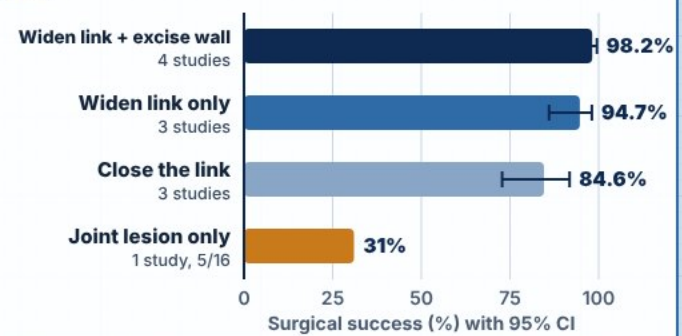


B · Walking
Knees 6° and 27°



C · Seated
Sustained flexion

When surgery is needed, address the joint–cyst link



Retrospective case series only; mean follow-up ≈25 months. Zhou et al. (2016).

Decision pathway

1. **SCREEN**
   Calf pain, swelling, redness or warmth needs an ultrasound: a ruptured cyst can mimic a deep-vein clot, and the two can coexist.
2. **TREAT THE KNEE**
   At least 6 weeks of non-operative care keeping knee movement; a joint injection can shrink the cyst. Manage the effusion, meniscus or OA behind it.
3. **ESCALATE**
   Persistent cases: arthroscopy for the joint cause first; excision only for large, highly symptomatic cysts or nerve/vessel compression.

NOT RECOMMENDED

Removing the cyst alone without treating the joint problem (high recurrence historically).

SEEK ASSESSMENT IF

Sudden calf swelling or redness, a tense, very painful calf, numbness or a cold, pale foot — urgent same-day assessment.

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Analysis: MMSx Authority Applied Biomechanics Lab · Dr. Neeraj Mehta, PhD · Educational content, not a diagnosis.

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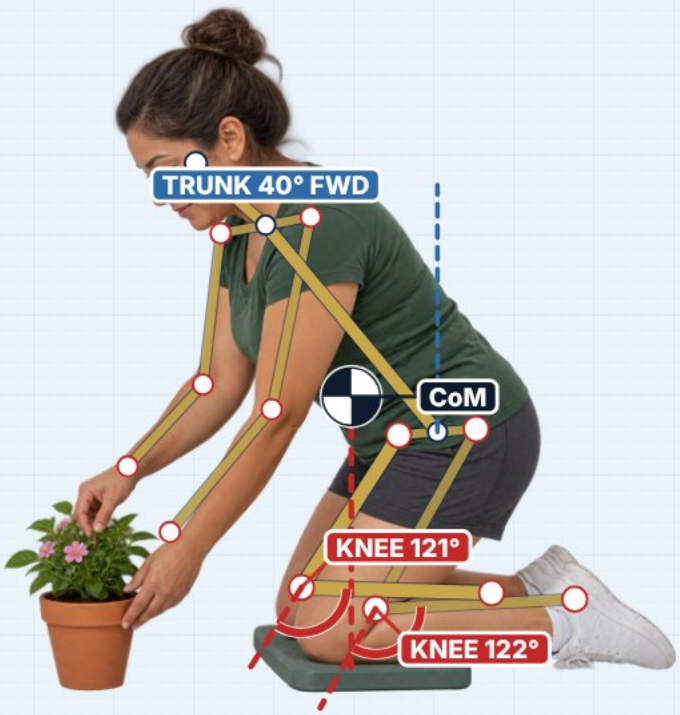
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INTEGRATING PERFORMANCE & REHABILITATION HEALTHCARE PATHWAYS.

KNEE PAIN WHEN KNEELING: UNDERSTANDING PREPATELLAR BURSITIS

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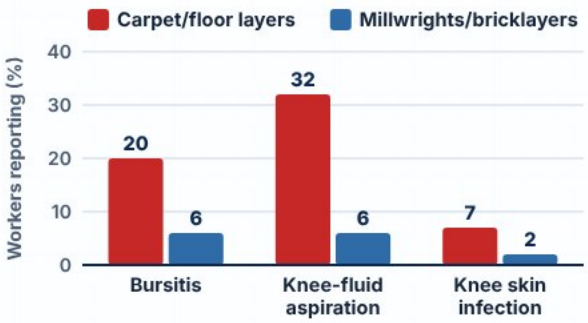
FRAME A · KNEELING GARDENING · SIDE VIEW



Pressure and friction over the kneecap

- Both knees deeply flexed (≈121°), trunk 40° forward over the bed: body weight rests on the front of the knees.
- The prepatellar bursa sits between the skin and the kneecap; repeated pressure or a blow can inflame it.
- About **one in three** cases is infected (septic), usually through a break in the skin.

Kneeling trades: more bursitis



Using a knee-kicker was the only significant predictor of bursitis.

Self-report, 112 vs 243 workers; cross-sectional. Thun et al. (1987). Septic share: Baumbach et al. (2014).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Feet not shown in the overlay while kneeling. Educational, not diagnostic.

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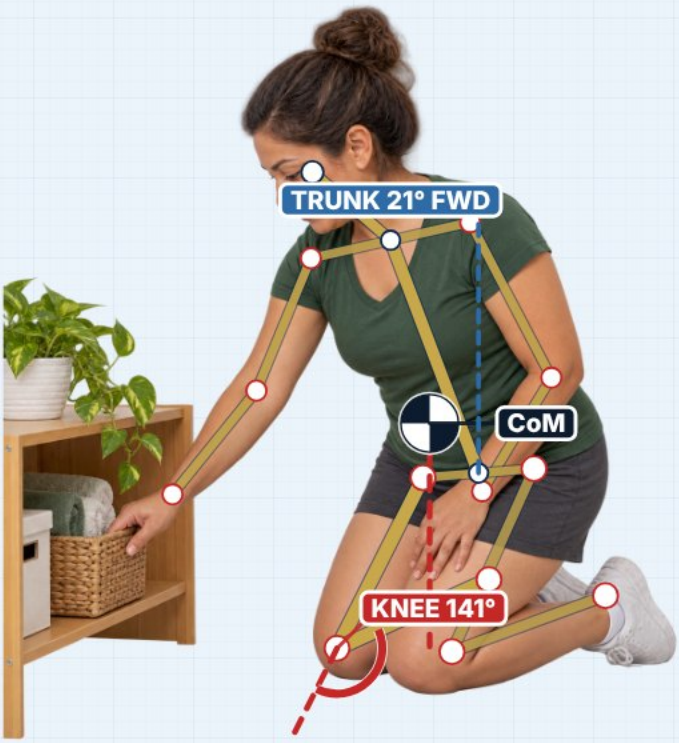
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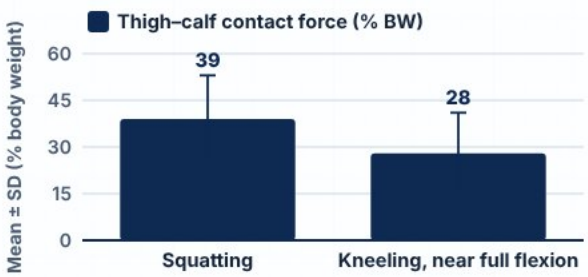
FRAME B · KNEELING AT A LOW SHELF · SIDE VIEW



Where kneeling pressure actually lands

- Knee flexed **≈141°**, sitting back toward the heels; trunk 21° forward.
- More than **60%** of kneeling pressure passed through the **patellar tendon and tibial tubercle**, not the kneecap itself.
- Peak tendon/tubercle pressure exceeded 25 psi in every posture; kneepads cut peak pressure and its variability but did not remove it.

Deep flexion: soft-tissue contact carries load



Kneeling near 90° flexion was the least hazardous loading posture tested.

10 adults, simulated low-height work. Moore et al. (2011); Porter et al. (2010); Gallagher et al. (2010).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Feet not shown in the overlay while kneeling. Educational, not diagnostic.

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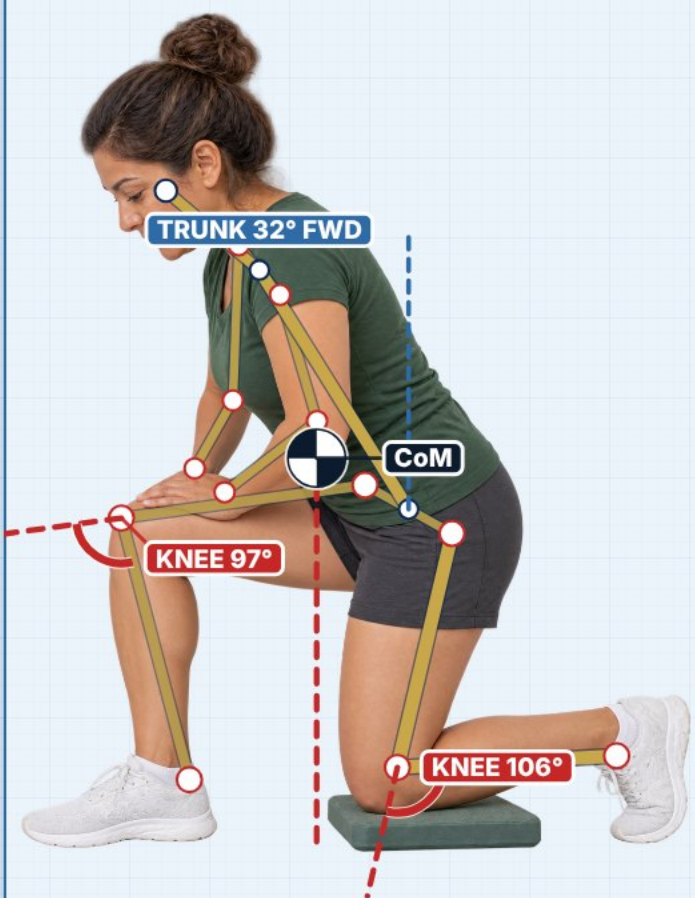
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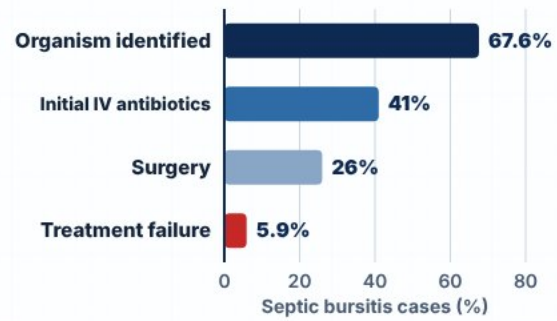
FRAME C · HALF-KNEELING RISE · SIDE VIEW



Half-kneeling rise: one knee on the ground

- Front knee ≈97°, kneeling knee ≈106°; trunk 32° forward as she pushes up.
- One-knee kneeling increased shear loading compared with kneeling on both knees (Gallagher et al., 2010).
- Most infected bursitis is managed without an operation.

Septic bursitis: how it is managed



272 cases, olecranon and prepatellar, multicentre. Bart et al. (2021).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Feet not shown in the overlay while kneeling. Educational, not diagnostic.

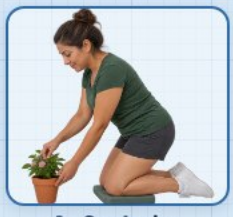
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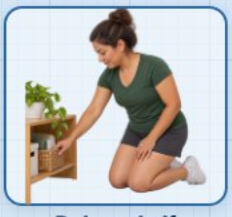
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A · Gardening
Both knees loaded

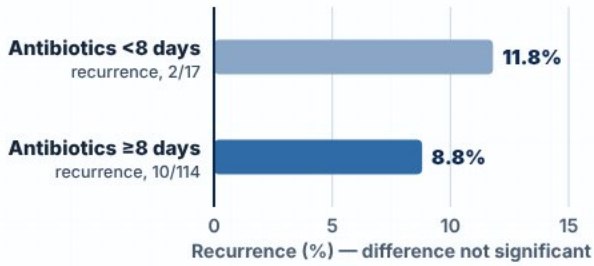


B · Low shelf
>60% via tendon/tubercle



C · Half-kneel
One-knee shear

Antibiotic duration and recurrence



Systematic review, 10 studies, 702 patients; OR 0.66 (0.13–3.29). Brown et al. (2022).

Decision pathway

1. **PROTECT**
   Reduce kneeling time, use kneepads or a cushion, and kneel near 90° rather than on one knee; never strike with the knee.
2. **SETTLE**
   Non-infected bursitis: rest from pressure, ice, compression, anti-inflammatories; aspiration if large.
3. **TREAT INFECTION**
   Suspected infection needs aspiration and antibiotics; steroid injection only once infection is excluded.

NOT RECOMMENDED

Immediate routine bursectomy for septic bursitis; steroid injection into a possibly infected bursa (Baumbach et al., 2014).

SEEK ASSESSMENT IF

Fever above 37.8 °C, spreading redness, a hot bursa, a cut or graze over the kneecap, diabetes or reduced immunity, or swelling extending into the joint.

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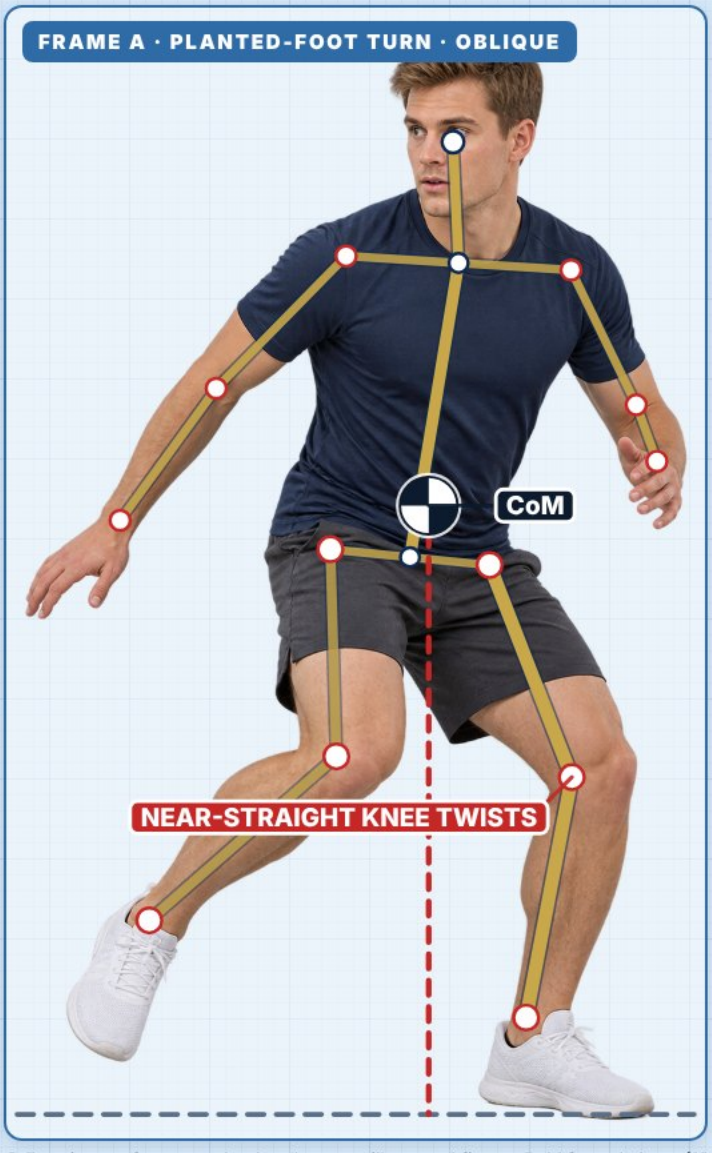
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KNEECAP INSTABILITY: WHEN THE KNEECAP FEELS LIKE IT SLIPS

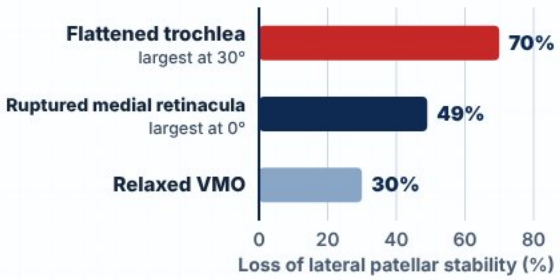
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Twisting on a planted foot, knee near straight

- Oblique view, so angles are not measured; the body turns over a fixed foot with the knee only slightly bent.
- Near extension the kneecap has not yet seated deep in its groove, so it relies on soft tissues and **groove shape**.
- The pull of the quadriceps then tends to draw it **outward**.

What holds the kneecap in? Bone shape matters most



8 cadaver knees, quadriceps tensed to 175 N. Senavongse & Amis (2005).

First-time dislocations

23.2
per 100,000 person-years overall

147.7
per 100,000 at age 14–18

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Frame A is oblique: no angles reported. Educational, not diagnostic.

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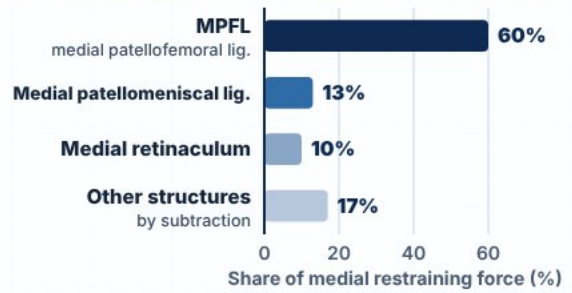
FRAME B · DANCE TURN · OBLIQUE



Dance turn: rotation on a loaded leg

- Oblique view, so angles are not measured; the stance leg pivots while the trunk spins.
- The **MPFL** is the main soft-tissue check against the kneecap sliding out; it is the ligament usually torn in a dislocation.
- Turning drills can be re-introduced once strength and control return.

The MPFL does most of the soft-tissue work



9 cadaver knees. Desio et al. (1998).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Frame B is oblique: no angles reported. Educational, not diagnostic.

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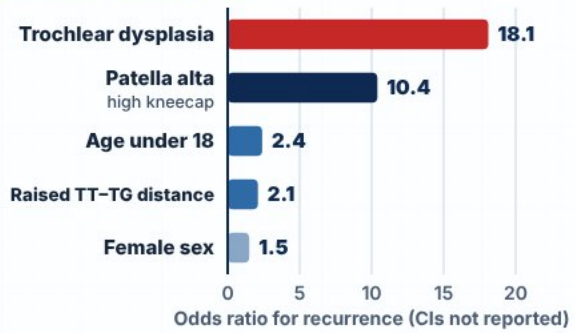
FRAME C · SEATED AFTER AN EPISODE · OBLIQUE



After an episode: will it happen again?

- Supporting the knee in slight flexion after an episode is common; large rapid swelling needs assessment.
- Over 20 years, **36%** had another dislocation on the same side and 5.4% on the other side.
- Bony anatomy — a shallow groove or a high kneecap — carried the highest recurrence risk.

Who dislocates again?



584 people after a first dislocation, mean 12.4-year follow-up. Christensen et al. (2017).

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KNEECAP INSTABILITY: WHEN THE KNEECAP FEELS LIKE IT SLIPS

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A · Planted turn
Near-straight twist

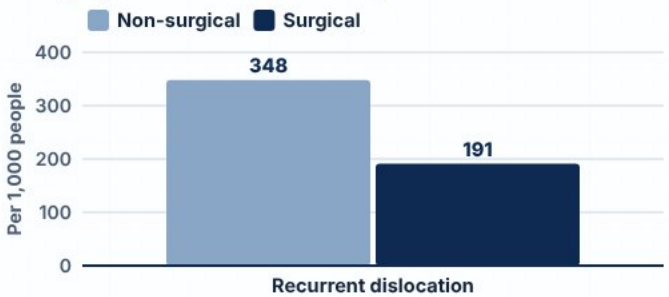


B · Dance turn
MPFL check



C · After
Recurrence risk

Surgery reduces recurrence; function similar



8 studies, 438 people; function +5.73 (−2.91 to 14.37); low to very low certainty. Smith et al. (2023).

Decision pathway

1. **ASSESS RISK**
   Check for trochlear dysplasia, patella alta, age under 18 and TT–TG distance: they drive recurrence.
2. **REHABILITATE**
   Quadriceps (including VMO) and hip control, then graded return to turning and cutting.
3. **CONSIDER SURGERY**
   Recurrent instability or high-risk anatomy: discuss stabilisation such as MPFL reconstruction.

NOT RECOMMENDED

Assuming every first dislocation needs surgery — or that exercise alone fixes severe groove dysplasia.

SEEK ASSESSMENT IF

A kneecap that stays out of place, large rapid swelling, locking or a loose-body feeling, or inability to straighten or bear weight.

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MCL INJURY: WHEN SIDEWAYS FORCE STRESSES THE KNEE

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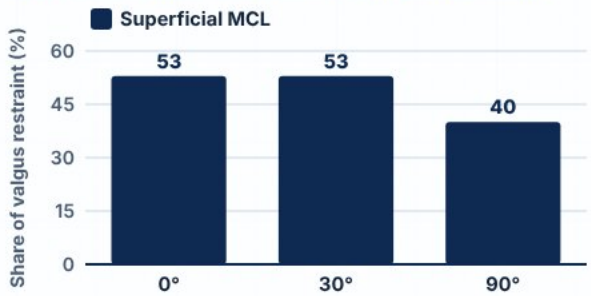
FRAME A · SIDE CONTACT · FRONT VIEW



A blow to the outside pushes the knee inward

- A tackle to the outside of the knee drives it into **valgus**, stretching the ligament complex on the inner side.
- The **superficial MCL** is the primary restraint; near extension the posterior oblique ligament and capsule add about 16%.
- About **70%** of MCL injuries in elite football are contact-related.

Superficial MCL: the main valgus restraint



Values are midpoints of the reported ranges (51–55% at 0° and 30°; ≈40% at 90°).

Robotic testing, 12 cadaver knees. Ball et al. (2020).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Front views: segments and CoM only; no knee angles reported. Educational, not diagnostic.

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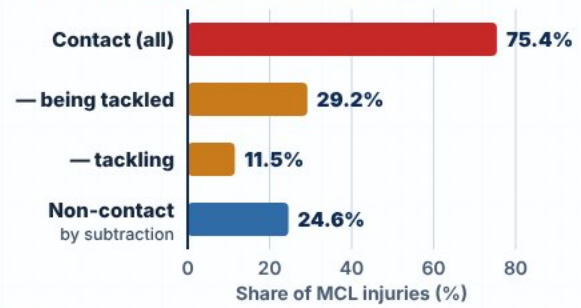
FRAME B · PLANTED LATERAL MOVE · FRONT VIEW



Planted lateral move: valgus without contact

- Planted leg loaded while the trunk leans 12° to the side and the pelvis tilts 7°.
- Pushing off sideways on a planted foot can load the inner knee even without a tackle.
- Injury rate in matches was about **9×** that in training (1.31 vs 0.14 per 1,000 h).

How MCL injuries happen in football



130 MCL injuries, male professional football. Lundblad et al. (2019). Rates: Lundblad et al. (2013).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Front views: segments and CoM only; no knee angles reported. Educational, not diagnostic.

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INTEGRATING PERFORMANCE & REHABILITATION HEALTHCARE PATHWAYS.

MCL INJURY: WHEN SIDEWAYS FORCE STRESSES THE KNEE

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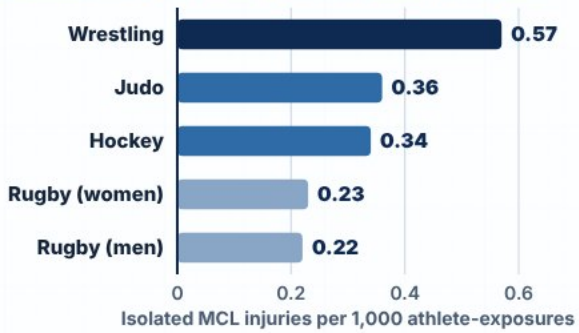
FRAME C · SEATED AFTER THE INCIDENT · FRONT VIEW



After the incident: pain on the inner side

- Tenderness along the inner knee, with pain on sideways stress, is the typical picture.
- Grade I is a stretch, grade II a partial tear and grade III a complete tear; clinical and MRI grading agreed in 92%.
- About **12%** had other injuries too, such as the medial meniscus or cartilage.

Contact and grappling sports carry the risk



US Military Academy cohort, 2005–2009. Roach et al. (2014).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Frame C is a reference view: no angles reported. Educational, not diagnostic.

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A · Contact
Blow to outer knee

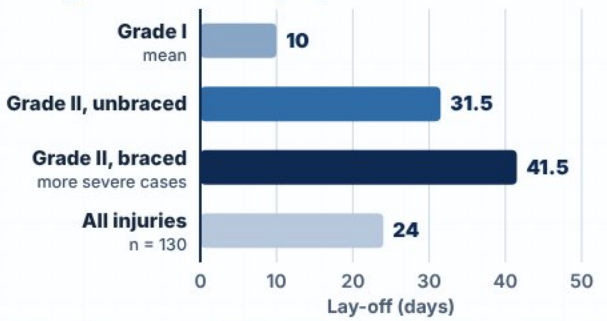


B · Lateral move
Planted valgus



C · After
Grade the injury

Grade guides return to play



Male professional football; braced cases likely more severe (observational). Lundblad et al. (2019).

Decision pathway

1. **GRADE IT**
   Examine for laxity at 0° and 30° of bend; laxity in full extension suggests the posteromedial corner is involved.
2. **REHABILITATE**
   Grade I–II: weight-bear as tolerated, progressive range, strength, running and agility; return usually in 3–12 weeks.
3. **ESCALATE**
   Combined ACL + MCL injuries need specialist care: untreated MCL laxity raised ACL graft revision risk.

NOT RECOMMENDED

Prolonged full immobilisation — it did not improve stability and reduced quadriceps muscle (Svantesson et al., 2024).

SEEK ASSESSMENT IF

A pop with rapid swelling, inability to bear weight, gross instability, giving way on turning, or locking.

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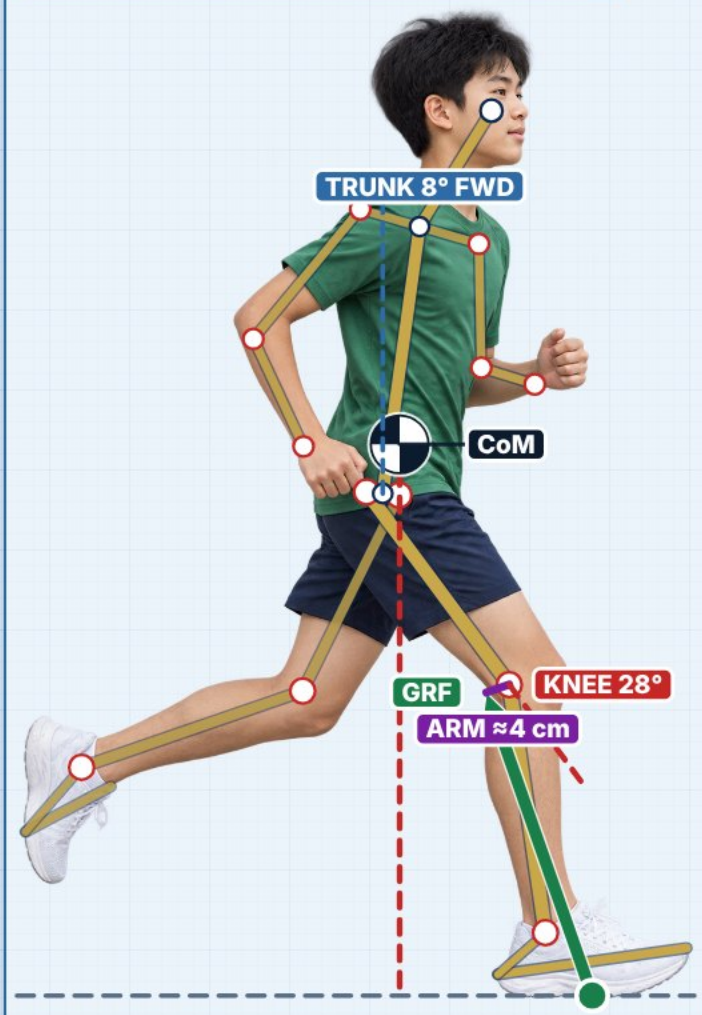
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OSGOOD–SCHLATTER DISEASE: KNEE PAIN IN GROWING ATHLETES

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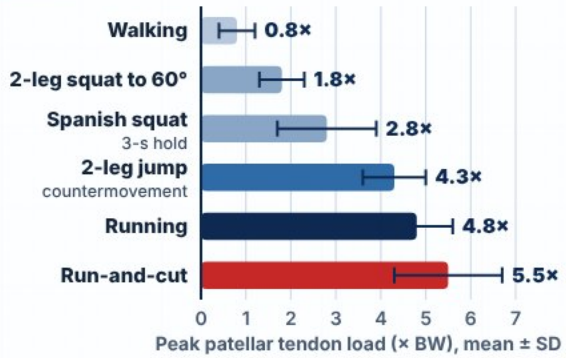
FRAME A · ADOLESCENT RUNNING · SIDE VIEW



A tendon pulling on a growing bone

- The patellar tendon pulls on the **tibial tubercle**, a growth area that is still soft in adolescents.
- In running stance the knee bends about 28° under load, and each stride tugs on the tubercle.
- Running and cutting load the tendon about **5–6× body weight** — the highest of these tasks.

Running and cutting pull hardest on the tendon



20 healthy adults: shows relative ranking, not adolescent tubercle stress. Scattone Silva et al. (2024).

Common in active adolescents

9.8% of 956 adolescents aged 12–15

1.94× odds with regular sport participation

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). GRF line from contact to CoM. Educational, not diagnostic.

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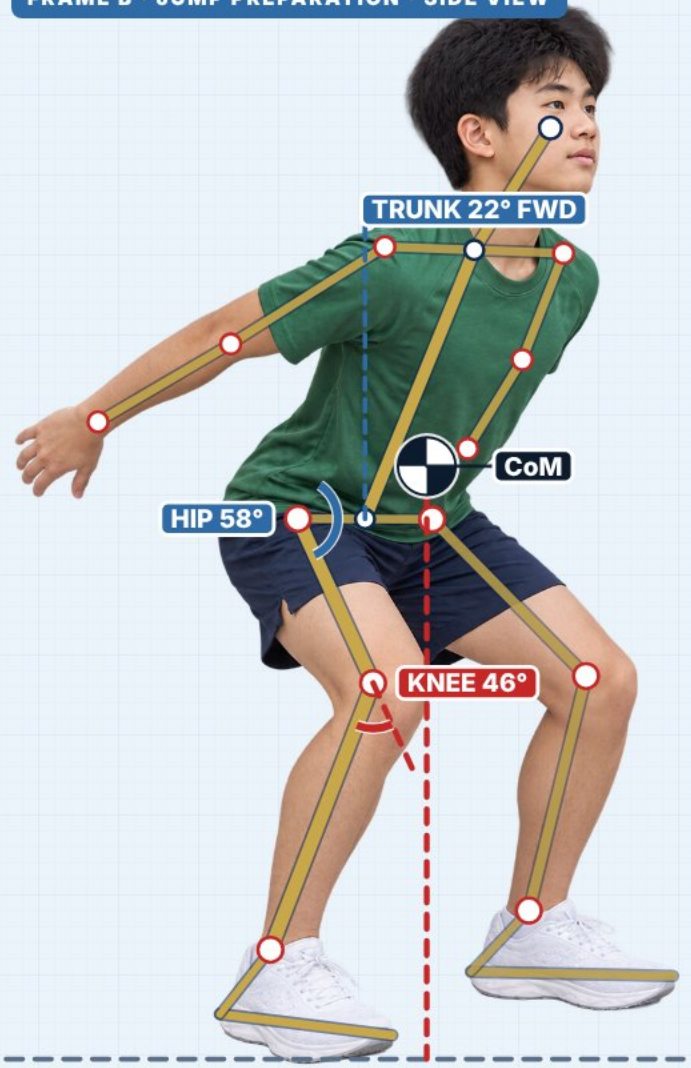
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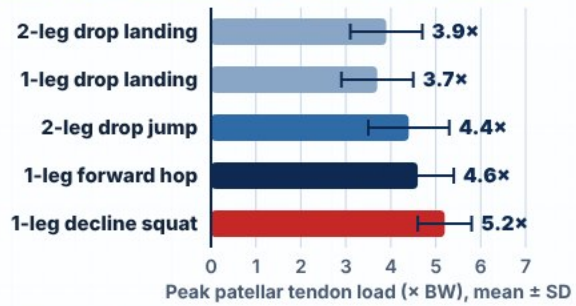
FRAME B · JUMP PREPARATION · SIDE VIEW



Preparing to jump: loading the tubercle

- Knee **46°**, hip **58°**, trunk 22° forward before take-off.
- Jumping and landing tasks sit high on the tendon-load ladder, so jump volume is a key dose to adjust.
- Shortened rectus femoris was strongly associated with the condition (OR 7.15).

Jumps and landings: a graded load ladder



Healthy adults; same source as slide 1. Scattone Silva et al. (2024). Association: de Lucena et al. (2011).

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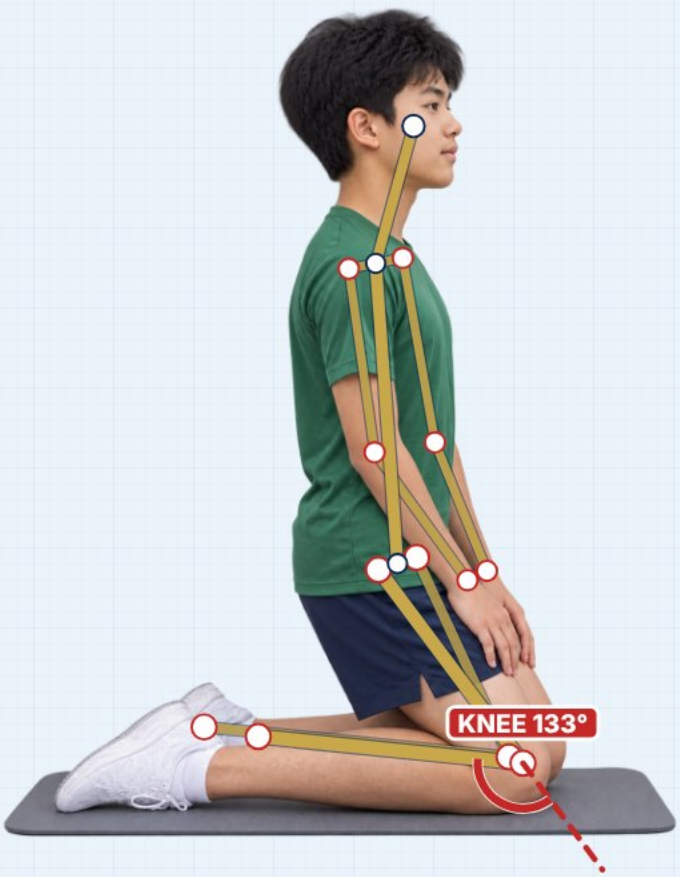
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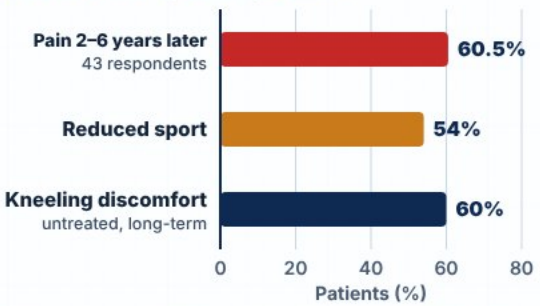
FRAME C · KNEELING · SIDE VIEW



Kneeling: direct pressure on the tubercle

- Knees deeply flexed (≈133°) with weight on the upper shin, right over the tender bump.
- In untreated patients followed long-term, **60%** could not kneel without discomfort.
- It is not always outgrown: many still had pain years after diagnosis.

It is not just "growing pains"



Guldhammer et al. (2019); kneeling: Krause et al. (1990), 50 patients.

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Feet not shown in the overlay while kneeling. Educational, not diagnostic.

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A · Running
Tendon pulls tubercle



B · Jump prep
Knee 46°



C · Kneeling
Direct pressure

Activity modification + strengthening



51 adolescents aged 10–14; case series, no control group. Rathleff et al. (2020b).

Decision pathway

1. **EDUCATE**
   Explain the tendon–growth-plate link; use pain to guide how much running and jumping to keep.
2. **STRENGTHEN**
   Progressive knee and hip strengthening: knee extension strength rose 32% in the programme.
3. **RETURN**
   Climb the load ladder: isometrics and squats, then running, jumping and cutting.

NOT RECOMMENDED

Complete, prolonged rest from all activity.

SEEK ASSESSMENT IF

Pain at rest or at night, severe swelling, sudden inability to straighten the knee after a jump, fever, or pain away from the tubercle (e.g. hip pain felt in the knee).

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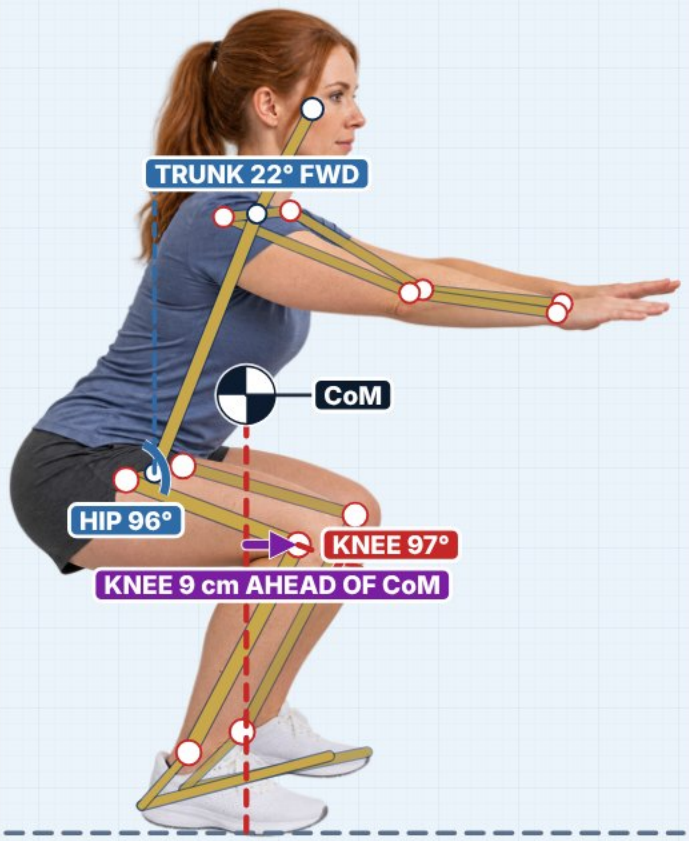
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WHY DO MY KNEES HURT WHEN I SQUAT?

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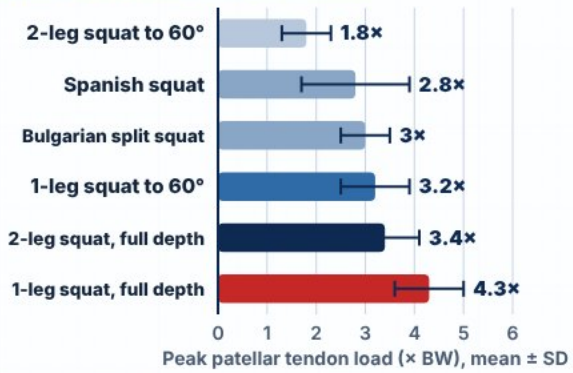
FRAME A · BODYWEIGHT SQUAT · SIDE VIEW



Depth is the main dose dial

- Knee **97°**, hip **96°**, trunk **22°** forward; the knee sits ≈9 cm ahead of the CoM line.
- Kneecap force and stress rise with knee bend and with added load, peaking near 90° in a squat to 90° (Wallace et al., 2002).
- Going deeper, or onto one leg, roughly doubles quadriceps and tendon load.

Squat variations: a load ladder



20 healthy adults. Scattone Silva et al. (2024).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Educational, not diagnostic.

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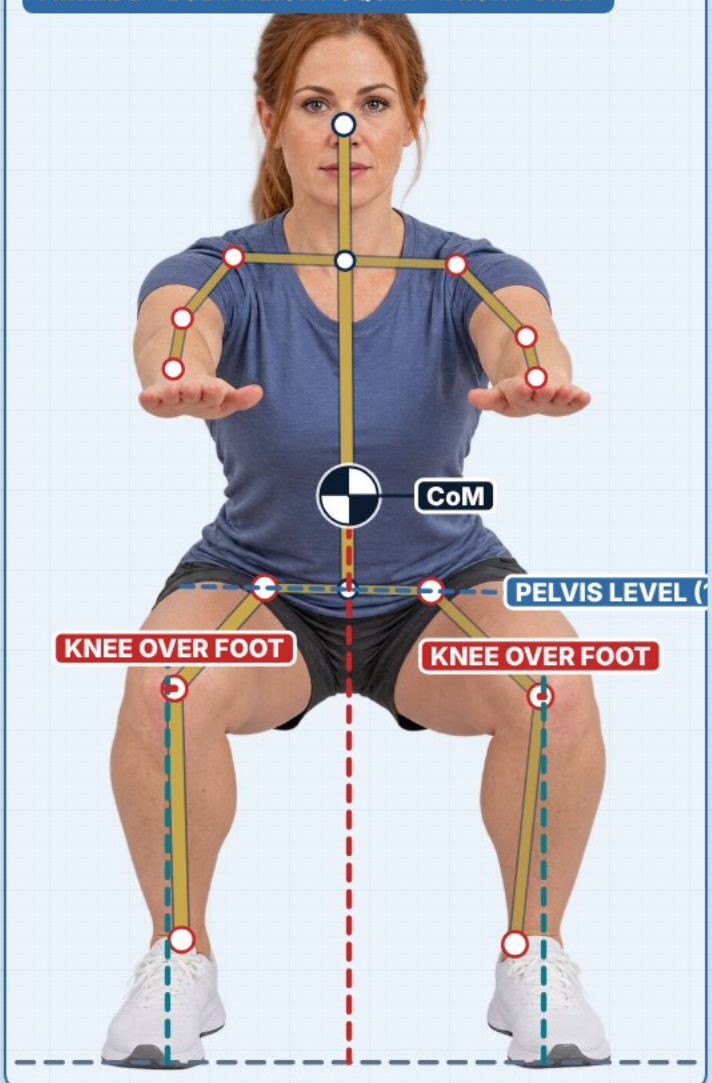
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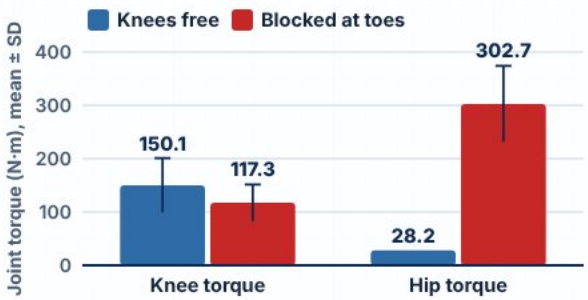
FRAME B · BODYWEIGHT SQUAT · FRONT VIEW



Front view: knees tracking over the feet

- Both knees track almost exactly over the feet (≈1 cm); pelvis level (1°).
- Blocking the knees from passing the toes cut knee torque by about 22% but raised hip torque about tenfold, with more trunk lean.
- The load moves; it does not disappear.

"Never past the toes" shifts load to the hip



Hip SD in the unrestricted condition (65.0) exceeded its mean and is omitted.

Barbell squat, 7 trained men. Fry et al. (2003).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Knee tracking distance is horizontal, knee centre to foot centre. Educational, not diagnostic.

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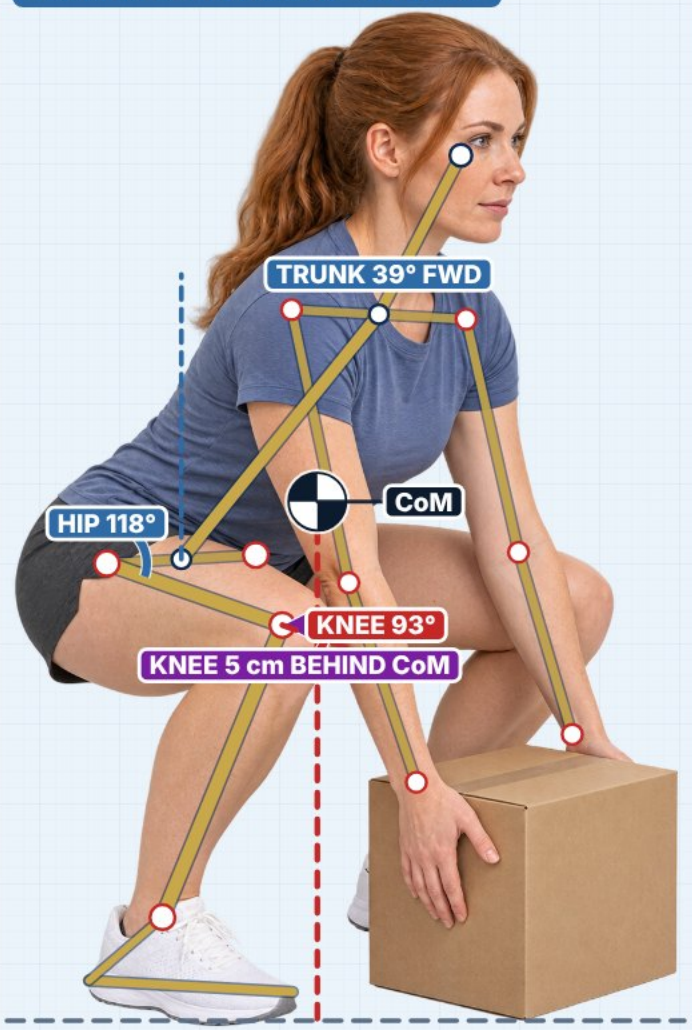
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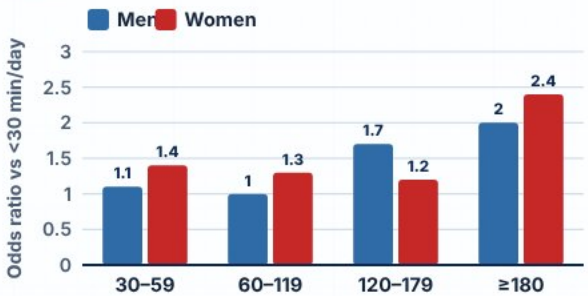
FRAME C · LIFTING A BOX · SIDE VIEW



Squatting to lift: everyday deep flexion

- Lifting knee **93°**, hip **118°**, trunk **39°** forward; box held close.
- A review concluded the parallel squat is not injurious to healthy knees (Escamilla, 2001).
- Knee OA was linked to **hours a day** of habitual squatting over decades, not to squat exercise.

Daily squatting time at age 25 and knee OA later



Cross-sectional; no CIs available; trend p ≈ 0.07–0.08.

Minutes per day of squatting; Beijing Osteoarthritis Study. Zhang et al. (2004).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Rear leg hidden behind the box in Frame C. Educational, not diagnostic.

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A · Squat, side
Knee 97°

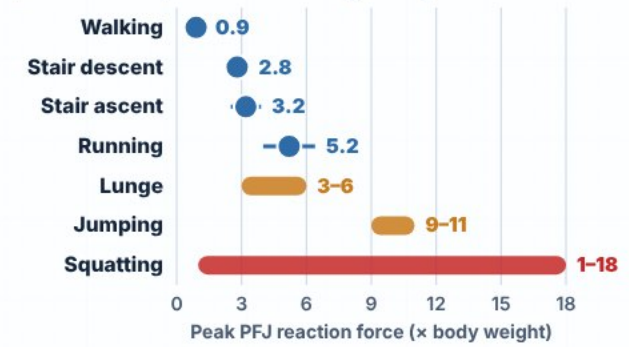


B · Squat, front
Knees over feet



C · Box lift
Load close

Squat load depends on how you squat



Dots: pooled mean ± SD; bars: ranges across studies, driven by depth and external load. Hart et al. (2022).

Decision pathway

1. **DOSE DEPTH**
   Start in a comfortable range (about 0–50° when load must be minimised), then progress depth.
2. **DOSE LOAD**
   Two legs before one, bodyweight before barbell; knee travel is one dial among depth and load.
3. **BUILD**
   Hip- and knee-targeted exercise is grade A for patellofemoral pain; squats are a usable therapeutic exercise.

NOT RECOMMENDED

Stand-alone manual therapy, dry needling, braces or sleeves, biofeedback, biophysical agents (Willy et al., 2019).

SEEK ASSESSMENT IF

Locking, giving way, marked swelling after squatting, inability to fully bend or straighten, pain after a twist, or a hot swollen knee.

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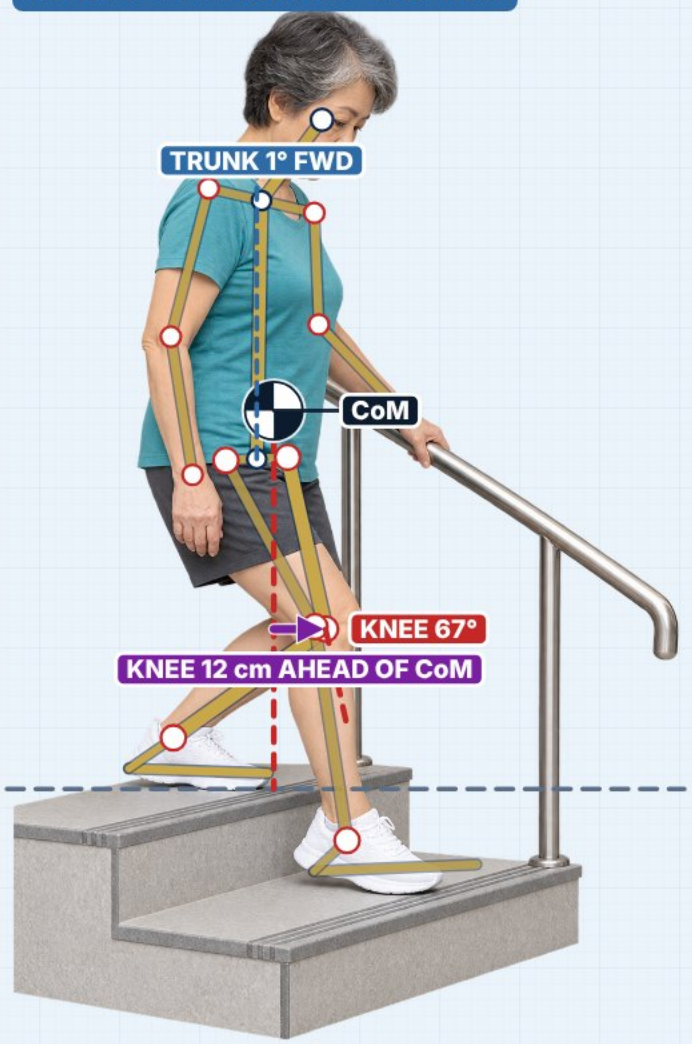
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INTEGRATING PERFORMANCE & REHABILITATION HEALTHCARE PATHWAYS.

WHY DOES GOING DOWNSTAIRS HURT MY KNEES?

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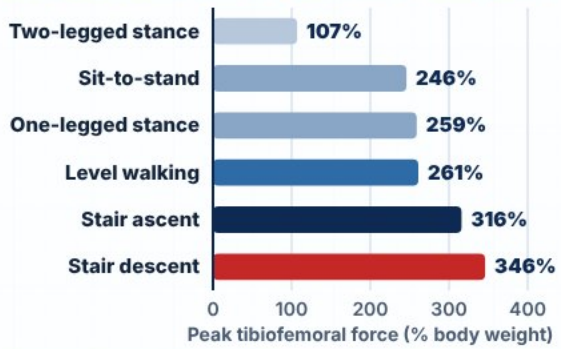
FRAME A · STAIR DESCENT · SIDE VIEW



Lowering the body on one bent knee

- Stance knee flexed **67°** on the upper step; trunk almost upright (1°).
- The knee sits **≈12 cm ahead of the CoM line**: the quadriceps must lengthen under load (eccentric control) to lower the body.
- Descent is an aggravating task in both patellofemoral pain and knee OA.

Stair descent is the highest daily knee load



Instrumented knee replacements, n = 5; no SD reported. Kutzner et al. (2010).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Educational, not diagnostic.

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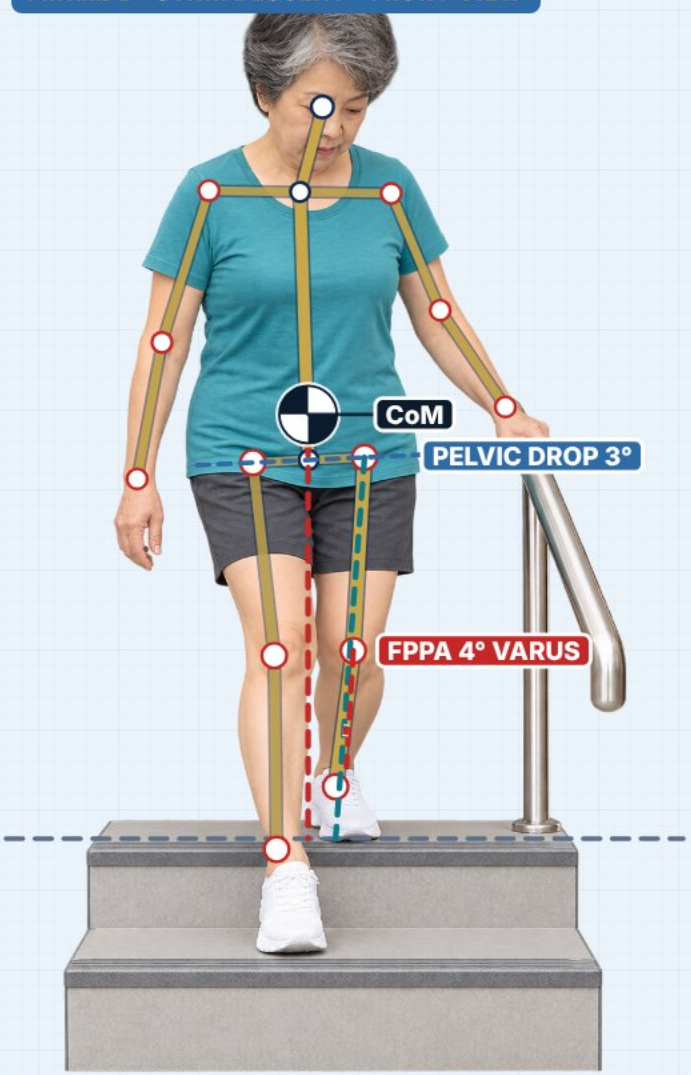
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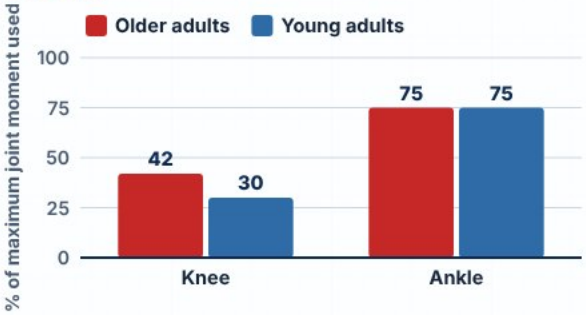
FRAME B · STAIR DESCENT · FRONT VIEW



Front view: knee control on the way down

- Stance knee near the hip–ankle line (FPPA ≈4°); pelvic drop 3° as the free leg reaches down.
- The handrail improves balance; in older adults it raised the **ankle** moment and steadied the CoM, but was not shown to offload the knee (Reeves et al., 2008b).
- Older adults work much closer to their knee capacity when descending.

How close to maximum the joints work in descent



Ankle ≈75% of maximum in both groups.

Instrumented staircase; sample size not given in abstract. Reeves et al. (2008a).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Educational, not diagnostic.

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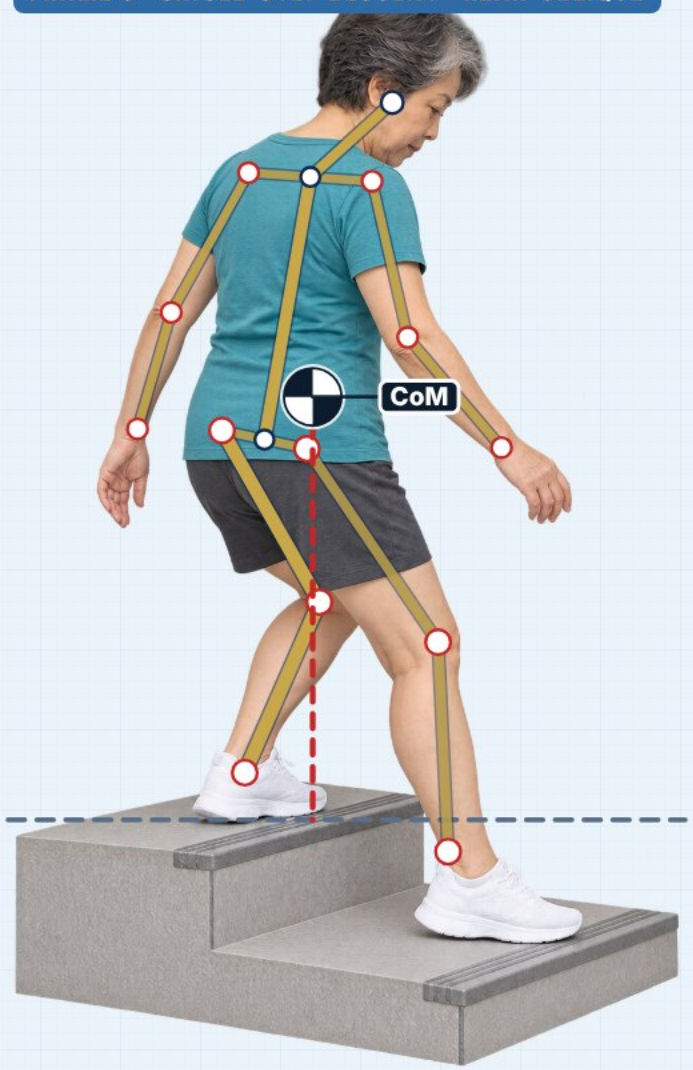
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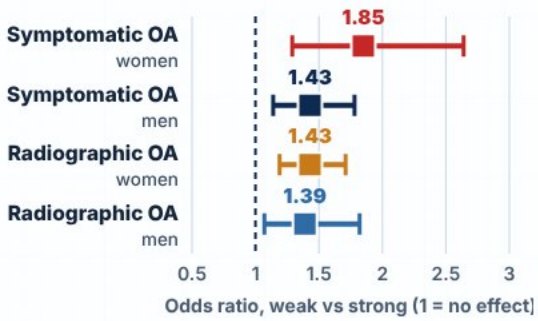
FRAME C · SINGLE-STEP DESCENT · REAR-OBLIQUE



Single-step descent: strength is the buffer

- Oblique rear view, so angles are not measured; the CoM travels forward and down over the stance foot.
- Weak knee extensors were linked to higher odds of developing knee OA over at least 2 years.
- Quadriceps strength is what lets the knee lower the body smoothly; it can be trained.

Weak quadriceps, higher OA risk



Low-quality evidence; association, not proof of cause.

11 studies, 46,819 people. Øiestad et al. (2022).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Frame C is oblique: no angles reported. Educational, not diagnostic.

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A · Descent, side
Knee 67° under load

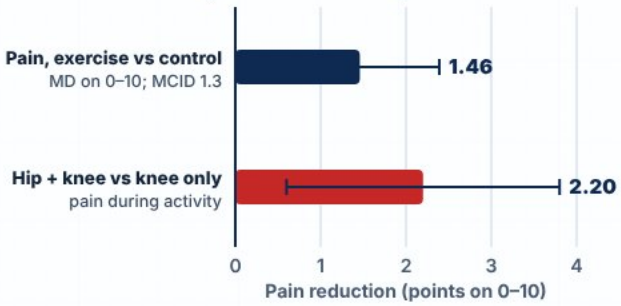


B · Descent, front
Rail = balance aid



C · Single step
Strength buffer

Exercise reduces patellofemoral pain



Short-term, 95% CI; very low to low-quality evidence. van der Heijden et al. (2015).

Decision pathway

1. **MODIFY**
   Use the rail for balance, take one step at a time, lead down with the less painful leg; keep moving.
2. **STRENGTHEN**
   Hip and knee strengthening (patellofemoral pain) or tailored exercise (OA); add slow step-downs from a low step.
3. **PROGRESS**
   Raise step height and repetitions as control and pain allow; descent is trainable, not something to avoid forever.

NOT RECOMMENDED

Mobilisation or electrophysical agents for patellofemoral pain (Crossley et al., 2016); acupuncture, electrotherapy or arthroscopic lavage for OA (NICE, 2022).

SEEK ASSESSMENT IF

Recent trauma, a hot swollen knee, rapidly worsening pain or deformity, prolonged morning stiffness, or falls on the stairs.

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Analysis: MMSx Authority Applied Biomechanics Lab · Dr. Neeraj Mehta, PhD · Educational content, not a diagnosis.

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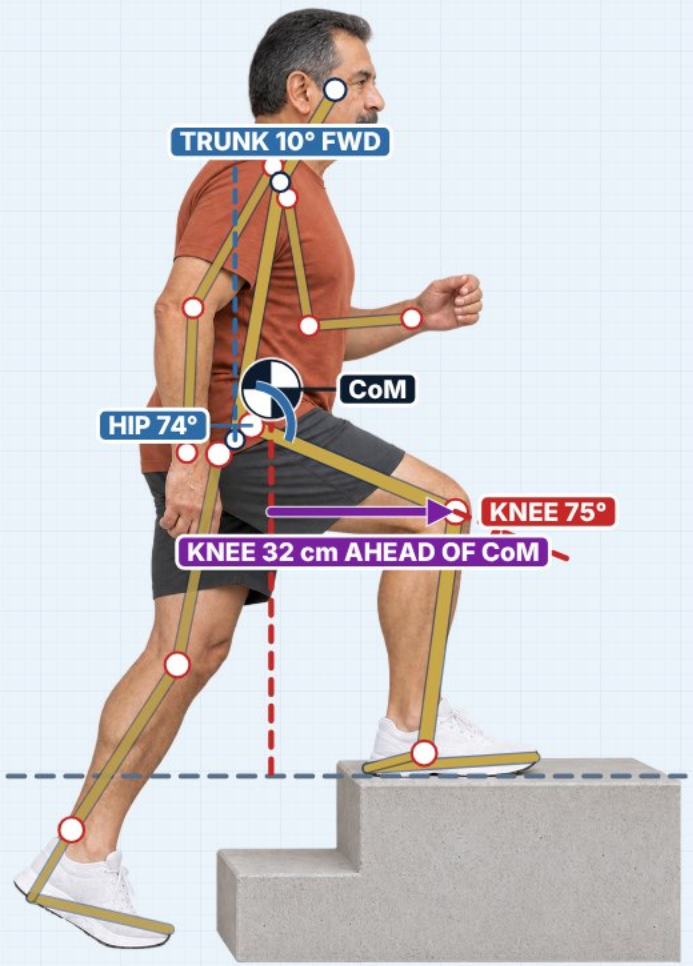
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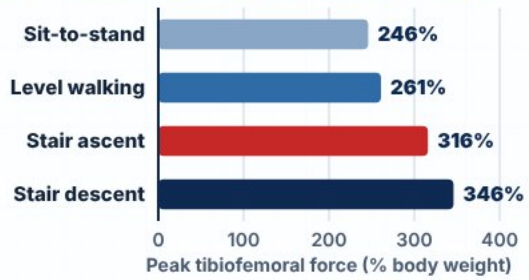
FRAME A · STAIR ASCENT · SIDE VIEW



Pushing the body up onto the step

- Leading knee flexed **75°**, hip **74°**; the knee sits **≈32 cm ahead of the CoM line.**
- That long lever is what the quadriceps must overcome to extend the knee and lift body mass (concentric work).
- Trunk 10° forward moves the CoM toward the step and shares work with the hip.

Ascent loads the knee ≈3.2× body weight



Instrumented knee replacements, n = 5; no SD reported. Kutzner et al. (2010).

Osteoarthritis is common and growing

595 M
people with OA in 2020; the knee is the commonest site

+74.9%
projected rise in knee OA cases, 2020–2050

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Educational, not diagnostic.

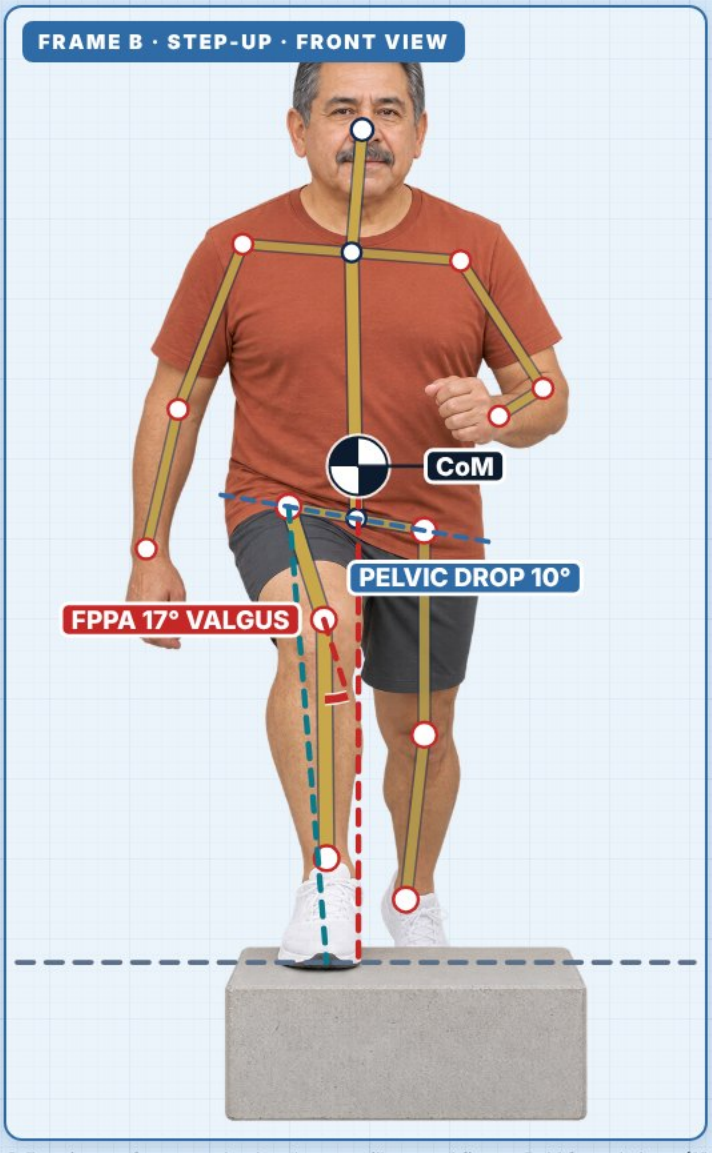
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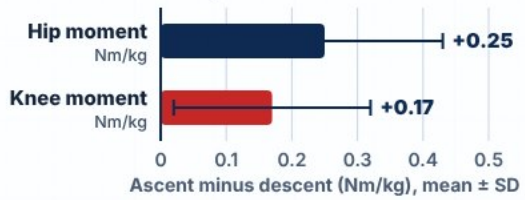
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Front view: the stance knee and pelvis

- Stance knee **17°** inside the hip–ankle line; pelvic drop **10°** on the lifting side.
- Ascent asks more of the hip and knee than descent in healthy young adults; the ankle runs near its ceiling.

Ascent vs descent: joint moments



Hip flexion angle was also **28°** greater in ascent.

Healthy adults, n = 33. Protopapadaki et al. (2007).

Decision: a hip-led, trunk-forward ascent shares load away from a painful knee.

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Educational, not diagnostic.

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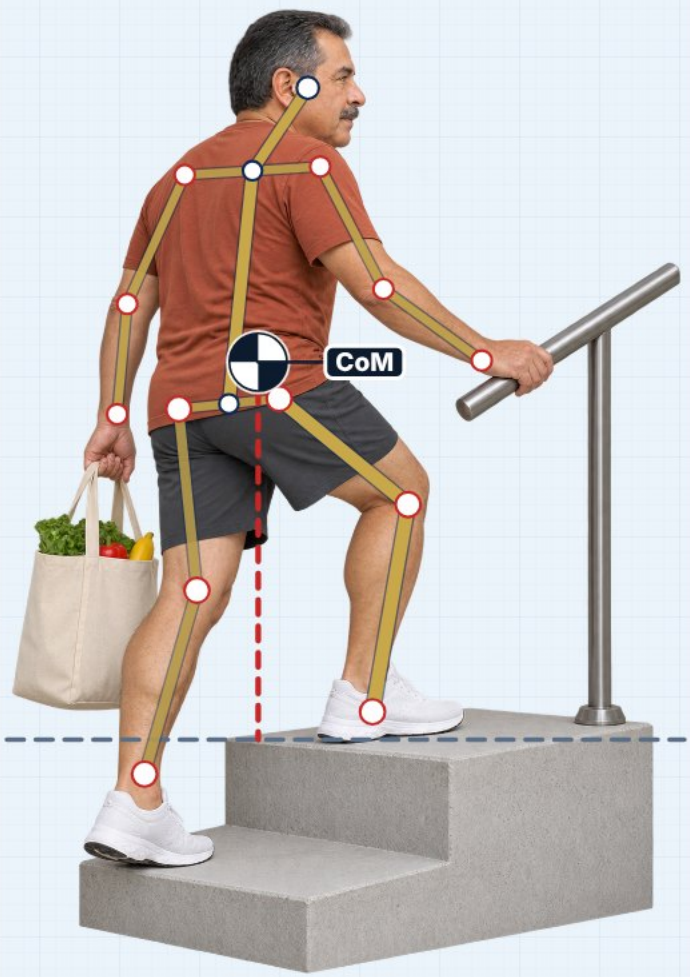
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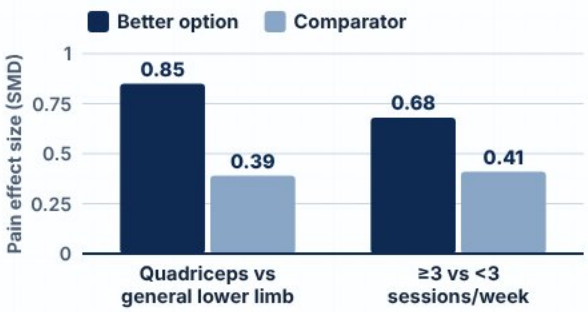
FRAME C · ASCENT WITH A BAG · REAR-OBLIQUE



Carrying a bag, holding the rail

- Oblique rear view, so angles are not measured; the bag shifts the CoM toward the carrying side.
- In older adults light rail use eased the trailing **ankle** but **increased** the leading knee moment (Reeves et al., 2008b): a balance aid, not a knee offloader.
- The effect of carrying a bag on knee load has not been quantified in the sources reviewed.

Which exercise helps knee OA pain most?



Meta-regression of 48 RCTs. Juhl et al. (2014).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Frame C is oblique: no angles reported. Educational, not diagnostic.

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A · Ascent, side
Knee 75°, lever ≈32 cm



B · Step-up, front
Pelvic drop 10°



C · With a bag
Rail = balance aid

Weak knee extensors, higher knee OA risk



11 studies, 46,819 people; low-quality evidence. Øiestad et al. (2022).

Decision pathway

1. **MODIFY**
   Lead up with the stronger leg, lean the trunk slightly forward, use the rail for balance; split heavy shopping into lighter loads.
2. **STRENGTHEN**
   Quadriceps-focused exercise, at least 3 sessions a week, gave the largest pain effects in knee OA.
3. **PROGRESS**
   Step-ups from a low step, then higher; add load and repetitions. Pain may rise briefly at first (NICE, 2022).

NOT RECOMMENDED

Acupuncture, electrotherapy, glucosamine, hyaluronan injections or arthroscopic lavage for knee OA (NICE, 2022).

SEEK ASSESSMENT IF

Inability to bear weight or sudden locking after an injury, a hot swollen knee, rapid worsening or deformity, prolonged morning stiffness.

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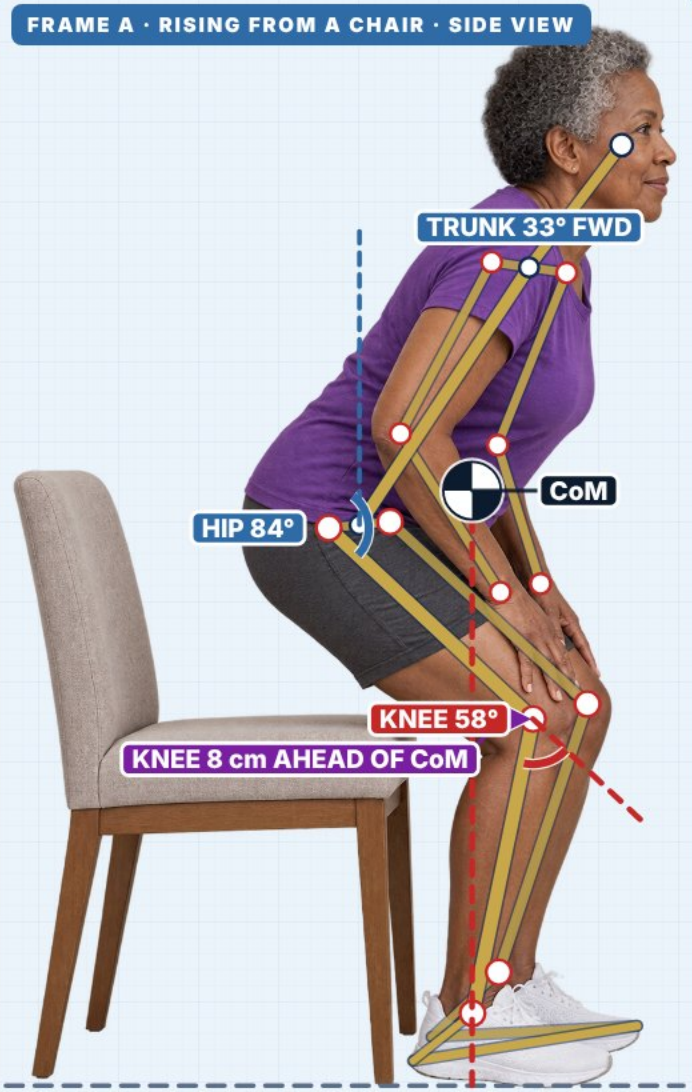
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KNEE PAIN WHEN STANDING UP FROM A CHAIR

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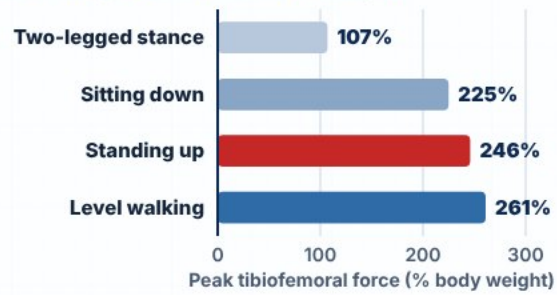
FRAME A · RISING FROM A CHAIR · SIDE VIEW



Rising: knee extension from deep flexion

- Knee flexed **58°**, hip **84°**, trunk **33°** forward to bring the CoM over the feet.
- The knee still sits **≈8 cm ahead of the CoM line**; hands on the thighs add a push.
- One sit-to-stand loads the knee about as much as a walking step.

Standing up ≈2.5× body weight



Instrumented knee replacements, n = 5; no SD reported. Kutzner et al. (2010).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Educational, not diagnostic.

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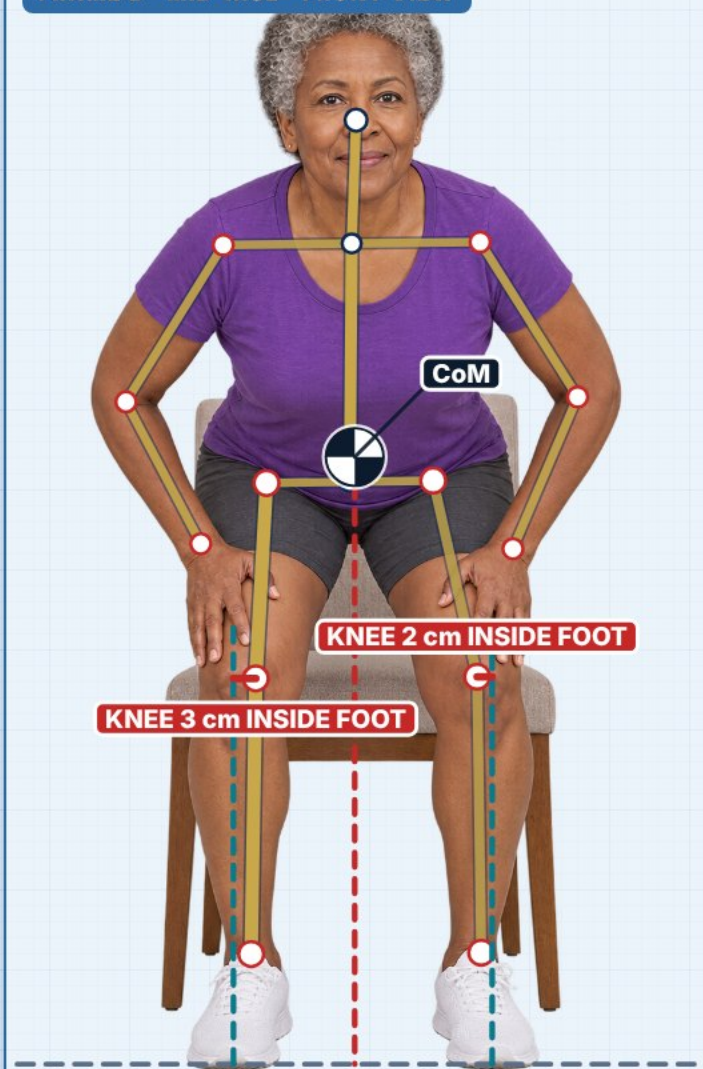
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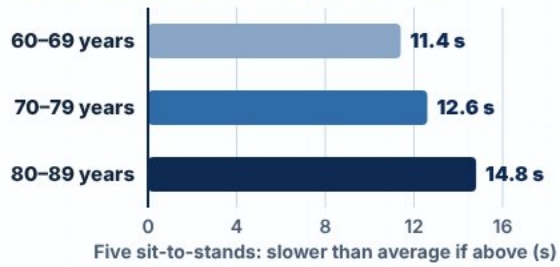
FRAME B · MID-RISE · FRONT VIEW



Front view: both knees share the lift

- Knees track close to the feet (≈2 cm and ≈3 cm inside); pelvis level (1°).
- Even weight-bearing spreads the demand; shifting weight onto the less painful leg overloads it over time.
- Timing five rises is a simple, reliable function check.

5× sit-to-stand reference thresholds



Descriptive meta-analysis of 14 studies. Bohannon (2006).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Knee tracking distance is horizontal, knee centre to foot centre. Educational, not diagnostic.

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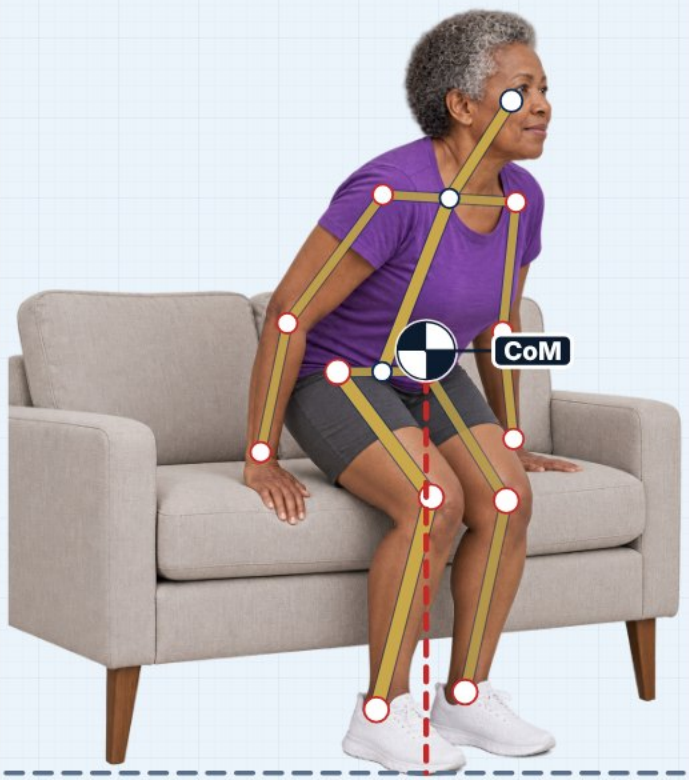
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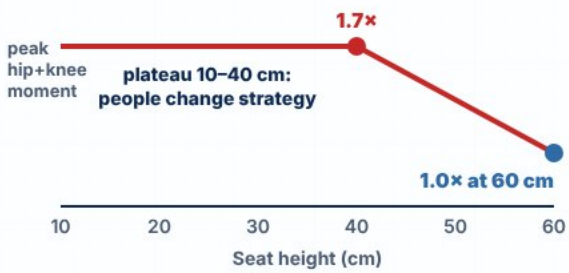
FRAME C · RISING FROM A SOFA · OBLIQUE



Low, soft seats: a harder start

- Oblique view, so angles are not measured; she pushes on the cushion with both hands.
- Lower seats raise knee demand: knee moments nearly doubled from 115% to 65% of knee height (Rodosky et al., 1989).
- Below about 40 cm, people change technique (more trunk lean, feet back), so peak moments level off.

Seat height and peak hip + knee moment



Only the reported points are drawn: relative values, not absolute moments.

8 healthy young adults, seats 10–60 cm. Yoshioka et al. (2014).

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KNEE PAIN WHEN STANDING UP FROM A CHAIR

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A · Low chair
Knee 58°, trunk 33°



B · Mid-rise
Even loading



C · Sofa
Low, soft seat

Progressive strength training in older adults



Cochrane review, 121 trials, 6,700 people; magnitudes shown, direction = benefit. Liu & Latham (2009).

Decision pathway

1. **TECHNIQUE**
   Feet slightly back, lean the trunk forward ("nose over toes"), then stand; use the arms if needed.
2. **SET-UP**
   Choose a firmer, higher seat while symptoms settle; very low sofas raise knee demand.
3. **STRENGTHEN**
   Sit-to-stand practice from progressively lower seats plus quadriceps and hip strengthening, about 3 times a week.

NOT RECOMMENDED

Electrotherapy or acupuncture for knee OA (NICE, 2022); mobilisation or electrophysical agents for patellofemoral pain (Crossley et al., 2016).

SEEK ASSESSMENT IF

Recent trauma, a hot swollen knee, rapid worsening or deformity, prolonged morning stiffness, or a 5× sit-to-stand time well above the age threshold.

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Analysis: MMSx Authority Applied Biomechanics Lab · Dr. Neeraj Mehta, PhD · Educational content, not a diagnosis.

DOI 10.5281/zenodo.23735752

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INTEGRATING PERFORMANCE & REHABILITATION HEALTHCARE PATHWAYS.

KNEE PAIN AFTER SITTING: WHY THE FIRST FEW STEPS HURT

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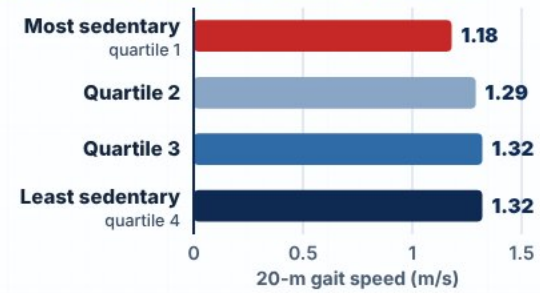
FRAME A · SEATED AT A DESK · SIDE VIEW



A long sit with the knees bent

- Knees held at about **98°** of flexion, hips 90°, for long periods.
- Prolonged sitting is a recognised aggravating position in patellofemoral pain (Willy et al., 2019).
- In knee OA, short-lived stiffness (≤30 min) is typical; longer morning stiffness suggests another diagnosis (NICE, 2022).

More sitting, slower walking (knee OA)



People with knee OA spent about two-thirds of the day sedentary.

n = 1,168; converted from ft/s (×0.3048); observational. Lee et al. (2015).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Educational, not diagnostic.

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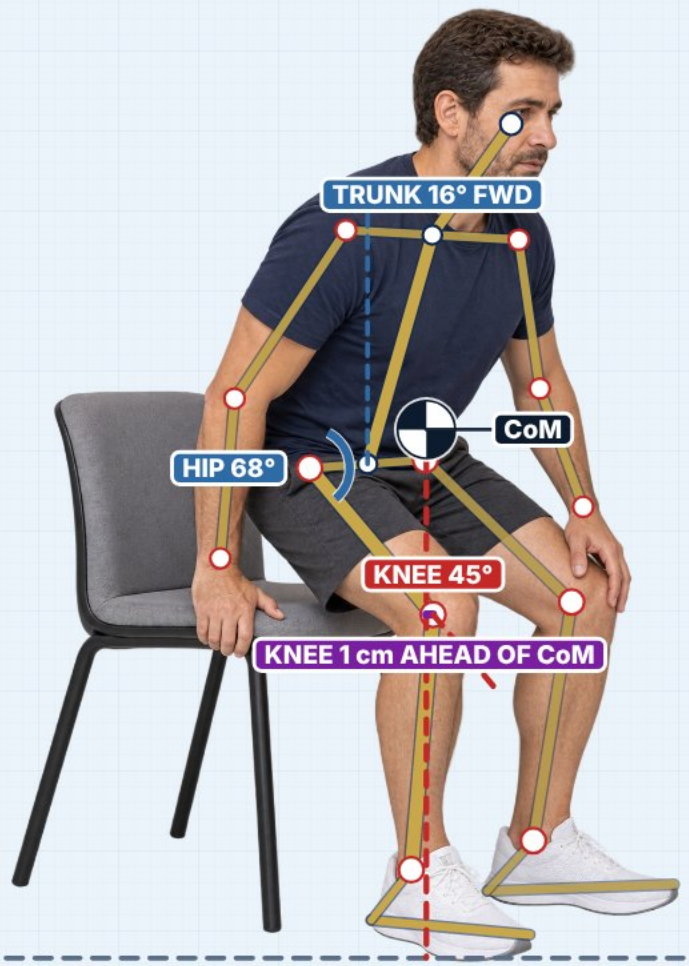
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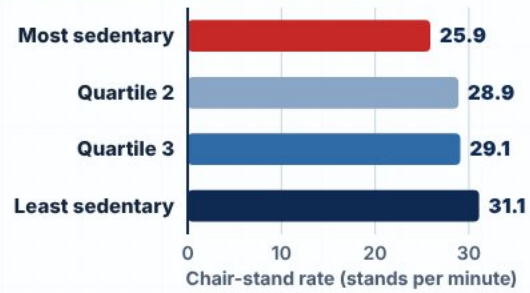
FRAME B · STARTING TO STAND · SIDE VIEW



The first rise: from rest to full load

- Knee 45°, hip 68°, trunk **16°** forward; the knee sits ≈1 cm from the CoM line.
- Knee force climbs from about **1.1×** (standing) to **2.5× body weight** within one movement (Kutzner et al., 2010).
- After a long sit, this is the first high load the joint meets.

More sitting, fewer chair stands



Linked to sitting time itself, independent of exercise.

Same cohort; observational. Lee et al. (2015).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Educational, not diagnostic.

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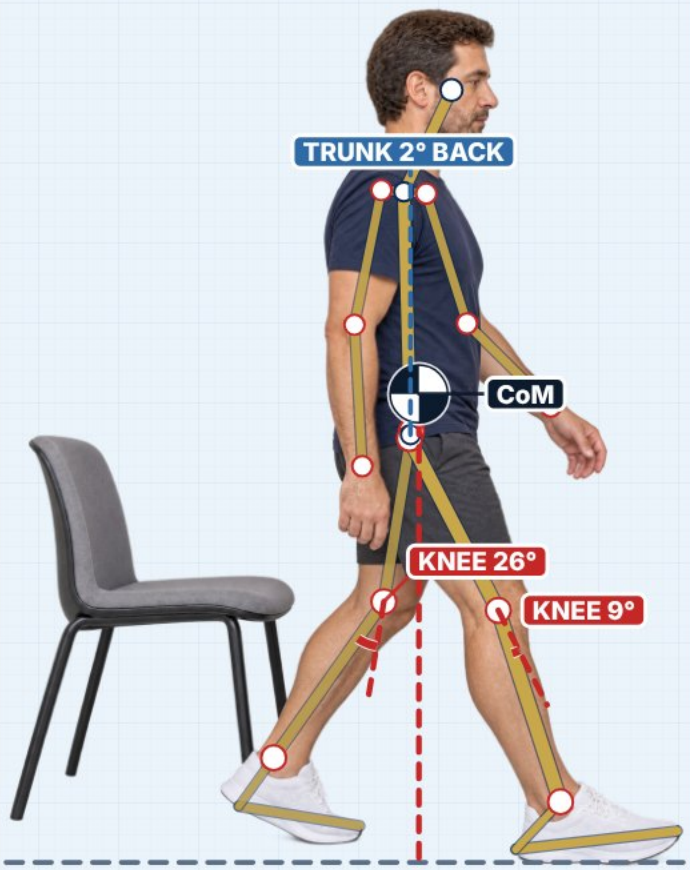
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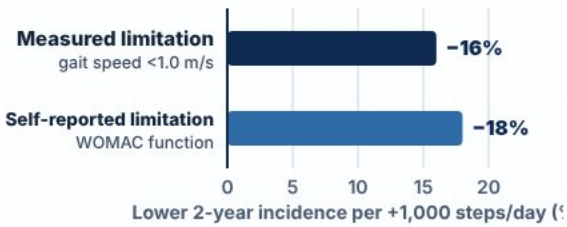
FRAME C · FIRST STEP · SIDE VIEW



The first steps: stiffness that eases

- Stance knee nearly straight (9°), trailing knee 26°; trunk upright.
- Start-up pain that settles within minutes of walking is common and typical of OA or patellofemoral pain.
- Each extra 1,000 steps a day was linked to less future functional limitation; about **6,000 steps/day** was the best threshold.

Daily steps and future function



1,788 adults with or at risk of knee OA, 2 years; observational. White et al. (2014).

Decision: break up long sits regularly and accumulate steps through the day.

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Educational, not diagnostic.

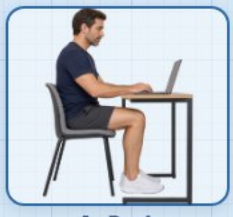
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A · Desk
Knees 98° for hours

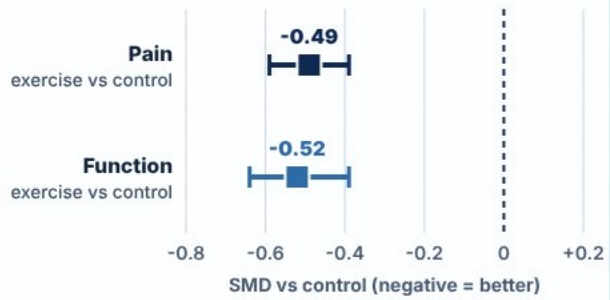


B · Rising
Rest to 2.5× BW



C · First step
Stiffness eases

Exercise reduces knee OA pain and improves function



Cochrane review, 44 trials. Fransen et al. (2015).

Decision pathway

1. **MOVE OFTEN**
   Break up long sitting with short walks; straighten and bend the knees while seated.
2. **BUILD**
   Exercise is core treatment: strengthening plus aerobic activity (NICE, 2022); hip and knee exercise for patellofemoral pain (Crossley et al., 2016).
3. **ACCUMULATE**
   Work toward about 6,000 steps a day, spread across the day.

NOT RECOMMENDED

Treating start-up stiffness with more rest; electrophysical agents for patellofemoral pain (Crossley et al., 2016).

SEEK ASSESSMENT IF

Morning stiffness lasting over 30 minutes, a hot swollen knee, rapid worsening, recent trauma, or concern about infection.

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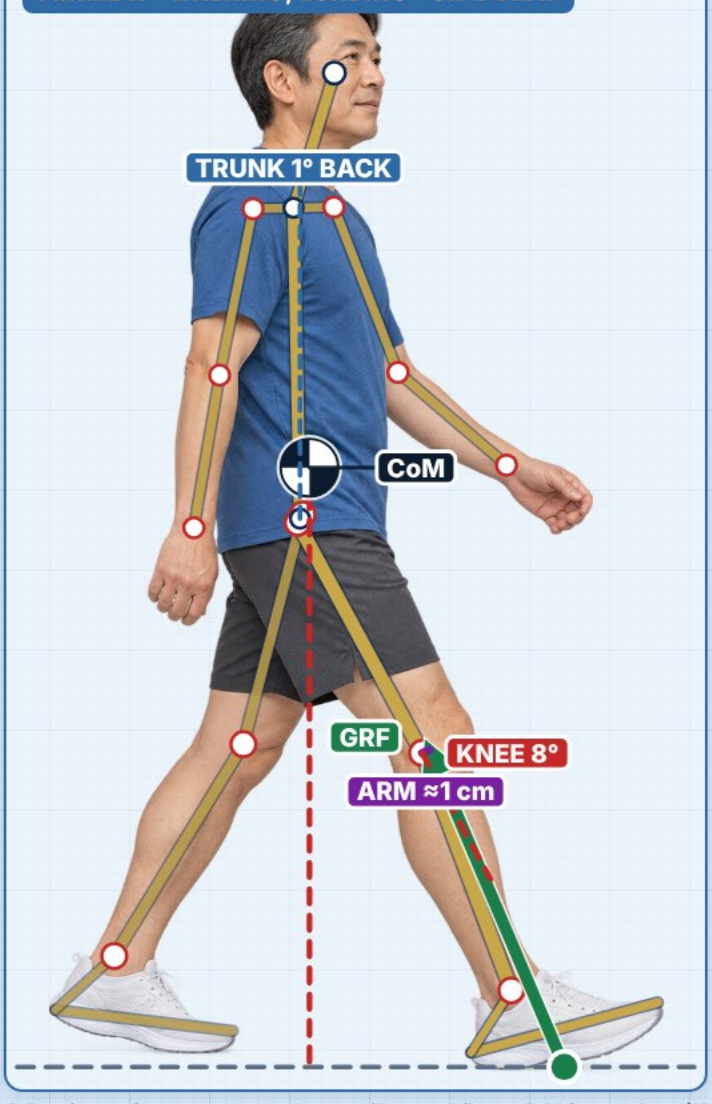
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KNEE PAIN WHILE WALKING: WHAT CHANGES UNDER LOAD?

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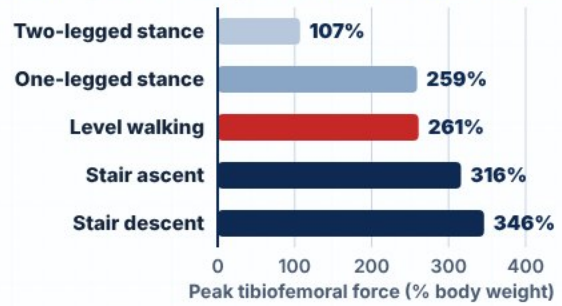
FRAME A · WALKING, LOADING · SIDE VIEW



Weight acceptance: heel strike to full load

- Front knee nearly straight at contact (**8°**); the ground force passes close to the knee (≈1 cm).
- As the knee flexes to absorb load, the quadriceps control it and joint force rises quickly.
- Each walking step loads the knee about as much as standing on one leg: **≈2.6× body weight**.

Walking ≈ one-legged stance in knee force



Instrumented knee replacements, n = 5; no SD reported. Kutzner et al. (2010).

Osteoarthritis: the commonest cause in adults

595 M
people with OA in 2020; knee most common

20.4%
of OA burden attributable to high BMI

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). GRF line from contact to CoM. Educational, not diagnostic.

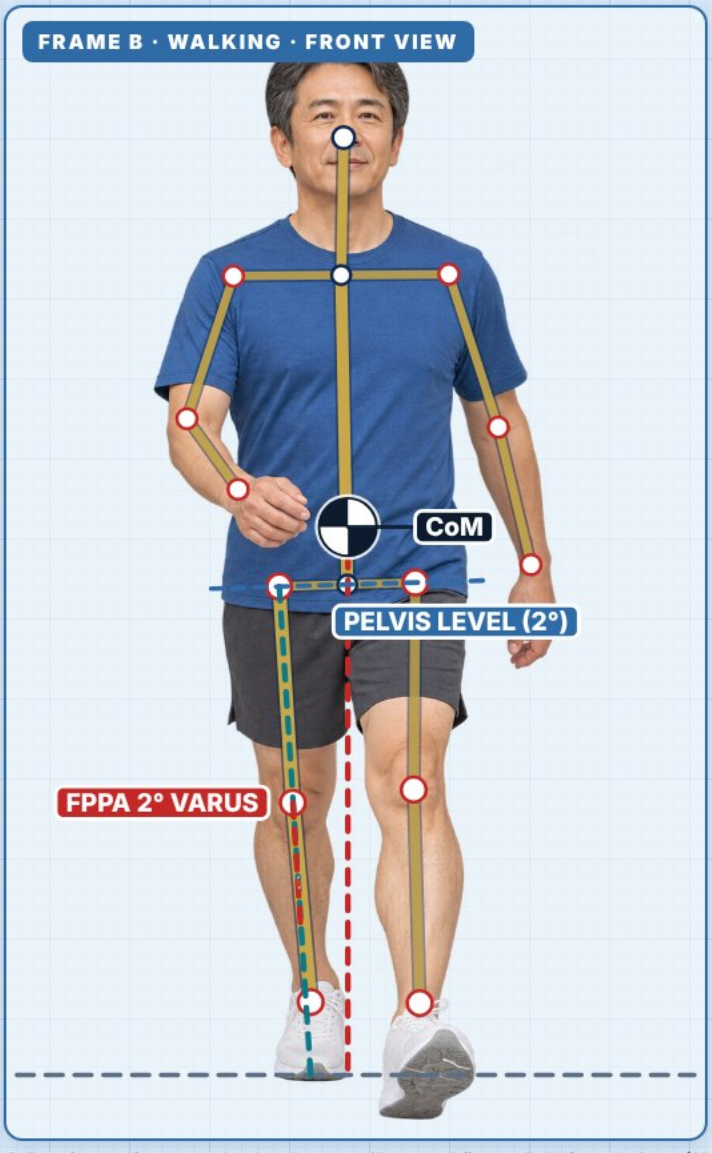
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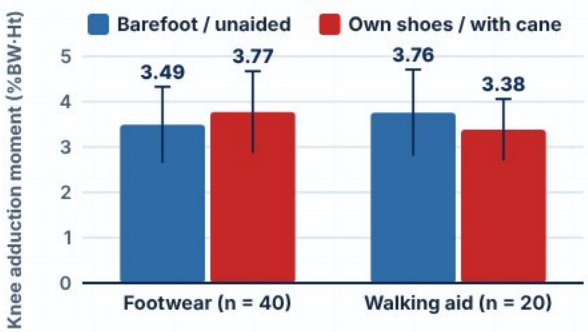
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Single-leg support: the medial load marker

- Stance knee close to the hip–ankle line (FPPA ≈2°); pelvis level (2°).
- The ground force passes medial to the knee, creating a **knee adduction moment** that loads the inner compartment.
- In medial knee OA, shoes raised it versus barefoot; a cane lowered it by about 10%.

Shoes and canes change medial knee load



Mean ± SD, medial knee OA. Kemp et al. (2008).

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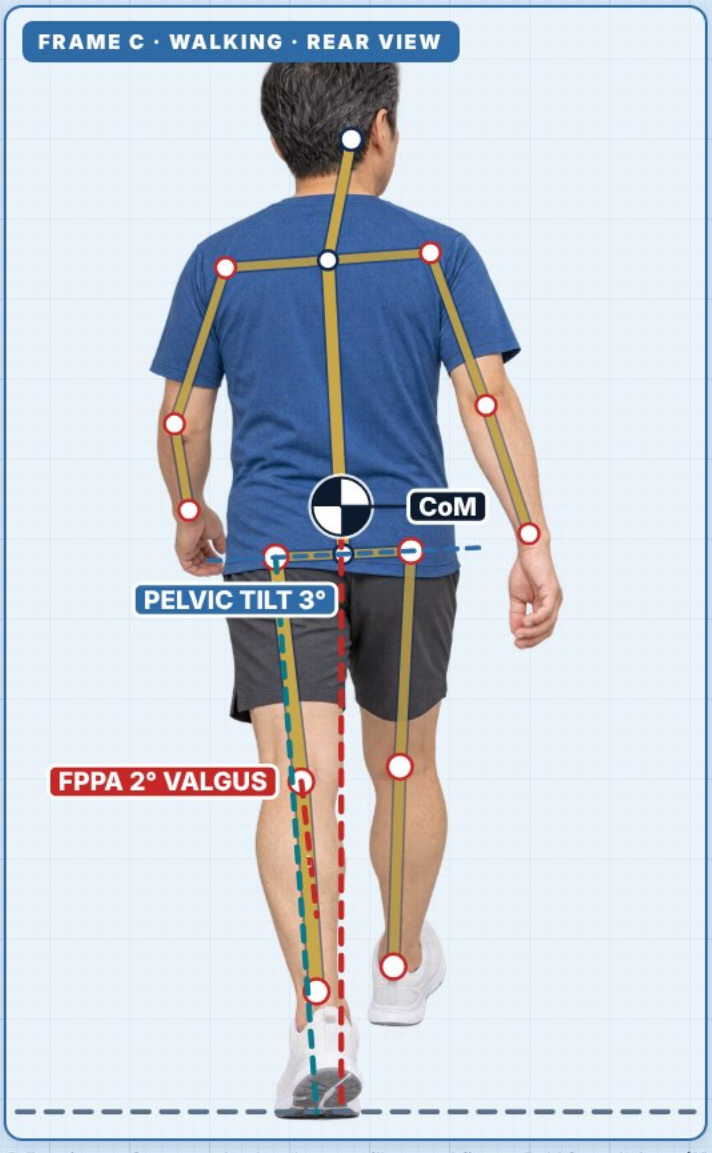
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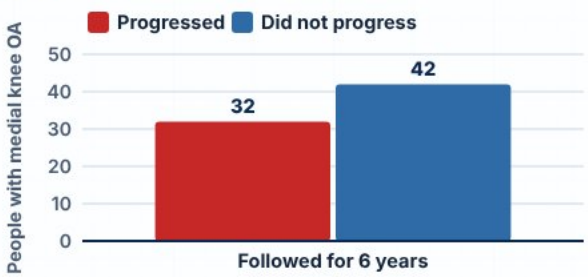
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Rear view: pelvis and knee in stance

- Stance knee FPPA ≈2°, trunk 3° from vertical, pelvic tilt 3°.
- Higher baseline adduction moment was linked to radiographic progression: risk rose **6.46-fold** per 1% increase.
- Load is modifiable: strength, body weight, walking aid and walking dose all change it.

Dynamic load at baseline predicted progression



Progressors had a higher baseline knee adduction moment.

106 enrolled, 74 re-examined; no CI in abstract. Miyazaki et al. (2002).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Frontal angles from the rear view. Educational, not diagnostic.

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A · Loading
Knee 8° at contact



B · Front
Adduction moment



C · Rear
Pelvis and knee

Exercise works while it continues



Cochrane review, 54 studies. Fransen et al. (2015).

Decision pathway

1. **KEEP WALKING**
   Exercise and weight management are core (NICE, 2022); pain may rise at first, but regular activity benefits the joint.
2. **LOWER THE LOAD**
   Consider a walking stick in the opposite hand; check footwear. Any weight loss helps; 10% beats 5%.
3. **BRACES**
   Guidelines differ: ACR/AF strongly recommends a tibiofemoral brace; NICE does not routinely offer braces.

NOT RECOMMENDED

Acupuncture, electrotherapy, glucosamine, strong opioids, hyaluronan injections or arthroscopic lavage (NICE, 2022).

SEEK ASSESSMENT IF

Recent trauma, prolonged morning stiffness, rapid worsening or deformity, a hot swollen knee, or concern about infection.

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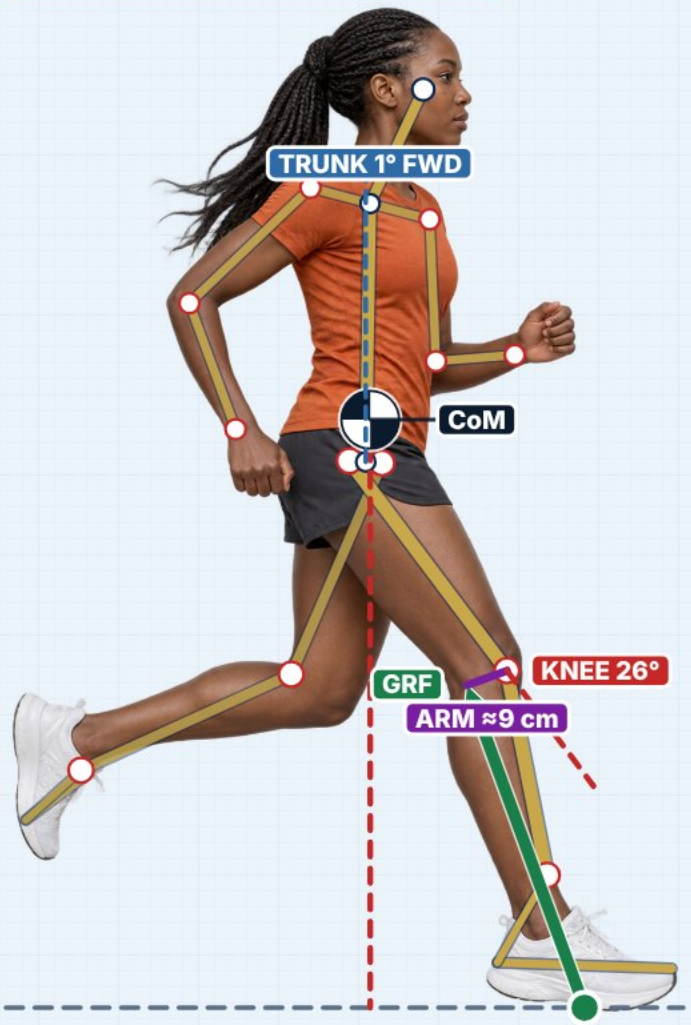
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KNEE PAIN AFTER RUNNING: IS YOUR CURRENT TRAINING LOAD TOO MUCH?

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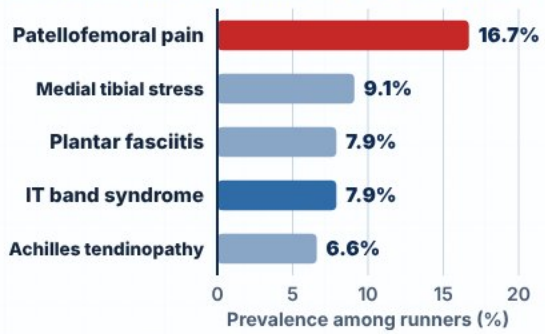
FRAME A · EASY RUNNING · SIDE VIEW



Easy running: the knee absorbs every landing

- Stance knee **26°**, ground force ≈9 cm behind the knee; trunk upright.
- The knee is the main **shock absorber** in running: more than half of lower-limb negative power at every slope (Nuckols et al., 2020).
- A modest step-rate increase (+5–10%) reduced knee energy absorption (Heiderscheit et al., 2011).

The commonest running injury is at the knee



Mean injury incidence 40.2%; prevalence 44.6%.

Systematic review. Kakouris et al. (2021).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). GRF line from contact to CoM. Educational, not diagnostic.

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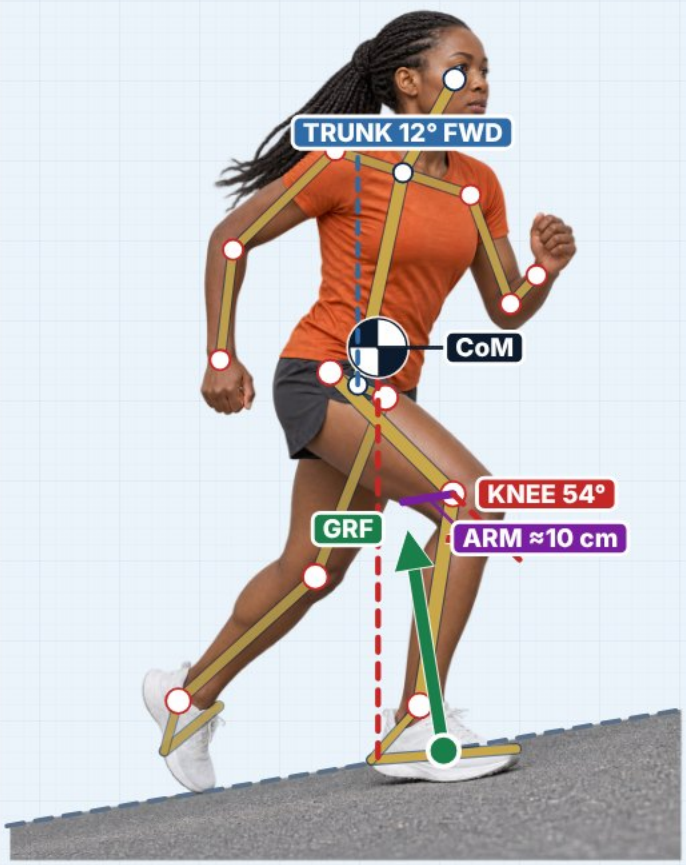
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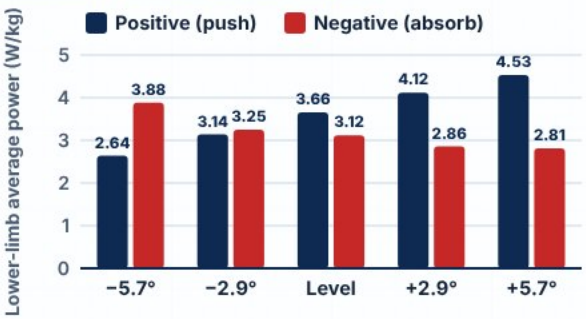
FRAME B · UPHILL RUNNING · SIDE VIEW



Uphill: more push, less braking

- Stance knee **54°**, trunk **12°** forward to keep the CoM over the foot on the slope.
- Uphill raises positive power and shifts work toward the hip; downhill raises the braking (absorbing) demand, mostly at the knee.
- Hills change the type of knee load, not just the amount.

Running power across slopes



Negative power shown as magnitude.

8 adults at 2.25 m/s; no SDs reported. Nuckols et al. (2020).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). GRF line from contact to CoM; ground drawn along the slope. Educational, not diagnostic.

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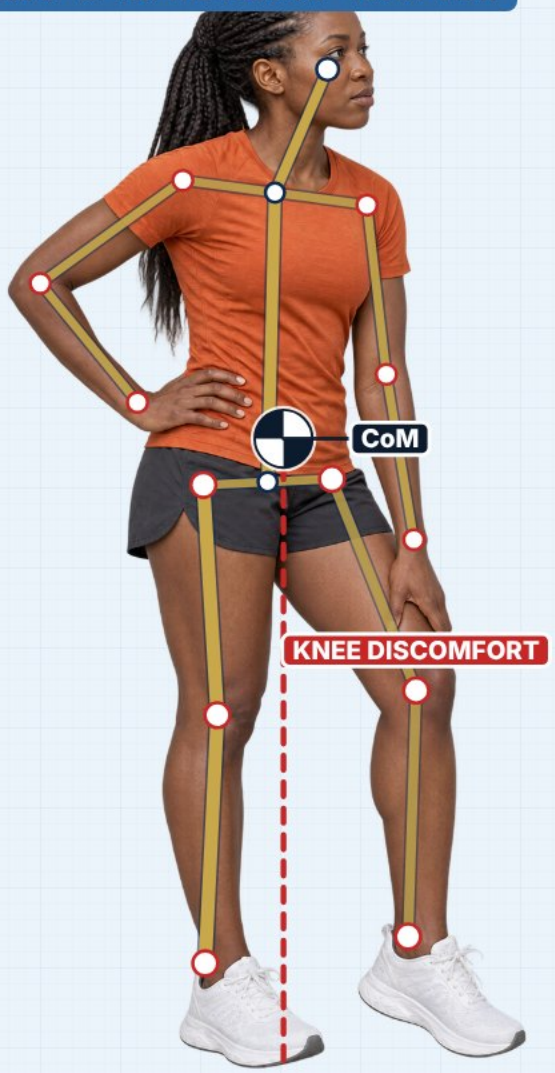
BIOMECHANICS IS A FORCE-GOVERNED DECISION SYSTEM – NOT A POSTURE MODEL.

INTEGRATING PERFORMANCE & REHABILITATION HEALTHCARE PATHWAYS.

KNEE PAIN AFTER RUNNING: IS YOUR CURRENT TRAINING LOAD TOO MUCH?

AN MMSX AUTHORITY | APPLIED BIOMECHANICS LAB EDUCATIONAL ANALYSIS

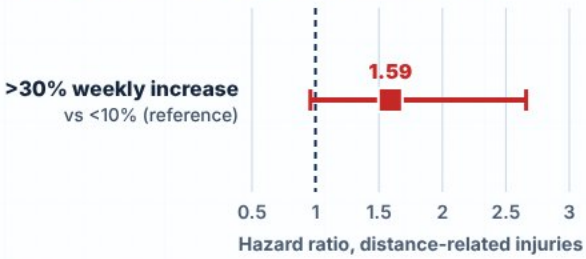
FRAME C · AFTER THE SESSION · FRONT VIEW



After the session: what to track

- Pain that appears during or after a run and lasts into the next day is a dose signal.
- Novice runners are injured about **twice as often per hour** as recreational runners (17.8 vs 7.7 per 1,000 h).
- A big jump in weekly distance was linked to more injuries, but the result is not definitive.

Weekly distance progression and injury



Confidence interval crosses 1: suggestive, not proven.

874 novice runners, 1 year. Nielsen et al. (2014). Injury rates: Videbæk et al. (2015).

Caution: no study has shown that keeping an acute:chronic workload ratio in a "safe zone" prevents injury (Impellizzeri et al., 2020).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Frame C is a reference view: no angles reported. Educational, not diagnostic.

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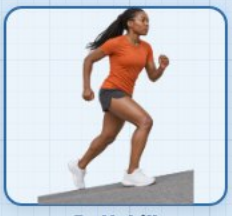
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A · Easy run
Knee 26° in stance

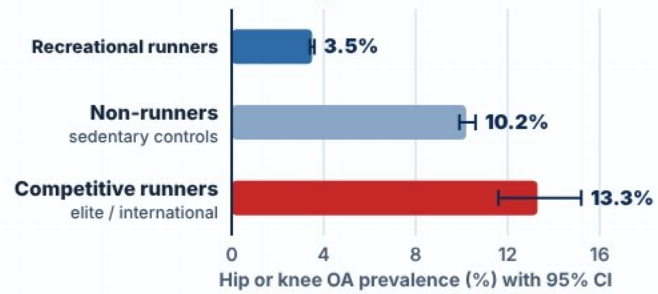


B · Uphill
More push, hip-led



C · After
Track the response

Does recreational running wear out knees?



17 pooled studies, 114,829 people; observational. Alentorn-Geli et al. (2017).

Decision pathway

1. **ADJUST THE DOSE**
   Reduce distance, pace or hills while symptoms settle; avoid large jumps in weekly distance, especially as a novice.
2. **STRENGTHEN**
   Exercise therapy, preferably hip plus knee, is recommended for patellofemoral pain (Crossley et al., 2016).
3. **RETRAIN**
   Consider a small step-rate increase; rebuild volume before adding hills or speed.

NOT RECOMMENDED

Mobilisation or electrophysical agents for patellofemoral pain (Crossley et al., 2016); trusting a fixed "10% rule" or workload-ratio zone as proven.

SEEK ASSESSMENT IF

A hot swollen knee, recent trauma, locking or giving way after injury, rapidly worsening pain, or night pain with feeling unwell.

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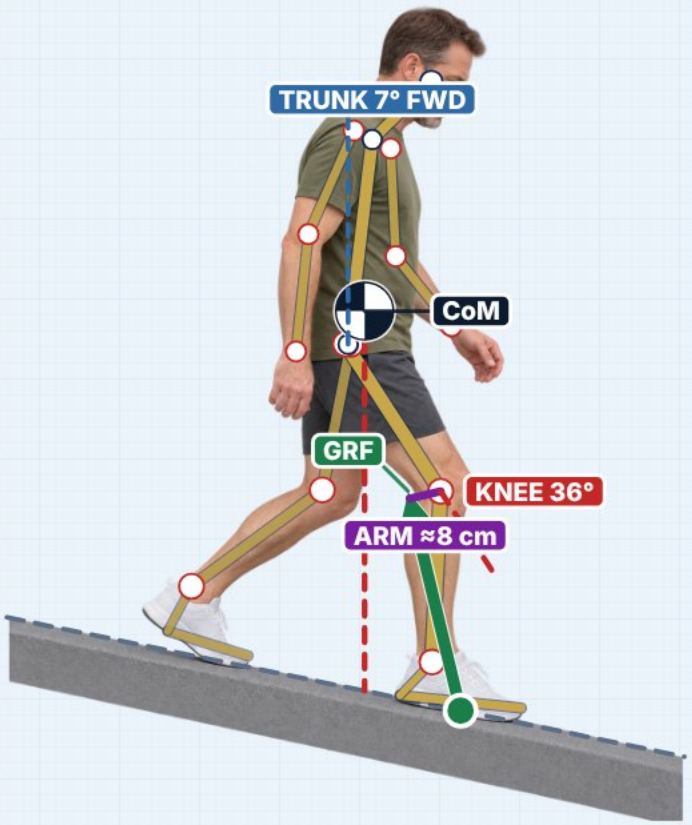
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INTEGRATING PERFORMANCE & REHABILITATION HEALTHCARE PATHWAYS.

WHY DOWNHILL WALKING CAN AGGRAVATE KNEE PAIN

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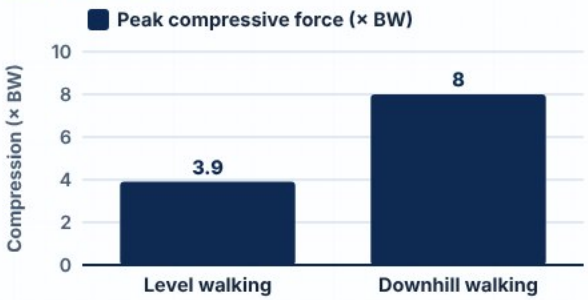
FRAME A · DOWNHILL WALKING · SIDE VIEW



Downhill: the quadriceps brake every step

- Front knee flexed **36°** as it accepts weight; the ground force passes ≈8 cm behind the knee.
- To lower the body the quadriceps work while lengthening (eccentric braking), and that muscle force compresses the joint.
- Downhill, about **80%** of peak joint compression came from muscle force (70% on the level).

Downhill roughly doubles estimated knee compression



Model estimates, 12 healthy adults; no SD in abstract. Kuster et al. (1997).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). GRF line from contact to CoM; ground drawn along the slope. Educational, not diagnostic.

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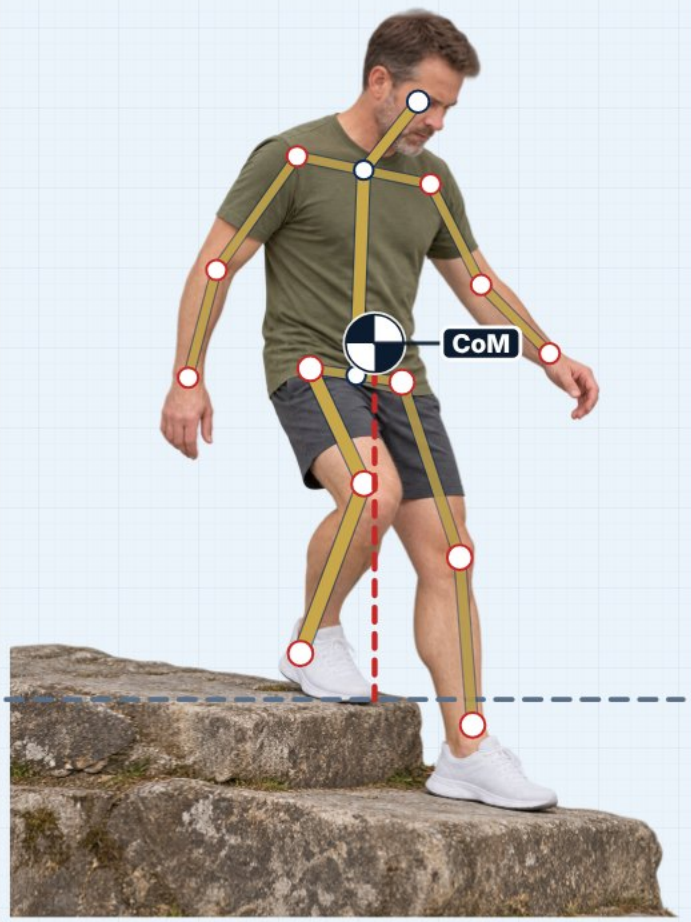
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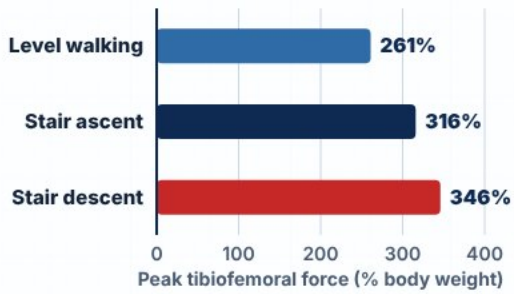
FRAME B · UNEVEN STEP DESCENT · OBLIQUE



Stepping down a rock: a single-leg drop

- Oblique view, so angles are not measured; the stance knee bends to lower the body onto the step below.
- Measured inside instrumented knees, **stepping down** gave the highest force of the daily tasks tested.
- Uneven, high steps add depth and impact to the same braking task.

Stepping down: the highest daily knee load



Instrumented knee replacements, n = 5; no SD reported. Kutzner et al. (2010).

Decision: shorter steps and a slower descent may reduce the drop each knee has to absorb (not directly tested).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Frame B is oblique: no angles reported. Educational, not diagnostic.

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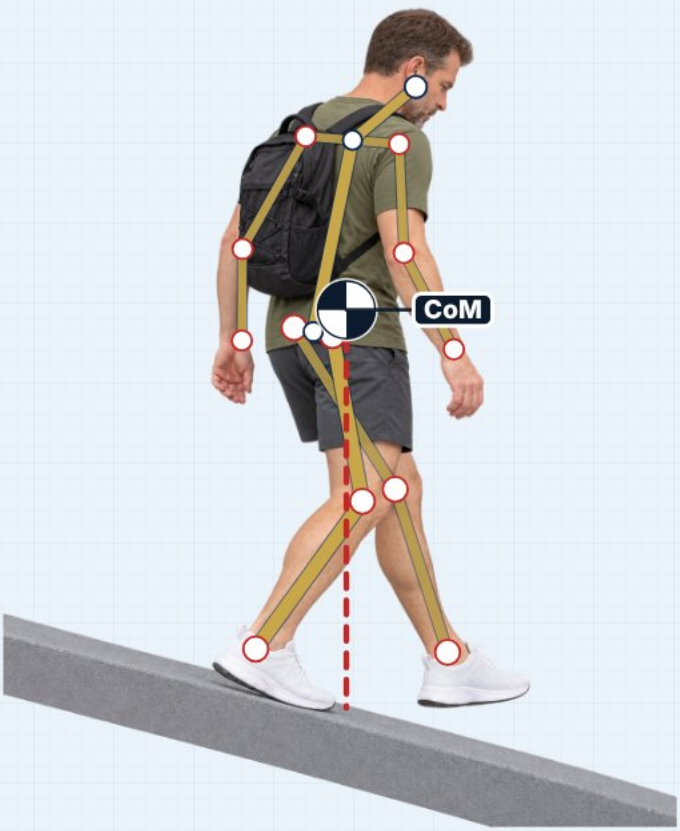
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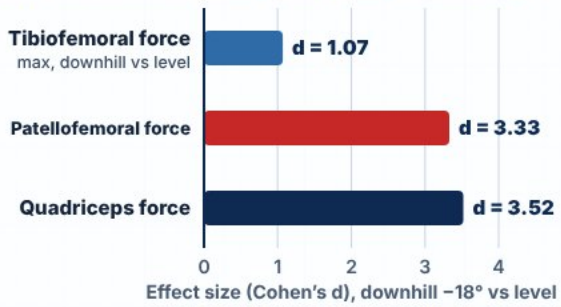
FRAME C · BACKPACK DOWNHILL · OBLIQUE



With a backpack: more mass to brake

- Oblique rear view, so angles are not measured; the pack moves the CoM back and adds mass the knees must lower.
- On a steep slope, quadriceps forces rose by more than **248%** versus level walking, and kneecap compression exceeded 3× body weight.
- Hiking poles with a heavy pack still reduced knee power absorption (Bohne et al., 2005; no values given).

Steep downhill walking: very large increases



Quadriceps value is the lower bound reported (d > 3.52).

18 healthy men; conference paper, not a journal article. Alexander & Schwameder (2016).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Frame C is oblique: no angles reported. Educational, not diagnostic.

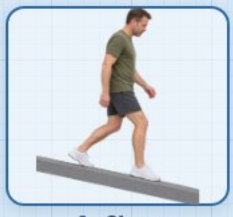
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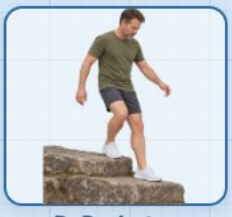
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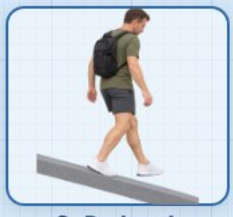
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A · Slope
Knee 36°, braking



B · Rock step
Single-leg drop



C · Backpack
More mass to lower

Hiking poles cut knee load downhill



8 men, 25° ramp; reported as a 12–25% range across these variables; TF = tibiofemoral. Schwameder et al. (1999).

Decision pathway

1. **USE POLES**
   Poles reduced knee moment and joint forces by 12–25% on a downhill ramp.
2. **CHANGE THE DOSE**
   Options: shorter steps, a slower descent, zig-zag routes, a lighter pack, and shorter downhill sections while symptoms settle.
3. **BUILD CAPACITY**
   Exercise therapy, preferably hip plus knee, is recommended for patellofemoral pain (Crossley et al., 2016); train slow step-downs.

NOT RECOMMENDED

Knee, patellofemoral or lumbar mobilisation; electrophysical agents (Crossley et al., 2016).

SEEK ASSESSMENT IF

After a fall: inability to bear weight, rapid swelling or bony tenderness; a hot, red, swollen knee; true locking; repeated giving way.

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KNEE PAIN WHILE CYCLING: LOOKING AT POSITION AND REPETITION

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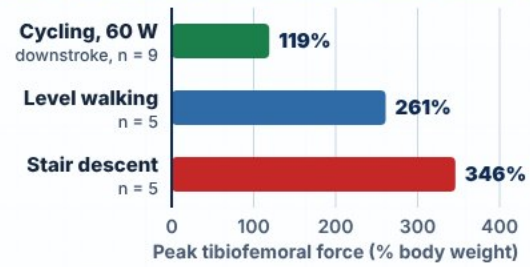
FRAME A · DOWNSTROKE · SIDE VIEW



Cycling: low load, very high repetition

- Mid-stroke the knees sit at about **61°** and **83°**; hip 98°, trunk 31° forward.
- Peak knee force in cycling is less than half that of walking, which is why it is used in rehabilitation.
- Forces rose in a straight line with **power**; thousands of cycles per ride make repetition the main dose.

Cycling loads the knee far less than walking



Instrumented knee replacements; different cohorts of the same programme. Kutzner et al. (2012, 2010).

Common in cyclists

36%
of professional road cyclists had anterior knee pain in a year

57%
of injuries causing time off were at the knee

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Educational, not diagnostic.

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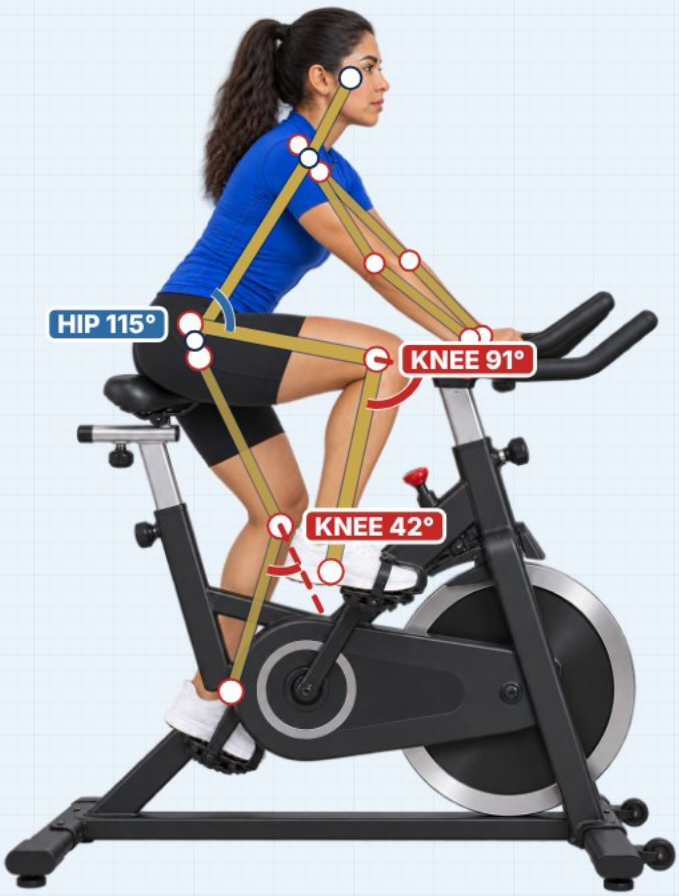
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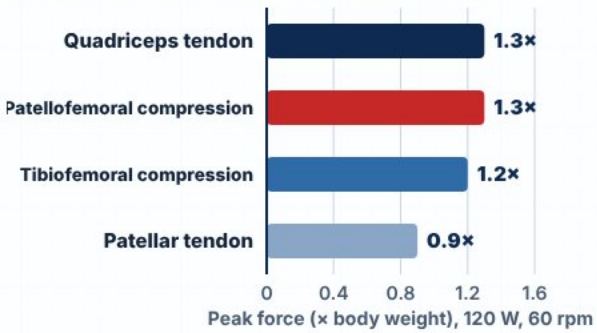
FRAME B · NEAR TOP OF STROKE · SIDE VIEW



Near the top: deepest knee bend

- Upper knee flexed **91°**, hip **115°**: the most flexed point of the stroke.
- Kneecap and tendon forces rose with **higher workload** or a **lower saddle**; pedalling rate and foot position had no significant effect.
- Tibiofemoral force rose with workload, not with cadence.

Modelled knee forces in steady cycling



Healthy adults, n = 6, mid saddle height. Ericson & Nisell (1986, 1987).

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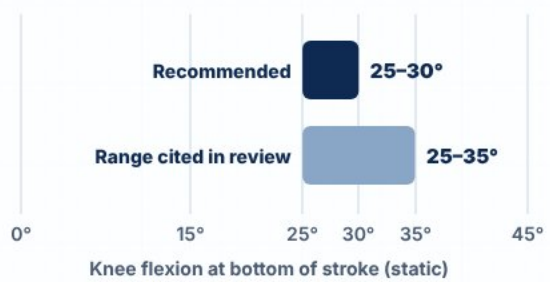
FRAME C · KNEE PATHS · FRONT VIEW



Front view: the knee path over the pedal

- Both knees track close to the feet (≈4 cm and ≈3 cm inside); pelvis level.
- Cyclists with a history of anterior knee pain showed slightly more shank adduction (1.9°) and less ankle dorsiflexion (4.9°) than pain-free riders.
- A **5% change in saddle height** altered knee kinematics by 35% and knee moments by 16%.

Saddle height: knee angle at the bottom



Changes under 4% of trochanteric length did not seem to affect injury risk.

Review. Bini et al. (2011). Knee path: 24 male cyclists, Bailey et al. (2003).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Knee tracking distance is horizontal, knee centre to foot centre. Educational, not diagnostic.

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A · Downstroke
Low force, many cycles

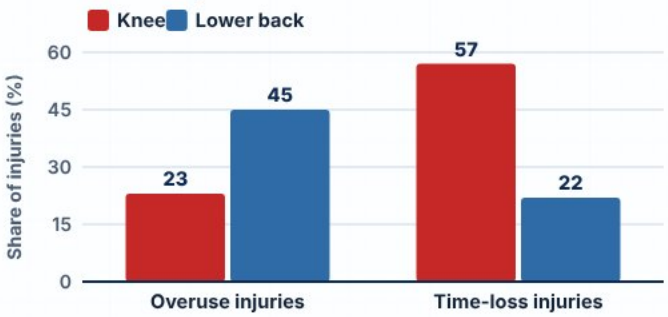


B · Top of stroke
Knee 91°



C · Front
Knee over pedal

Professional cyclists: where overuse strikes



109 professional road cyclists, 12-month recall. Clarsen et al. (2010).

Decision pathway

1. **CHECK THE FIT**
   Set the saddle so the knee is flexed about 25–30° at the bottom of the stroke; avoid a low saddle; change it in small steps.
2. **LOWER THE LOAD**
   Reduce resistance (power) before cadence: knee forces rose with workload, not with pedalling rate.
3. **STRENGTHEN**
   For anterior knee pain apply the patellofemoral consensus: hip plus knee exercise (Crossley et al., 2016).

NOT RECOMMENDED

Claiming a bike fit prevents injury or that a set cleat float stops pain — not shown in these sources.

SEEK ASSESSMENT IF

Swelling, locking or giving way; pain at rest or at night; pain after a crash; calf pain or swelling after long sitting.

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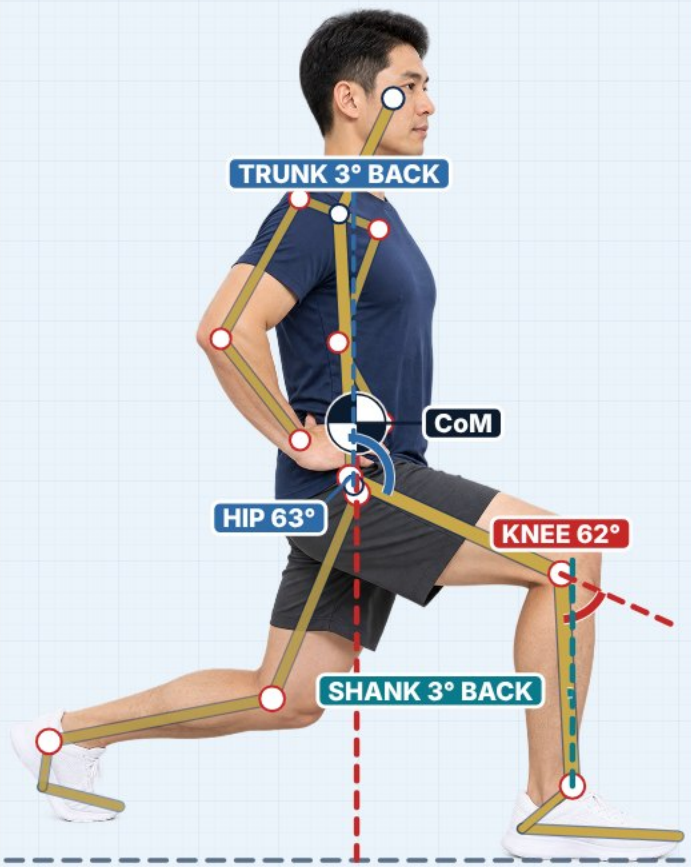
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INTEGRATING PERFORMANCE & REHABILITATION HEALTHCARE PATHWAYS.

KNEE PAIN DURING LUNGES: DEPTH, POSITION, AND LOAD

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FRAME A · FORWARD LUNGE · SIDE VIEW



Forward lunge: depth is the dose

- Front knee flexed **62°** with the shank near vertical (3° back); trunk upright.
- Kneecap (patellofemoral) stress climbs steeply beyond about **50–60°** and peaks near **80–90°**, and is higher on the way **up**.
- Grade depth (for example 0–50° early) rather than banning deep lunges.

Patellofemoral stress vs knee angle (bodyweight)



Peaks labelled; side lunge reached 3.25 MPa at 80°.

Means, 16 healthy adults, ascent phase. Escamilla et al. (2022).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Shank angle measured from vertical. Educational, not diagnostic.

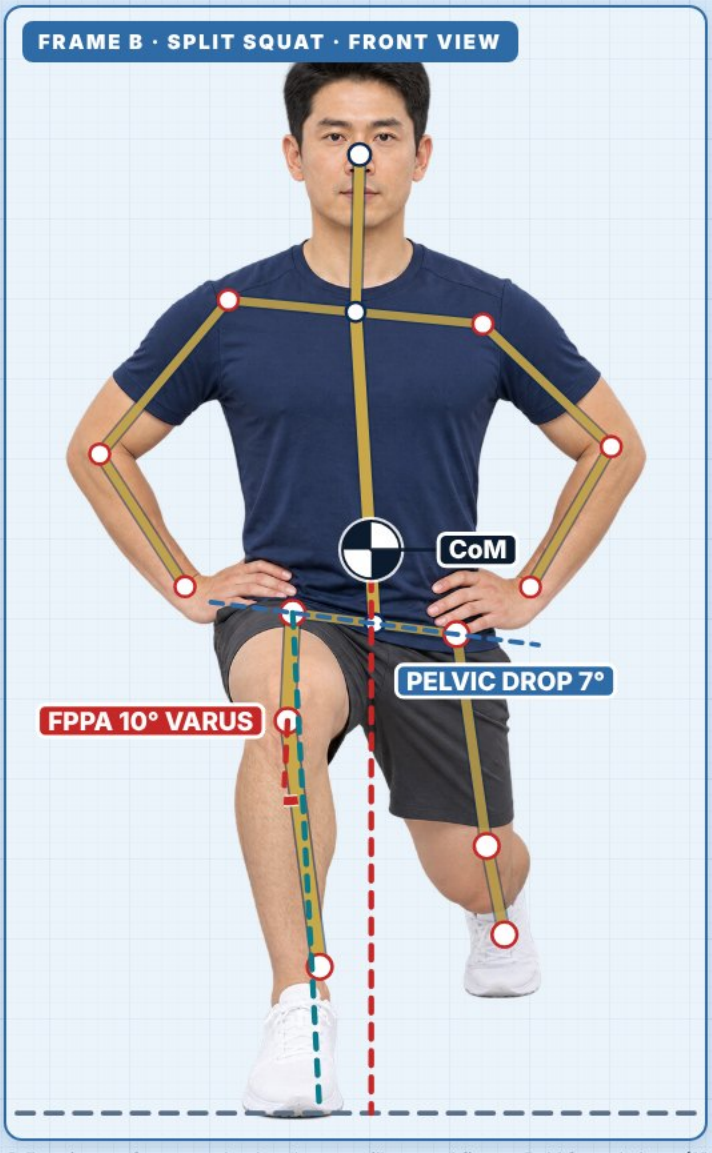
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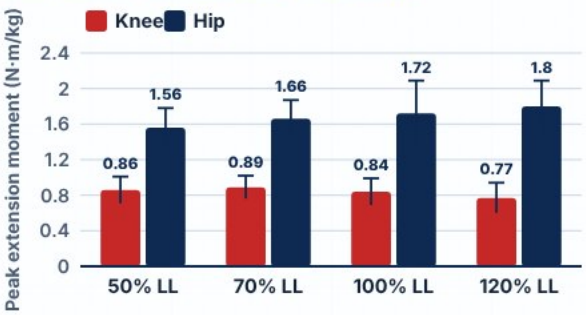
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Split squat: step length shifts the load

- Front knee 10° from the hip–ankle line; pelvic drop 7° toward the rear leg.
- A **longer step** lowered the front-knee moment and raised the hip moment.
- In loaded forward lunges, a short step raised kneecap force and stress at 70–90° (Escamilla et al., 2008).

Longer step: less knee, more hip



Mean ± SD, 20 trained men; LL = leg length. Song et al. (2023).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Educational, not diagnostic.

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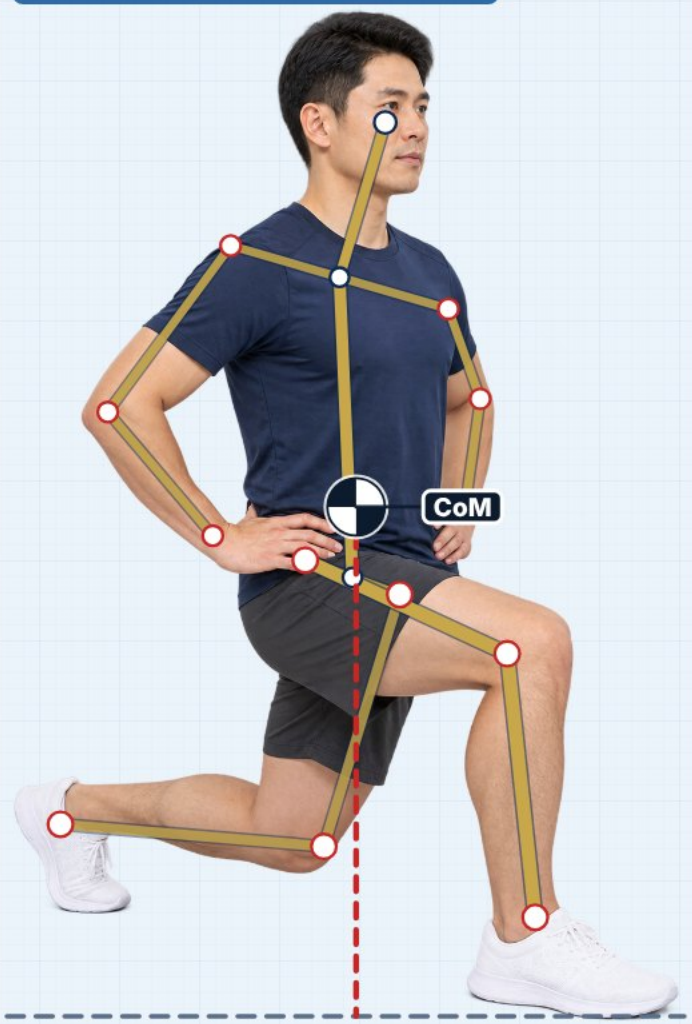
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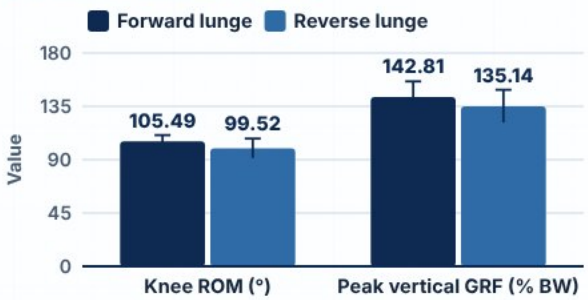
FRAME C · REVERSE LUNGE · OBLIQUE



Reverse lunge: a gentler entry

- Oblique view, so angles are not measured; stepping back keeps the CoM over the front foot instead of driving it forward.
- The reverse lunge produced slightly less knee motion and impact force than the forward lunge.
- Kneecap stress was not measured in this study, so it cannot be called "safer" for the joint.

Forward vs reverse lunge



Both differences significant ($p < 0.05$); preliminary data.

Mean ± SD, 15 healthy men. Park et al. (2021).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Frame C is oblique: no angles reported. Educational, not diagnostic.

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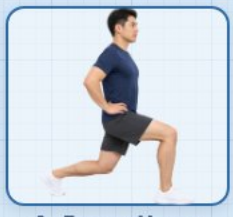
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A · Forward lunge
Knee 62°

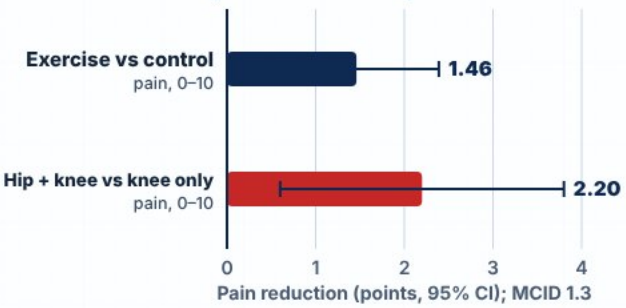


B · Split squat
Step length dial



C · Reverse lunge
Gentler entry

Exercise reduces patellofemoral pain



Short-term, very low to low-quality evidence. van der Heijden et al. (2015).

Decision pathway

1. **DEPTH**
   Start in a pain-acceptable range (often under 50–60°) and extend depth gradually.
2. **GEOMETRY**
   Use a longer step and no forward stride; try reverse lunges first.
3. **LOAD**
   Master bodyweight before adding external load — loaded lunges multiply kneecap force.

NOT RECOMMENDED

Knee, patellofemoral or lumbar mobilisation; electrophysical agents (Crossley et al., 2016).

SEEK ASSESSMENT IF

Swelling after loading, locking or catching, giving way, pain that persists into rest or night, or inability to bear weight after injury.

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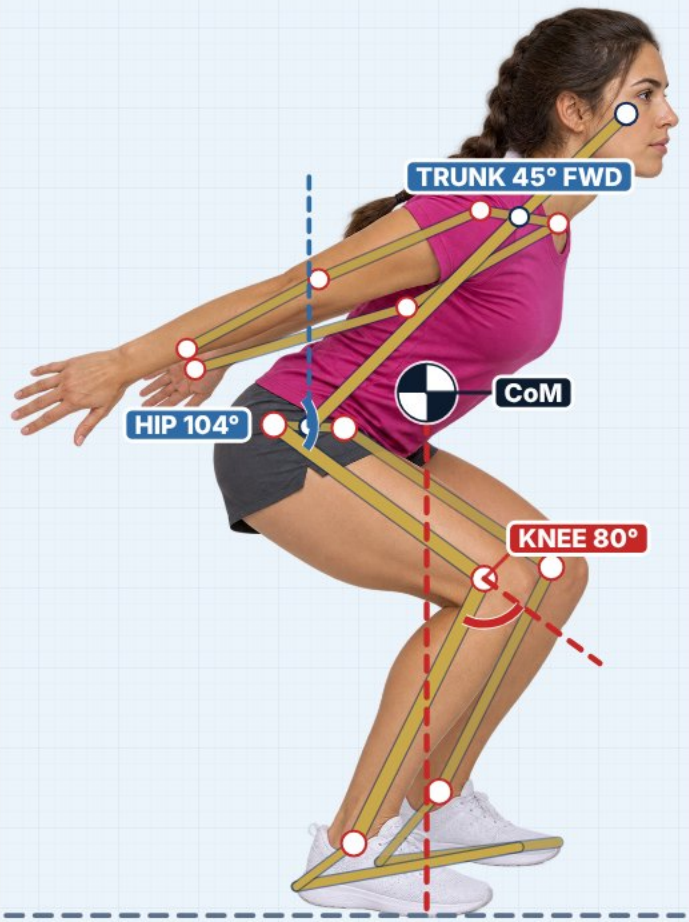
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KNEE PAIN WHEN JUMPING OR LANDING

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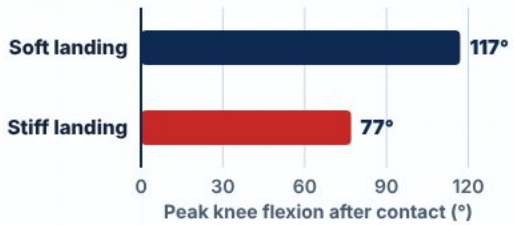
FRAME A · COUNTERMOVEMENT · SIDE VIEW



Countermovement: loading the spring

- Knee **80°**, hip **104°**, trunk **45°** forward: a hip-and-knee-shared crouch with arms swung back.
- The extensors stretch under load before take-off; landing reverses this and asks them to absorb it.
- A deeper, softer landing bends the knee further and spreads the work across hip and knee muscles.

Soft vs stiff landings



Stiff landings produced larger ground reaction forces; soft landings shifted energy absorption to hip and knee muscles.

8 female athletes, 59 cm drop. DeVita & Skelly (1992).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Educational, not diagnostic.

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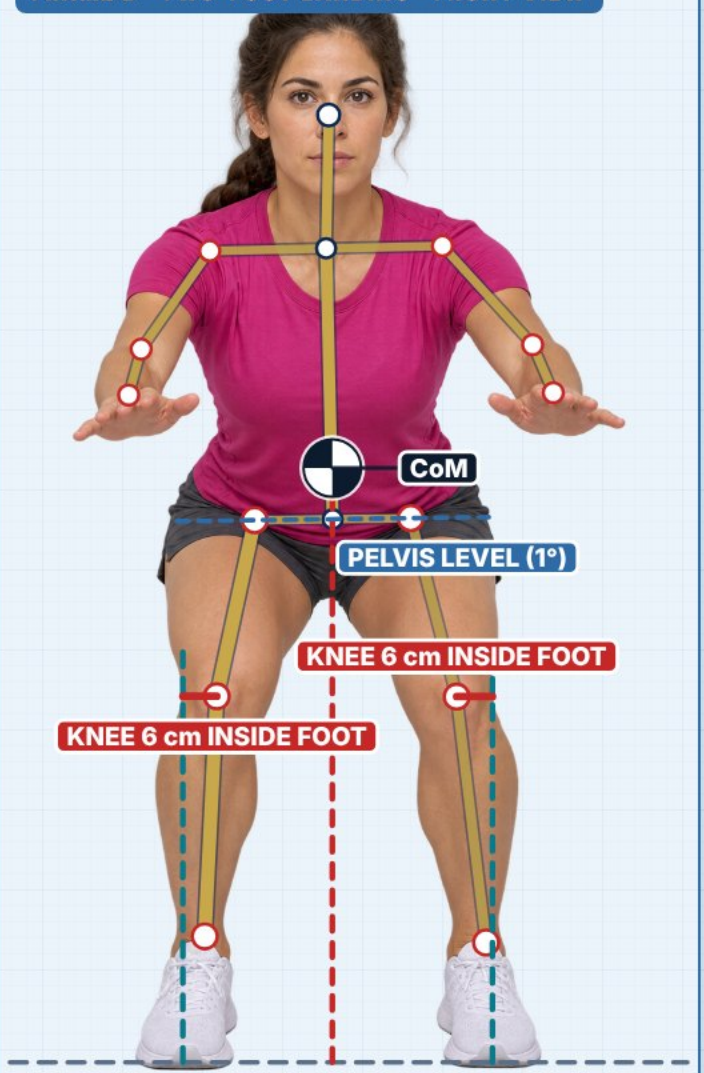
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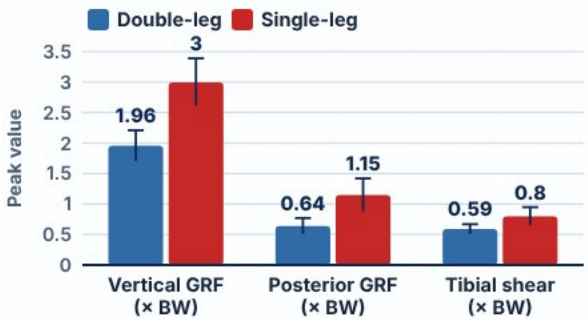
FRAME B · TWO-FOOT LANDING · FRONT VIEW



Two-foot landing: sharing the load

- Both knees track **≈6 cm inside the feet**; pelvis level (1°), trunk upright.
- Two legs share the impact, so each knee bends more and takes less force and less valgus moment.
- As drop height rises, landing force climbs faster than the knee's flexion response (Yeow et al., 2009).

Two legs vs one: peak forces per landing limb



Mean ± SD, 10 elite male volleyball players, stop-jump. Wang (2011).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Knee tracking distance is horizontal, knee centre to foot centre. Educational, not diagnostic.

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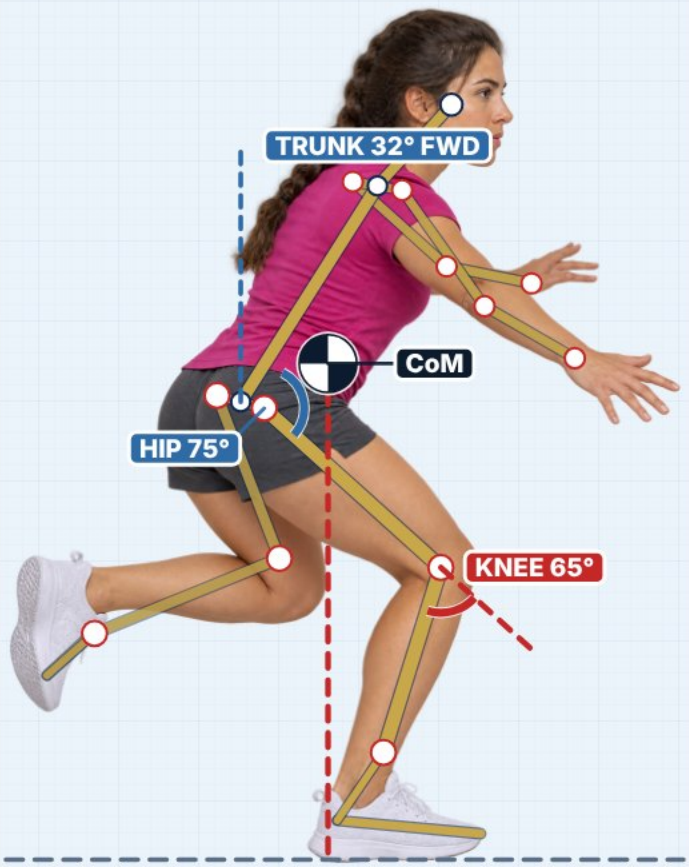
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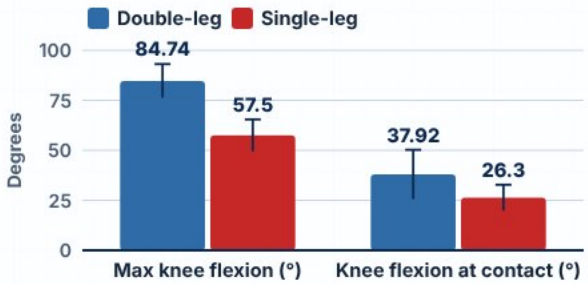
FRAME C · SINGLE-LEG LANDING · SIDE VIEW



Single-leg landing: straighter, stiffer, heavier

- Landing knee **65°**, hip **75°**, trunk 32° forward in this frame.
- On one leg, players landed with a straighter knee and bent it less, while vertical force rose about 50%.
- Knee valgus moment more than doubled (0.27 vs 0.12 BW×BH).

One leg: less knee bend to absorb more force



Mean ± SD, 10 elite male volleyball players. Wang (2011).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Educational, not diagnostic.

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A · Countermovement
Knee 80°, hip-led

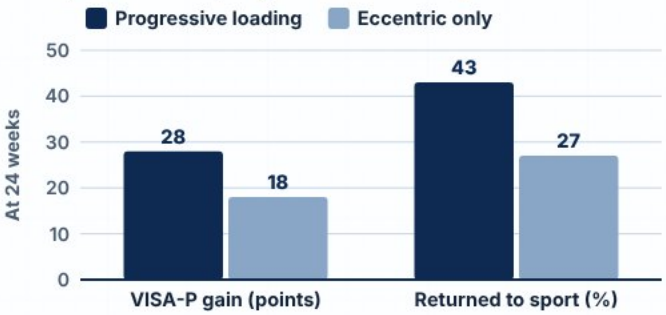


B · Two-foot landing
Load shared



C · Single-leg landing
≈3× BW on one knee

Jumper's knee: progressive loading wins



76 athletes; VISA-P adjusted difference 9 (95% CI 1–16); return to sport not significant. Breda et al. (2021).

Decision pathway

1. **LAND SOFT**
   Practise deeper hip-and-knee landings; start with two-foot landings before single-leg.
2. **GRADE HEIGHT**
   Progress drop and jump heights gradually: force rises faster than the knee's bend as height increases.
3. **LOAD THE TENDON**
   For jumper's knee, a staged programme from isometric to energy-storage work beat eccentric-only exercise.

NOT RECOMMENDED

Claiming that soft landing alone prevents tendinopathy, or that any single landing angle is "safe".

SEEK ASSESSMENT IF

A pop with inability to straighten the knee, rapid swelling after landing, giving way, or inability to bear weight.

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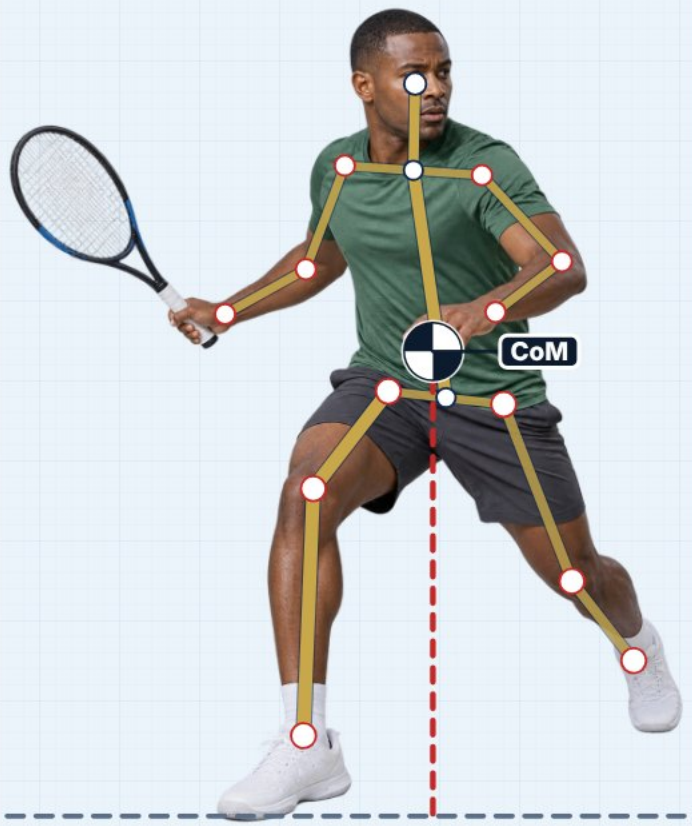
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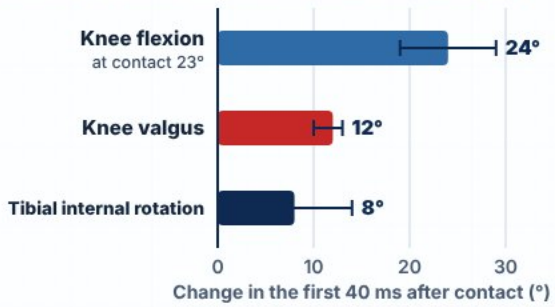
FRAME A · TENNIS DIRECTION CHANGE · OBLIQUE



Redirecting the body over a planted foot

- Oblique view, so angles are not measured; the CoM moves sideways away from the planted foot.
- Pivoting loads the knee in flexion plus **side-to-side (valgus/varus)** and **rotational** moments at the same time.
- In real non-contact ACL injuries, valgus and internal rotation appeared within 40 ms; peak force reached 3.2× body weight.

The first 40 ms of a non-contact ACL injury



Mean (95% CI), 10 injury videos, women's handball and basketball. Koga et al. (2010).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Frame A is oblique: no angles reported. Educational, not diagnostic.

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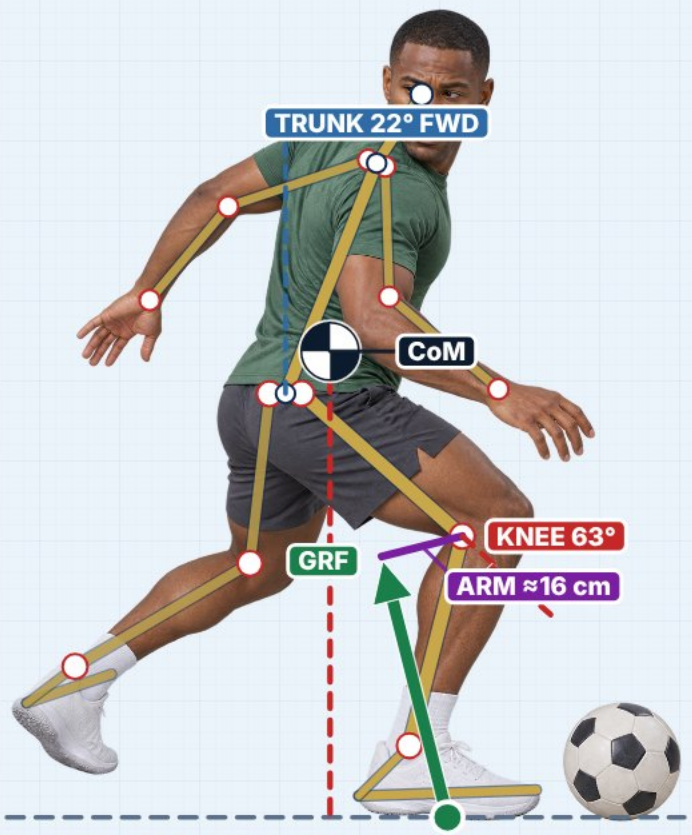
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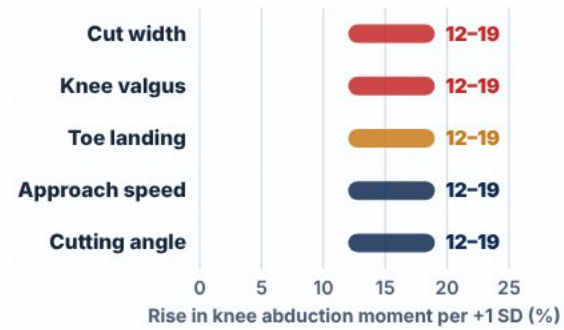
FRAME B · FOOTBALL CUT · SIDE VIEW



Football cut: technique drives knee load

- Plant knee **63°**, trunk **22°** forward; the ground force passes ≈16 cm behind the knee.
- Technique explained **62%** of the variation in knee abduction moment; the force's lever arm mattered more than its size.
- Sharper cuts (90° or more) raised valgus moment compared with 45° cuts (Schreurs et al., 2017).

Five technique factors that raise knee abduction moment



Reported as a combined 12–19% range; per-factor values not given.

123 female handball players, sidestep cuts. Kristianslund et al. (2014).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). GRF line from contact to CoM. Educational, not diagnostic.

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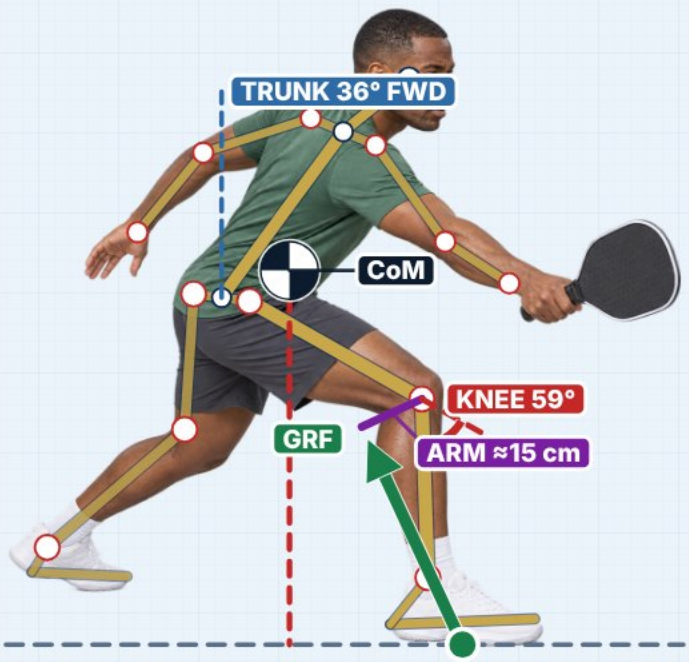
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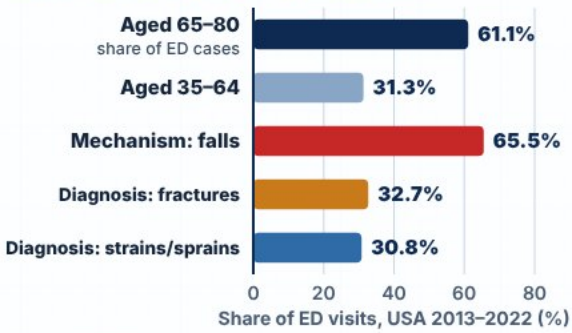
FRAME C · PICKLEBALL BRAKING REACH · SIDE VIEW



Pickleball: braking into a low reach

- Lead knee **59°**, hip **89°**, trunk **36°** forward; ground force ≈15 cm behind the knee.
- Short, sharp braking steps and lateral reaches load the knee eccentrically.
- Most injured players were older adults, falls were the main mechanism, and fractures the commonest diagnosis.

Who gets hurt playing pickleball



About 66,350 estimated visits; knee share not reported.

National injury surveillance data. Yu et al. (2025).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). GRF line from contact to CoM. Educational, not diagnostic.

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KNEE PAIN DURING PIVOTING: TENNIS, FOOTBALL, AND PICKLEBALL

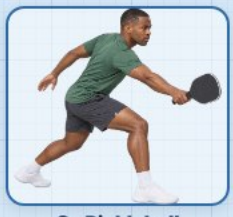
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A · Tennis
Planted pivot

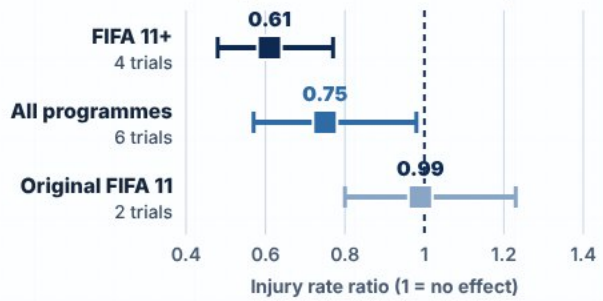


B · Football cut
Arm ≈16 cm



C · Pickleball
Brake and reach

Exercise-based warm-ups reduce football injuries



Overall injuries (all body regions), 6 cluster RCTs. Thorborg et al. (2017).

Decision pathway

1. **WARM UP**
   Use a structured programme such as FIFA 11+: about 39% fewer injuries overall.
2. **CUT SMARTER**
   Narrower foot placement and less knee valgus during cuts were linked to lower knee abduction moment (laboratory data).
3. **OLDER PLAYERS**
   In pickleball, balance and deceleration training matter: falls and fractures dominate the injuries.

NOT RECOMMENDED

Relying on a single technique cue to prevent ACL injury; assuming pickleball injuries are minor.

SEEK ASSESSMENT IF

A pop, immediate swelling, giving way, locking, or inability to take 4 steps after a pivot or fall; after a fall do not assume a sprain.

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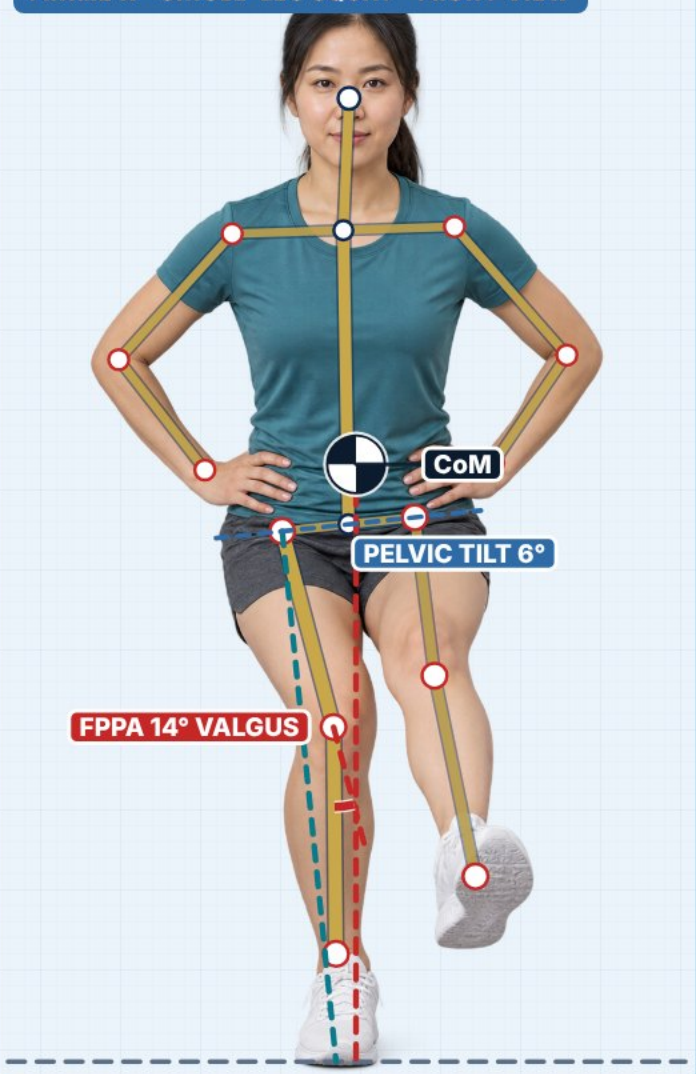
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INTEGRATING PERFORMANCE & REHABILITATION HEALTHCARE PATHWAYS.

KNEES MOVING INWARD: WHAT DOES DYNAMIC KNEE VALGUS TELL US?

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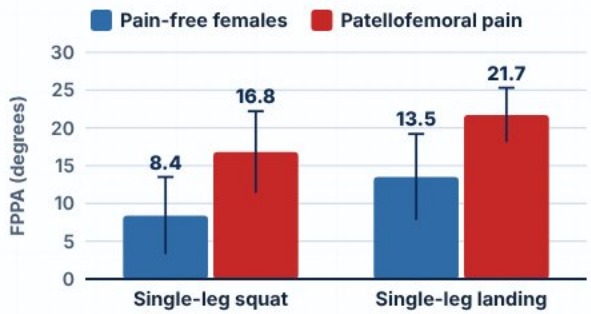
FRAME A · SINGLE-LEG SQUAT · FRONT VIEW



A movement observation, not a diagnosis

- Frontal-plane projection angle (FPPA) **≈14°** on the stance leg; pelvic tilt 6°.
- Dynamic valgus combines hip adduction and internal rotation, knee abduction and foot motion — not just the knee.
- Pain-free women averaged about **8°** in the same task, so some inward motion is normal.

Higher FPPA with patellofemoral pain



Cross-sectional: valgus may be a cause, a consequence of pain, or neither.

Mean ± SD; 12 females with PFP vs 30 controls. Herrington (2014).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). FPPA measured from the front view. Educational, not diagnostic.

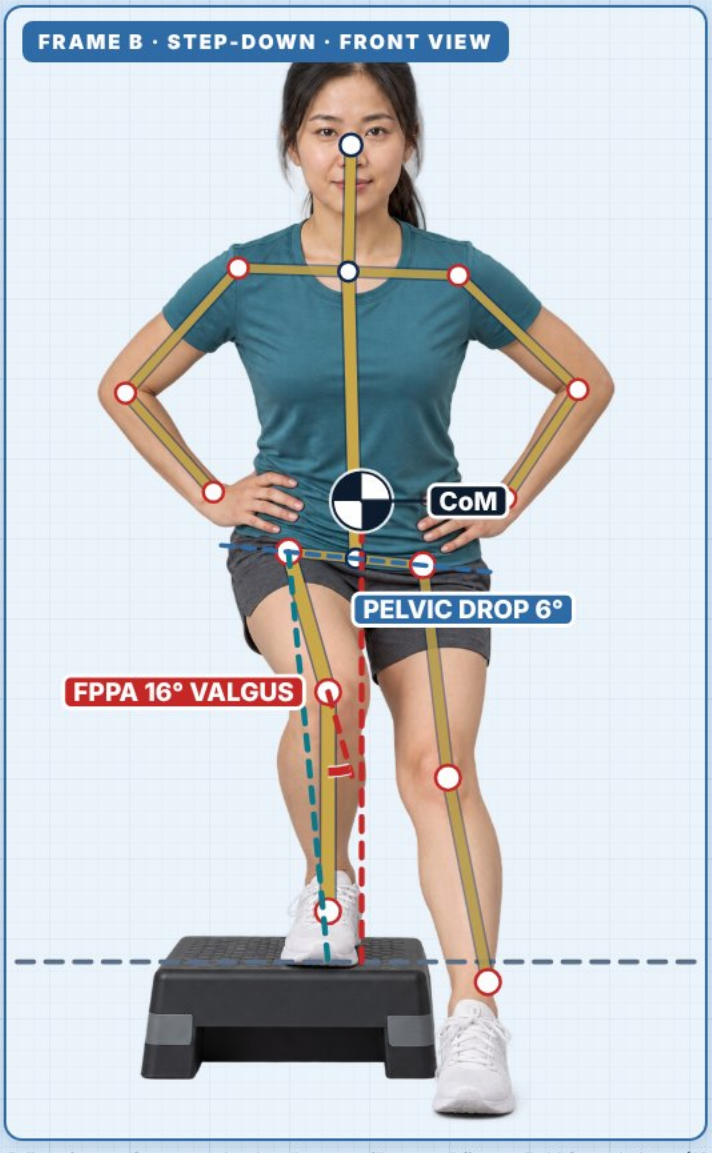
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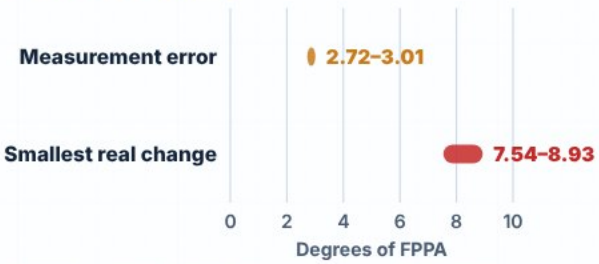
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Step-down: how reliable is a phone video?

- FPPA ≈**16°** on the stance leg; pelvic drop 6° on the free-leg side.
- A change smaller than about **8°** between two videos may be measurement error.
- Agreement between 2D video and 3D valgus varied widely by task and leg (r −0.05 to 0.90).

2D FPPA reliability



Reliability (ICC): 0.59–0.88 within a day, 0.72–0.91 between days.

20 adults, squat and landing tasks. Munro et al. (2012). 2D vs 3D: Jamaludin et al. (2022).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). FPPA measured from the front view. Educational, not diagnostic.

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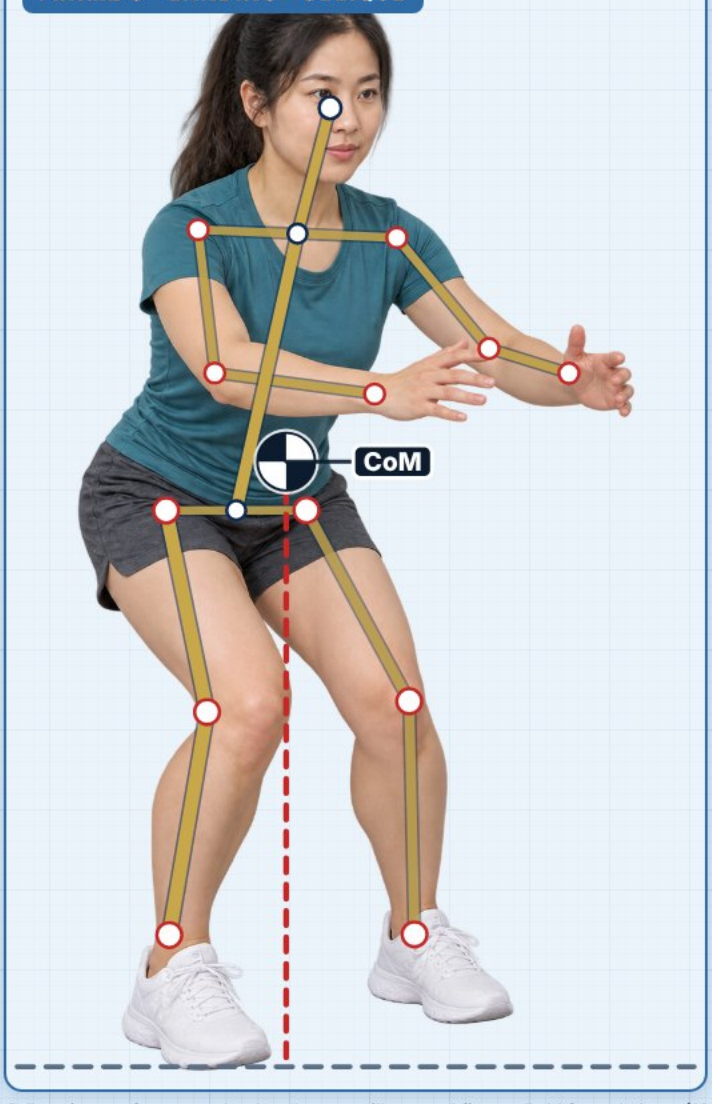
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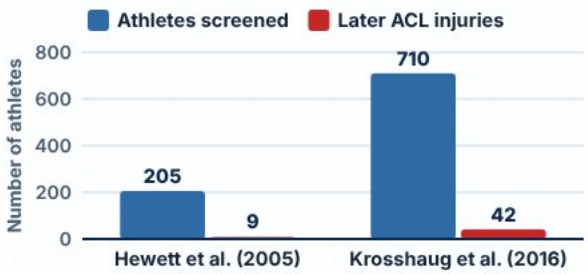
FRAME C · LANDING · OBLIQUE



Landing: does valgus predict injury?

- Oblique rear view, so angles are not measured here.
- A small cohort found knee abduction moment predicted ACL injury (sensitivity 78%, specificity 73%).
- A much larger cohort found drop-jump screening could not predict ACL injury (**AUC ≈ 0.6**).

Promising small study, poor large-scale screen



In 12-week military training, landing FPPA ≥5.2° carried 2.2× the risk of patellofemoral pain (Alrayani et al., 2023).

Prospective cohorts of female athletes.

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Frame C is oblique: no angles reported. Educational, not diagnostic.

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A · Single-leg squat
FPPA ≈14°



B · Step-down
FPPA ≈16°



C · Landing
Screening limits

Training reduces ACL injuries



Meta-analysis of 8 meta-analyses. Webster & Hewett (2018).

Decision pathway

1. **OBSERVE**
   Film consistently (same camera height, distance, task); treat changes under ~8° with caution.
2. **INTERPRET**
   Valgus is one observation within the clinical picture, not a screening verdict on its own.
3. **TRAIN**
   Neuromuscular prevention programmes for sport; hip plus knee exercise for patellofemoral pain (Crossley et al., 2016).

NOT RECOMMENDED

Labelling any inward knee as dangerous; mobilisation or electrophysical agents for patellofemoral pain (Crossley et al., 2016).

SEEK ASSESSMENT IF

Valgus collapse with a pop, rapid swelling or giving way in sport; locking; night pain; visible malalignment at rest.

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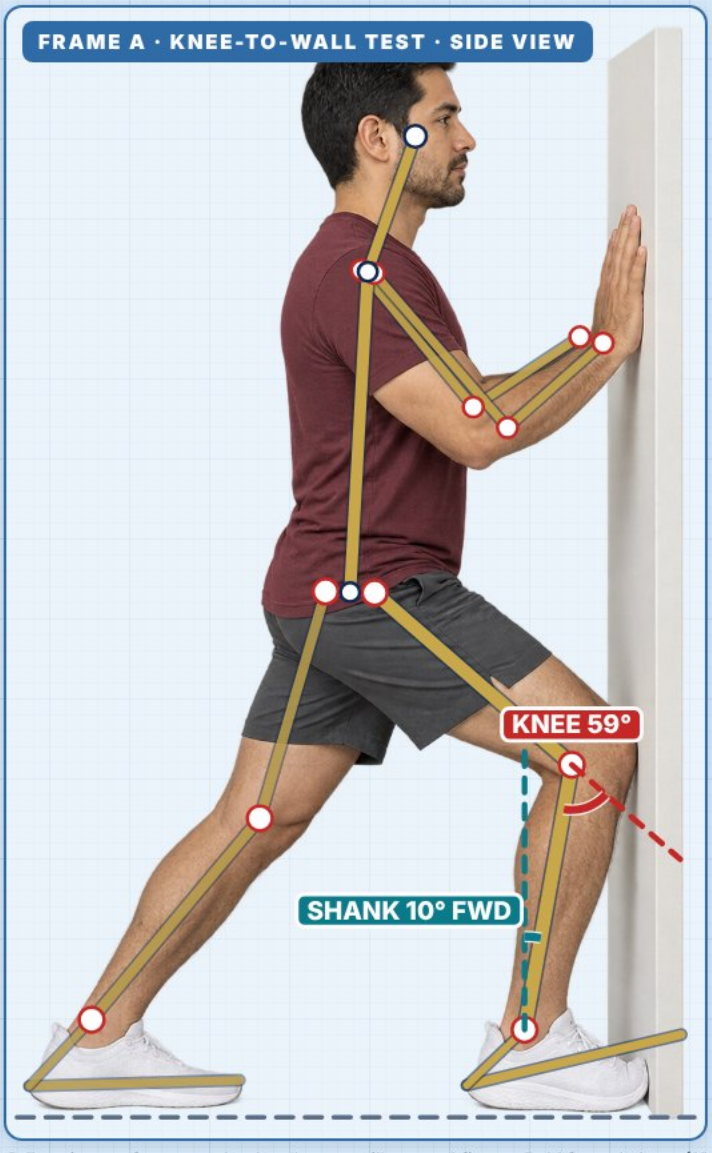
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INTEGRATING PERFORMANCE & REHABILITATION HEALTHCARE PATHWAYS.

CAN LIMITED ANKLE MOBILITY CHANGE HOW YOU LOAD YOUR KNEES?

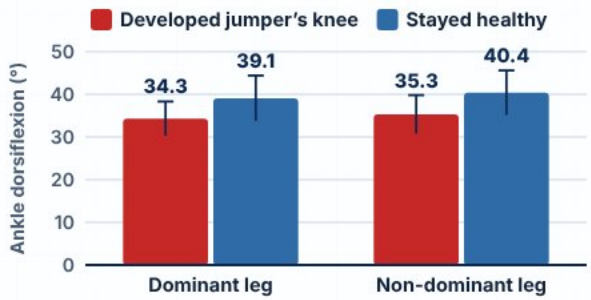
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The knee-to-wall test

- Front shank tilted **10°** forward from vertical, knee 59° — the shin angle is what the test measures.
- Ankle dorsiflexion lets the shin travel forward over the foot; when it runs out, the body finds the motion elsewhere.
- Basketball players below **36.5°** had a 1-year jumper's knee risk of 18.5–29.4% vs about 2% above it.

Less dorsiflexion before jumper's knee



Mean ± SD; 75 junior elite basketball players, 1 year. Backman & Danielson (2011).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Shank angle measured from vertical; heel at the floor line. Educational, not diagnostic.

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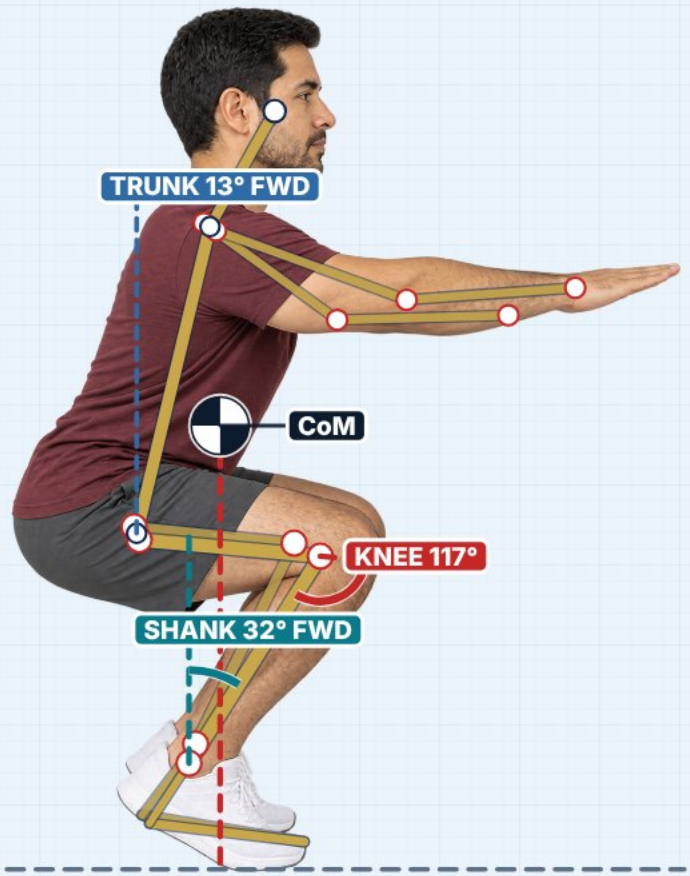
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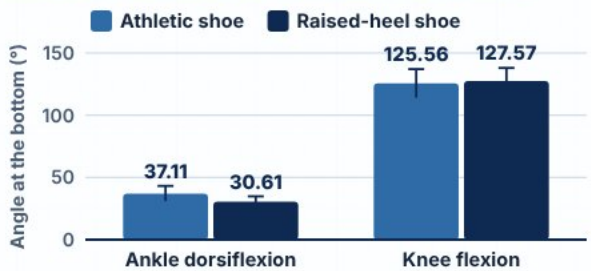
FRAME B · SQUAT WITH HEELS RISING · SIDE VIEW



Heels rising: the ankle runs out of range

- Knee **117°** with the shank **32°** forward and heels lifting.
- A raised heel reduced the dorsiflexion needed by 3.6° and let the knee bend 3.3° further, with a slightly higher knee extensor moment.
- A heel lift helps depth and comfort; it is not a knee-unloading tool.

Raised heel: less ankle, a little more knee



Mean ± SD, experienced male lifters, unloaded squat. Legg et al. (2017).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Shank angle measured from vertical. Educational, not diagnostic.

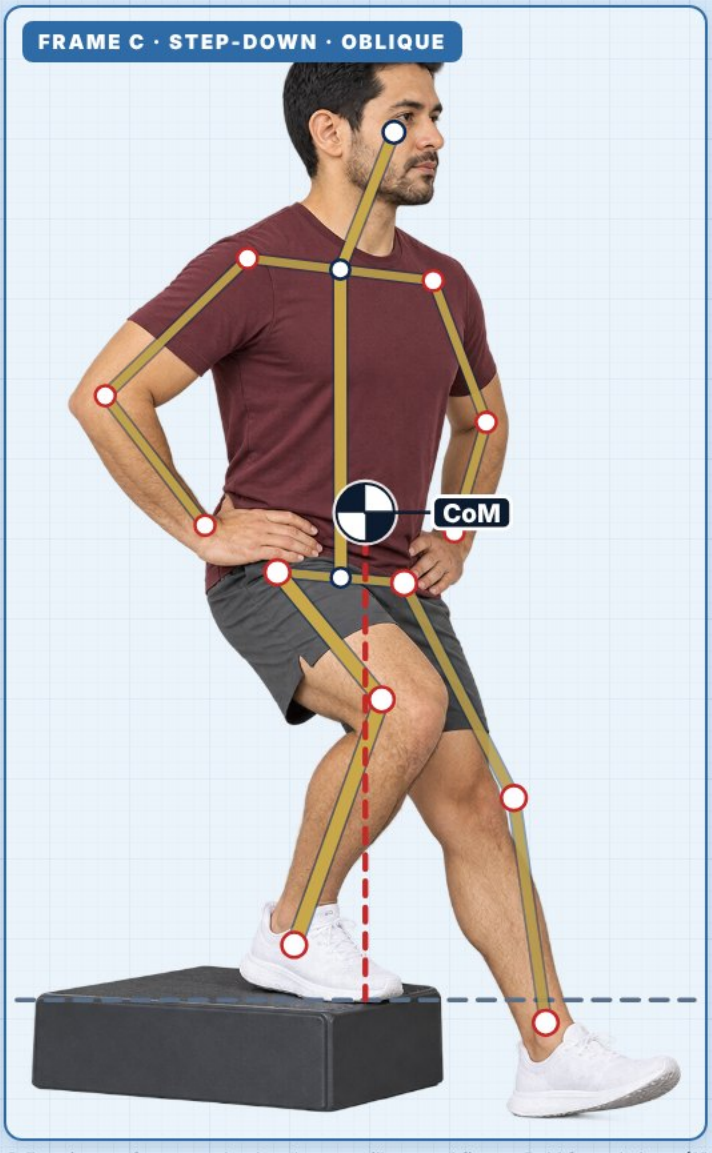
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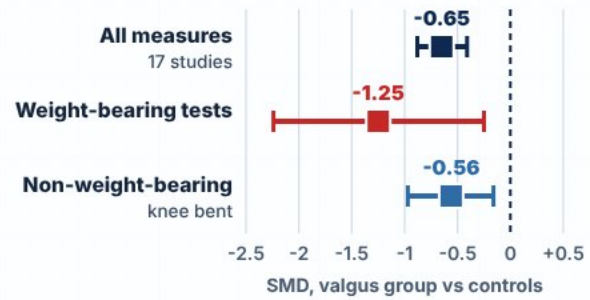
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Step-down: where the knee goes when the ankle stops

- Oblique view, so angles are not measured; the stance shin must travel forward to lower the body.
- People with dynamic knee valgus had less dorsiflexion than controls — most clearly when it was measured **weight-bearing.**
- A squat with a forefoot wedge increased inward knee displacement (effect size 2.92) (Macrum et al., 2012).

Limited dorsiflexion goes with knees moving inward



Meta-analysis. Lima et al. (2018).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Frame C is oblique: no angles reported. Educational, not diagnostic.

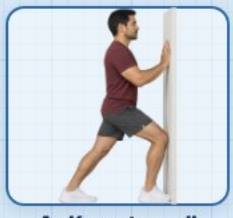
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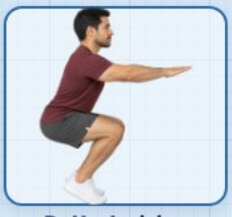
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A · Knee-to-wall
Shank 10°

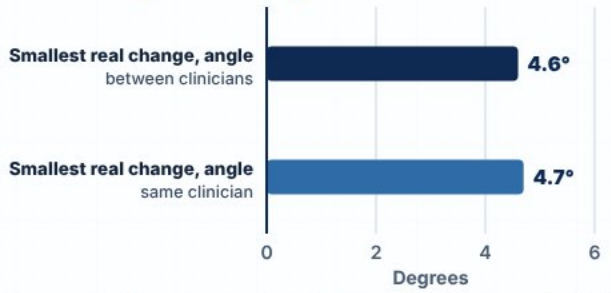


B · Heels rising
Shank 32°



C · Step-down
Shin travel needed

Is the change real? Lunge-test measurement error



Distance: 1.6–1.9 cm. Systematic review, 12 studies. Powden et al. (2015).

Decision pathway

1. **TEST WEIGHT-BEARING**
   Use the knee-to-wall lunge, not only a lying measure; re-test against ~2 cm or ~5° before calling it a change.
2. **TRAIN THE RANGE**
   Where dorsiflexion is limited, work on calf length and ankle mobility alongside strength.
3. **LOAD SMART**
   Use heel lifts for comfort or depth, knowing they shift a little more load to the knee.

NOT RECOMMENDED

Treating a lying-down ankle measure as proof of how the ankle behaves in a squat (Dill et al., 2014).

SEEK ASSESSMENT IF

Knee pain with swelling after injury, inability to bear weight, locking or giving way.

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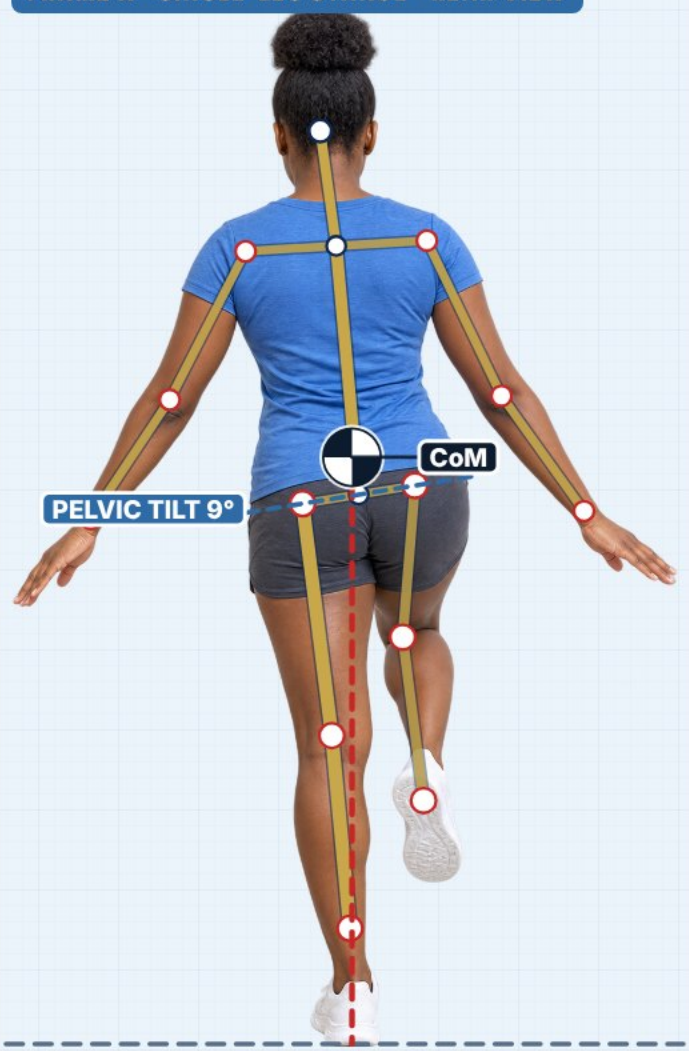
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HIP AND TRUNK CONTROL: HOW THE WHOLE BODY INFLUENCES KNEE LOADING

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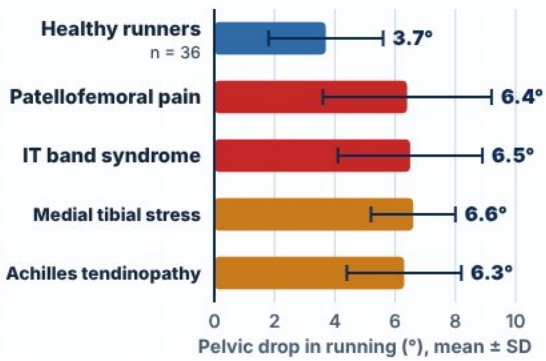
FRAME A · SINGLE-LEG STANCE · REAR VIEW



Single-leg stance: the pelvis sets the knee's line

- Rear view: pelvis tilted **9°**, trunk 5° from vertical over the stance leg.
- When the free-leg side of the pelvis drops, the knee adduction moment rises; adding trunk lean raises it further (Takacs & Hunt, 2012).
- Each extra degree of pelvic drop raised the odds of being an injured runner by **87%** (OR 1.87).

Injured runners show more pelvic drop



108 runners, 3D analysis; case–control, so association only. Bramah et al. (2018).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Rear view; pelvic tilt is the line through both hip centres. Educational, not diagnostic.

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INTEGRATING PERFORMANCE & REHABILITATION HEALTHCARE PATHWAYS.

HIP AND TRUNK CONTROL: HOW THE WHOLE BODY INFLUENCES KNEE LOADING

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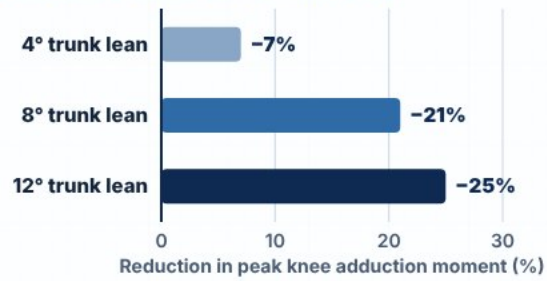
FRAME B · SINGLE-LEG SQUAT · FRONT VIEW



Single-leg squat: trunk position moves the force line

- FPPA **≈10°**, trunk **8°** toward the stance side, pelvic tilt 4°.
- Leaning the trunk over the stance leg moves the ground force toward the knee centre and **lowers** the knee adduction moment.
- In knee OA the effect was dose-dependent, but cost about 9.5% more oxygen and gave no immediate pain change.

Trunk lean toward the stance leg



9 healthy adults, walking. Hunt et al. (2011). OA: Simic et al. (2012); Takacs et al. (2014).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). FPPA measured from the front view. Educational, not diagnostic.

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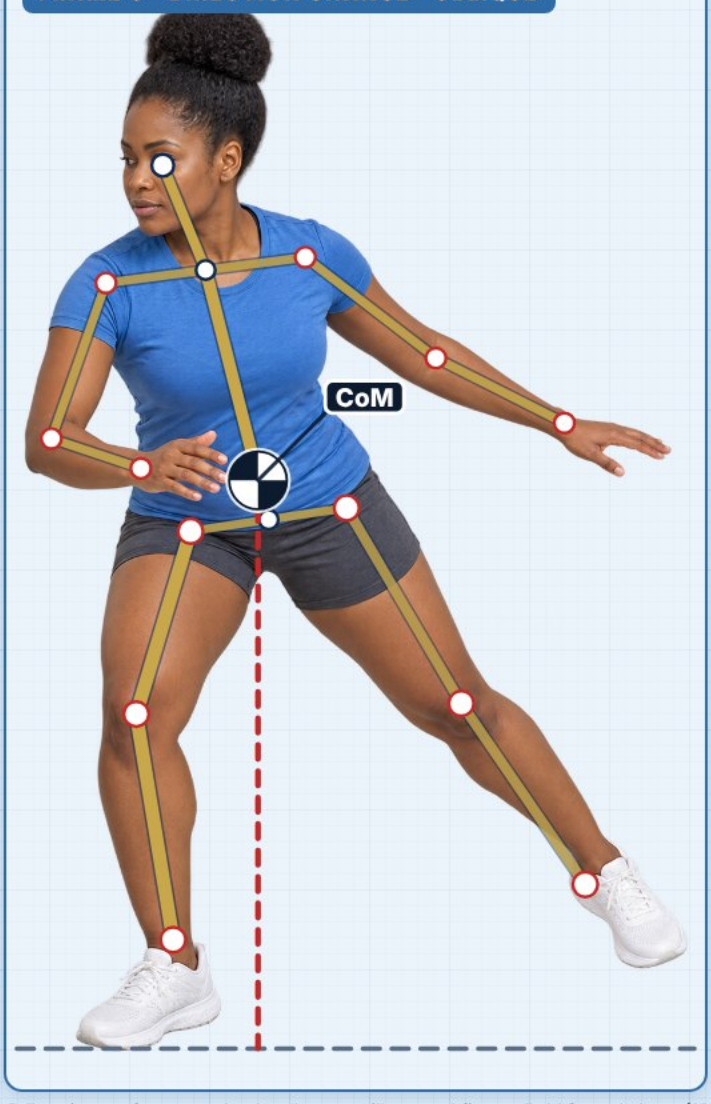
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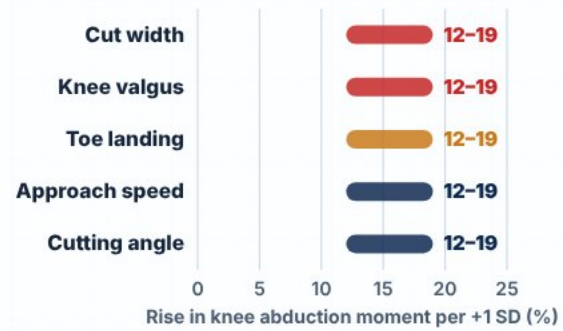
FRAME C · DIRECTION CHANGE · OBLIQUE



Direction change: the trunk steers the knee load

- Oblique view, so angles are not measured; the trunk rotates and leans as the plant leg pushes off.
- Leaning the torso away from the cut and planting the foot wide increased valgus moments (Dempsey et al., 2007).
- In 277 athletes, lateral trunk displacement was the strongest predictor of later knee ligament injury (Zazulak et al., 2007).

Cutting technique and knee abduction moment



Technique explained 62% of variation; reported as a combined 12–19% range.

123 female handball players. Kristianslund et al. (2014).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Frame C is oblique: no angles reported. Educational, not diagnostic.

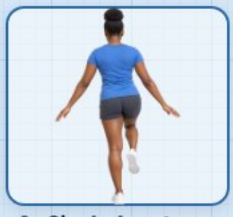
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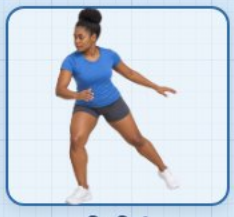
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A · Single-leg stance
Pelvic tilt 9°



B · Single-leg squat
FPPA ≈10°



C · Cut
Trunk steers load

Adding hip work to knee work in patellofemoral pain



14 trials, 673 people; benefit came without measurable strength change. Nascimento et al. (2018).

Decision pathway

1. **ASSESS THE CHAIN**
   Watch pelvis and trunk, not just the knee, in single-leg tasks and cuts.
2. **TRAIN HIP + KNEE**
   Combined hip and knee exercise is preferred over knee exercise alone (Collins et al., 2018).
3. **COACH TECHNIQUE**
   Narrower plant, trunk over the stance leg, less knee valgus when cutting; trunk-lean gait for OA remains experimental.

NOT RECOMMENDED

Mobilisation alone or electrophysical agents for patellofemoral pain (Collins et al., 2018).

SEEK ASSESSMENT IF

Giving way during a cut or landing, rapid swelling, inability to bear weight, or locking.

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Analysis: MMSx Authority Applied Biomechanics Lab · Dr. Neeraj Mehta, PhD · Educational content, not a diagnosis.

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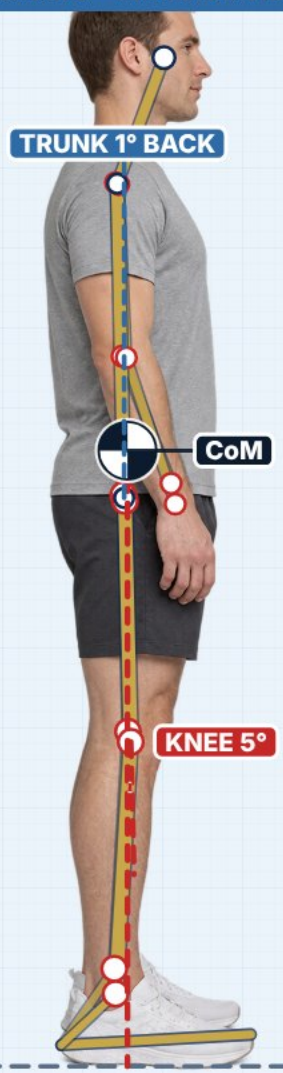
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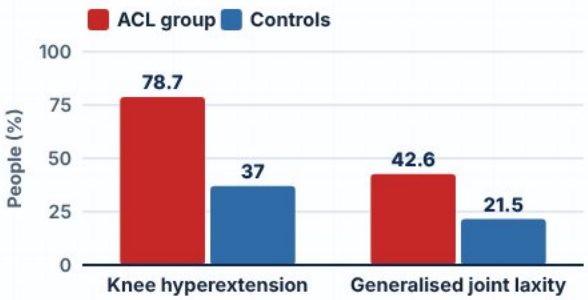
FRAME A · STANDING · TRUE SIDE VIEW



Standing: how straight is straight?

- In this figure the knee measures **≈5° of flexion** — near straight, not visibly hyperextended.
- Hyperextension (genu recurvatum) means the knee extends past 0°; a few degrees can be normal, and thresholds differ between studies.
- Hyperextension was twice as common in people who had ACL reconstruction as in matched controls.

Hyperextension and laxity after ACL injury



169 ACL-reconstructed vs 65 matched controls; case–control, association only.

Ramesh et al. (2005). Population context: hypermobility in 26.2% of students (Russek & Errico, 2016).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Educational, not diagnostic.

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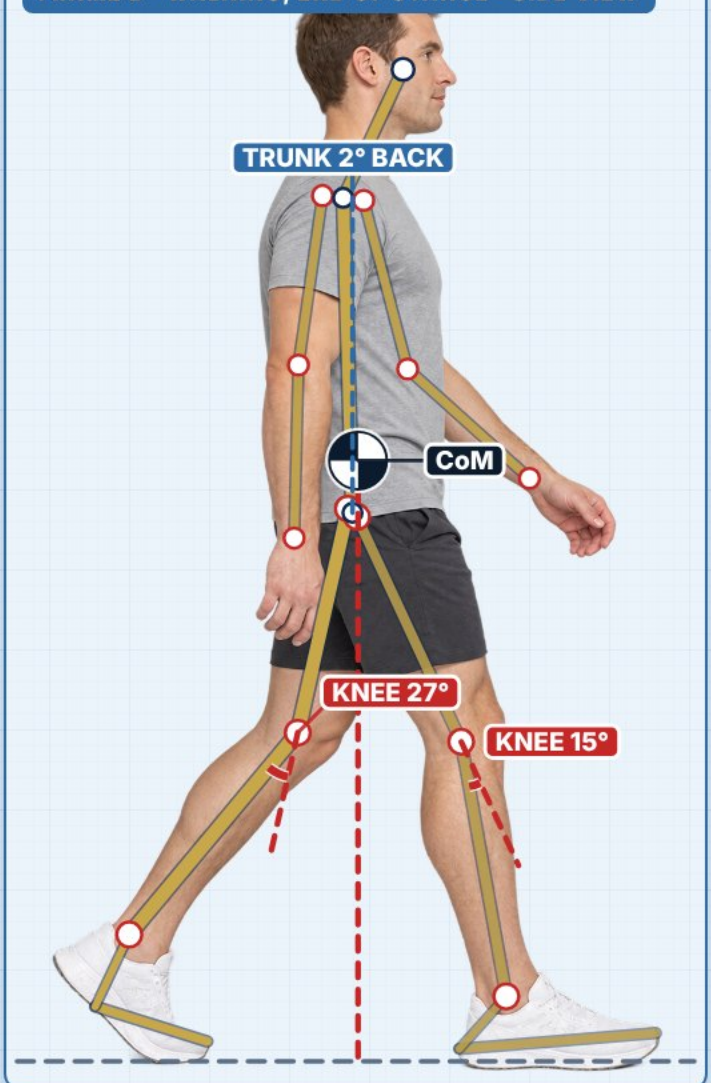
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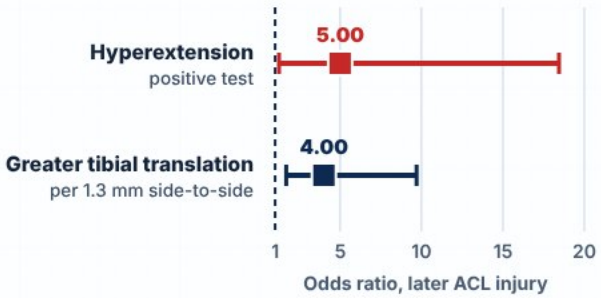
FRAME B · WALKING, END OF STANCE · SIDE VIEW



Walking: where the knee is nearest straight

- Front knee near straight at contact (**15°**); trailing knee **27°** as it unloads before push-off.
- A knee that habitually snaps back past straight in stance loads the posterior capsule and ligaments.
- In a screening cohort, hyperextension carried about **5×** the odds of later ACL injury — with a very wide interval.

Laxity markers and later ACL injury



Point ORs approximate ("5-fold", "4-fold"); 1,558 female players screened, 19 injuries. Myer et al. (2008).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Educational, not diagnostic.

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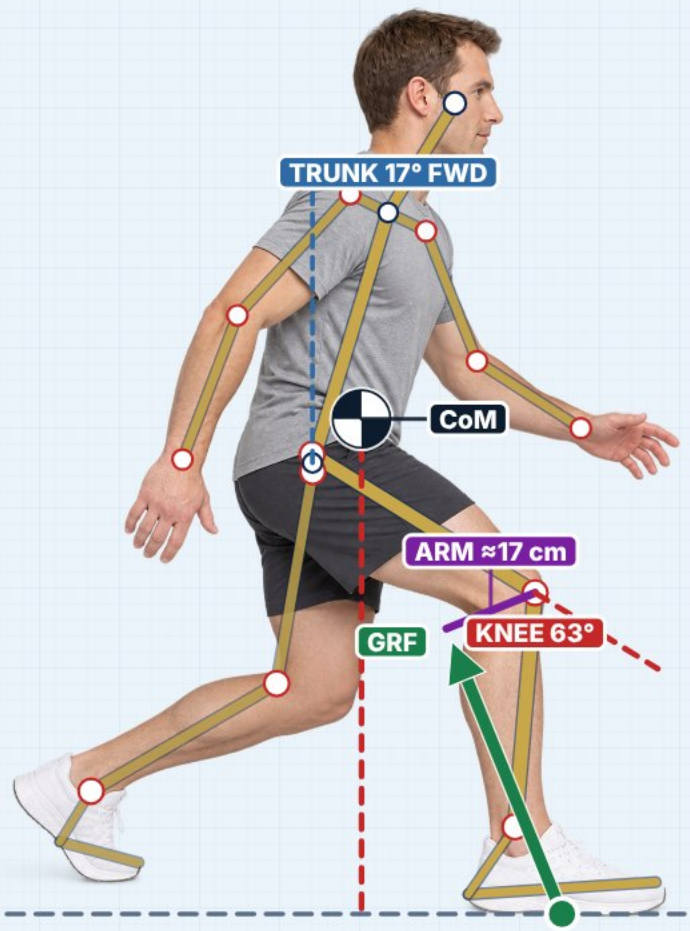
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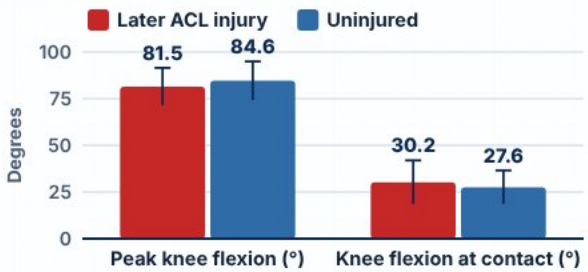
FRAME C · BRAKING STEP · SIDE VIEW



Braking with a straighter knee

- Lead knee **63°**, trunk 17° forward; ground force ≈17 cm behind the knee.
- What mattered for ACL risk was how far the knee **kept bending** after contact: each extra 10° of peak flexion lowered the hazard (HR 0.55).
- Higher impact force also raised risk (HR 1.26 per 100 N).

Stiff landings and ACL injury



Group means differed little; the hazard model showed the effect.

Mean ± SD; 171 female players, 15 ACL injuries. Leppänen et al. (2017).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). GRF line from contact to CoM. Educational, not diagnostic.

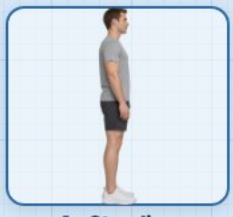
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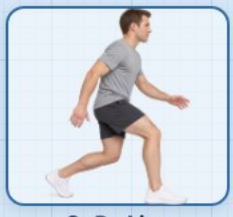
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A · Standing
≈5° flexion here

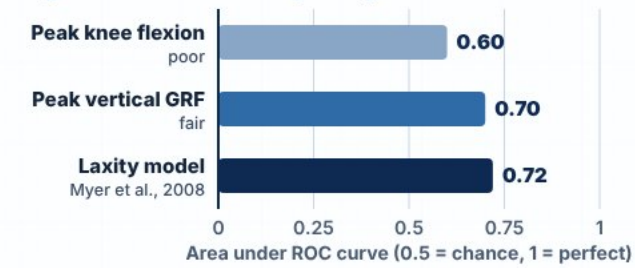


B · Walking
Near-straight at contact



C · Braking
Knee 63°

Single markers screen poorly



Leppänen et al. (2017); Myer et al. (2008).

Decision pathway

1. **EDUCATE**
   Some hyperextension is common; hypermobility alone was not linked to more injuries in students.
2. **TRAIN BENDING**
   Practise landings and braking that keep the knee bending after contact.
3. **STRENGTHEN**
   Progressive strength and control work for hypermobile knees rather than restriction.

NOT RECOMMENDED

Treating hyperextension or a single landing number as a diagnosis or a reliable predictor.

SEEK ASSESSMENT IF

New or one-sided hyperextension after an injury, giving way, swelling or instability; frequent dislocations or widespread pain with hypermobility.

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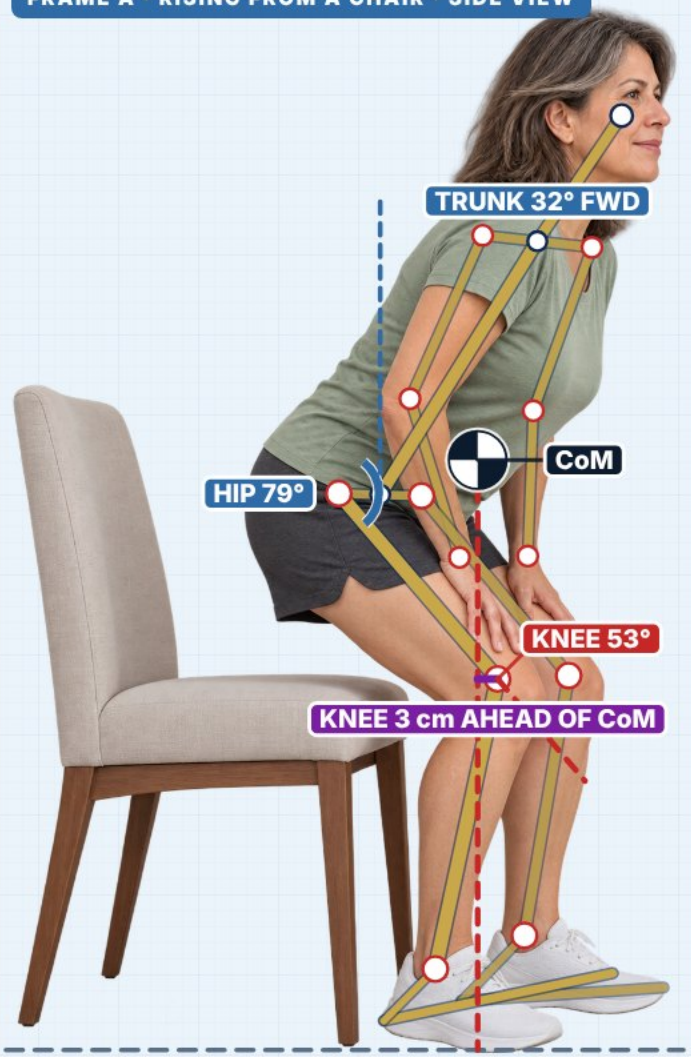
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KNEE CLICKING, CATCHING, AND LOCKING: WHAT IS THE DIFFERENCE?

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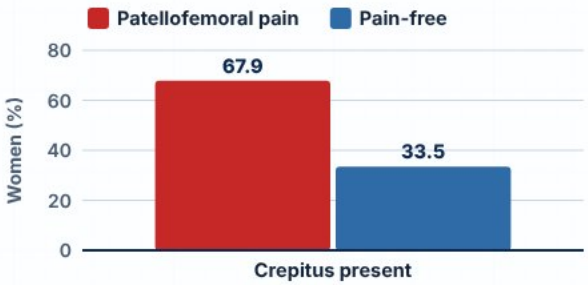
FRAME A · RISING FROM A CHAIR · SIDE VIEW



Clicking: noise under load, often harmless

- Rising: knee **53°**, trunk **32°** forward — kneecap force is several times body weight in tasks like this.
- **Crepitus** is audible or palpable cracking or grinding during movement, and is often painless.
- In women with patellofemoral pain, crepitus was **not related** to pain, function or activity.

Noisy knees are common, with or without pain



One in three pain-free women had crepitus.

165 women with PFP vs 158 pain-free women. de Oliveira Silva et al. (2018).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Educational, not diagnostic.

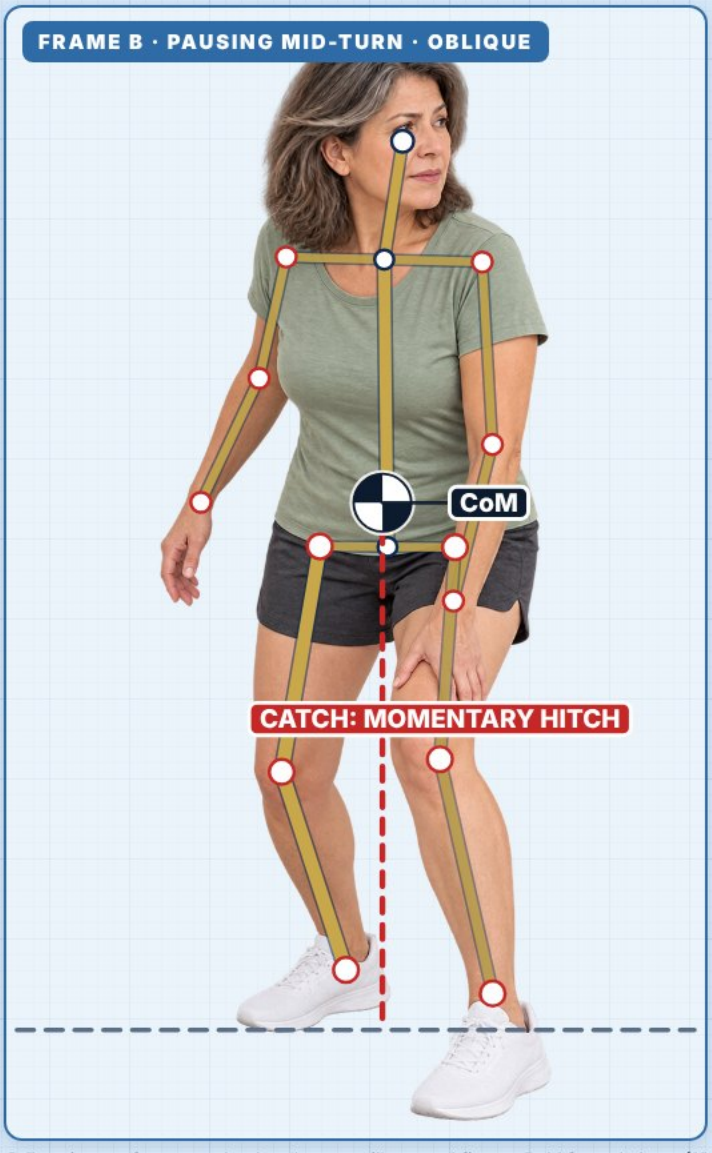
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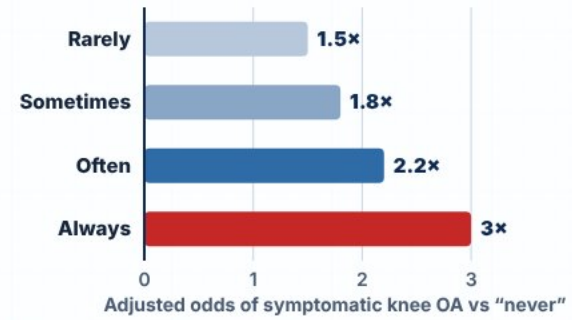
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Catching: a momentary hitch that frees itself

- Oblique view, so angles are not measured; she pauses mid-turn as the knee "sticks" briefly, then moves on.
- **Catching** is transient; it is not the same as a knee that cannot be straightened.
- In people at risk of OA, more frequent crepitus was linked to higher odds of developing symptomatic OA — a marker to monitor, not a diagnosis.

Frequent crepitus: a marker worth monitoring



3,495 people, up to 48 months; CIs not in abstract. Lo et al. (2018).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Frame B is oblique: no angles reported. Educational, not diagnostic.

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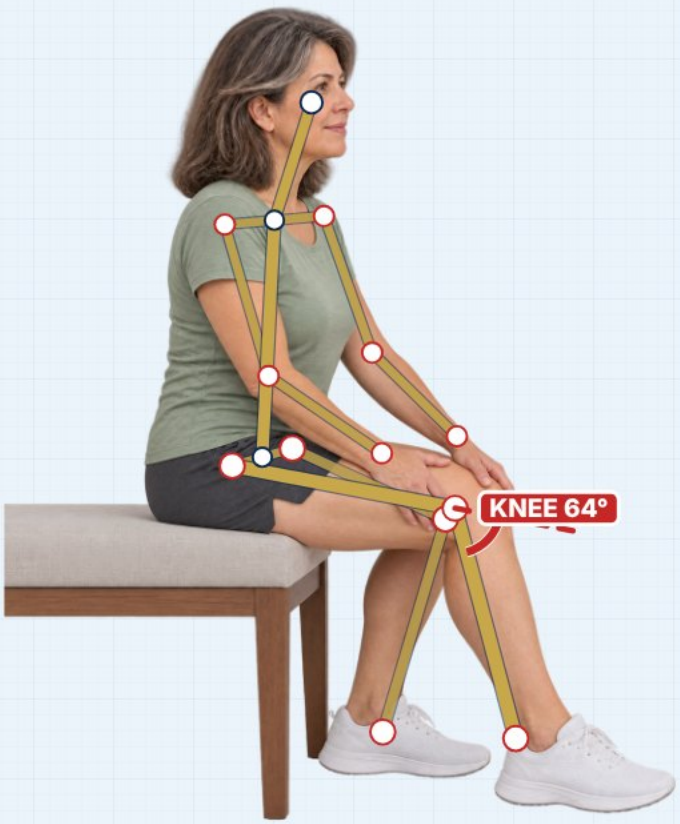
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FRAME C · SEATED, KNEE BENT · SIDE VIEW



True locking: the knee will not straighten

- Knee held at about **64°** of flexion.
- **True locking** is a mechanical block — a fixed loss of extension, classically from a displaced meniscal fragment or loose body — and needs prompt assessment.
- For a degenerative tear, catching and occasional locking persisted at similar rates after real or sham surgery.

Removing a degenerative tear did not stop catching



Risk difference 0.03 (95% CI −0.06 to 0.12).

Sham-controlled RCT, post hoc analysis; does not apply to a fixed locked knee. Sihvonen et al. (2016).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Frame C knee landmarks set manually where legs overlap. Educational, not diagnostic.

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A · Click
Noise under load

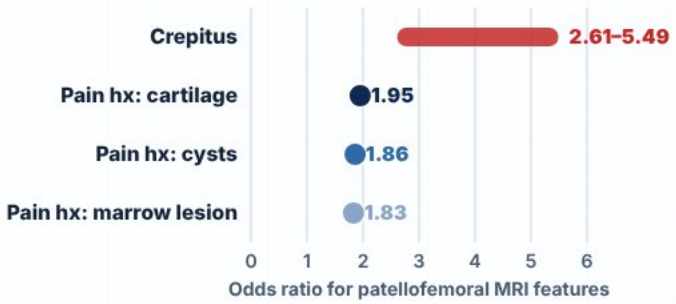


B · Catch
Momentary hitch



C · Lock
Fixed block

What crepitus may signal on MRI



Crepitus: range across features; hx = history of patellar pain. 888 women aged 45–60; cross-sectional. Schiphof et al. (2014).

Decision pathway

1. **CLICK**
   Painless clicking: reassurance and education; keep active. If painful at the front of the knee, follow patellofemoral care (hip + knee exercise).
2. **CATCH**
   Occasional catching with a degenerative tear: exercise-based care; mechanical symptoms alone are not a reason for meniscectomy.
3. **LOCK**
   A knee that cannot fully straighten, especially after a twist, needs prompt orthopaedic assessment.

NOT RECOMMENDED

Arthroscopic partial meniscectomy just for catching or occasional locking in a degenerative knee.

SEEK ASSESSMENT IF

A truly locked knee, new swelling, giving way, or noise that starts after an injury.

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Analysis: MMSx Authority Applied Biomechanics Lab · Dr. Neeraj Mehta, PhD · Educational content, not a diagnosis.

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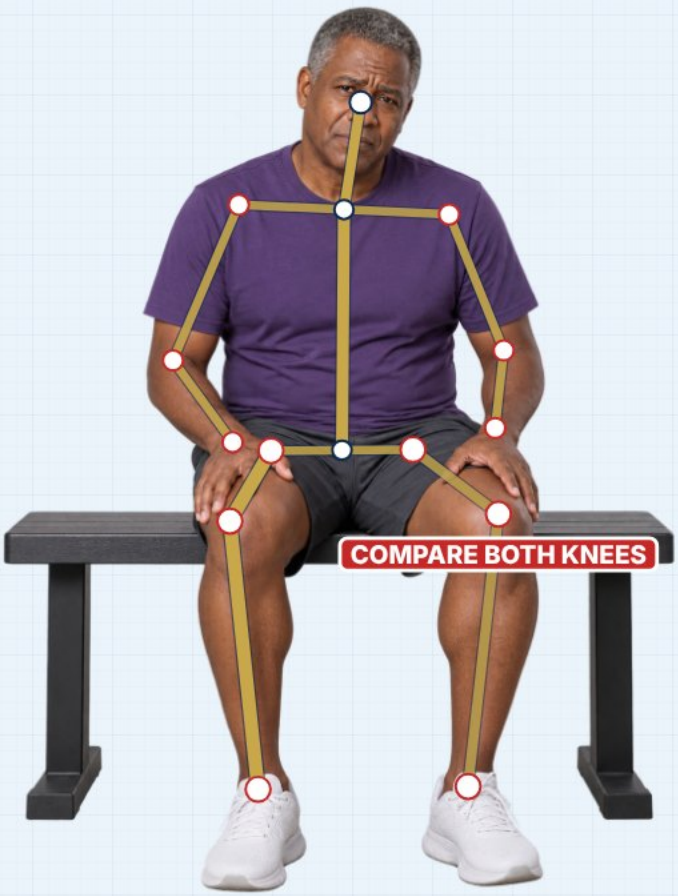
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INTEGRATING PERFORMANCE & REHABILITATION HEALTHCARE PATHWAYS.

A SWOLLEN KNEE AFTER ACTIVITY: WHEN IT NEEDS ASSESSMENT

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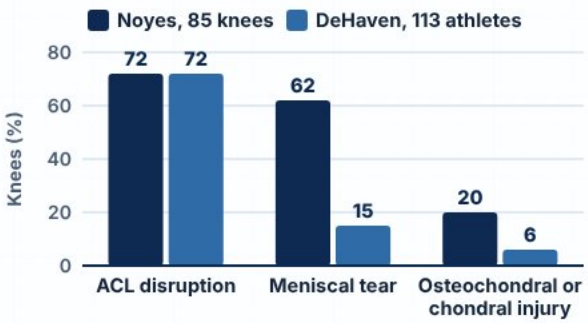
FRAME A · SEATED AFTER ACTIVITY · FRONT VIEW



Compare both knees

- An **effusion** is extra fluid inside the joint: synovial fluid, blood (haemarthrosis) or, rarely, pus.
- Swelling within hours of a twist or landing suggests **bleeding into the joint**, usually from a significant internal injury.
- A "pop" did not tell torn from intact ACLs (36% vs 33%), so swelling matters more than the sound.

Behind an acute bloody effusion (arthroscopy)



DeHaven meniscal figure is major tears without a cruciate lesion.

Noyes et al. (1980); DeHaven (1980).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Seated reference view: no angles reported. Educational, not diagnostic.

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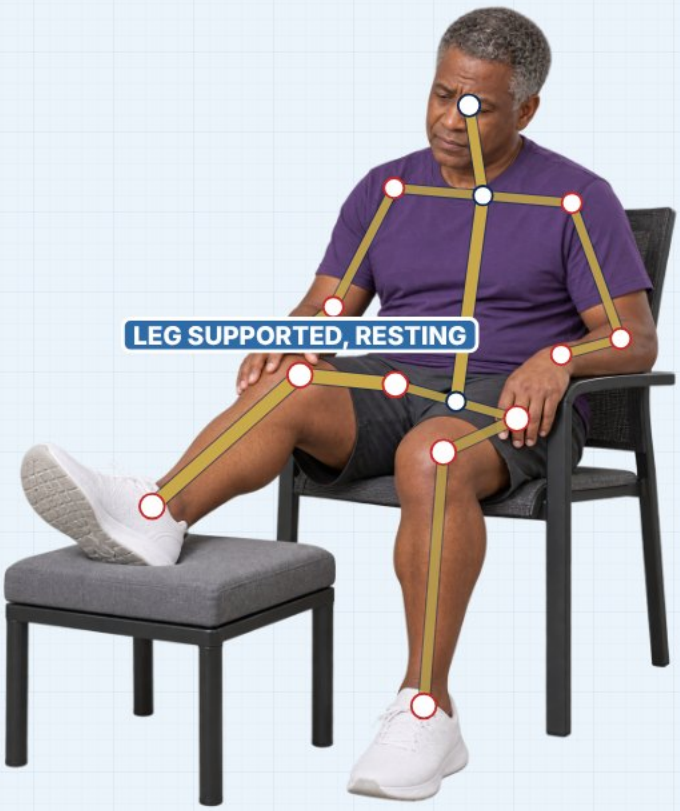
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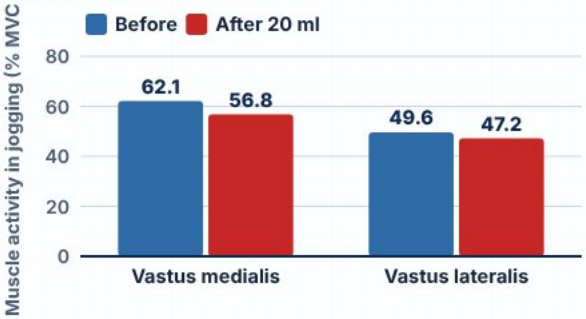
FRAME B · LEG SUPPORTED · OBLIQUE



Why even small swelling matters

- Resting with the leg supported is sensible after activity, but swelling has a mechanical cost.
- Fluid in the joint switches off the quadriceps reflexively (**arthrogenic muscle inhibition**).
- Just 20 ml of fluid cut vastus medialis activity by **8.5%**; larger volumes also stiffened landings (Palmieri-Smith et al., 2007).

20 ml of fluid: measurable quadriceps inhibition



13 healthy adults, saline injection. Torry et al. (2005).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Frame B is oblique: no angles reported. Educational, not diagnostic.

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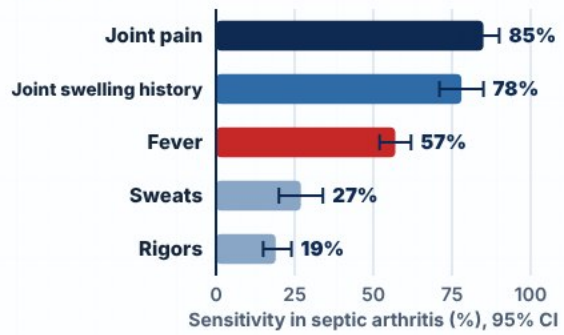
FRAME C · CLINICAL EXAMINATION · OBLIQUE



The hot, swollen knee: rule out infection

- Clinicians check for fluid, warmth, redness and range of motion, and aspirate if infection is possible.
- Fever was absent in about **4 in 10** people with septic arthritis — no fever does not rule it out.
- Joint-fluid white cells above 100,000/µL carried a likelihood ratio of 28.

How often each feature is present in septic arthritis



14 studies, 6,242 patients. Margaretten et al. (2007).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Frame C is oblique: no angles reported. Educational, not diagnostic.

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A · Compare knees
Effusion?

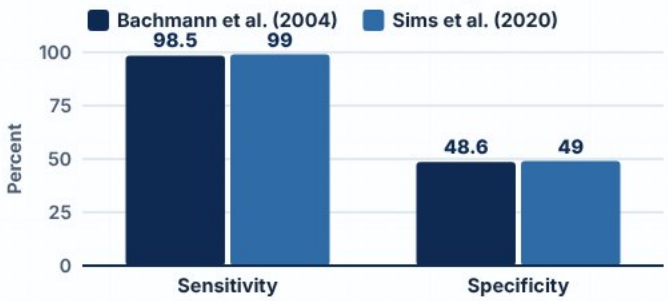


B · Rest
Swelling inhibits quads



C · Examine
Hot knee = urgent

Ottawa knee rule: rules out fracture, not in



X-ray if any: age ≥55; fibular-head tenderness; isolated patellar tenderness; cannot flex to 90°; cannot take 4 steps. Adults only (Ebell, 2005).

Decision pathway

1. **TRIAGE**
   Hot, red, painful swollen knee — with or without fever — needs same-day assessment and aspiration.
2. **AFTER INJURY**
   Swelling within hours of a twist or landing: assess for ACL, meniscal and bone injury; use the Ottawa rule for X-ray.
3. **REHAB**
   Monitor swelling and restore quadriceps activation before adding impact load.

NOT RECOMMENDED

Assuming "no fever, no infection", or that a swollen knee you can walk on is "just a sprain".

SEEK ASSESSMENT IF

Hot, red, swollen knee; swelling within hours of injury, a pop or giving way; unable to take 4 steps; a knee that will not straighten; age ≥55 with bony tenderness after a fall.

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AFTER ACL RECONSTRUCTION: WHEN IS THE KNEE READY TO RETURN TO SPORT?

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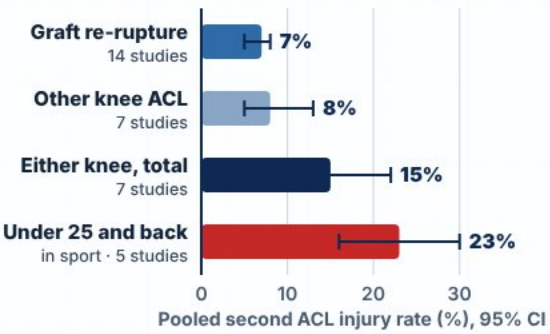
FRAME A · SINGLE-LEG LANDING · SIDE VIEW



Single-leg landing: can the knee take the brake?

- Landing knee flexed **57°**, trunk **30°** forward; ground force passes **≈6 cm** behind the knee.
- That lever is what the quadriceps must control. Athletes who shifted this work off the operated knee (knee-moment asymmetry) or let the knee fall inward were more likely to re-injure (Paterno et al., 2010).
- A four-factor landing and balance model predicted second ACL injury with C = **0.94** (n = 56).

How often does a second ACL injury happen?



Meta-analysis of 19 studies. Wiggins et al. (2016).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Educational, not diagnostic.

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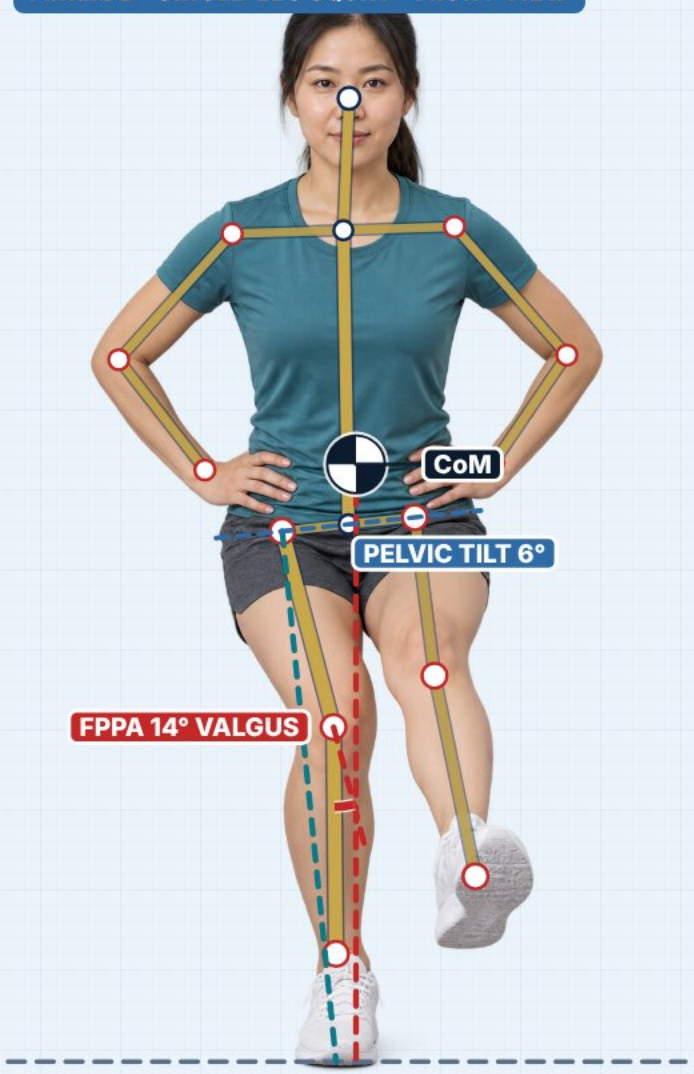
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FRAME B · SINGLE-LEG SQUAT · FRONT VIEW



Single-leg squat: strength and control

- Knee **14°** inside the hip–ankle line (frontal-plane projection angle); pelvis tilted **6°**.
- Each 1-point rise in quadriceps limb symmetry index (LSI) went with a **3%** lower re-injury rate; each month of delay up to 9 months, with a **51%** lower rate.
- All four athletes who returned before 5 months re-injured within 2 months.

Strength and time both matter



Delaware-Oslo cohort, 106 pivoting-sport athletes, 2 years. Grindem et al. (2016).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). FPPA from hip, knee and ankle points in the front view. Educational, not diagnostic.

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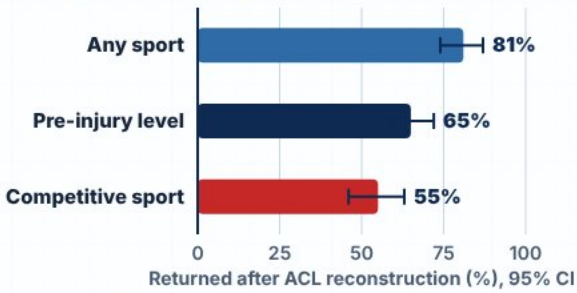
FRAME C · CHANGE OF DIRECTION · OBLIQUE



Cutting: the last thing to come back

- Oblique view, so angles are not measured. A planted foot with the body turning over it combines knee flexion, inward collapse and rotation, the loading pattern sport asks of the graft.
- Cutting and pivoting come last in the progression: after strength, hopping and straight-line running are symmetrical.
- Elite athletes were more likely to return to competitive level (OR **5.9**); a positive psychological response also favoured return.

Who gets back to sport?



69 articles, 7,556 participants. Ardern et al. (2014).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Frame C is oblique: no angles reported. Educational, not diagnostic.

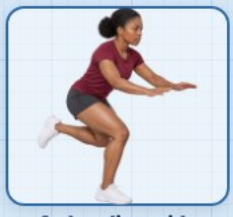
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A · Landing, side
Knee 57°, lever ≈6 cm

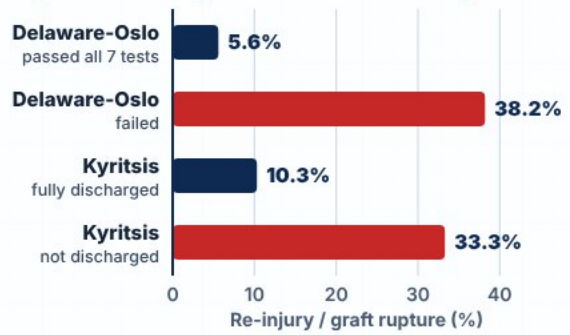


B · Single-leg squat
FPPA 14°



C · Cutting
Last to return

Passing return-to-sport criteria vs failing



Grindem et al. (2016), n = 74 level I returners; Kyritsis et al. (2016), n = 158 professional athletes (HR 4.1).

Decision pathway

1. **TEST, NOT DATE**
   Quadriceps strength and four hop tests above 90% symmetry, plus self-reported function, before pivoting sport.
2. **RESPECT TIME**
   Return to level I pivoting sport no earlier than about 9 months after surgery.
3. **BENCHMARK HIGH**
   Both legs lose capacity after injury: compare with pre-injury capacity where known, and address fear of re-injury.

NOT RECOMMENDED

Clearing return on time alone or on one symmetry number; returning with quadriceps LSI below 90%.

SEEK ASSESSMENT IF

New giving way, a pop with rapid swelling, loss of trust in the knee, or loss of extension after returning.

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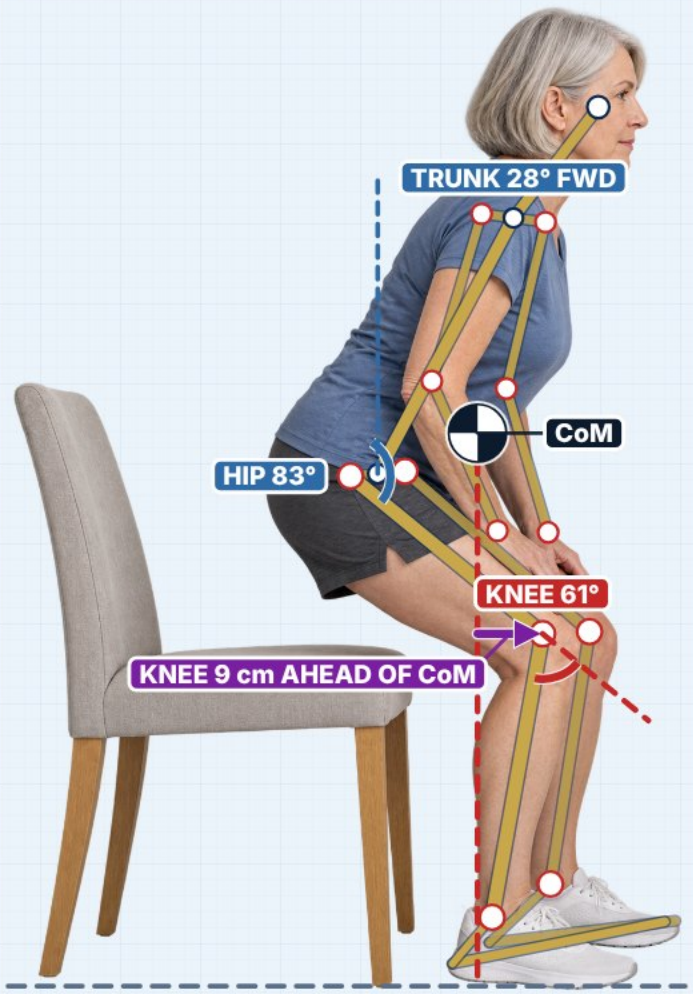
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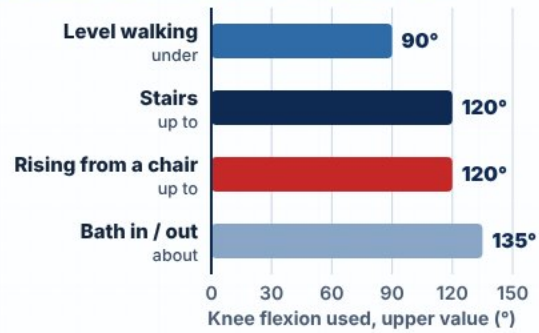
FRAME A · SIT-TO-STAND · SIDE VIEW



Sit-to-stand: the bend and strength test

- Knee flexed **61°**, trunk **28°** forward; the knee sits **≈9 cm** ahead of the CoM line, the lever the quadriceps must overcome.
- Healthy older adults used 90–120° of knee flexion to rise from standard and low chairs.
- A practical goal after replacement is about **110°** of flexion, with full straightening.

How much bend do daily tasks need?



20 healthy older adults, electrogoniometry; ranges, no SD. Rowe et al. (2000).

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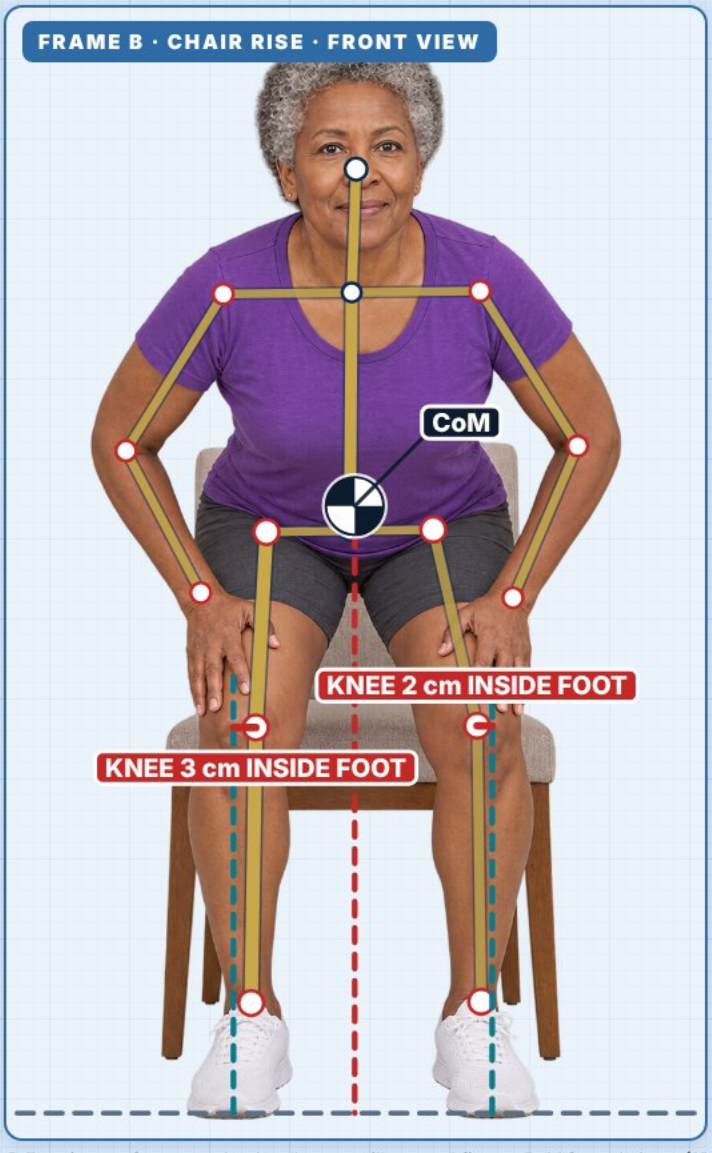
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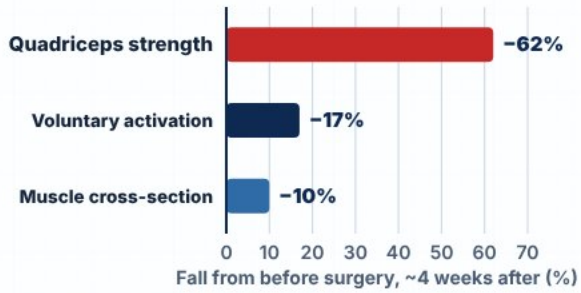
FRAME B · CHAIR RISE · FRONT VIEW



Chair rise from the front: sharing the load

- Knees sit **2** and **3 cm** inside the foot lines as she pushes up with hands on thighs.
- Four weeks after surgery, the muscle is partly "switched off": activation failure and atrophy explained **85%** of the strength loss; pain did not.
- That is why early quadriceps activation work matters.

The early strength drop



20 patients, 27 days after surgery; all P < .01. Mizner et al. (2005).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Knee-to-foot distance in the front view. Educational, not diagnostic.

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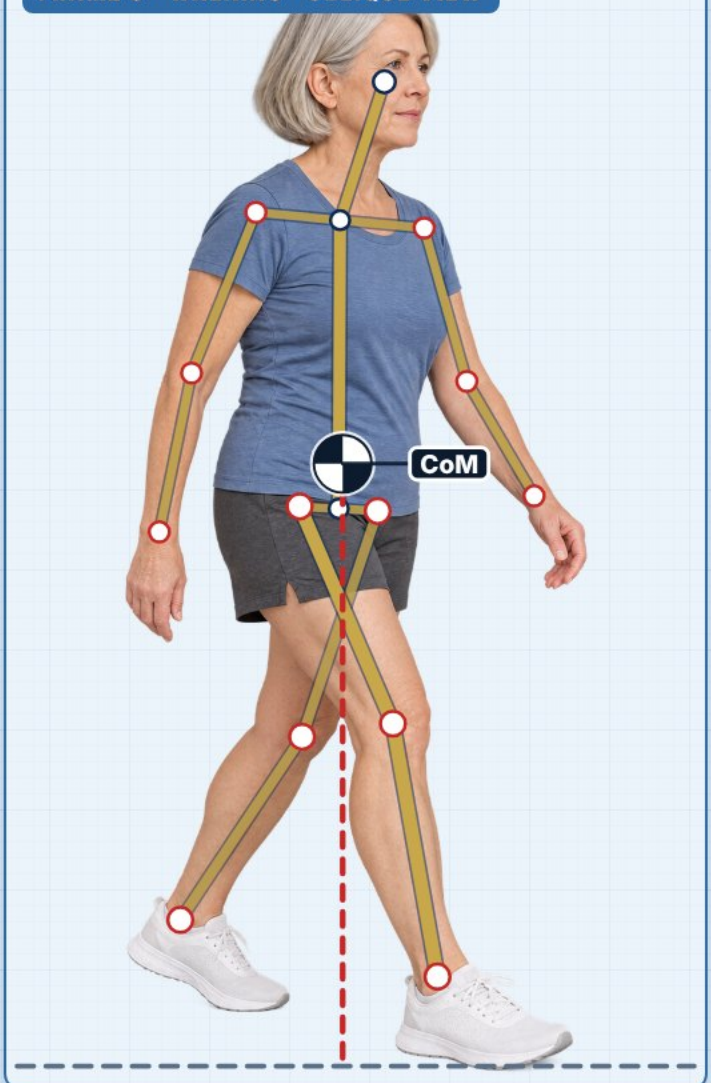
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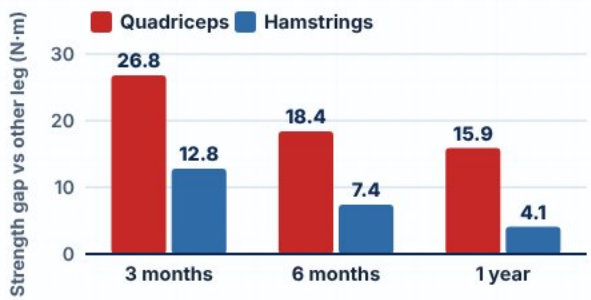
FRAME C · WALKING · OBLIQUE VIEW



Walking: the gap that lingers

- Oblique view, so angles are not measured.
- The operated quadriceps stayed weaker than the other side at 1 year (gap **15.9 N·m**), which invites shifting weight onto the stronger leg.
- Walking itself uses less than 90° of knee flexion; strength, not range, is often what limits it.

Strength gap between legs over the first year



Meta-analysis, 5 studies; all P < .001; no CIs reported. Moon et al. (2016).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Frame C is oblique: no angles reported. Educational, not diagnostic.

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BIOMECHANICS IS A FORCE-GOVERNED DECISION SYSTEM – NOT A POSTURE MODEL.

INTEGRATING PERFORMANCE & REHABILITATION HEALTHCARE PATHWAYS.

AFTER KNEE REPLACEMENT: GETTING BEND, STRAIGHTENING AND STRENGTH BACK

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A · Sit-to-stand
Knee 61°



B · Chair rise
Hands assist



C · Walking
Strength gap lingers

What the clinical guideline recommends



Clinical practice guideline after knee replacement. Jette et al. (2020).

Decision pathway

1. **MOVE EARLY**
   Start within 24 hours; daily range-of-motion work toward full straightening and about 110° of bend.
2. **STRENGTHEN HARD**
   Progressive, high-intensity quadriceps strengthening from the first week; add NMES if activation is poor.
3. **KEEP GOING**
   Walking, balance and symmetry training beyond the early months: the strength gap persists at 1 year.

NOT RECOMMENDED

Continuous passive motion (CPM) machines for primary, uncomplicated replacement.

SEEK ASSESSMENT IF

Redness, heat, wound discharge, fever or rising pain; calf pain or breathlessness; steadily losing bend despite exercise.

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WEAK QUADRICEPS: WHY THIGH STRENGTH PROTECTS YOUR KNEE

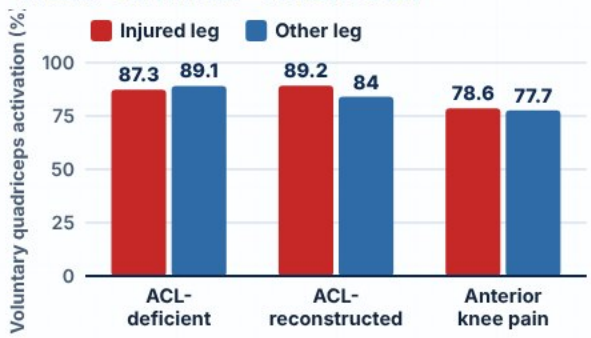
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Step-up: the quadriceps lifts the body

- Leading knee flexed **70°**, hip **92°**; the knee sits **≈18 cm** ahead of the CoM line, the lever the quadriceps must overcome.
- After knee injury the quadriceps often cannot be fully switched on (activation below 95%): arthrogenic muscle inhibition.
- The "good" leg was often affected too, so it is not a perfect benchmark.

"Weak" can mean "switched off"



Weighted means, 17 data sets; failure = below 95%. Hart et al. (2010).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Educational, not diagnostic.

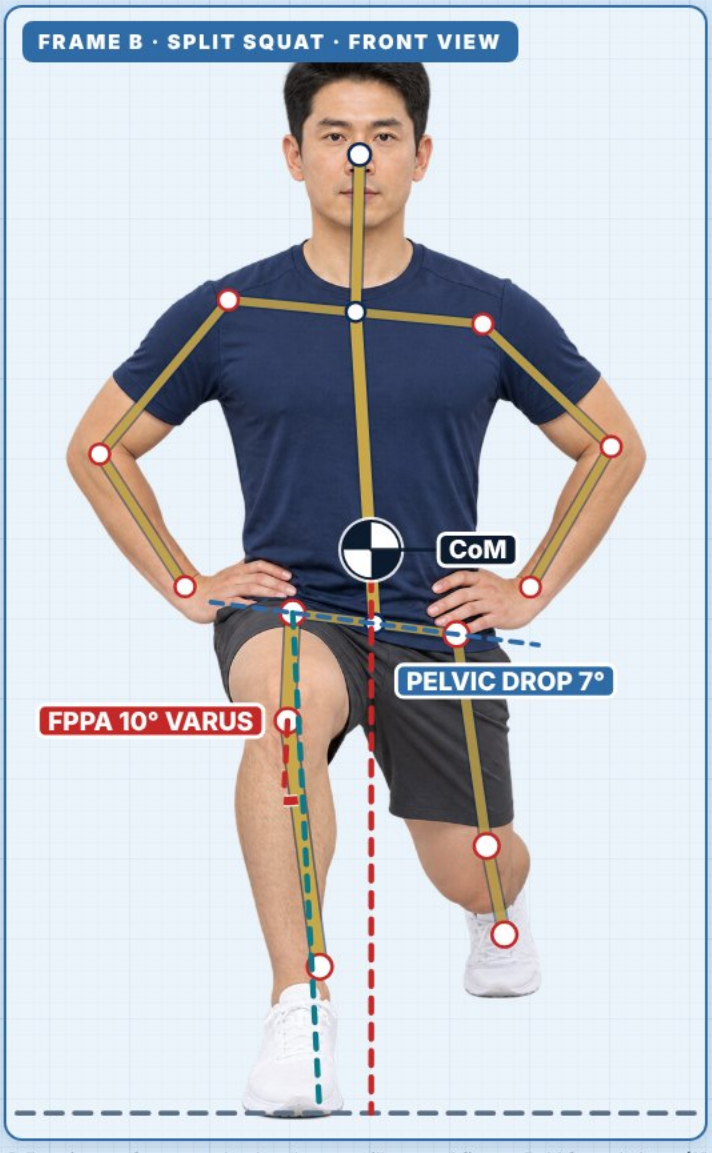
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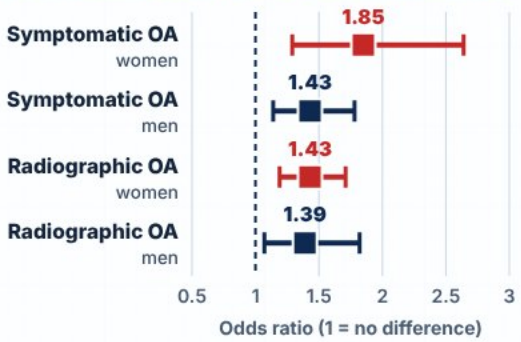
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Split squat: strength under control

- Front knee **10°** off the hip–ankle line; pelvis dropped **7°** as the front leg takes the load.
- Across 46,819 people followed for at least 2 years, weaker knee extensors went with higher odds of developing knee OA.
- Low-quality evidence (GRADE) and an association, not proof of cause.

Weak knee extensors, higher odds of knee OA



11 cohort studies, 46,819 people. Øiestad et al. (2022).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). FPPA from hip, knee and ankle points in the front view. Educational, not diagnostic.

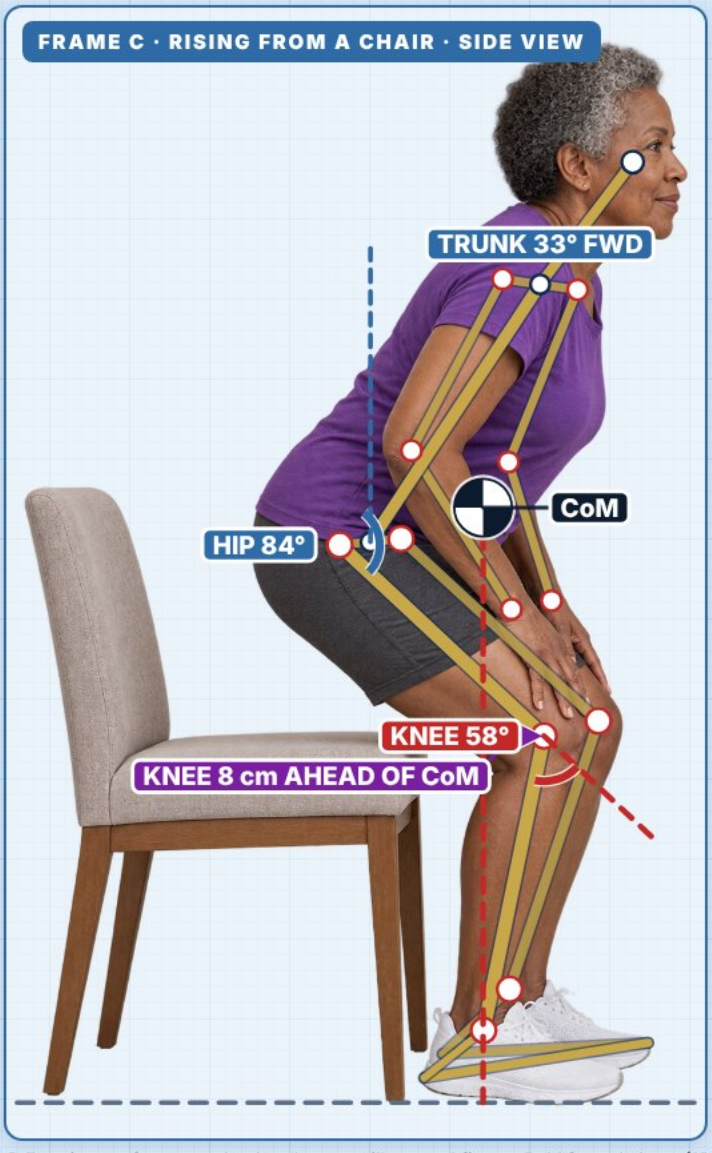
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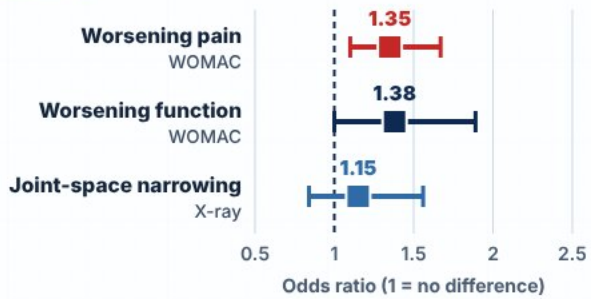
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Rising from a chair: the everyday strength test

- Knee flexed **58°**, trunk **33°** forward; leaning forward brings the CoM over the feet and reduces knee demand.
- In people who already have knee OA, lower knee-extensor strength went with worsening pain and function, but not with joint-space loss.
- Strength tracks symptoms more than the X-ray.

Weakness predicts symptoms, not X-ray change



15 studies, more than 8,000 people with knee OA. Culvenor et al. (2017).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Educational, not diagnostic.

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A · Step-up
Knee 70°

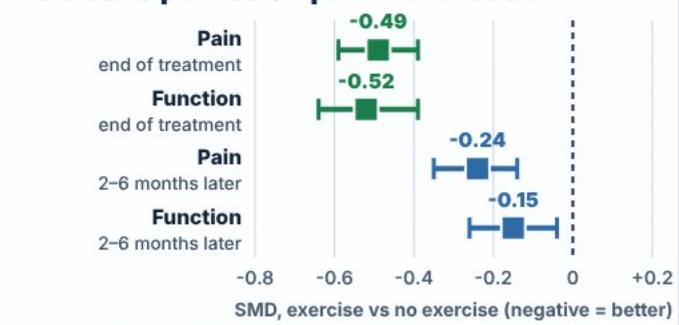


B · Split squat
Pelvis 7°



C · Chair rise
Knee 58°

Exercise helps knee OA pain and function



Cochrane review of land-based exercise for knee OA. Fransen et al. (2015).

Decision pathway

1. **SWITCH IT ON**
   Settle swelling and pain first; quadriceps activation work where inhibition is present.
2. **STRENGTHEN**
   Progressive quadriceps strengthening: step-ups, split squats, chair rises, adding load over weeks.
3. **KEEP GOING**
   Benefits shrank by 2–6 months after programmes ended: strength work needs to continue.

NOT RECOMMENDED

Using the uninjured leg as the only benchmark; stopping exercise once pain eases.

SEEK ASSESSMENT IF

Sudden inability to straighten the knee or do a straight-leg raise after a fall, or rapid thigh wasting with numbness or weakness.

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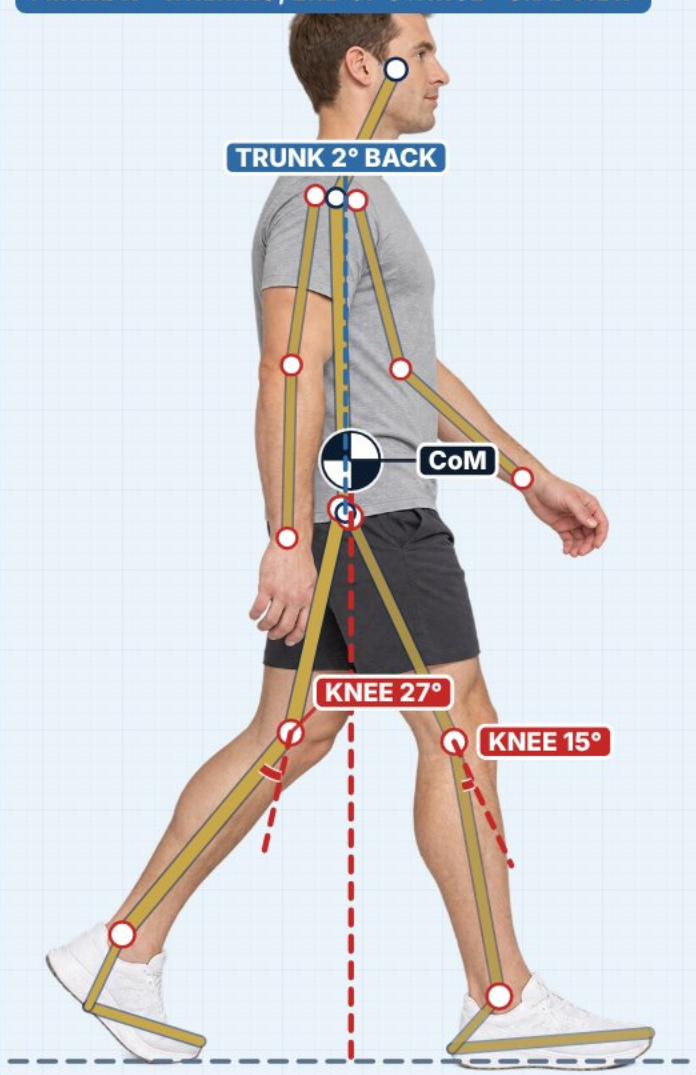
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CAN'T FULLY STRAIGHTEN YOUR KNEE? UNDERSTANDING EXTENSION LOSS

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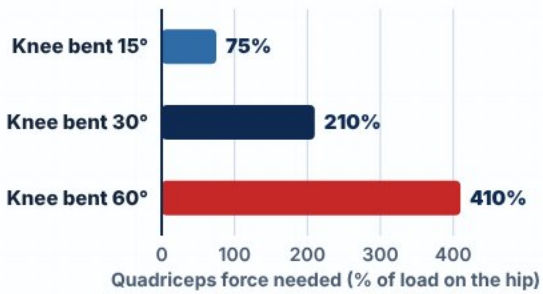
FRAME A · WALKING, END OF STANCE · SIDE VIEW



Walking: the knee should straighten late in stance

- Knees here at **27°** and **15°** of flexion; a healthy knee comes close to straight before push-off.
- A knee that cannot straighten stays on a bent-knee lever: the quadriceps must work through every step to stop it buckling.
- In flexed-knee stance, quadriceps force rose steeply with each extra degree of bend.

The cost of standing on a bent knee



Flexed-knee stance, measured and calculated forces. Perry et al. (1975).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Knee angle: 0° = fully straight. Educational, not diagnostic.

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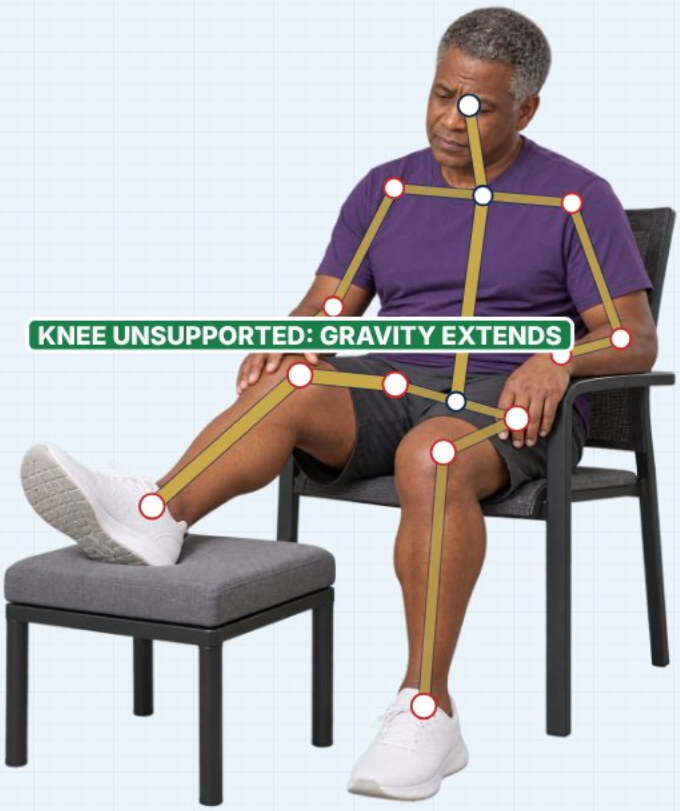
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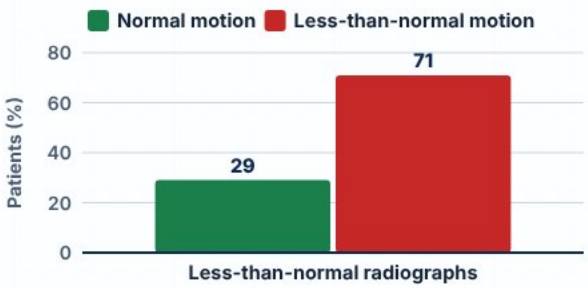
FRAME B · HEEL PROPPED · OBLIQUE



Heel propped: letting gravity straighten the knee

- Oblique view, so angles are not measured. With the heel on a stool and nothing under the knee, body weight of the leg works toward full extension.
- A pillow under the knee does the opposite: it rests the joint in flexion.
- "Normal" motion after ACL reconstruction meant extension within **2°** of the other knee, including hyperextension.

Lost motion, more arthritis on X-ray



502 patients, mean 14.1 years after ACL reconstruction. Shelbourne & Gray (2009).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Frame B is oblique: no angles reported. Educational, not diagnostic.

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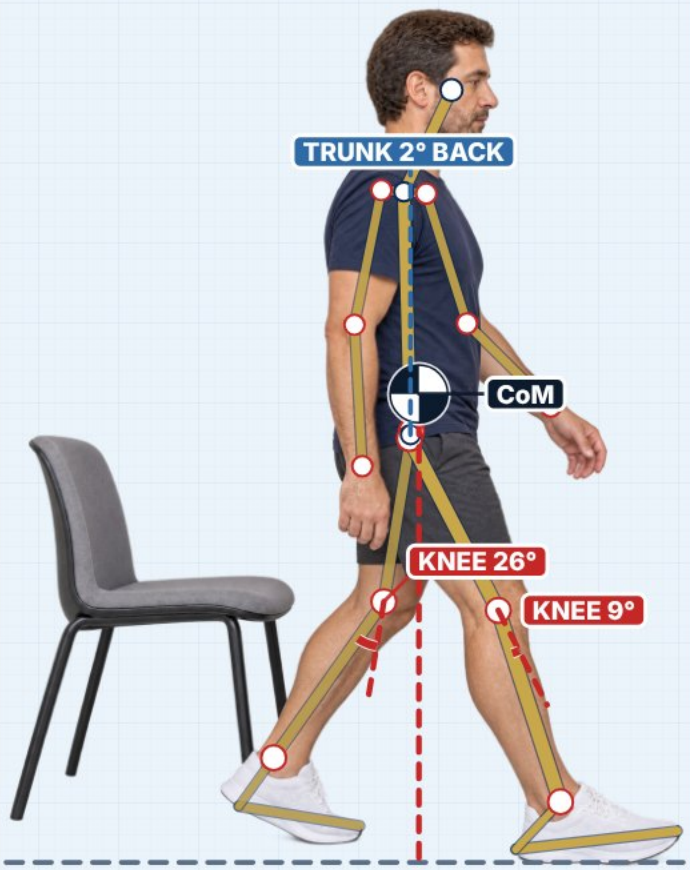
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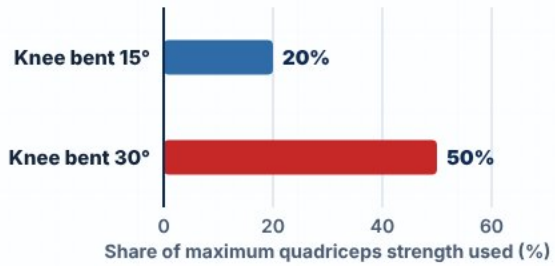
FRAME C · FIRST STEP AFTER SITTING · SIDE VIEW



First step after sitting: does it straighten?

- Knees at **9°** and **26°** as the first step is taken; stiffness after sitting is often felt as a knee that will not lock out.
- Standing on a knee bent 30° used about half of maximum quadriceps strength: tiring, and sore if the joint is irritable.
- Small losses matter: losing **3–5°** of extension worsened long-term results after ACL reconstruction.

A bent knee tires the quadriceps



Torque tests on five healthy adults. Perry et al. (1975).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Knee angle: 0° = fully straight. Educational, not diagnostic.

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A · Walking
Knees 27° / 15°

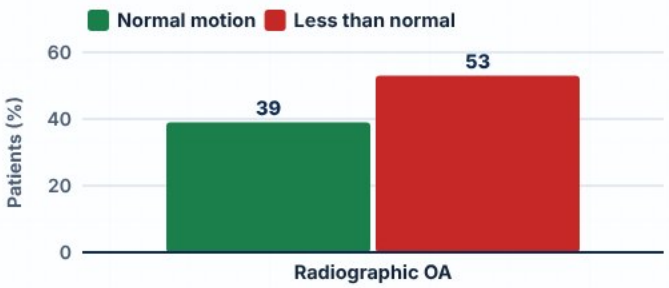


B · Heel prop
Gravity extends



C · First step
Knee 9°

Odds of arthritis about 2× with lost motion



479 normal vs 60 less-than-normal motion, mean 10.5 years (P = .036). Shelbourne et al. (2012).

Decision pathway

1. **MEASURE**
   Compare extension with the other knee, including hyperextension; a 2–3° loss is already meaningful.
2. **RESTORE EARLY**
   Heel props, quadriceps setting and frequent gentle extension work; never rest with a pillow under the knee.
3. **LOAD THROUGH RANGE**
   Once extension returns, strengthen through it so it stays.

NOT RECOMMENDED

Resting the knee bent on a pillow for long periods; forcing painful end-range stretches.

SEEK ASSESSMENT IF

A knee that suddenly cannot straighten (a block, not stiffness), loss of motion after surgery that is getting worse, or a hot swollen knee.

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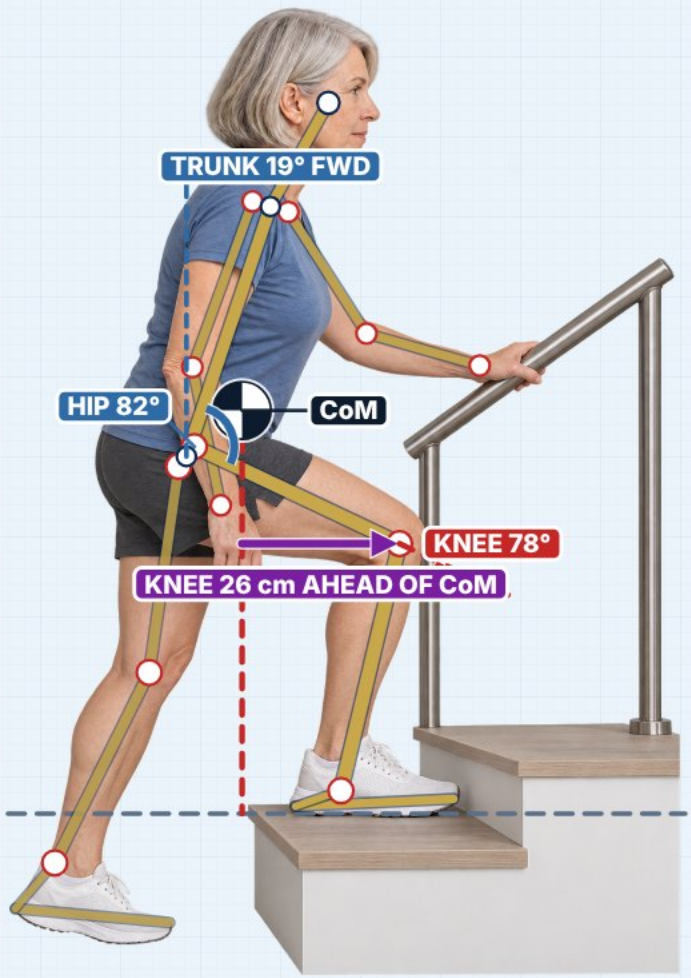
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PES ANSERINE PAIN: TENDERNESS JUST BELOW THE INNER KNEE

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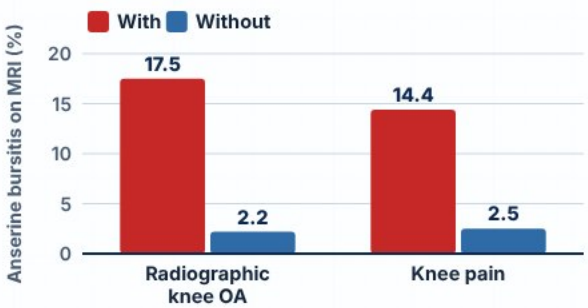
FRAME A · STAIR ASCENT WITH RAIL · SIDE VIEW



Stair ascent: the inner knee under load

- Leading knee flexed **78°**, hip **82°**; the knee sits **≈26 cm** ahead of the CoM line.
- Sartorius, gracilis and semitendinosus insert 3–5 cm below the inner joint line; the anserine bursa lies beneath them.
- In a community MRI study (mean age 72), anserine bursitis was far commoner with knee OA and with knee pain.

It travels with knee OA and pain



348 community adults, cross-sectional MRI. Kim et al. (2016).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Educational, not diagnostic.

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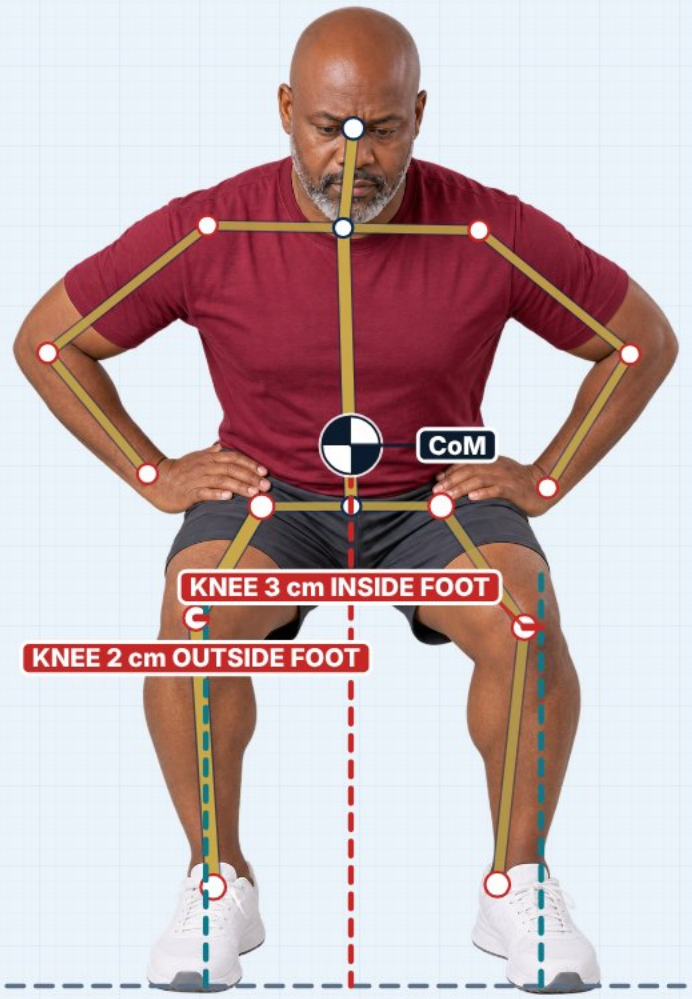
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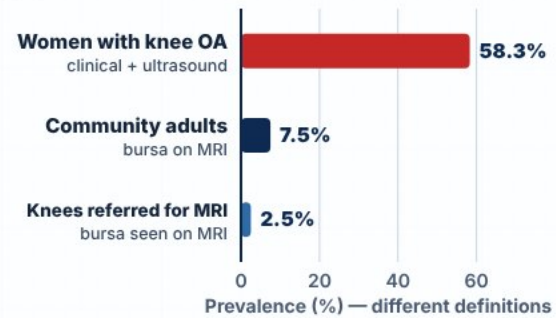
FRAME B · SHALLOW SQUAT · FRONT VIEW



Front view: knee alignment in the squat

- One knee sits **3 cm** inside its foot line, the other **2 cm** outside; the pes anserinus wraps the inner knee to the shin.
- The painful syndrome is common where it is looked for in knee OA, but a fluid-filled bursa on imaging is uncommon.
- These bars use different definitions and populations: read each on its own.

A painful region more often than a visible lesion



Toktas et al. (2015), 314 knees; Kim et al. (2016), n = 348; Rennie & Saifuddin (2005), 509 MRI studies.

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Knee-to-foot distance in the front view. Educational, not diagnostic.

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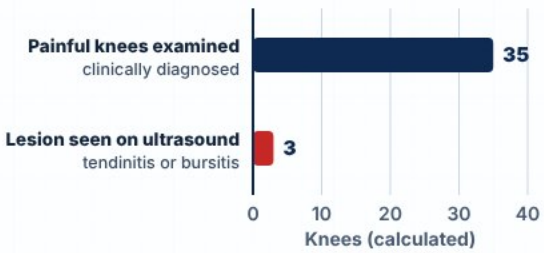
FRAME C · SEATED REFERENCE · FRONT VIEW



Finding the spot: a clinical diagnosis

- Tenderness sits on the inner upper shin, below the joint line, not on the line itself (where meniscal pain is felt).
- In clinically diagnosed patients, ultrasound showed a lesion in only **3** painful knees; one bursitis was in a knee that did not hurt.
- In that series 93% had radiographic knee OA and 75% had a BMI above 27.

A normal scan does not rule it out



37 patients (23 one-sided, 6 two-sided), 7.5 MHz ultrasound. Uson et al. (2000).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Seated reference image: location only, no angles reported. Educational, not diagnostic.

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A · Stair ascent
Knee 78°

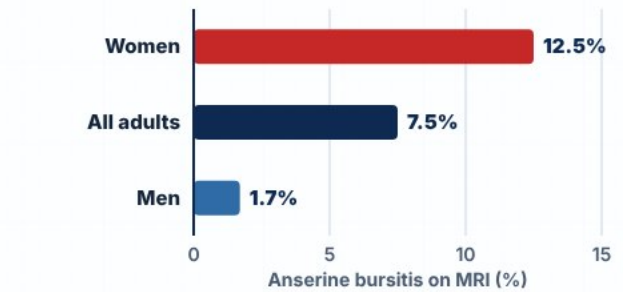


B · Shallow squat
Inner-knee load



C · Location
Below the joint line

Commonest in older women



348 community adults, mean age 72 (P < .0001 for sex). Kim et al. (2016).

Decision pathway

1. **CONFIRM THE SITE**
   Tenderness 3–5 cm below the inner joint line; check for knee OA, which usually travels with it.
2. **TREAT WITHIN OA CARE**
   Exercise and weight management; physiotherapy and local injection both improved pain and function at 8 weeks, with no difference between them.
3. **PROGRESS**
   Graded step-ups and stairs as the tender area settles.

NOT RECOMMENDED

Relying on imaging to confirm or exclude it: few clinically diagnosed knees show a lesion.

SEEK ASSESSMENT IF

A large, firm or growing lump, night pain, fever, a hot red knee, locking or a large joint swelling.

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Analysis: MMSx Authority Applied Biomechanics Lab · Dr. Neeraj Mehta, PhD · Educational content, not a diagnosis.

DOI 10.5281/zenodo.23735752

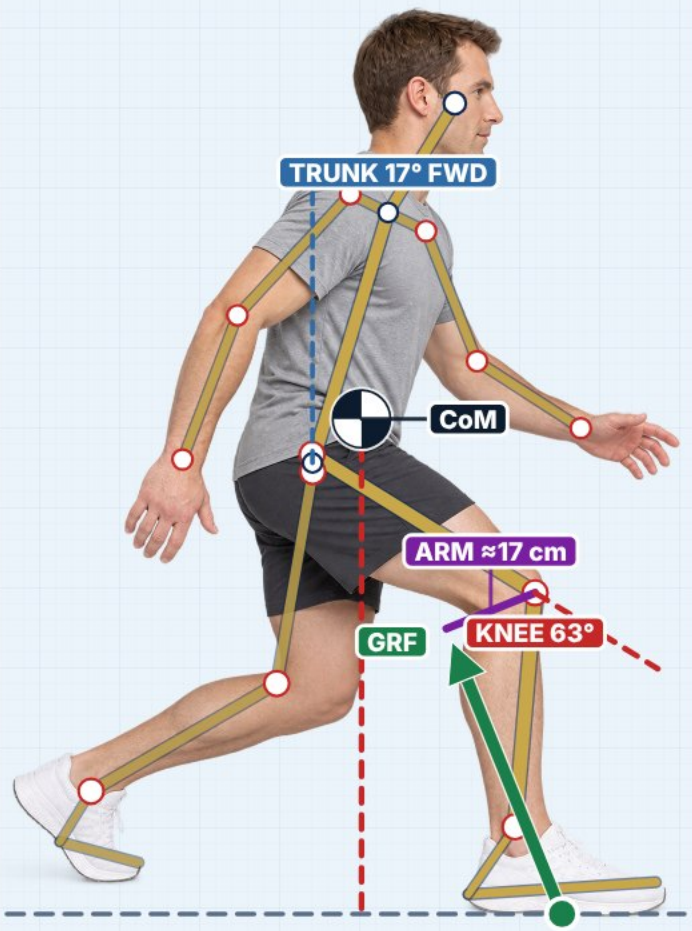
BIOMECHANICS IS A FORCE-GOVERNED DECISION SYSTEM – NOT A POSTURE MODEL.

INTEGRATING PERFORMANCE & REHABILITATION HEALTHCARE PATHWAYS.

FAT PAD PAIN: PAIN UNDER THE KNEECAP WHEN THE KNEE LOCKS STRAIGHT

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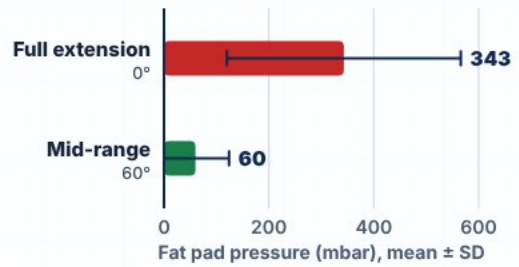
FRAME A · BRAKING STEP · SIDE VIEW



Braking: heavy load on the front of the knee

- Front knee flexed **63°** as it brakes; ground force passes ≈**17 cm** behind the knee, and the quadriceps works hard to stop it; the stride then drives the knee toward straight.
- The infrapatellar (Hoffa) fat pad sits behind and beside the patellar tendon. In cadaver knees its pressure was highest at **full extension** and lowest near 60°.
- Pressure rose significantly below 20° and above 100° of flexion.

Why the straight knee hurts



10 cadaver knees, simulated extension moments. Bohnsack et al. (2005).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Educational, not diagnostic.

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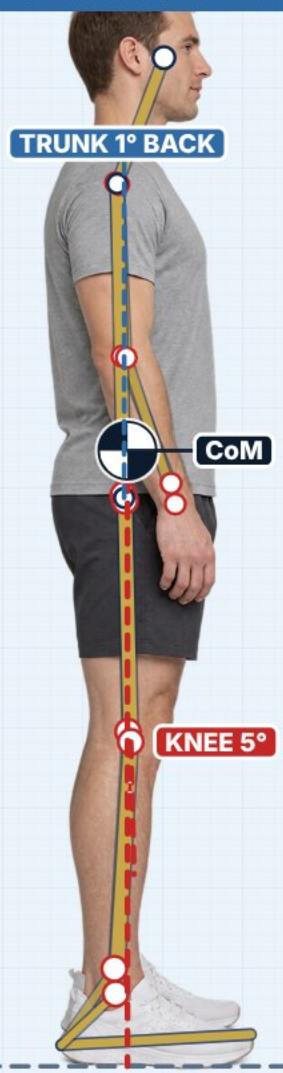
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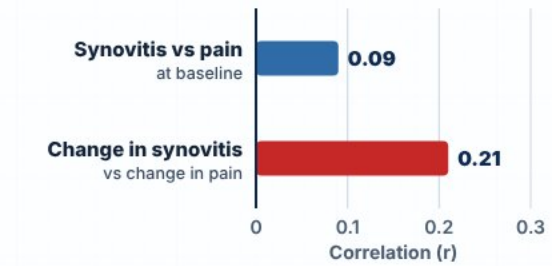
FRAME B · RELAXED STANDING · TRUE SIDE VIEW



Relaxed standing: near-locked knee

- Knee within **5°** of straight: standing "locked back" holds the fat pad in its highest-pressure zone.
- In knee OA, a rise in MRI synovitis tracked a rise in pain (P = .0003), most strongly at the fat pad site; the scan at one time point did not.
- Imaging must be read with the symptoms and the tender spot.

Change, not a single scan, tracked pain



270 adults with knee OA, MRI over 30 months. Hill et al. (2007).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Knee angle: 0° = fully straight. Educational, not diagnostic.

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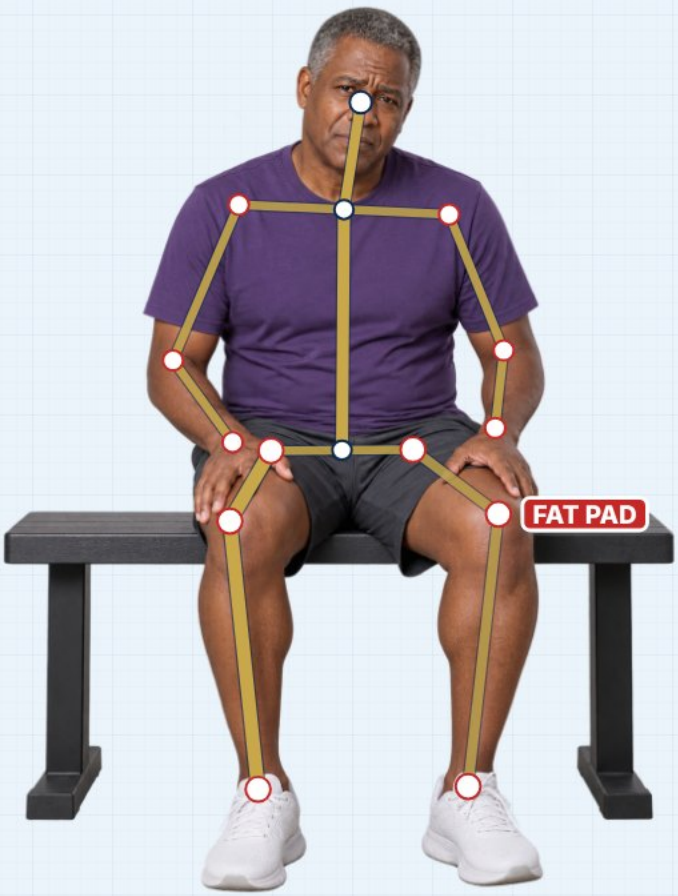
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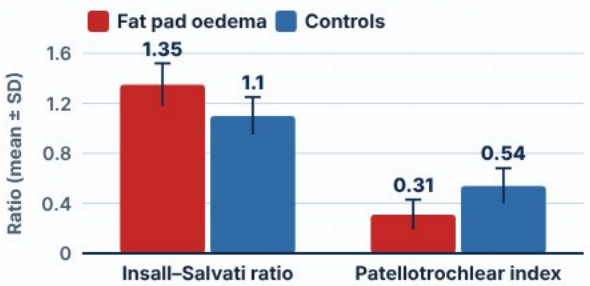
FRAME C · SEATED REFERENCE · FRONT VIEW



Where it hurts: either side of the tendon

- Pain and tenderness sit just below the kneecap, beside the patellar tendon, and are often worse with direct pressure.
- Oedema in the upper-outer fat pad went with a **higher-riding kneecap** and less kneecap–groove overlap: consistent with impingement, but an association.
- Tenderness below the kneecap: 38 of 50 cases vs 20 of 50 controls.

Fat pad oedema and kneecap position



50 cases vs 50 matched controls, MRI; P < .001 for both. Lyu et al. (2023).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Seated reference image: location only, no angles reported. Educational, not diagnostic.

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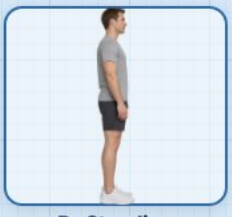
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A · Braking
Knee 63°

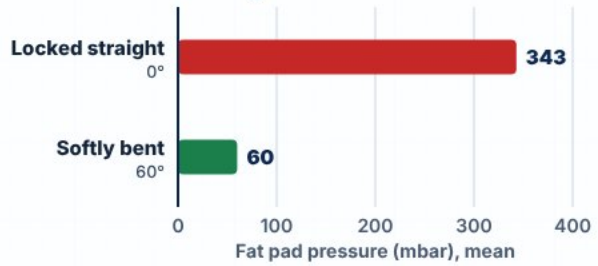


B · Standing
Knee 5° from straight



C · Location
Beside the tendon

Unload the end of range



Cadaver data. Bohnsack et al. (2005). A rationale for unloading, not a tested treatment.

Decision pathway

1. **UNLOAD**
   Avoid standing locked back; keep a soft knee and avoid end-range extension drills while symptoms are high.
2. **STRENGTHEN**
   Hip and knee strengthening as for other front-of-knee pain, in mid-range angles first.
3. **PROGRESS**
   Return toward full extension under load gradually as pressure-type pain settles.

NOT RECOMMENDED

Treating an MRI signal change alone as the cause of pain; fat-pad taping has no verified trial outcome.

SEEK ASSESSMENT IF

Sudden swelling after injury, locking, giving way, a hot swollen knee or fever, or inability to straighten after a blow.

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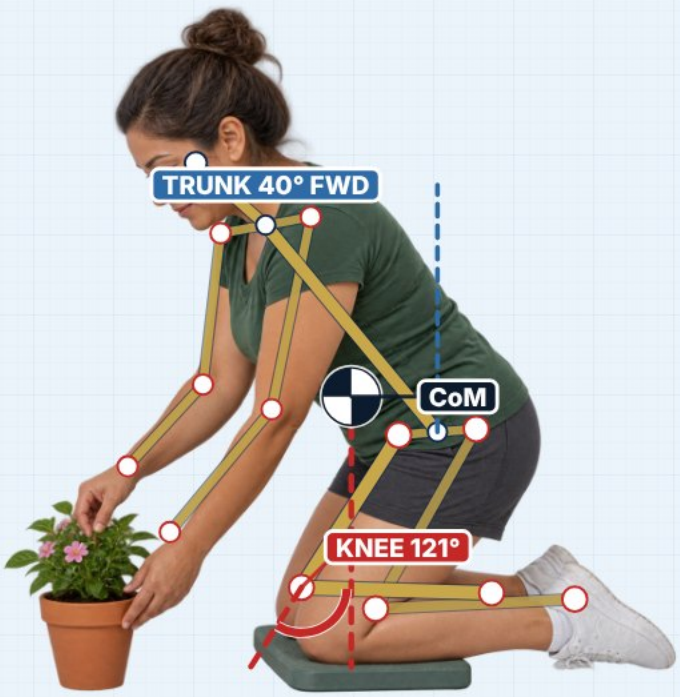
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PCL INJURY: WHEN THE SHIN IS PUSHED BACKWARDS

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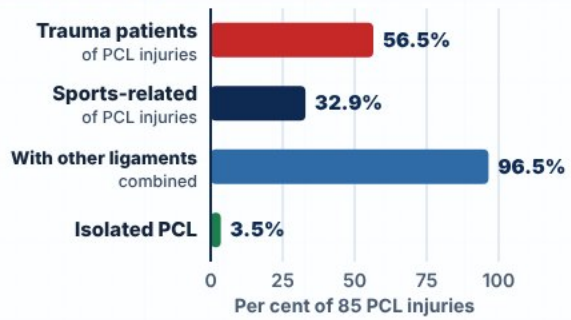
FRAME A · KNEELING · SIDE VIEW



Kneeling: the shin takes the hit from the front

- Knee flexed **121°** with the upper shin on the ground: a fall onto a bent knee drives the tibia backwards under the femur.
- That is the direction the posterior cruciate ligament (PCL) resists; a dashboard blow does the same.
- Among acute knee injuries at a regional trauma centre, PCL injuries were found in **38%**, and almost all were combined with other ligament injuries.

Where PCL injuries come from



222 acute knee injuries over 38 months, regional trauma centre. Fanelli & Edson (1995).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Educational, not diagnostic.

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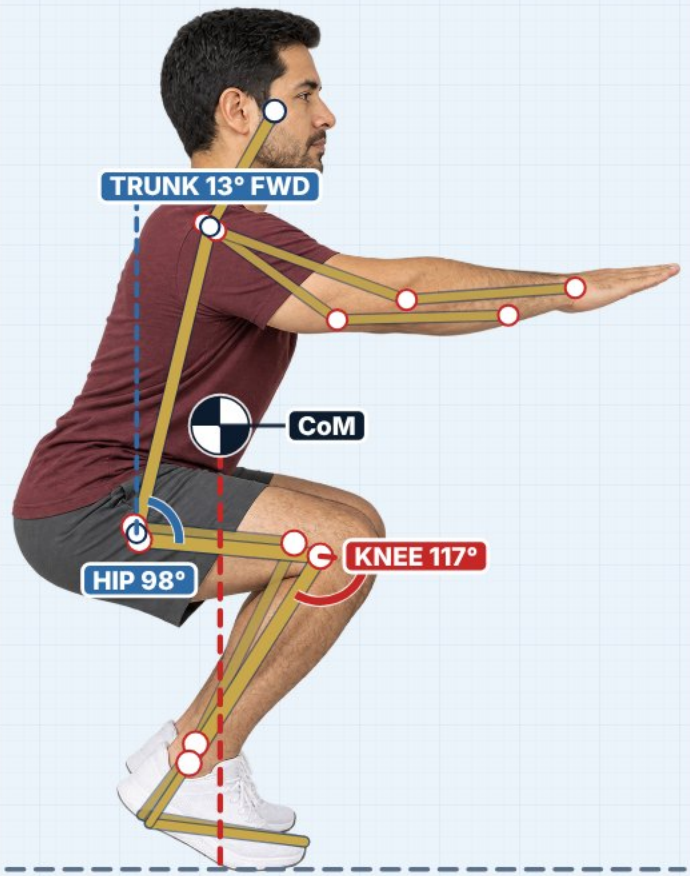
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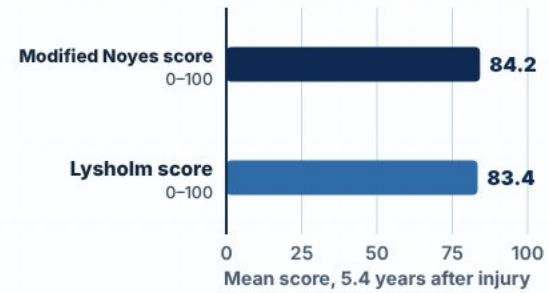
FRAME B · DEEP SQUAT · SIDE VIEW



Deep squat: the shin under backward pull

- Knee flexed **117°**, hip **98°**: in deep bends the hamstrings and body weight tend to draw the shin backwards, the direction the PCL resists.
- After an isolated PCL tear, deep loaded flexion is often the last range to feel secure.
- Treated without surgery, active patients scored in the mid-80s, and greater laxity did **not** mean worse scores.

Isolated PCL tears treated without surgery



133 athletically active patients; 68 examined at follow-up. Shelbourne et al. (1999).

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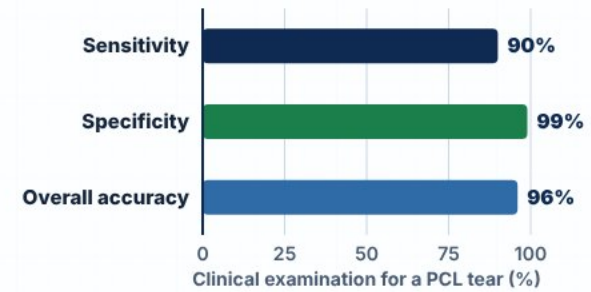
FRAME C · SEATED, KNEE BENT · OBLIQUE



Knee at 90°: where the sag shows

- Oblique view, so angles are not measured. With the knee bent to about 90°, a torn PCL lets the shin sag backwards: clinicians test it with a posterior drawer.
- Skilled examination detected PCL tears with high accuracy; it was better for grade II–III laxity than grade I.
- Examiners agreed on the grade **81%** of the time.

The examination is accurate



39 subjects, blinded examiners. Rubinstein et al. (1994).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Frame C is oblique: no angles reported. Educational, not diagnostic.

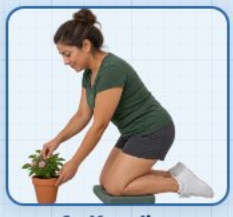
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A · Kneeling
Knee 121°

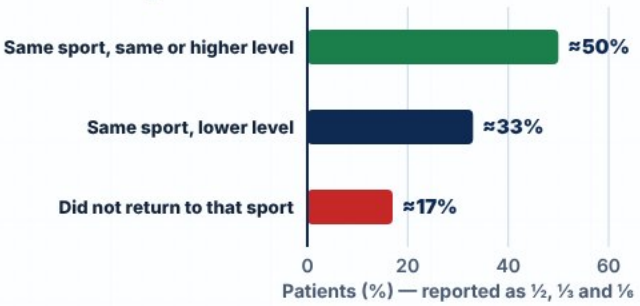


B · Deep squat
Knee 117°



C · Seated 90°
Sag test position

Return to sport after an isolated PCL tear



Nonoperative care, active patients, mean 5.4 years. Shelbourne et al. (1999).

Decision pathway

1. **CHECK WHAT ELSE**
   Most PCL injuries come with other ligament damage: combined injuries need specialist assessment.
2. **ISOLATED TEAR**
   Often managed without surgery; quadriceps strength supports the shin against backward sag.
3. **PROGRESS DEPTH**
   Return to deep loaded flexion and pivoting gradually, guided by symptoms and stability.

SEEK ASSESSMENT IF

A fall onto a bent knee or dashboard blow with swelling, a visible backward sag of the shin, instability, or numbness, coldness or colour change below the knee.

REFERENCES (APA 7)

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QUADRICEPS TENDON PAIN: PAIN JUST ABOVE THE KNEECAP

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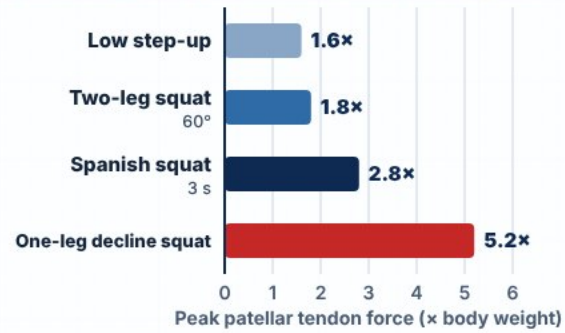
FRAME A · DECLINE SQUAT · SIDE VIEW



Decline squat: the extensor mechanism at full stretch

- Knee flexed **95°** on the slant board; the knee sits **≈21 cm** ahead of the CoM line, a long lever for the quadriceps.
- The quadriceps tendon (above the kneecap) and patellar tendon (below) carry the same pull, but differ in anatomy and role: treat them as distinct problems (Sprague et al., 2019).
- Measured loads exist for the patellar tendon only; the single-leg decline squat was among the heaviest rehabilitation exercises.

How hard do knee-extensor exercises pull?



Patellar tendon, 20 healthy adults, modelled force. Scattone Silva et al. (2024).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Educational, not diagnostic.

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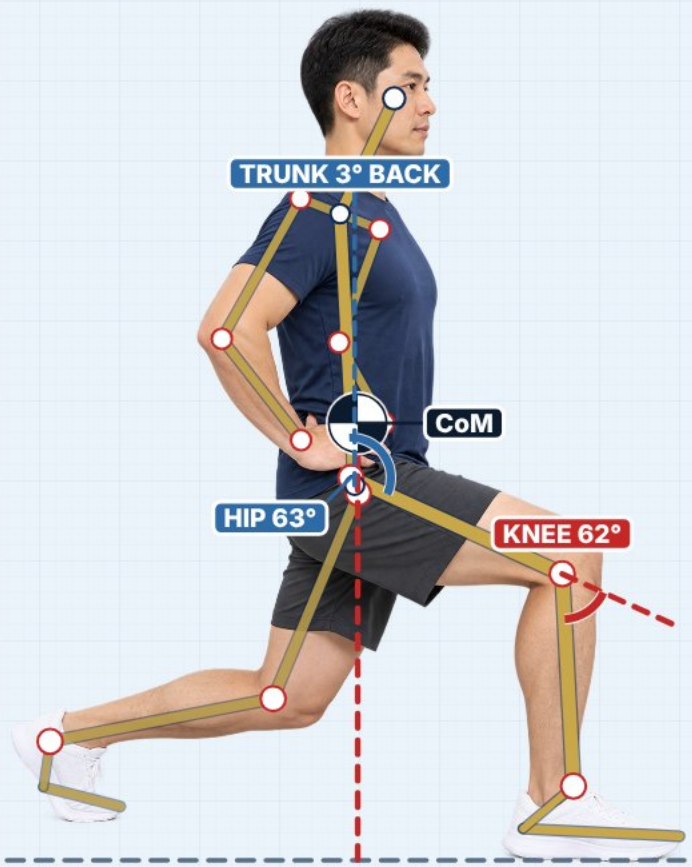
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FRAME B · FORWARD LUNGE · SIDE VIEW



Forward lunge: depth is the dial

- Front knee flexed **62°**, hip **63°**; deeper lunges press the kneecap harder into its groove, and the quadriceps tendon wraps over it.
- Patellofemoral stress climbed steeply past 50–60° and peaked near 80–90°, higher on the way up than on the way down.
- So depth, and rising from depth, can be graded rather than banned.

Joint stress rises with lunge depth



Mean, 16 healthy adults, bodyweight forward lunge. Escamilla et al. (2022).

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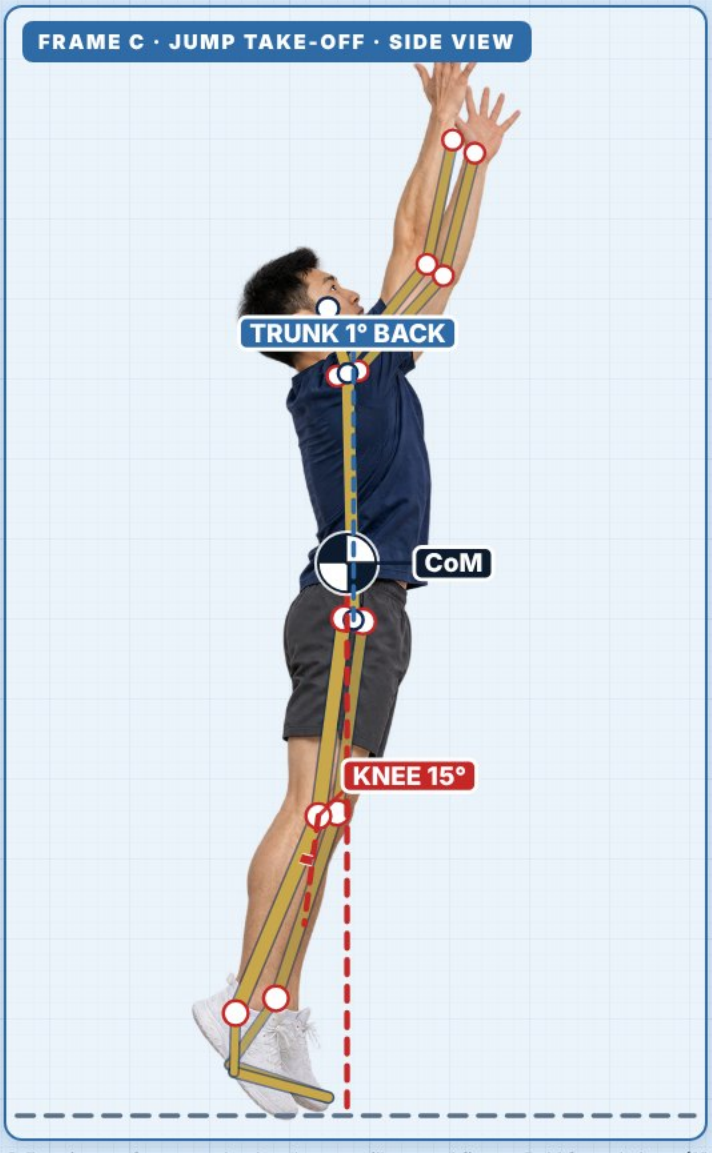
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Jump take-off: the fast, heavy load

- Knee extending to **15°** at take-off: the extensor mechanism has just released stored energy.
- Running, jumping and cutting were among the heaviest tendon loads measured: the last tasks to return.
- Jumping sports carry the most extensor-tendon pain: jumper's knee affected 44.6% of elite volleyball players (Lian et al., 2005).

Energy-storage tasks load the tendon most



Patellar tendon, 20 healthy adults, modelled force. Scattone Silva et al. (2024).

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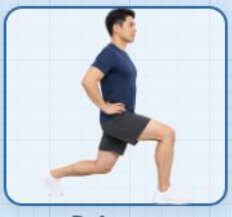
INTEGRATING PERFORMANCE & REHABILITATION HEALTHCARE PATHWAYS.

QUADRICEPS TENDON PAIN: PAIN JUST ABOVE THE KNEECAP

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A · Decline squat
Knee 95°

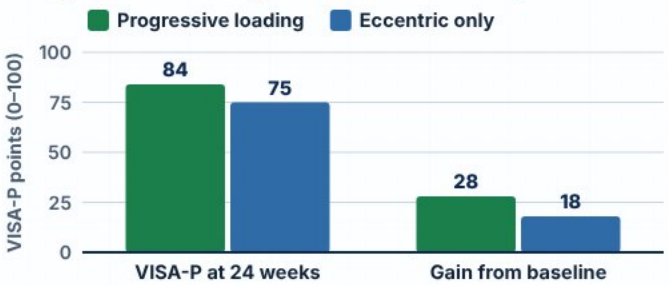


B · Lunge
Knee 62°



C · Jump
Heaviest load

Progressive loading beat eccentric-only



Patellar tendinopathy RCT, n = 76; difference 9 points (95% CI 1–16). Breda et al. (2021). No quadriceps-tendon trials found.

Decision pathway

1. **CONFIRM THE SITE**
   Pain and tenderness just above the kneecap, not below it; the two tendons are distinct problems.
2. **LOAD, DON'T REST**
   Graded tendon loading: isometric holds, then heavy slow work through range, then energy-storage tasks.
3. **PROGRESS DEPTH AND SPEED**
   Deeper flexion and jumping last; keep symptoms settled by the next morning.

NOT RECOMMENDED

Complete rest as the only plan; assuming patellar-tendon protocols transfer unchanged.

SEEK ASSESSMENT IF

A sudden pop with inability to straighten the knee or lift the leg (possible tendon rupture), a gap above the kneecap, or marked swelling.

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Analysis: MMSx Authority Applied Biomechanics Lab · Dr. Neeraj Mehta, PhD · Educational content, not a diagnosis.

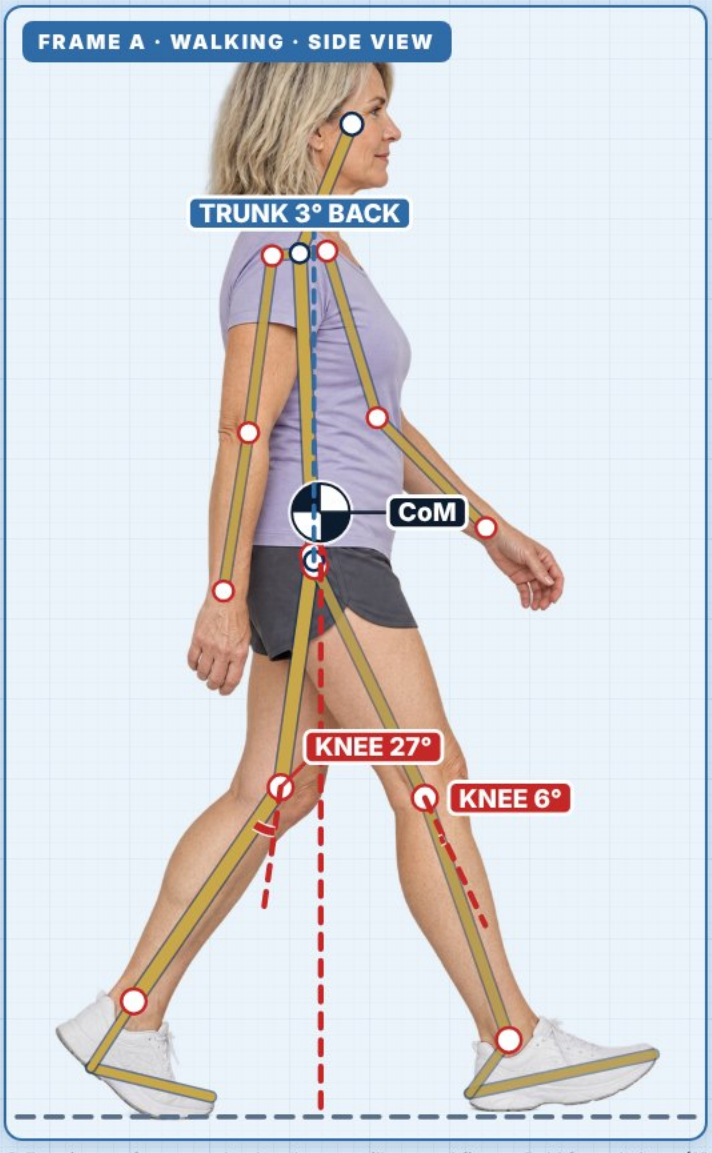
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BIOMECHANICS IS A FORCE-GOVERNED DECISION SYSTEM – NOT A POSTURE MODEL.

INTEGRATING PERFORMANCE & REHABILITATION HEALTHCARE PATHWAYS.

CARTILAGE DAMAGE: WHAT A "WORN SPOT" MEANS FOR KNEE LOADING

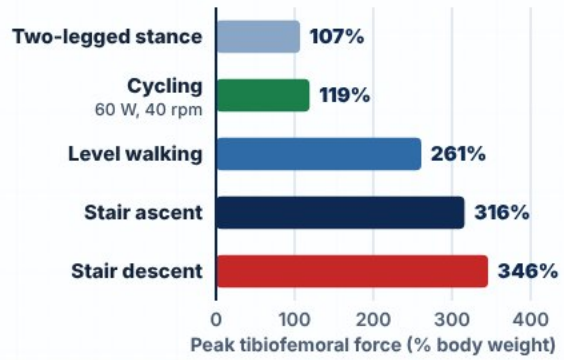
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Walking: the everyday load on the surface

- Stance knee flexed **27°** as body weight rolls over the foot; each step presses the joint surfaces together.
- Measured inside instrumented knees, walking reached about **2.6×** body weight; stairs reached more than 3×.
- Cartilage has no nerves: pain from a "worn spot" usually comes from the bone, synovium or swelling around it.

How hard does the knee press? By task



Instrumented knee replacements; no SD reported. Kutzner et al. (2010; cycling: 2012, n = 9).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Educational, not diagnostic.

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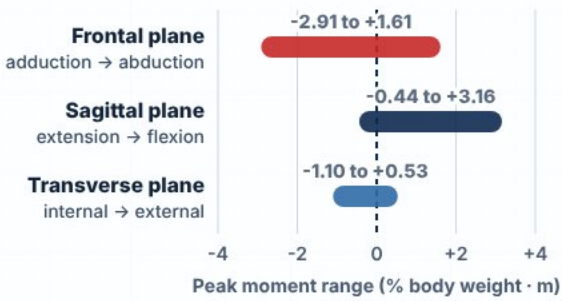
FRAME B · CYCLING, DOWNSTROKE · SIDE VIEW



Cycling: motion with less compression

- Downstroke knee **83°**, hip **98°**; the saddle carries body weight, so the knee only meets pedal force.
- At moderate power cycling loaded the knee to about **1.2×** body weight, under half the walking peak; shear was only 5–7% of body weight.
- The inward-bending (adduction) moments were the largest in daily tasks, which loads the inner compartment.

Which way is the knee bent and twisted?



Peak moments across daily activities, 5 instrumented knees. Kutzner et al. (2010).

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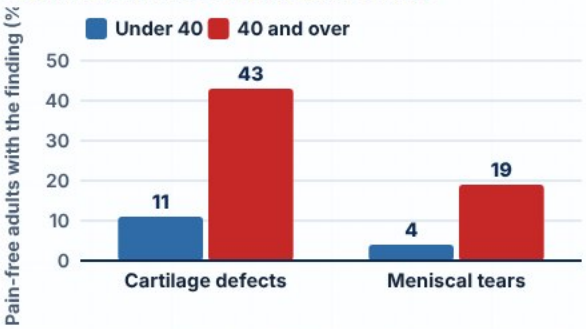
FRAME C · CYCLING · FRONT VIEW



Is my "worn spot" unusual?

- Front view: both knees sit within **4 cm** inside the foot line on the pedals.
- On MRI, **24%** of adults with no knee pain or injury have cartilage defects, rising to 43% from age 40.
- In 25,124 arthroscopies, lesions were commonest on the kneecap (36%) and inner thigh-bone condyle (34%).

Common in knees that do not hurt



Pooled prevalence; 63 studies, 5,397 knees. Culvenor et al. (2019). Widuchowski et al. (2007).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Knee-to-foot distance in the front view. Educational, not diagnostic.

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A · Walking
Knee 27°, ≈2.6× BW

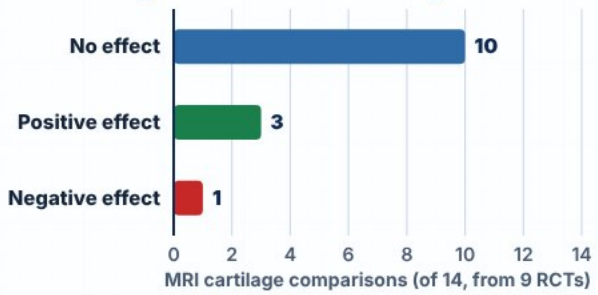


B · Cycling
Knee 83°, ≈1.2× BW



C · Cycling, front
Knee tracks the pedal

Does loading exercise harm cartilage?



People at risk of, or with, knee OA; low-quality evidence. Bricca et al. (2019).

Decision pathway

1. **MODIFY**
   Use low-compression movement such as cycling while symptoms are high; reduce stairs and long walks briefly.
2. **STRENGTHEN**
   Graded, knee-loading exercise: it has not been shown to damage cartilage.
3. **PROGRESS**
   Walking, then stairs and impact as tolerated. Surgery fits few: 7% of under-40s had repair-type lesions.

NOT RECOMMENDED

Treating a scan finding alone, or stopping all loading: neither has evidence of benefit.

SEEK ASSESSMENT IF

True locking, repeated giving way, a large swelling soon after injury, or a hot, red knee with fever.

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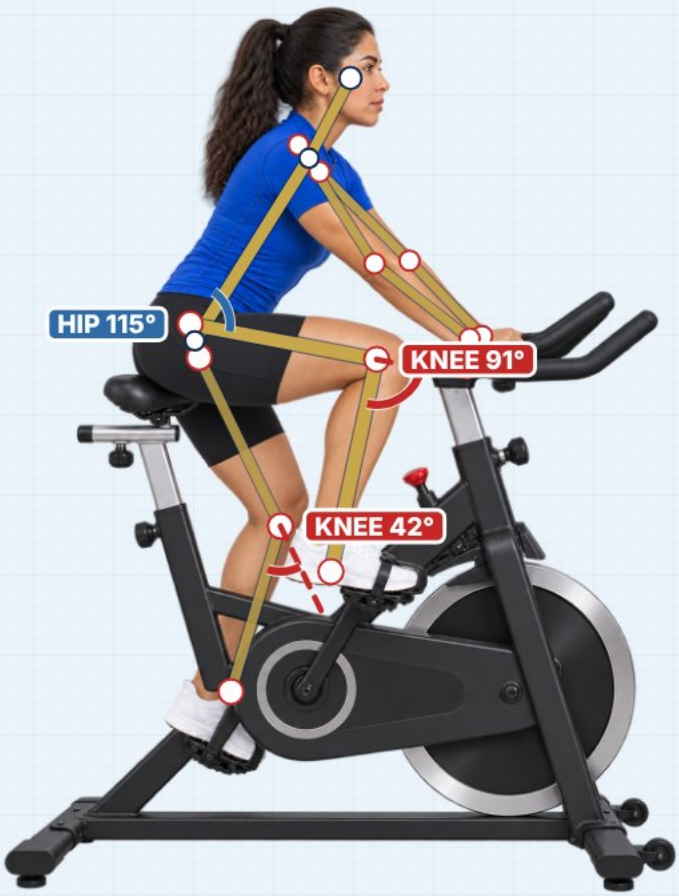
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INTEGRATING PERFORMANCE & REHABILITATION HEALTHCARE PATHWAYS.

PLICA SYNDROME: A PAINFUL FOLD INSIDE THE KNEE

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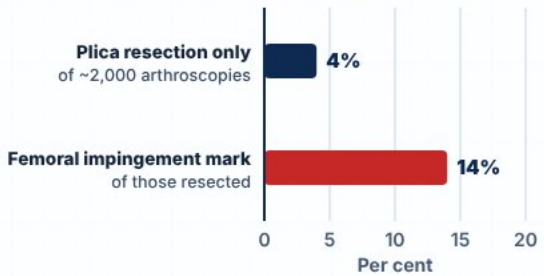
FRAME A · PEDAL NEAR THE TOP · SIDE VIEW



Pedal near the top: repeated deep bending

- Knee flexed **91°**, hip **115°** at the top of the stroke; thousands of bend–straighten cycles per ride.
- A plica is a normal fold of the joint lining. It becomes a problem only when it thickens and rubs over the inner femoral condyle.
- A symptomatic plica as the only finding was uncommon at arthroscopy; some showed a groove worn into the condyle.

How often is the plica the whole story?



76 patients treated by plica resection, 1981–1987. Dorchak et al. (1991).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Educational, not diagnostic.

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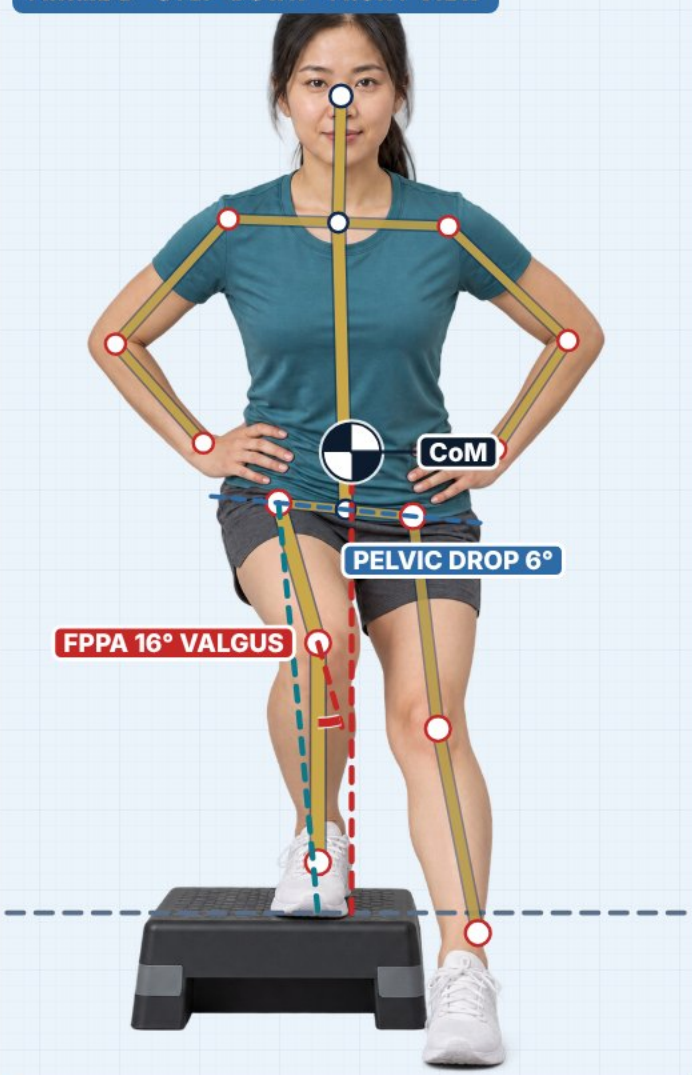
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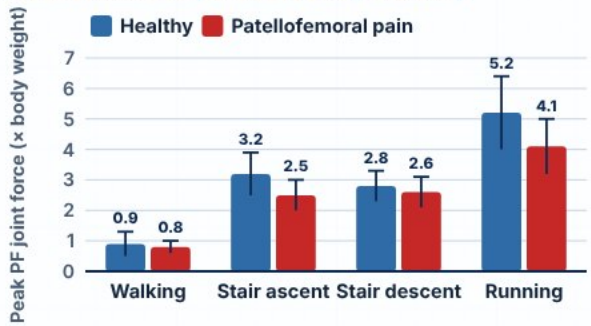
FRAME B · STEP-DOWN · FRONT VIEW



Step-down: front-of-knee load under control

- Stance knee **16°** inside the hip–ankle line; pelvis dropped **6°**.
- A medial plica sits at the front-inner knee, a region that stairs and running load several times body weight.
- People with patellofemoral pain loaded the joint less than healthy people, consistent with protective movement.

Patellofemoral joint force by activity



Weighted mean ± SD, systematic review and meta-analysis. Hart et al. (2022).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). FPPA from hip, knee and ankle points in the front view. Educational, not diagnostic.

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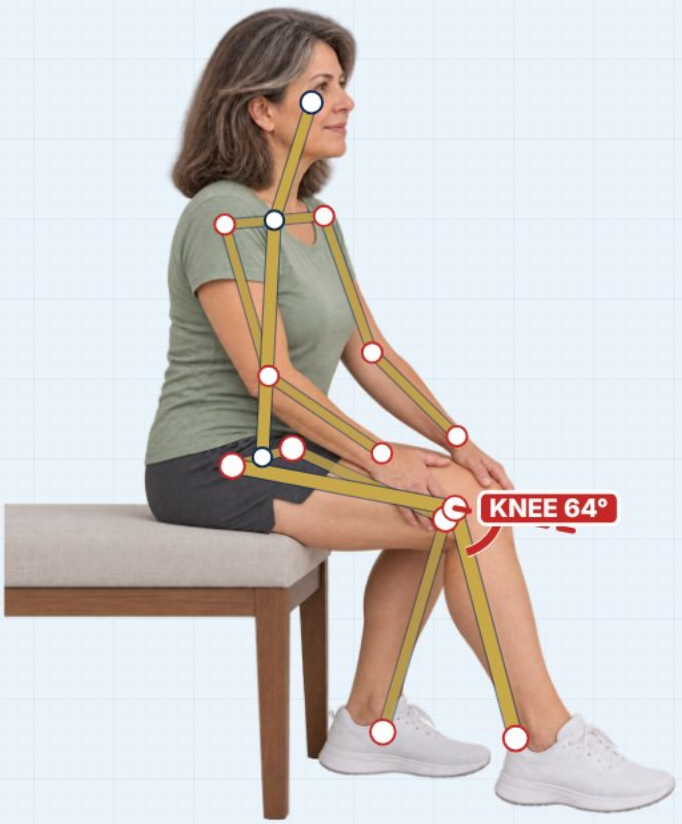
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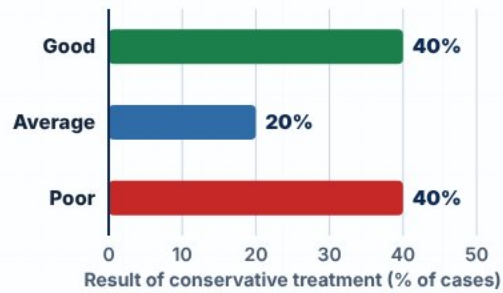
FRAME C · SEATED, KNEE BENT · SIDE VIEW



Seated with the knee bent: the fold under tension

- Knee flexed **64°**: a sustained bent-knee position. Note whether symptoms build with long sitting.
- Physiotherapy aimed to reduce front-of-knee compression by stretching the hamstrings, calf and quadriceps.
- Results were mixed: worth trying first, but not always enough.

Conservative care first



136 cases of pathological synovial plica. Amatuzzi et al. (1990).

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A · Cycling
Knee 91°

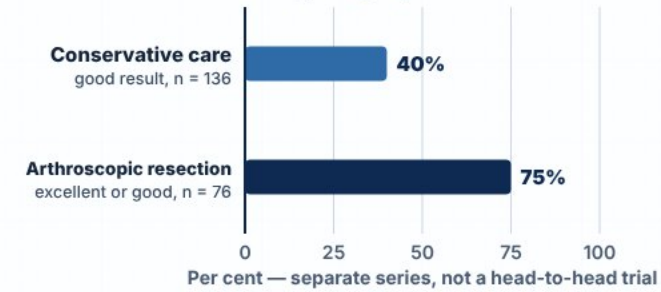


B · Step-down
FPPA 16°



C · Seated
Knee 64°

Conservative care first, surgery for some



Amatuzzi et al. (1990); Dorchak et al. (1991). Different patients and definitions.

Decision pathway

1. **RULE OUT OTHERS**
   A plica alone was the finding in only about 4% of arthroscopies: rule out commoner causes of front-inner knee pain first.
2. **TREAT CONSERVATIVELY**
   Flexibility of the hamstrings, calf and quadriceps; reduce repeated deep bending for a while; strengthen hip and knee.
3. **REFER IF PERSISTENT**
   Surgery suited selected patients with a specific diagnosis and impingement findings.

NOT RECOMMENDED

Removing a plica that is normal: plicae are common and often harmless.

SEEK ASSESSMENT IF

Locking, giving way, a large swelling, or pain after a twisting injury.

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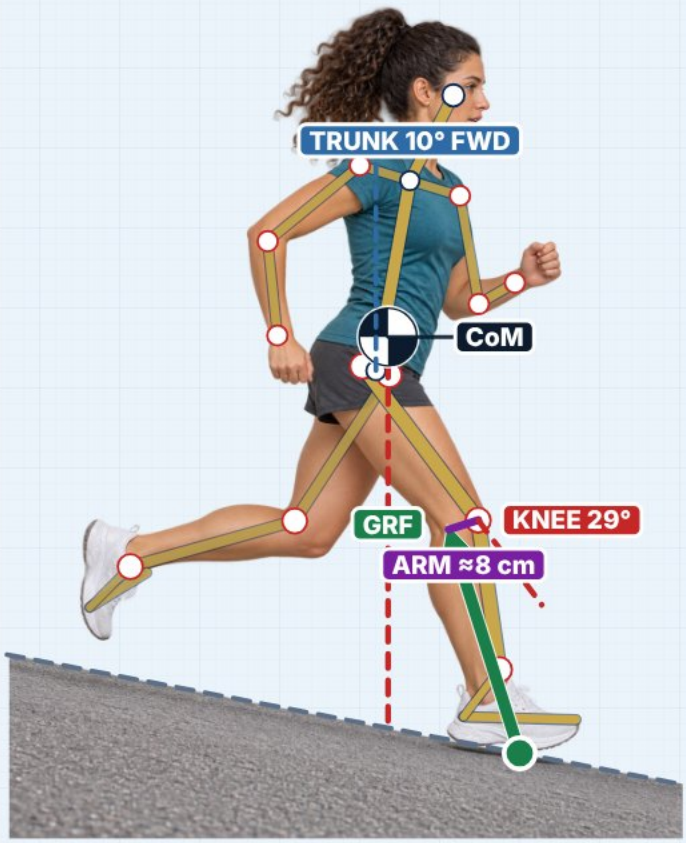
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OUTER-BACK KNEE PAIN: HAMSTRING AND POPLITEUS TENDONS

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FRAME A · DOWNHILL RUNNING · SIDE VIEW



Downhill running: braking every stride

- Stance knee flexed **29°**, trunk **10°** forward; ground force **≈8 cm** behind the knee on the slope.
- The biceps femoris tendon inserts on the outer-back knee (fibular head); the popliteus runs across the back of the knee and helps control rotation as it bends under load.
- In professional football, most hamstring strains happened while running.

Running is where hamstrings get hurt



91 professional clubs, two seasons. Woods et al. (2004).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Educational, not diagnostic.

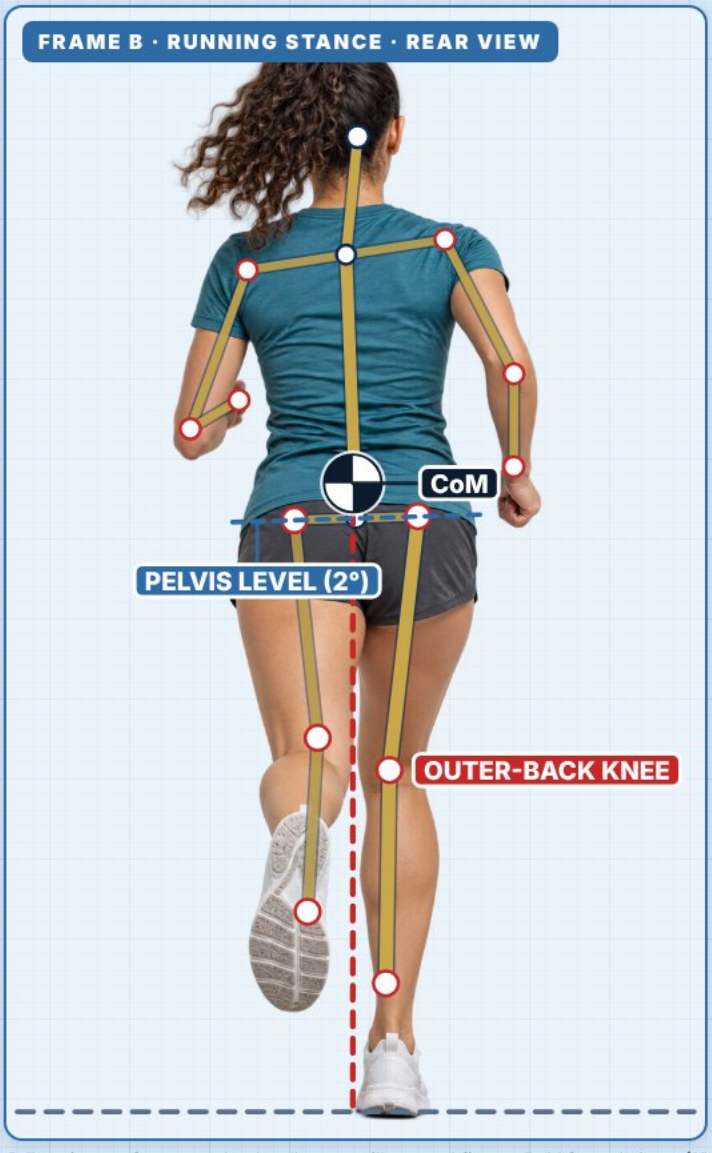
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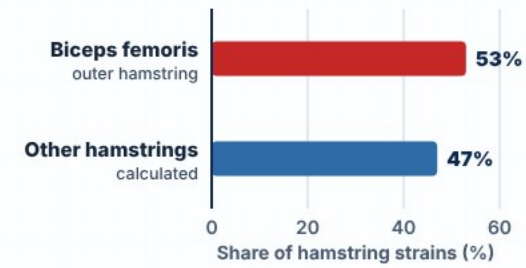
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Rear view: the outer hamstring line

- Pelvis within **2°** of level in stance; the marked point is where outer-back knee pain is felt.
- The biceps femoris (outer hamstring) showed the **largest peak strain** of the hamstrings in sprinting, late in the swing (Schache et al., 2012).
- It was also the hamstring most often strained.

The outer hamstring takes the most strain



Professional football audit. Woods et al. (2004).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Pelvic tilt from left and right hip points in the rear view. Educational, not diagnostic.

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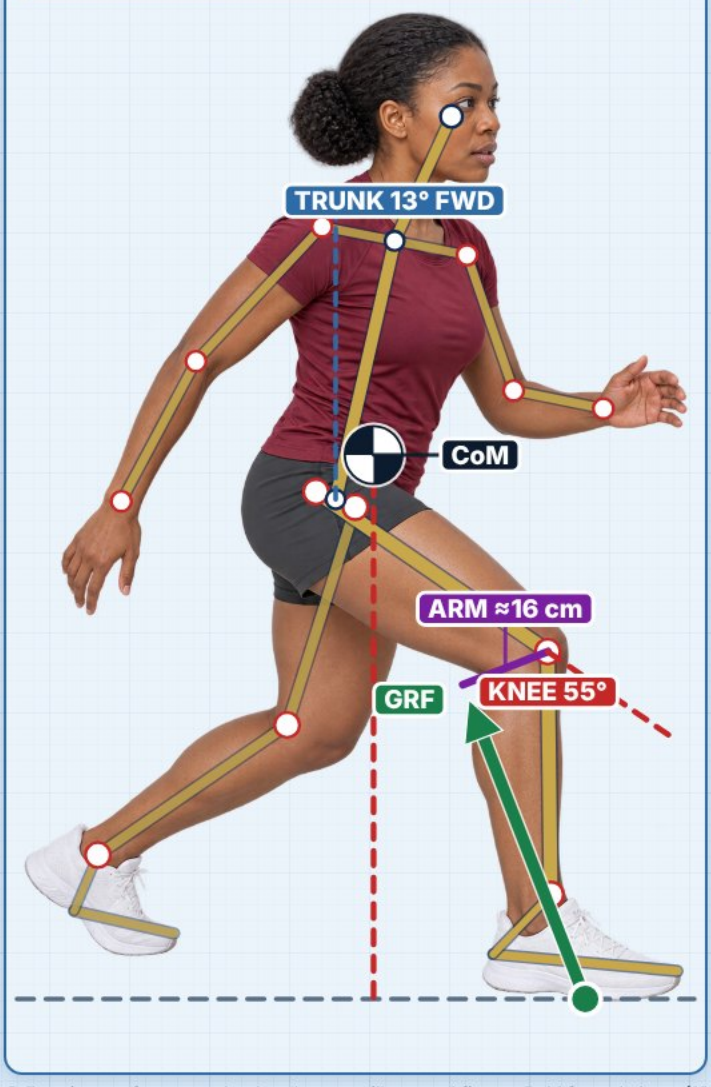
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FRAME C · DECELERATION STEP · SIDE VIEW



Deceleration: the knee bends under a big lever

- Front knee flexed **55°**; ground force ≈**16 cm** behind the knee: the quadriceps brake while the hamstrings and popliteus control rotation.
- Hamstrings reached peak force and strain around the same moment in the stride: the highest-risk window (Schache et al., 2012).
- Few hamstring injuries were ever imaged, so diagnosis rests on careful examination.

Hamstring problems recur

12%
reinjury rate after a hamstring strain

5%
of strains had any diagnostic investigation

Evidence gap

Tendon pain at the outer-back knee (distal biceps femoris, popliteus) has little high-quality data; principles are borrowed from hamstring and tendon research.

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Source for statistics: Woods et al. (2004). Educational, not diagnostic.

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INTEGRATING PERFORMANCE & REHABILITATION HEALTHCARE PATHWAYS.

OUTER-BACK KNEE PAIN: HAMSTRING AND POPLITEUS TENDONS

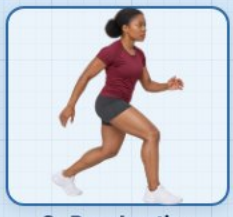
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A · Downhill run
Knee 29°

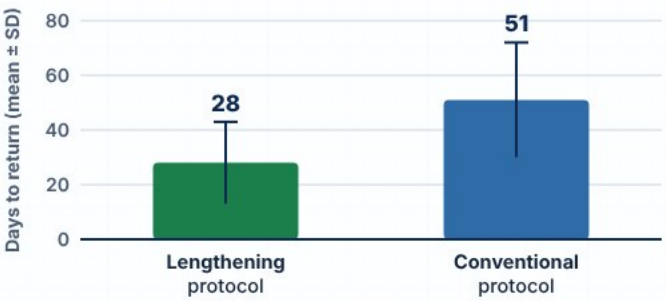


B · Rear view
Outer-back knee



C · Deceleration
Knee 55°

Lengthening exercises: faster return



75 elite footballers with MRI-verified hamstring injury, RCT. Askling et al. (2013).

Decision pathway

1. **LOCATE**
   Outer-back knee pain: biceps femoris tendon at the fibular head, or popliteus behind the joint line; rule out joint and nerve causes.
2. **LOAD PROGRESSIVELY**
   Hamstring strengthening that includes lengthened positions; settle downhill and sprint volume first.
3. **RETURN GRADUALLY**
   Rebuild sprinting, braking and downhill running last.

SEEK ASSESSMENT IF

Swelling or instability after a twisting injury (possible posterolateral corner injury), numbness or foot drop, or a calf that is swollen and tender.

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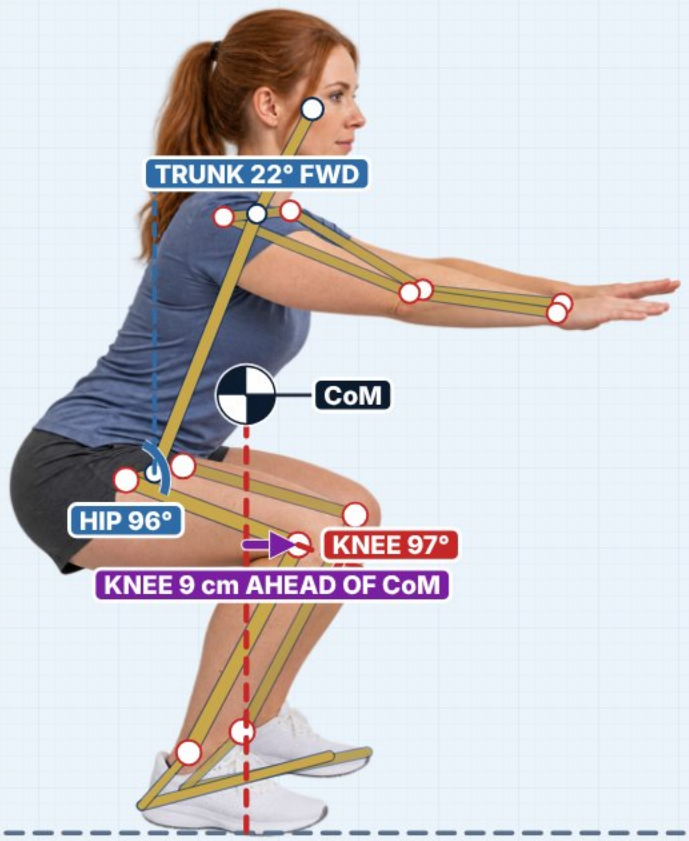
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KNEE PAIN IN PREGNANCY: LOAD, POSTURE AND SAFE MOVEMENT

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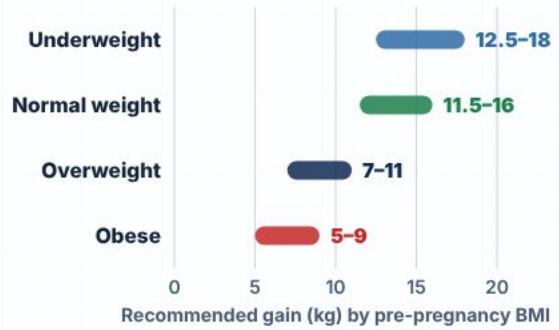
FRAME A · SQUAT · SIDE VIEW



Squat: added mass on a bending knee

- Demonstration model (not pregnant): knee **97°**, hip **96°**, knee ≈**9 cm** ahead of the CoM line.
- Pregnancy adds mass in front of the trunk; every kilogram is carried through the knees in squats, stairs and lifts.
- Recommended gain depends on starting body size (Institute of Medicine, 2009, as reported by Goldstein et al., 2017).

How much weight gain is recommended?



IOM 2009 ranges as reported in Goldstein et al. (2017).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Demonstration model: no pregnancy-specific angles are implied. Educational, not diagnostic.

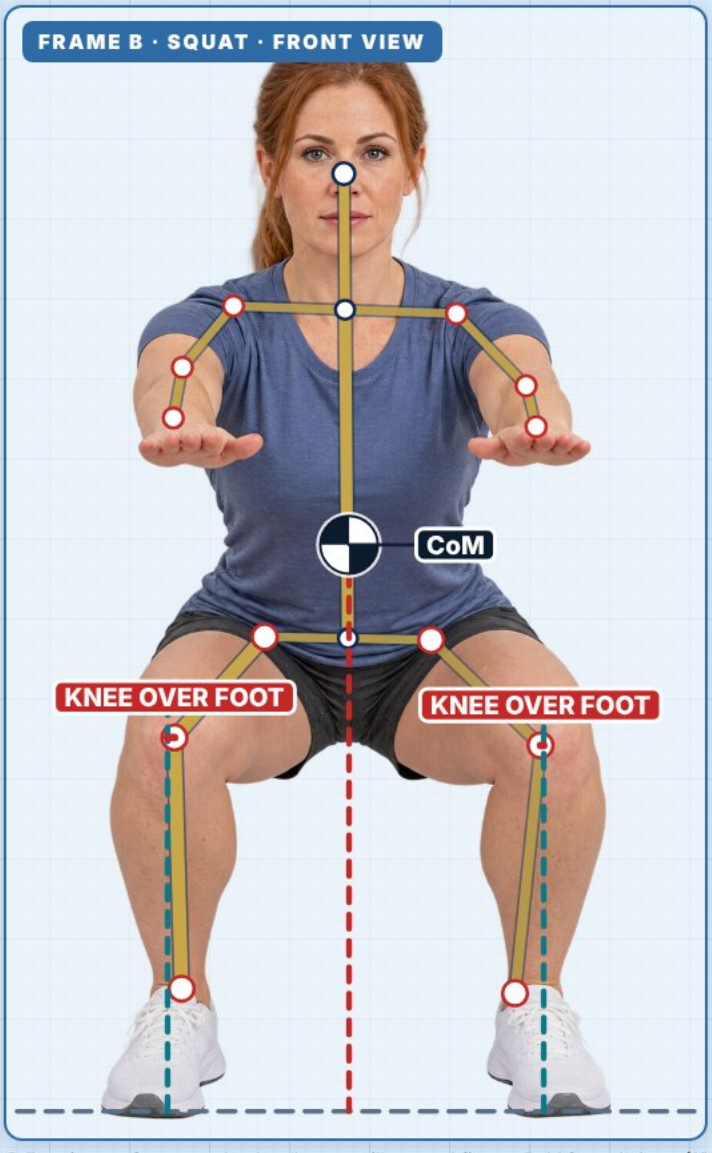
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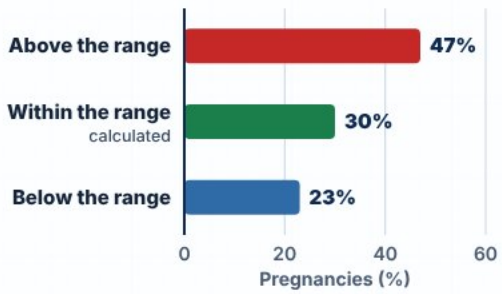
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Front view: a wide, stable base

- Demonstration model: knees track over the feet (within **1 cm** of the foot line) with a shoulder-width stance.
- Nearly half of pregnancies gained more than the recommended range: more mass for the knees to manage.
- Gaining above the range was linked with more large babies and caesarean births.

Most pregnancies sit outside the range



23 studies, 1,309,136 women. Goldstein et al. (2017).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Knee-to-foot distance in the front view. Educational, not diagnostic.

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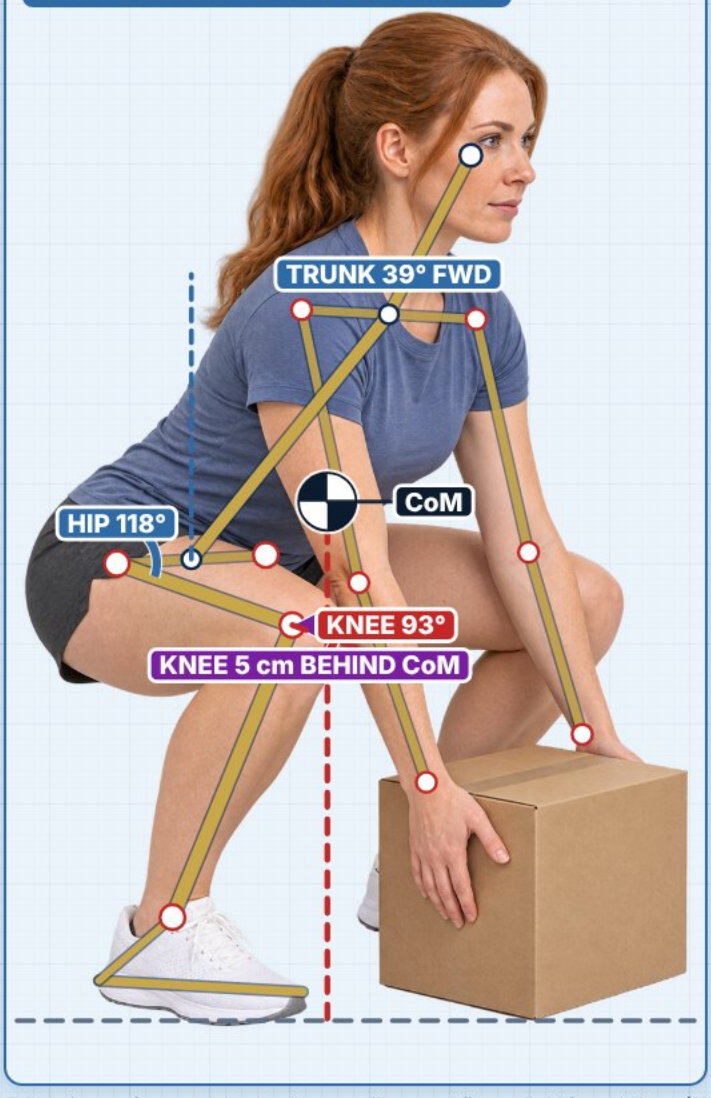
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FRAME C · LIFTING A BOX · SIDE VIEW

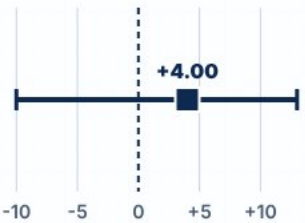


Lifting: hips back, load close

- Demonstration model: knee **93°**, hip **118°**, trunk **39°** forward with the box held close.
- In late pregnancy, walking changed little in shape, but **hip and ankle** muscle demands rose; pelvic tilt varied widely between women.
- Foot arch height fell during pregnancy and stayed lower afterwards in 49 women (Segal et al., 2013).

Posture changes differ from woman to woman

Peak anterior pelvic tilt
late pregnancy vs after



Change (°): mean and individual range

15 women, gait analysis in the last trimester and 1 year post partum. Foti et al. (2000).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Demonstration model: no pregnancy-specific angles are implied. Educational, not diagnostic.

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A · Squat
Knee 97°

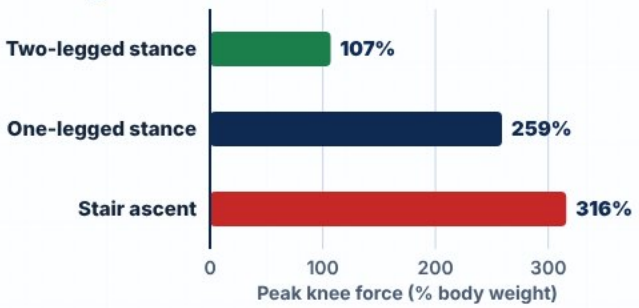


B · Squat, front
Wide base



C · Lift
Load close

Two legs share the load



Instrumented knee replacements, n = 5 (not pregnant). Kutzner et al. (2010).

Decision pathway

1. **KEEP MOVING**
   Pregnant women should be encouraged to continue or begin safe physical activity (ACOG, 2020).
2. **SHARE THE LOAD**
   Favour two-legged, supported squats and use the handrail on stairs; hold loads close.
3. **STRENGTHEN HIPS**
   Hip and ankle muscles work harder late in pregnancy: include hip and calf strengthening.

SEEK ASSESSMENT IF

A calf that is painful, swollen or warm (possible clot), a hot swollen knee, sudden severe pain, or any pregnancy warning sign: contact your maternity team.

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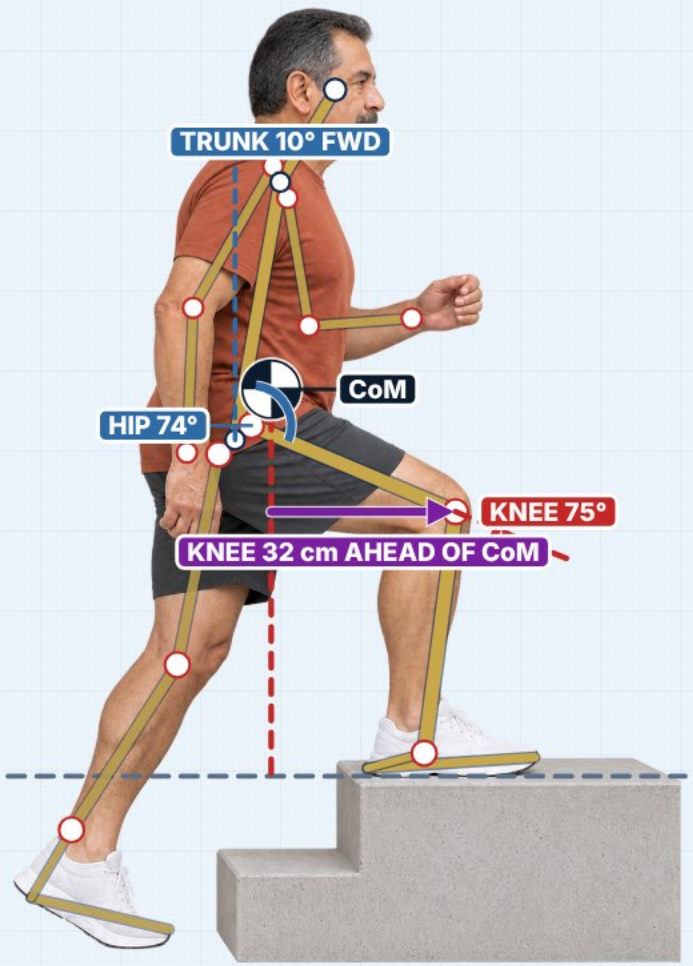
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BODY WEIGHT AND KNEE LOAD: HOW EVERY KILOGRAM COUNTS

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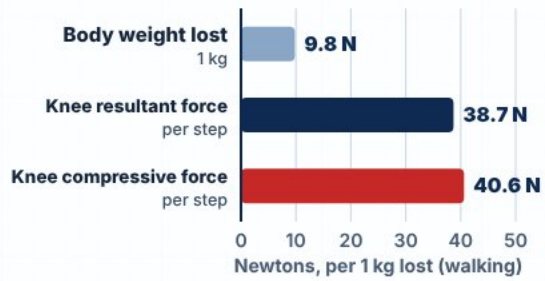
FRAME A · STAIR ASCENT · SIDE VIEW



Stair ascent multiplies body weight

- Leading knee flexed **75°**, hip **74°**; the knee sits **≈32 cm** ahead of the CoM line.
- Measured inside instrumented knees, stair ascent reached about **3.2×** body weight (Kutzner et al., 2010): every extra kilogram is multiplied on every step.
- In walking, each kilogram lost removed about **4×** its weight from the knee per step.

Every kilogram lost: the 4-to-1 ratio



142 overweight or obese older adults with knee OA, 18-month trial. Messier et al. (2005).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Educational, not diagnostic.

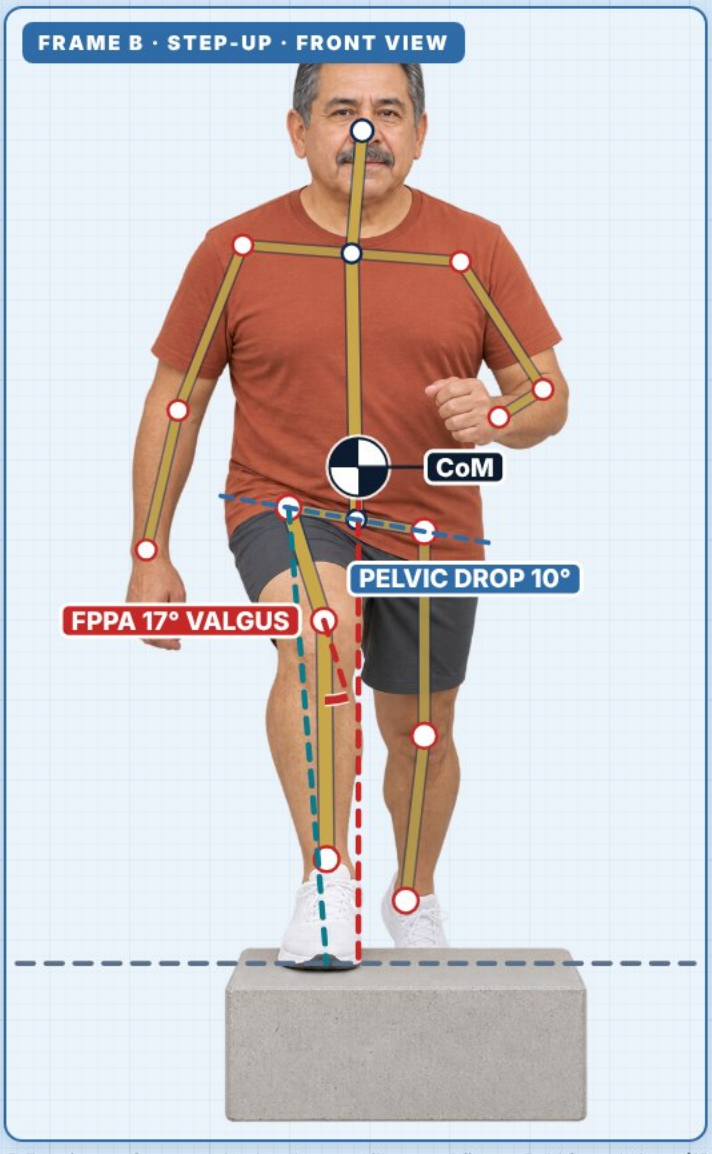
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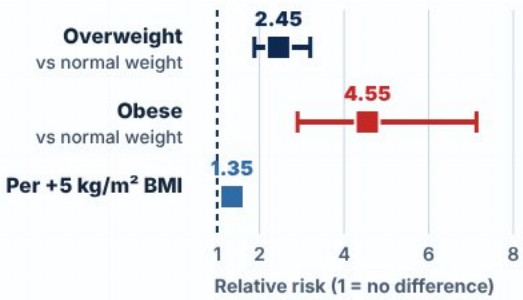
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Step-up: one leg lifts all the mass

- Front view: stance knee **17°** inside the hip–ankle line; pelvis dropped **10°** on the free side.
- Each step-up lifts the whole body on one knee, so body mass and control act together.
- Across 14 prospective cohorts, risk of knee OA rose with every BMI band.

Body weight and the risk of knee OA



Meta-analysis of 14 prospective studies. Zheng & Chen (2015).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). FPPA from hip, knee and ankle points in the front view. Educational, not diagnostic.

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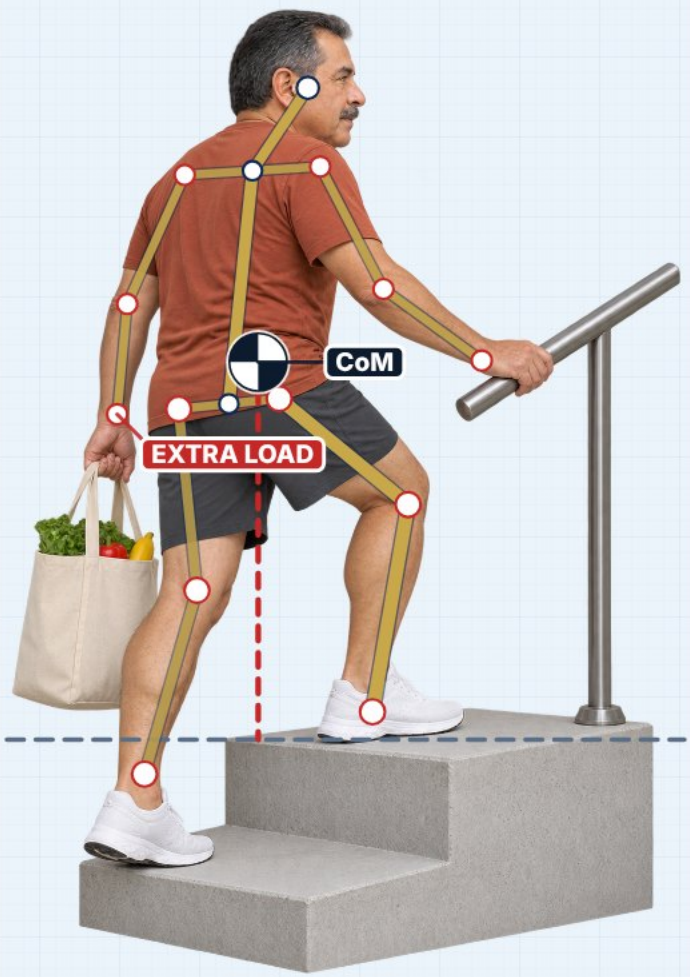
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FRAME C · ASCENT CARRYING A BAG · REAR-OBLIQUE



Carrying a bag adds load like body mass

- Rear-oblique view, so angles are not measured.
- Carrying 13.6 kg increased the peak knee adduction moment in healthy adults, and stair ascent raised it more than walking (Hall et al., 2013).
- In the IDEA trial, diet lowered knee compressive force by **200 N** more than exercise alone; exercise alone lost only 2% of body weight.

What actually takes weight off?



454 adults with knee OA, 18 months, adjusted means. Messier et al. (2013).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Frame C is oblique: no angles reported. Educational, not diagnostic.

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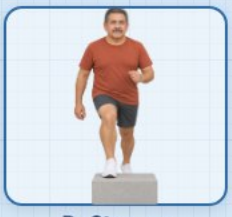
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A · Stair ascent
≈3.2× body weight

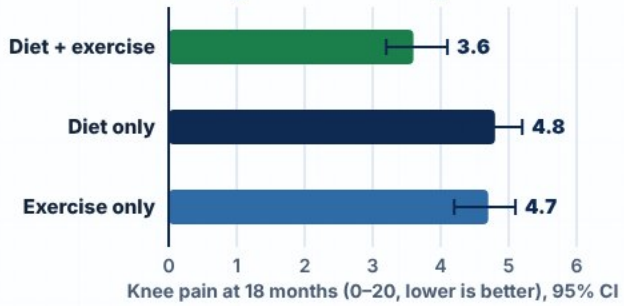


B · Step-up
FPPA 17°



C · With a bag
Load adds like mass

Diet and exercise together reduced pain most



IDEA randomised trial, n = 454. Messier et al. (2013).

Decision pathway

1. **LOSE**
   Aim for more than 5% of body weight within about 20 weeks: disability improved beyond that point (Christensen et al., 2007).
2. **COMBINE**
   Pair diet with exercise: the combined arm had the least pain and the best function.
3. **STRENGTHEN**
   Graded step-ups and stair practice; split heavy shopping into lighter loads.

NOT RECOMMENDED

Relying on exercise alone when weight loss is the goal (about 2% loss in 18 months).

SEEK ASSESSMENT IF

A rapidly swelling, hot or red knee, inability to bear weight, locking, or unexplained weight loss or fever.

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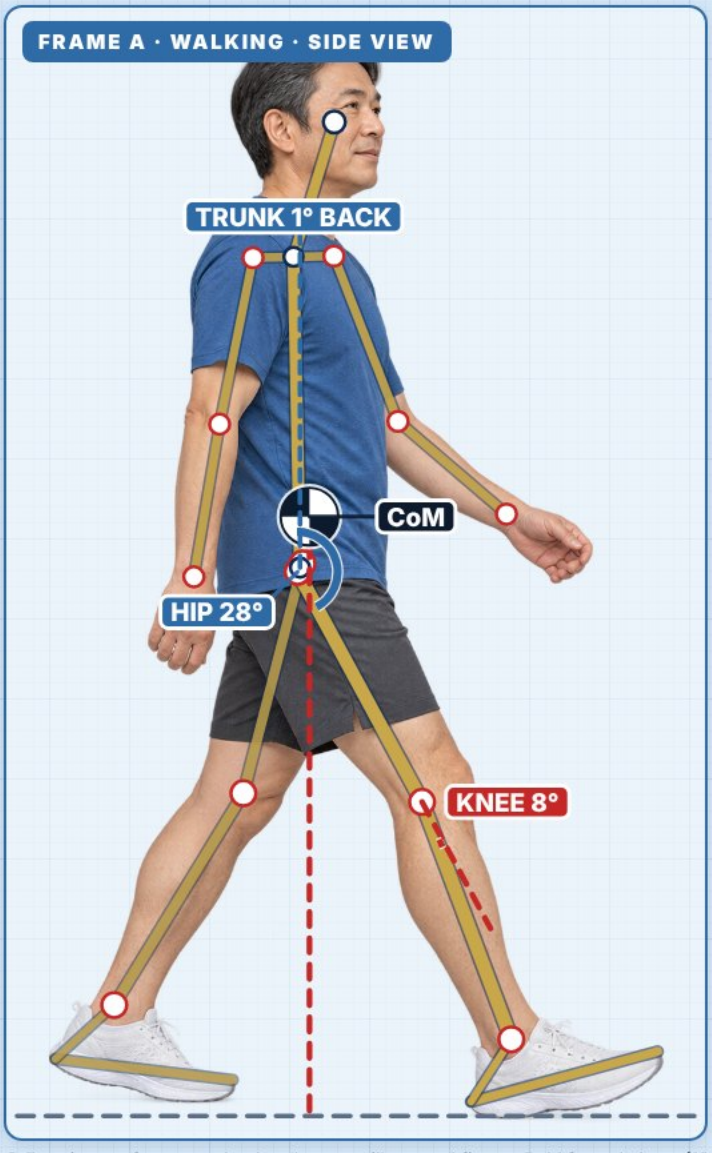
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WHEN KNEE PAIN COMES FROM THE HIP

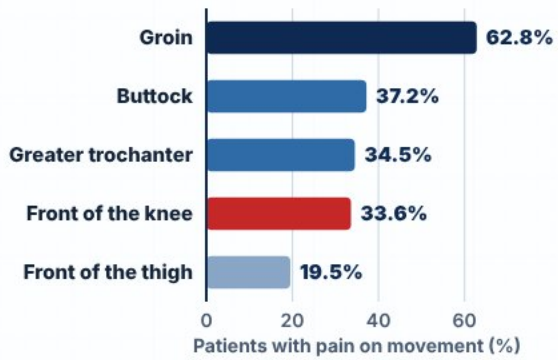
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Walking: the hip moves, the knee hurts

- Hip flexed **28°** at the front leg, knee **8°**; each step rotates and loads the hip joint.
- Hip disease is often felt in the thigh and the knee, so the knee can hurt while the problem sits higher up.
- One in three people awaiting hip replacement had front-of-knee pain on movement, as often as pain over the outer hip.

Where does hip disease hurt?



113 patients with hip OA or osteonecrosis before hip replacement. Sakamoto et al. (2014).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Educational, not diagnostic.

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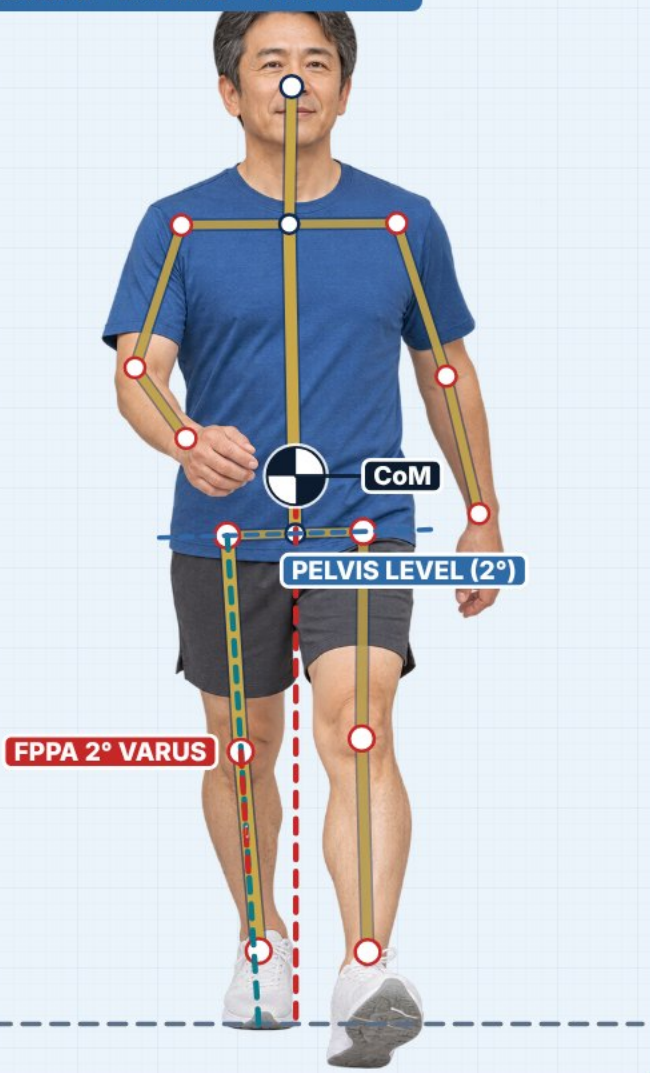
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FRAME B · WALKING · FRONT VIEW



Front view: the knee may look normal

- Stance knee only **2°** off the hip–ankle line; pelvis near level (**2°**). Nothing at the knee explains the pain.
- The proof that pain was referred: after the hip was replaced, front-of-knee pain resolved in most patients.
- Short follow-up (about 2 weeks); counts differ between tables in the paper.

Fix the hip, the knee pain goes



Of 15 (rest) and 38 (movement) with knee pain before surgery. Sakamoto et al. (2014).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). FPPA from hip, knee and ankle points in the front view. Educational, not diagnostic.

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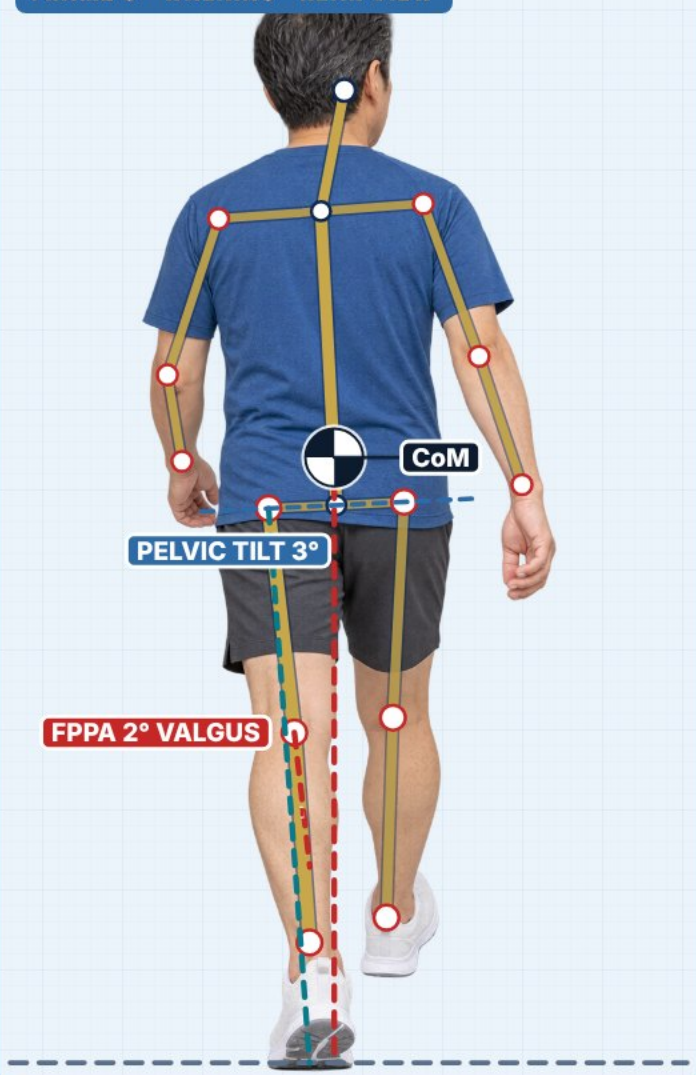
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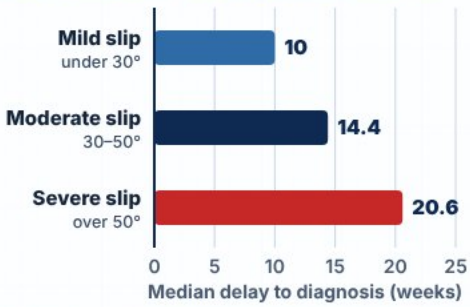
FRAME C · WALKING · REAR VIEW



Rear view: pelvis and the hip abductors

- Pelvis tilted **3°** over the stance leg; hip abductor weakness shows as a pelvic drop or a trunk lean.
- In adolescents, a slipped capital femoral epiphysis (SCFE) often presents as knee or thigh pain, and knee pain was an independent predictor of a longer delay.
- Longer delays went with more severe slips.

The cost of missing the hip in a teenager



196 patients with SCFE; overall median delay 8.0 weeks. Kocher et al. (2004).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Pelvic tilt from left and right hip points in the rear view. Educational, not diagnostic.

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BIOMECHANICS IS A FORCE-GOVERNED DECISION SYSTEM – NOT A POSTURE MODEL.

INTEGRATING PERFORMANCE & REHABILITATION HEALTHCARE PATHWAYS.

WHEN KNEE PAIN COMES FROM THE HIP

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A · Walking, side
Hip 28°

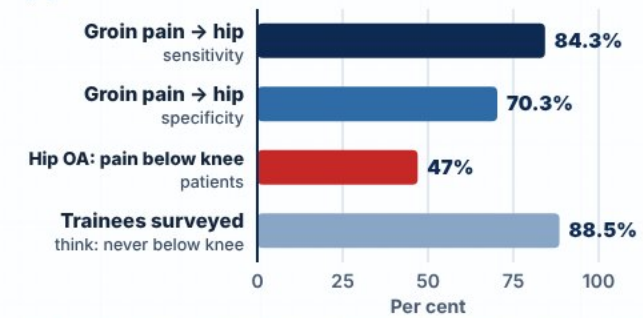


B · Walking, front
Knee looks normal



C · Walking, rear
Pelvis 3°

Hip pain can travel below the knee



60 hip OA vs 60 spinal stenosis patients; 33 orthopaedic trainees. Khan et al. (2004).

Decision pathway

1. **EXAMINE THE HIP**
   In every knee-pain assessment: hip rotation (especially internal rotation) and pain provocation.
2. **LISTEN FOR CLUES**
   Groin pain (sensitivity 84%) or knee pain with an unremarkable knee examination points to the hip.
3. **ACT FAST IN TEENS**
   Knee or thigh pain with a limp in a young person: same-day assessment for SCFE.

NOT RECOMMENDED

Treating an adolescent's knee pain with a limp as a simple knee problem without examining the hip.

SEEK ASSESSMENT IF

A child or teenager with knee or thigh pain and a limp, inability to bear weight, night pain, or fever.

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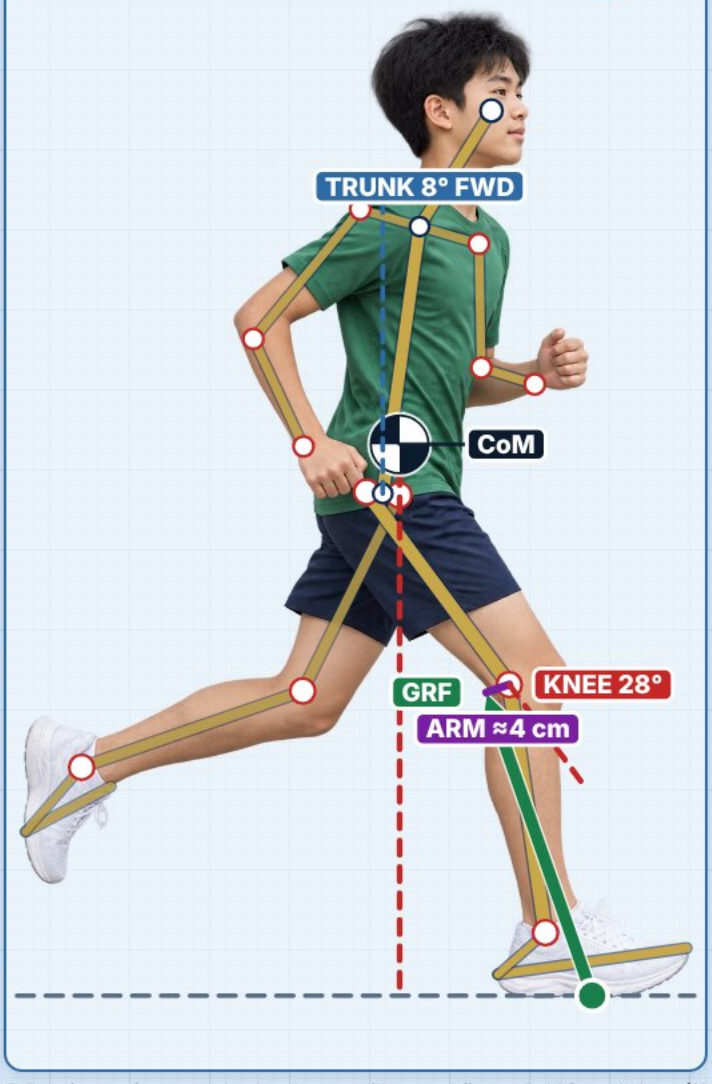
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SINDING-LARSEN-JOHANSSON: LOWER KNEECAP PAIN IN CHILDREN

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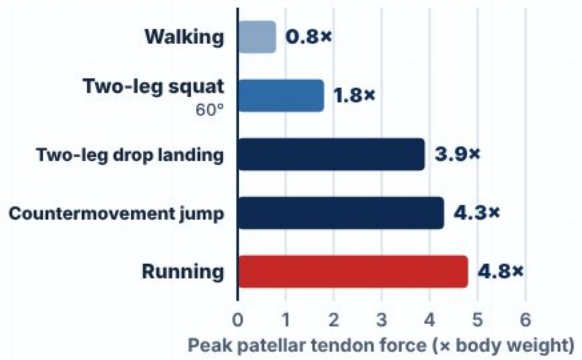
FRAME A · ADOLESCENT RUNNING · SIDE VIEW



Running: the tendon pulls on a growing bone

- Stance knee flexed **28°**; ground force passes **≈4 cm** behind the knee, so the quadriceps pulls hard through the patellar tendon.
- In SLJ that pull irritates the growth area at the **lower pole of the kneecap**; Osgood–Schlatter is the same process at the shin end.
- Running loaded the patellar tendon about **6×** more than walking (adult data).

How hard does the patellar tendon work?



Mean, 20 healthy adults; modelled tendon force. Scattone Silva et al. (2024).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Educational, not diagnostic.

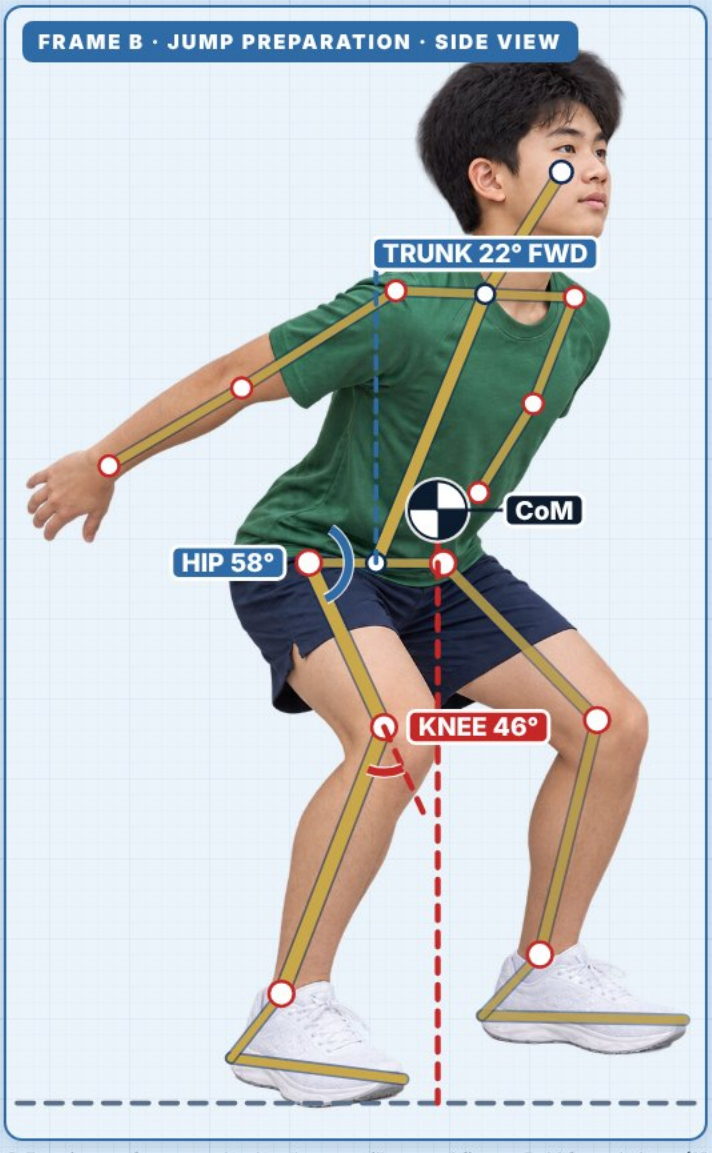
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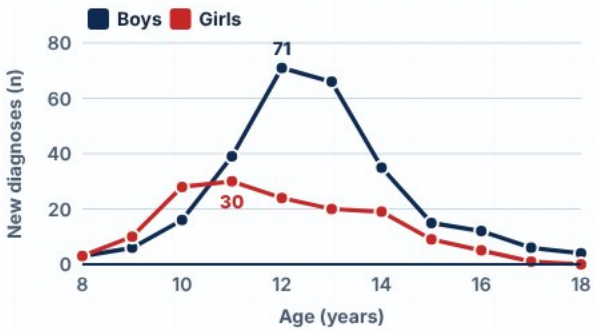
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Jump preparation: loading the knee deep

- Knee flexed **46°**, hip **58°**, trunk **22°** forward before take-off: jumping is one of the highest tendon loads.
- Traction apophysitis peaks in the growth spurt; SLJ case reports describe ages 9–17 (mean about 12).
- The chart shows Osgood–Schlatter, the best-counted relative of SLJ.

Peaks at 11–13 years (Osgood–Schlatter)



422 new cases, Dutch general practice. van Leeuwen et al. (2022); SLJ ages: Wilczyński et al. (2024).

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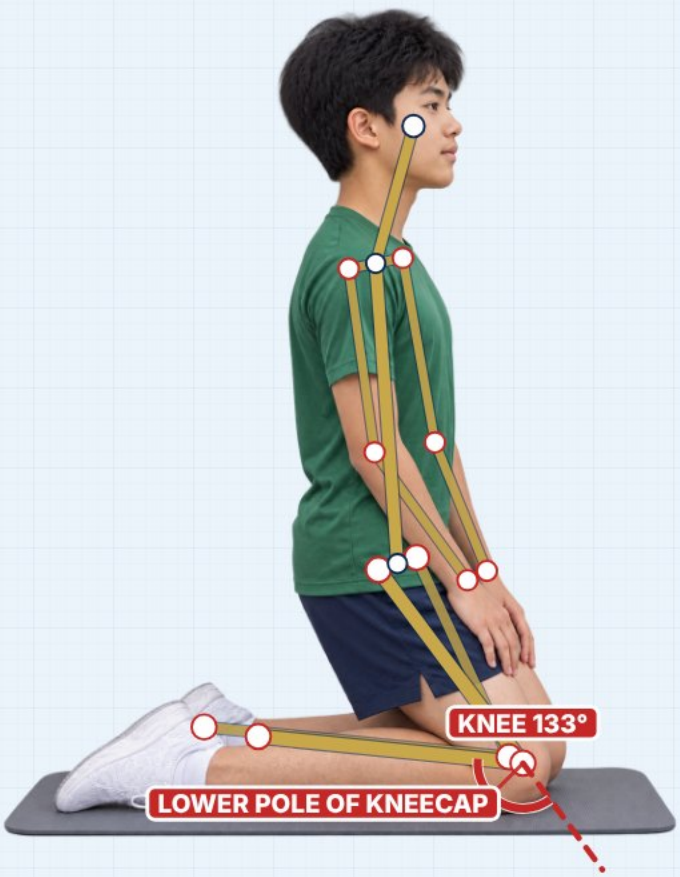
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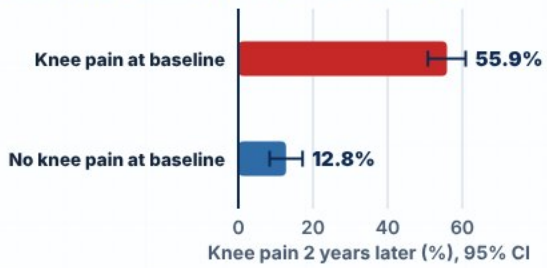
FRAME C · KNEELING · SIDE VIEW



Kneeling: direct pressure on the sore spot

- Knee flexed **133°**; body weight rests on the front of the knee, close to the lower pole of the kneecap.
- Kneeling is commonly painful in SLJ; use a cushion or avoid it while symptoms are high (no load data available).
- Adolescent knee pain is not always "growing pains": more than half still had pain 2 years on.

Does teenage knee pain just go away?



504 adolescents with knee pain, aged 15–19, 2-year follow-up. Rathleff et al. (2016).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Educational, not diagnostic.

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A · Running
Knee 28°, ≈6× walking



B · Jump prep
Knee 46°



C · Kneeling
Pressure on the pole

Load management + strengthening works, slowly



51 adolescents aged 10–14 with Osgood–Schlatter; case series. Rathleff et al. (2020).

Decision pathway

1. **EXPLAIN**
   Common in growing, active children and usually settles; recovery takes months, not weeks.
2. **MODIFY LOAD**
   Pain-guided: cut jumping, sprinting and deep single-leg work for a while; cushion kneeling.
3. **STRENGTHEN, THEN RETURN**
   Progressive quadriceps and hip strengthening, then graded running and jumping.

NOT RECOMMENDED

Prolonged complete rest as the only plan; routine imaging for a typical case.

SEEK ASSESSMENT IF

Cannot straighten the knee or bear weight after a jump or fall, night or constant rest pain, fever, marked swelling, or a limp with hip or thigh pain.

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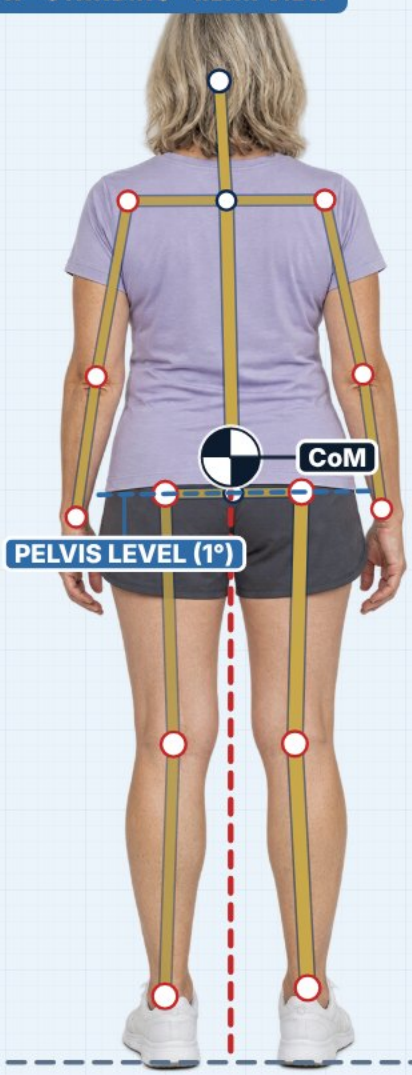
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INTEGRATING PERFORMANCE & REHABILITATION HEALTHCARE PATHWAYS.

KNEE PAIN FROM STANDING ALL DAY

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FRAME A · STANDING · REAR VIEW



Quiet standing: weight shared, load low

- Rear view: pelvis level within **1°**, weight on both feet; the CoM line falls between them.
- Measured inside instrumented knees, two-legged standing loaded the knee at about body weight; shifting weight onto one leg more than doubled it.
- Long standing days invite that habit, so the problem is static time and one-sided loading, not standing itself.

What standing costs the knee



Instrumented knee replacements, n = 5; no SD reported. Kutzner et al. (2010).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Pelvic tilt from left and right hip points in the rear view. Educational, not diagnostic.

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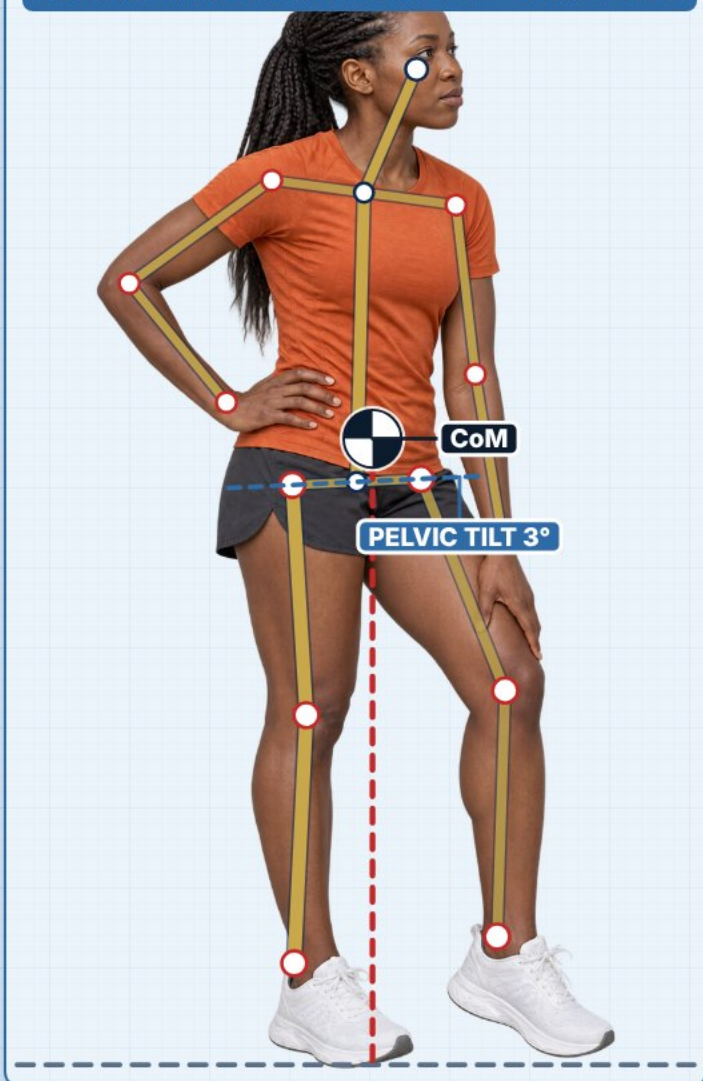
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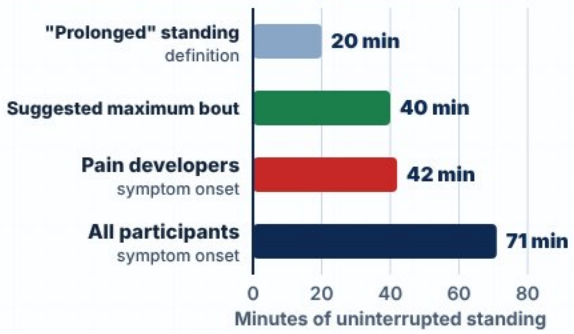
FRAME B · STANDING AFTER ACTIVITY · FRONT VIEW



Standing after activity: the slow drift

- Front view: pelvis tilted **3°**, weight drifting toward one leg with a hand on the hip.
- In laboratory studies, symptoms (low back) reached a clinically relevant level after **42–71 min**; the authors advise against standing more than 40 min at a time.
- After a 5-hour standing day, muscle fatigue outlasted the feeling of discomfort by more than 30 min (Garcia et al., 2015).

How long before standing starts to hurt?



25 laboratory studies, 591 participants; low-back data, knee not reported. Coenen et al. (2017).

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KNEE PAIN FROM STANDING ALL DAY

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FRAME C · SEATED AT A DESK · SIDE VIEW



Sitting breaks: the other half of the answer

- Knee flexed **98°**, hip **90°**: seated, the knee carries almost no body weight.
- Standing more than 2 h a day was associated with higher odds of knee OA; sitting more than 2 h was not.
- Observational data: associations, not proof of cause.

Work postures and knee OA



Meta-analysis of 71 observational studies. Wang et al. (2020).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Educational, not diagnostic.

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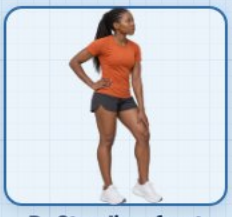
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KNEE PAIN FROM STANDING ALL DAY

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A · Standing, rear
Weight shared

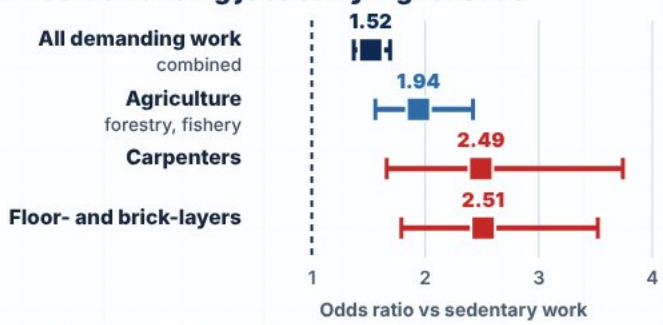


B · Standing, front
Pelvis 3°



C · Seated
Knee 98°

Knee-demanding jobs carry higher odds



Meta-analysis of observational studies. Wang et al. (2020).

Decision pathway

1. **BREAK IT UP**
   Change position or sit briefly before about 40 min of static standing; keep mostly static standing under 3 h (Garcia et al., 2018).
2. **SHARE THE LOAD**
   Weight on both legs, not hanging on one; walk a few steps regularly.
3. **CUSHION**
   Cushioned flooring or insoles reduced discomfort with moderate evidence (Speed et al., 2018).

NOT RECOMMENDED

Swapping all sitting for all-day standing without breaks.

SEEK ASSESSMENT IF

Knee swelling, locking or giving way, night or rest pain, a hot red joint, or calf pain or swelling after long standing.

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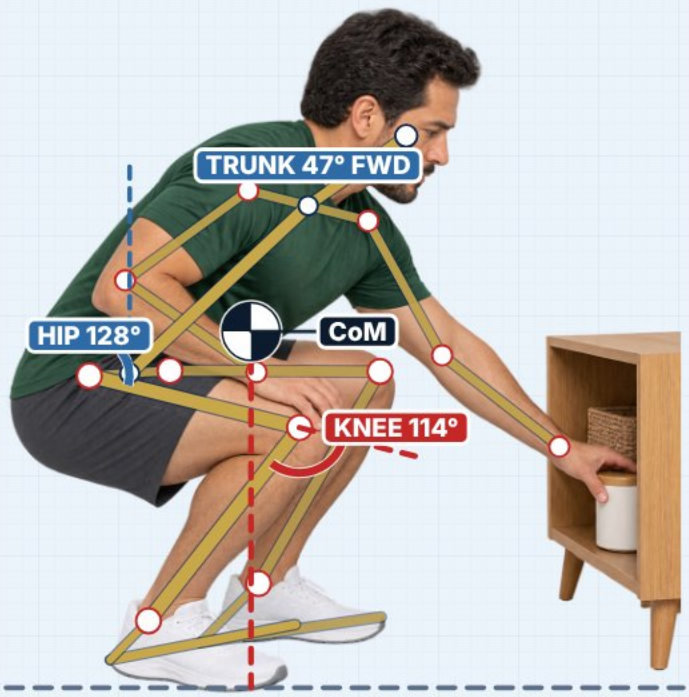
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INTEGRATING PERFORMANCE & REHABILITATION HEALTHCARE PATHWAYS.

AFTER MENISCUS SURGERY: REPAIR, REMOVAL AND RETURN TO LOAD

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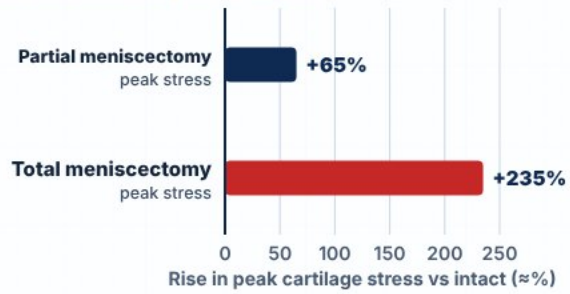
FRAME A · DEEP SQUAT TO A LOW SHELF · SIDE VIEW



Deep squat: the meniscus at work

- Knee flexed **114°**, hip **128°**, trunk **47°** forward: deep loaded flexion is among the last loads restored after a repair.
- The meniscus spreads load across the joint. In cadaver knees, total removal cut contact area by about **75%**; repair restored contact close to intact.
- The more tissue removed, the higher the stress on the cartilage beneath.

Less meniscus, more stress



Cadaveric knees, static ~1,780 N load at 0° or 30°; approximate values. Baratz et al. (1986).

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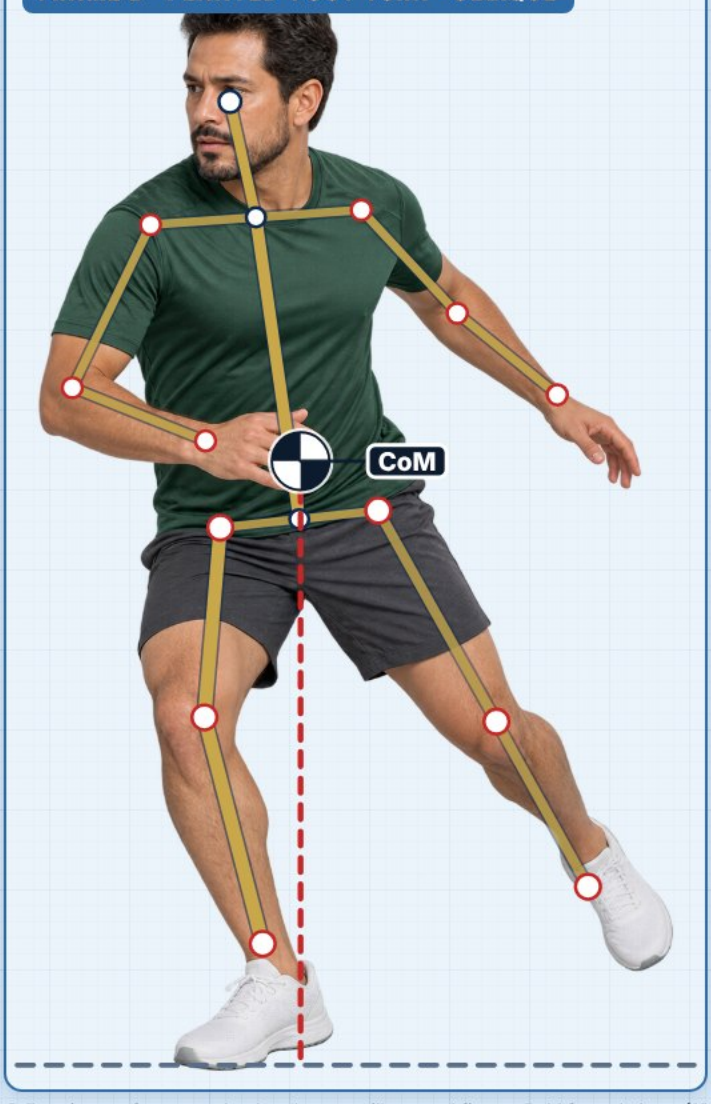
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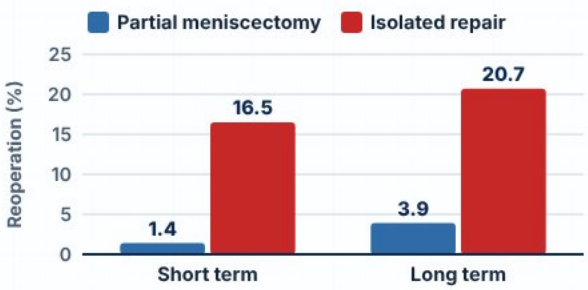
FRAME B · PLANTED-FOOT TURN · OBLIQUE



Planted-foot turn: twisting a flexed knee

- Oblique view, so angles are not measured. Turning over a planted foot rotates the femur on the tibia while the meniscus is compressed.
- Repairs are re-operated more often than partial removals, especially medial repairs.
- Repair still keeps the load-sharing tissue, which shows up years later.

Repair: more reoperation in the short run



Systematic review of traumatic tears. Paxton et al. (2011).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Frame B is oblique: no angles reported. Educational, not diagnostic.

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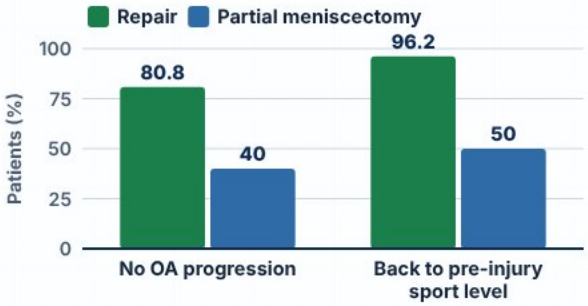
FRAME C · GETTING OUT OF A CAR · OBLIQUE



Getting out of a car: deep flexion plus twist

- Oblique view, so angles are not measured. Everyday tasks like this combine deep knee flexion with rotation, the load a fresh repair is protected from.
- At a mean of 8.8 years, repaired knees more often showed no arthritis progression and more patients regained their sport level.
- Non-randomised cohort: tear types differed between groups.

Repair: better joint and sport outcomes later



Isolated traumatic medial tears, long-term group n = 46. Stein et al. (2010).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Frame C is oblique: no angles reported. Educational, not diagnostic.

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INTEGRATING PERFORMANCE & REHABILITATION HEALTHCARE PATHWAYS.

AFTER MENISCUS SURGERY: REPAIR, REMOVAL AND RETURN TO LOAD

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A · Deep squat
Knee 114°

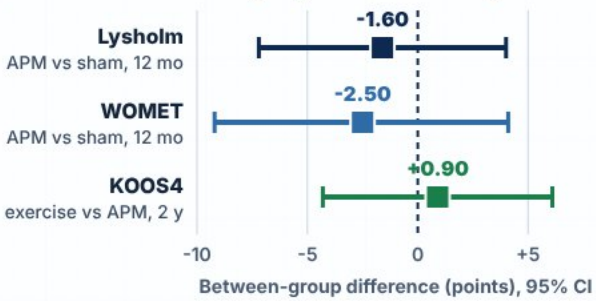


B · Planted turn
Rotation under load



C · Car exit
Flexion + twist

Degenerative tears: surgery added nothing



APM = partial meniscectomy. Sihvonen et al. (2013), n = 146; Kise et al. (2016), n = 140.

Decision pathway

1. **MATCH THE TEAR**
   Degenerative tear in mid-life: supervised exercise first. Traumatic tear in a young knee: repair is often preferred.
2. **PROTECT A REPAIR**
   Early motion and weight-bearing are common; deep loaded squats and pivoting come last. Follow the surgeon's protocol.
3. **RETURN ON CRITERIA**
   Return times after repair ranged 3.3–10 months; 97% of protocols used criteria, not just time.

NOT RECOMMENDED

Routine partial meniscectomy for degenerative tears: no added benefit over sham surgery or exercise.

SEEK ASSESSMENT IF

Redness, heat, fever or wound discharge; calf pain or breathlessness; new locking, giving way or sudden swelling after a twist.

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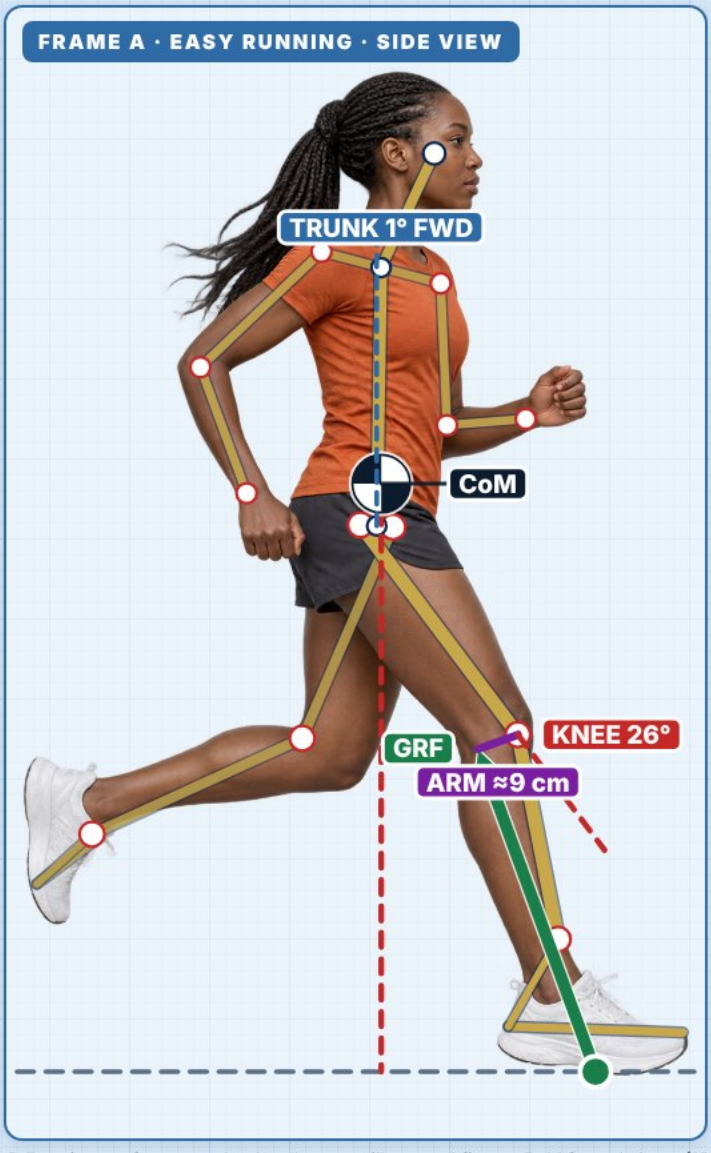
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INTEGRATING PERFORMANCE & REHABILITATION HEALTHCARE PATHWAYS.

RETURNING TO RUNNING AFTER A KNEE INJURY

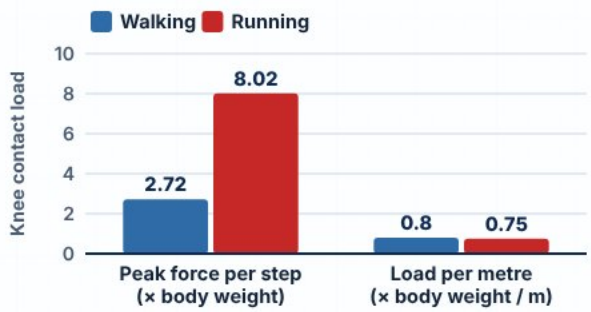
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Easy running: a step up in load per step

- Stance knee flexed **26°**; ground force passes **≈9 cm** behind the knee.
- Each running step loaded the knee about **3×** more than a walking step (8.02 vs 2.72 body weights).
- Yet load per metre travelled was similar (0.75 vs 0.80; not significant): how far and how often matter as much as each step.

Walking vs running: two ways to count load



14 healthy adults, self-selected speeds; no SD reported. Miller et al. (2014).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Educational, not diagnostic.

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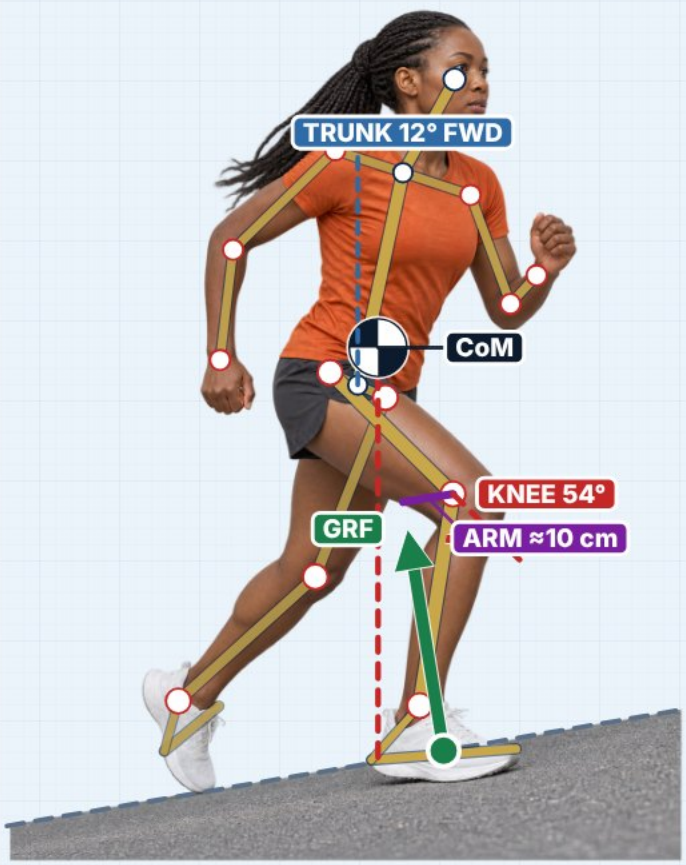
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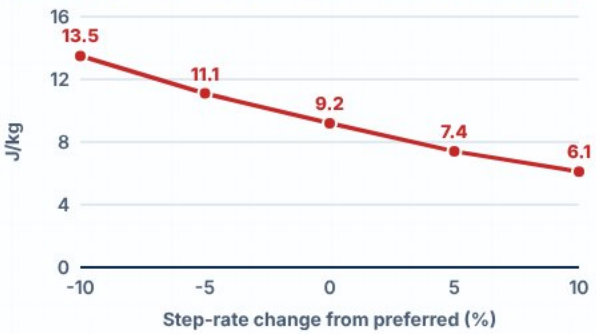
FRAME B · UPHILL RUNNING · SIDE VIEW



Uphill running: more knee bend under load

- Stance knee flexed **54°**, trunk **12°** forward; ground force ≈**10 cm** behind the knee.
- No verified data on uphill knee load were found, so this frame is shown for mechanics only.
- One lever that is measured: a **5–10%** higher step rate cut knee energy absorption; +10% lowered modelled patellofemoral force by 14% (Lenhart et al., 2014).

Shorter, quicker steps absorb less at the knee



Mean, 45 healthy recreational runners, treadmill. Heiderscheit et al. (2011).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Educational, not diagnostic.

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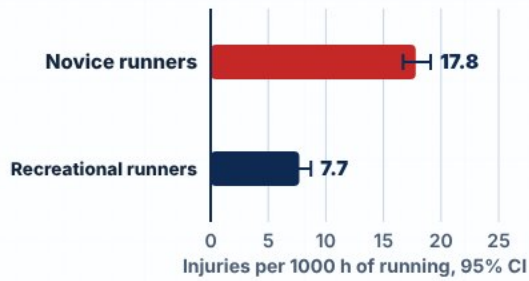
FRAME C · RUNNING STANCE · SIDE VIEW



Back to running: start like a beginner

- Stance knee flexed **30°**, trunk **8°** forward; ground force ≈**6 cm** behind the knee.
- Novice runners were injured more than twice as often per hour as recreational runners.
- After a knee injury, exposure is closer to a novice's: low volume first, then build.

New runners get hurt more often



Meta-analysis of 13 prospective studies. Videbæk et al. (2015).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Educational, not diagnostic.

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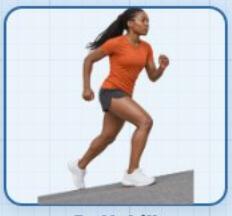
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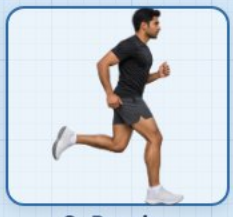
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A · Easy running
Knee 26°

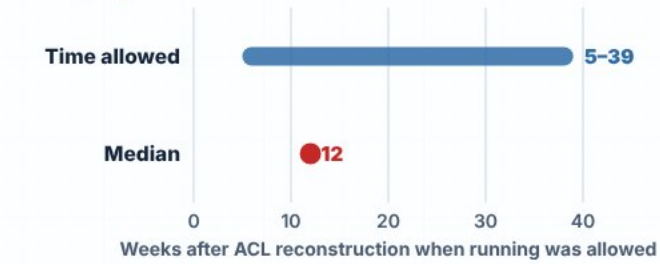


B · Uphill
Knee 54°



C · Running
Knee 30°

Most programmes use time alone



201 studies; fewer than 1 in 5 used clinical or performance criteria.
Rambaud et al. (2018).

Decision pathway

1. **GATE**
   Time plus criteria: range of motion over 95% of the other knee, pain under 2/10, strength and hop symmetry over 70%.
2. **BUILD**
   Start with short walk–run intervals; increase total time gradually, as a novice would.
3. **ADJUST**
   If the knee is sensitive, try a 5–10% higher step rate to reduce knee load.

NOT RECOMMENDED

Returning to previous volume and speed in one step, or using time since injury as the only gate.

SEEK ASSESSMENT IF

Swelling after running that lasts to the next day, new giving way, locking, or pain at night or at rest.

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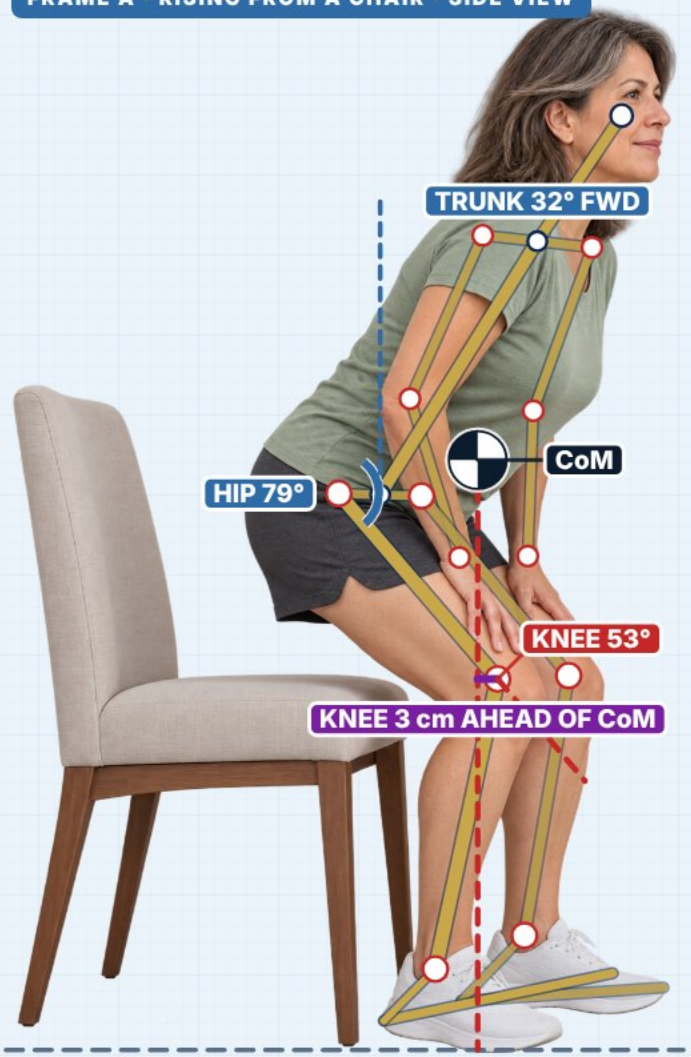
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FEAR OF MOVING A PAINFUL KNEE: HOW AVOIDANCE CHANGES MOVEMENT

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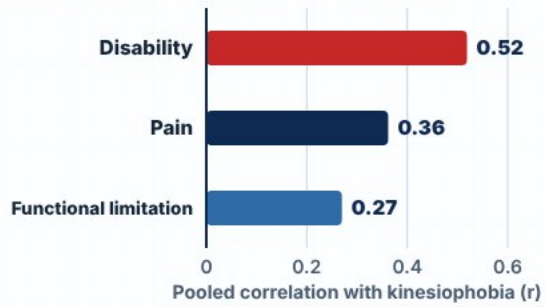
FRAME A · RISING FROM A CHAIR · SIDE VIEW



Rising from a chair: guarding the knee

- Trunk **32°** forward, knee **53°**, hands on the thighs: the knee sits only ≈**3 cm** ahead of the CoM line, a low-knee-demand strategy.
- Leaning forward and pushing on the thighs takes work away from the quadriceps; useful short term, limiting if it becomes the only way.
- Kinesiophobia (fear of movement) is usually measured with the Tampa Scale; in knee OA it tracked disability and pain.

More fear, more disability in knee OA



17 studies, 1,574 adults; association, high heterogeneity. Lozano-Meca et al. (2024).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Educational, not diagnostic.

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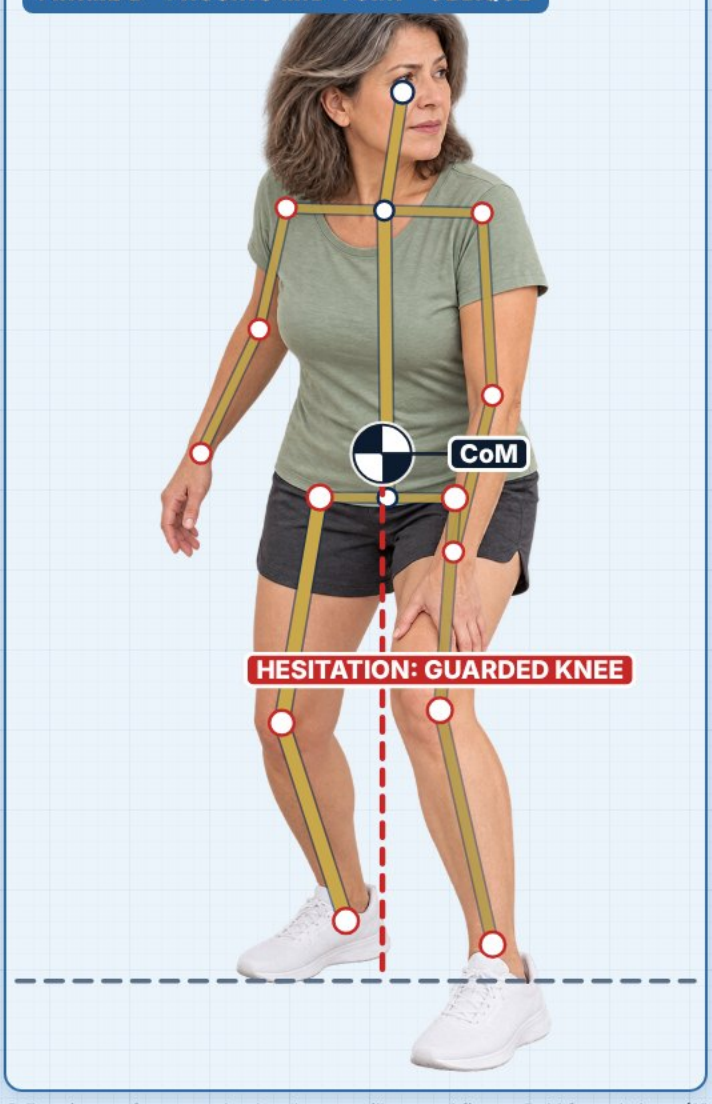
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FRAME B · PAUSING MID-TURN · OBLIQUE



Pausing mid-turn: the hesitant knee

- Oblique view, so angles are not measured. A pause or hitch in a turn is a typical sign of a guarded knee.
- After ACL reconstruction, women with more fear landed with **less trunk and knee bending**: a stiffer pattern.
- Small study (n = 15), cross-sectional: fear and stiffness travel together, cause not shown.

Higher fear, stiffer landing



Tampa Scale (TSK-11) vs drop-jump kinematics, 15 women after ACL reconstruction. Dudley et al. (2022).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Frame B is oblique: no angles reported. Educational, not diagnostic.

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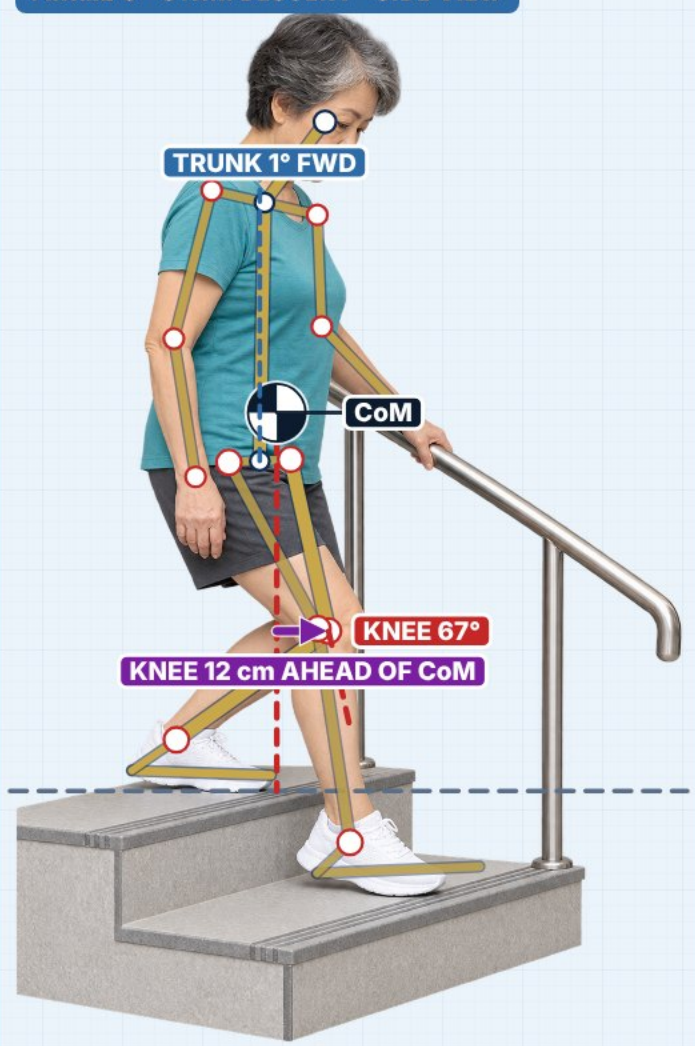
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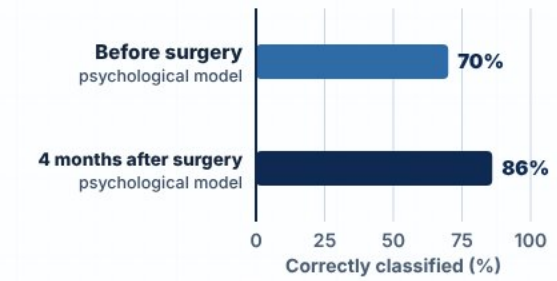
FRAME C · STAIR DESCENT · SIDE VIEW



Stair descent: where fear shows most

- Stance knee flexed **67°** while lowering, the knee **≈12 cm** ahead of the CoM line: an eccentric quadriceps task many people avoid.
- Fear, confidence and readiness measured after ACL surgery predicted who got back to pre-injury sport.
- Only **55%** returned to competitive sport overall (Ardern et al., 2014).

The mind predicts the return



Return to pre-injury sport, 187 athletes; 31% returned at 12 months. Ardern et al. (2013).

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A · Chair rise
Trunk 32° forward

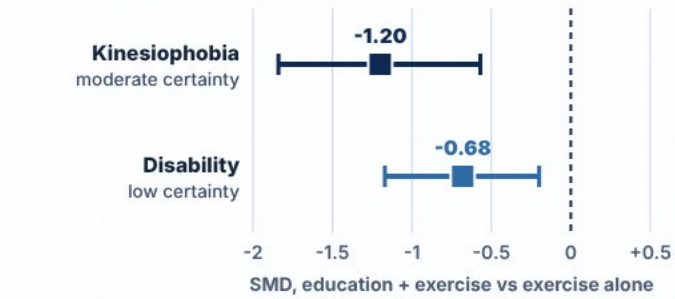


B · Mid-turn pause
Hesitation



C · Stair descent
Knee 67°

Explaining pain adds to exercise



5 RCTs, 460 people with chronic musculoskeletal pain (not knee only), 0–12 weeks. Siddall et al. (2022).

Decision pathway

1. **ASK ABOUT FEAR**
   Screen early with a fear-of-movement questionnaire; psychological responses predicted return to sport after ACL surgery.
2. **EXPLAIN**
   Pain is a protective signal, not a damage meter: explanation plus exercise reduced fear more than exercise alone.
3. **EXPOSE GRADUALLY**
   Practise the feared tasks (chair rise, turning, stairs) in small, successful steps.

NOT RECOMMENDED

Advice to rest and avoid the feared movement indefinitely, or passive treatment alone.

SEEK ASSESSMENT IF

Fear after a real mechanical event: giving way, locking, or a large swelling after a twist. Check the knee first.

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KNEE BRACES, SLEEVES AND TAPE: WHAT THEY CAN AND CAN'T DO

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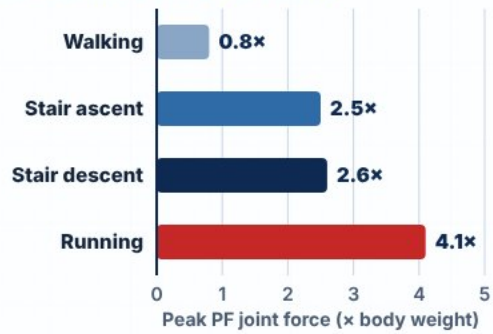
FRAME A · STEP-DOWN · SIDE VIEW



Step-down: the load a support has to live with

- Stance knee flexed **49°**, hip **46°** as the other foot reaches down; the kneecap is pressed into its groove.
- In people with patellofemoral pain, stairs loaded the joint about **2.5×** body weight and running about 4×.
- Tape and sleeves sit on the skin; they cannot remove forces of this size.

Front-of-knee load by activity



People with patellofemoral pain; weighted means, systematic review. Hart et al. (2022).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Educational, not diagnostic.

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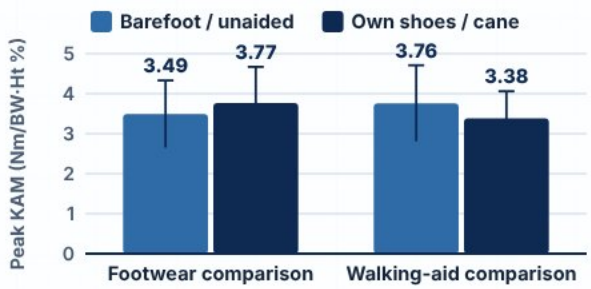
FRAME B · SINGLE-LEG SQUAT · FRONT VIEW



Single-leg squat: alignment under load

- Stance knee **12°** inside the hip–ankle line (frontal-plane projection angle).
- Unloader braces aim to reduce inner-knee (adduction) loading in medial knee OA. Simple measures change it too: in one study a cane cut it by about 10%, while people's own shoes raised it.
- Strength and control change alignment more lastingly than an external support.

What changes inner-knee load?



KAM = knee adduction moment. Medial knee OA; shoes n = 40, cane n = 20; mean ± SD. Kemp et al. (2008).

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). FPPA from hip, knee and ankle points in the front view. Educational, not diagnostic.

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FRAME C · SEATED · FRONT VIEW



Where a sleeve or tape sits

- Seated reference: sleeves cover the kneecap region; patellar tape is applied over and around the kneecap.
- Guidelines disagree on braces for knee OA: the ACR/Arthritis Foundation strongly recommends tibiofemoral bracing; NICE advises not to routinely offer braces, tape or supports unless there is instability or abnormal loading.
- For patellofemoral pain, tailored taping may be used short term with exercise; braces and sleeves should not be prescribed.

Guideline positions

Strong
ACR/AF: tibiofemoral brace for knee OA

Not routinely
NICE NG226: braces, tape, supports

2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Seated reference image: location only. Sources: Kolasinski et al. (2020); NICE (2022); Willy et al. (2019). Educational, not diagnostic.

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BIOMECHANICS IS A FORCE-GOVERNED DECISION SYSTEM – NOT A POSTURE MODEL.

INTEGRATING PERFORMANCE & REHABILITATION HEALTHCARE PATHWAYS.

KNEE BRACES, SLEEVES AND TAPE: WHAT THEY CAN AND CAN'T DO

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A · Step-down
Knee 49°

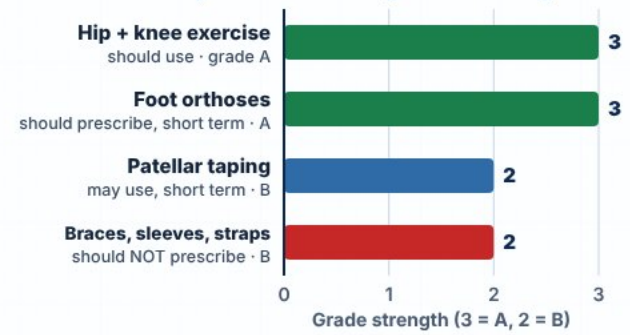


B · Single-leg squat
FPPA 12°



C · Sleeve zone
Skin-level support

Patellofemoral pain: what the guideline says



Clinical practice guideline for patellofemoral pain. Willy et al. (2019).

Decision pathway

1. **EXERCISE FIRST**
   Hip- and knee-strengthening is the core treatment; supports are add-ons, not substitutes.
2. **USE SHORT TERM**
   Tape or foot orthoses can help symptoms short term alongside exercise; reassess and wean.
3. **MATCH THE PROBLEM**
   Medial knee OA with instability or abnormal loading: discuss a brace or a cane; guidelines differ.

NOT RECOMMENDED

Relying on a brace or sleeve instead of exercise; long-term use without review.

SEEK ASSESSMENT IF

Skin irritation or numbness under tape or a brace, a knee that gives way despite support, or a hot, swollen knee.

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Analysis: MMSx Authority Applied Biomechanics Lab · Dr. Neeraj Mehta, PhD · Educational content, not a diagnosis.

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