MMSx AUTHORITY · APPLIED BIOMECHANICS LAB

Hip and Groin Rehabilitation

30 Evidence-Based Biomechanics Analyses

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

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

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

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HIP PAIN: JOINT, TENDON, MUSCLE OR REFERRED FROM THE BACK?

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EYE-OPENER

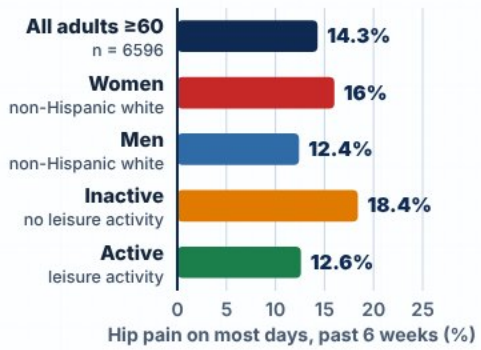
84% of hip-joint patients marked groin pain on a body map: the strongest single pointer to the joint itself.

Sensitivity vs spinal stenosis. Khan et al. (2004).

Groin points to the joint

- Hand pressed on the front hip crease, pelvis level (**1°**): pain here usually comes from the hip joint (osteoarthritis, impingement, labrum).
- "Hip pain" is a location, not a diagnosis; the first job is to find which structure is producing it.

Hip pain is common after 60



US adults ≥60 years, NHANES III; cross-sectional, so activity is an association only. Christmas 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). Pelvis line joins the two hip landmarks in the front view. Educational, not diagnostic.

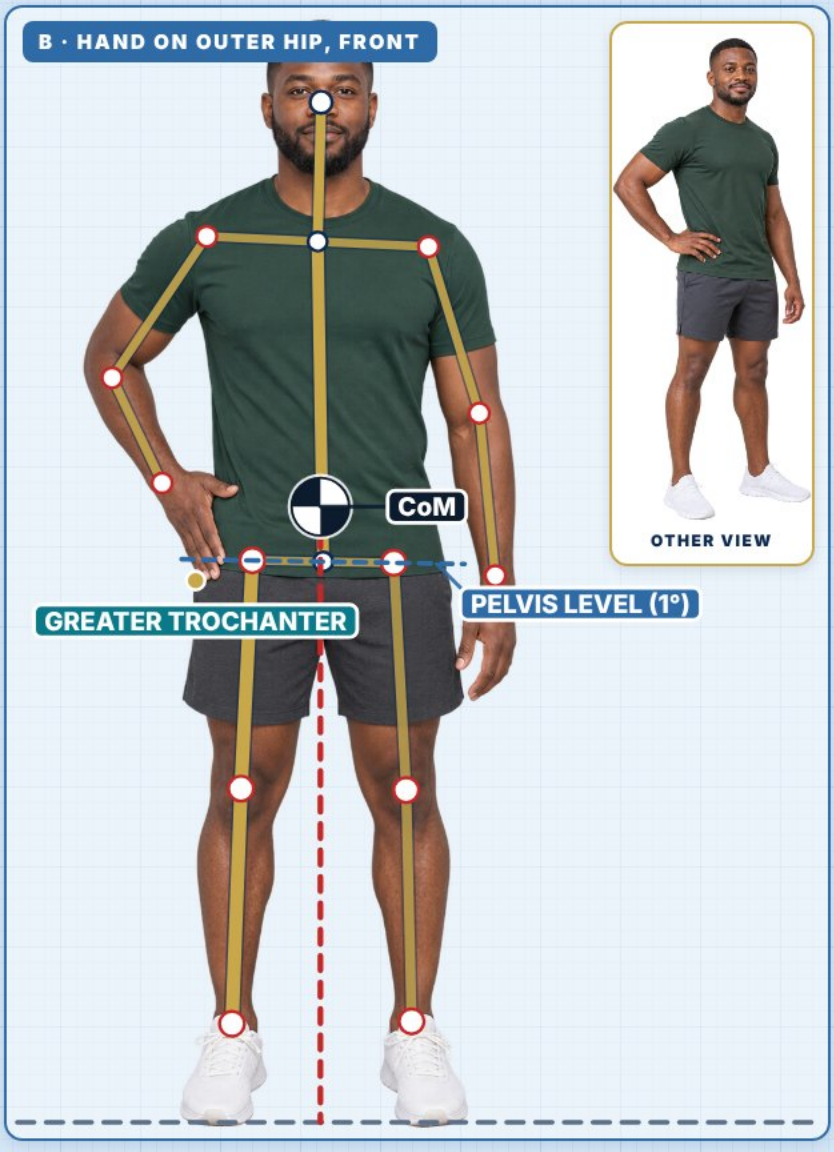
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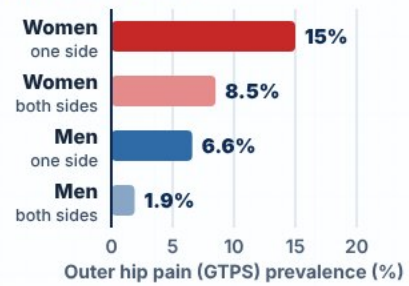
23.5% of women aged 50–79 have a painful outer hip on one or both sides: nearly 1 in 4.

15.0% one side + 8.5% both sides. Segal et al. (2007).

The bony outer hip: tendons

- Hand on the greater trochanter: pain here points to the gluteal tendons and bursa (greater trochanteric pain syndrome), not the joint.
- It is much more common in women and often coexists with low back or knee pain.

Outer hip pain by sex



3026 adults aged 50–79, Multicenter Osteoarthritis Study. Segal et al. (2007).

Key point: body weight was not independently linked to outer hip pain (BMI ≥30 vs <25: OR 1.10, not significant); sex, back pain and knee OA were.

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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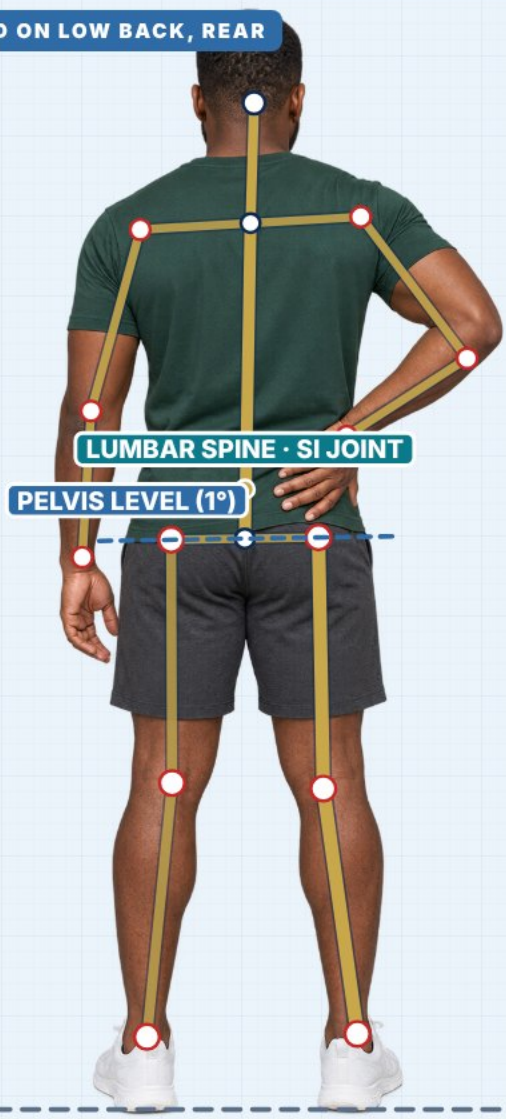
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C · HAND ON LOW BACK, REAR



EYE-OPENER

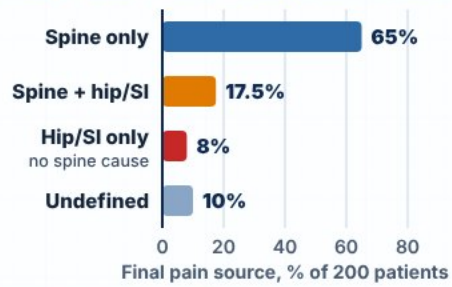
47% of people with hip osteoarthritis feel pain below the knee, yet most trainees surveyed thought it could not.

88.5% of 33 orthopaedic trainees. Khan et al. (2004).

Low back or buttock: check both

- Hand above the buttock: pain here may come from the lumbar spine or sacroiliac joint, and sometimes from the hip.
- In a spine clinic, about a quarter of patients with "back pain" had a hip or SI-joint contribution.

Where "back pain" really came from



200 new spine-clinic patients with low back ± leg pain. Sembrano & Polly (2009).

Myth: "Buttock pain is always the back." In 8% of spine-clinic patients the hip or SI joint was the source with no spinal cause at all.

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 · Groin Joint

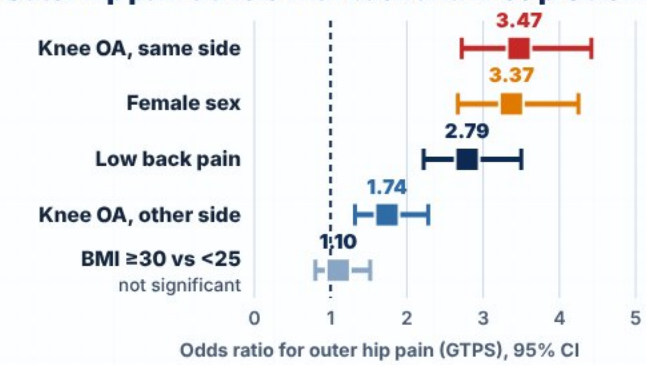


B · Outer hip Tendon



C · Low back Spine / SI

Outer hip pain travels with back and knee problems



Multivariable odds ratios, 3026 adults aged 50–79. Segal et al. (2007).

Decision pathway

1. **LOCATE**
   Note where the pain sits: groin, bony outer hip, or low back and buttock.
2. **SCREEN**
   Examine the hip, lumbar spine and SI joint together; leg pain alone does not prove a spinal source.
3. **TREAT**
   Match care to the source: exercise for hip OA, load management for gluteal tendons.

NOT RECOMMENDED

Assuming all leg pain is from the back, or routine imaging for typical hip OA in people over 45.

SEEK ASSESSMENT IF

A fall then inability to bear weight, a hot painful hip with fever, severe night pain or weight loss, or leg numbness or weakness: seek prompt medical assessment.

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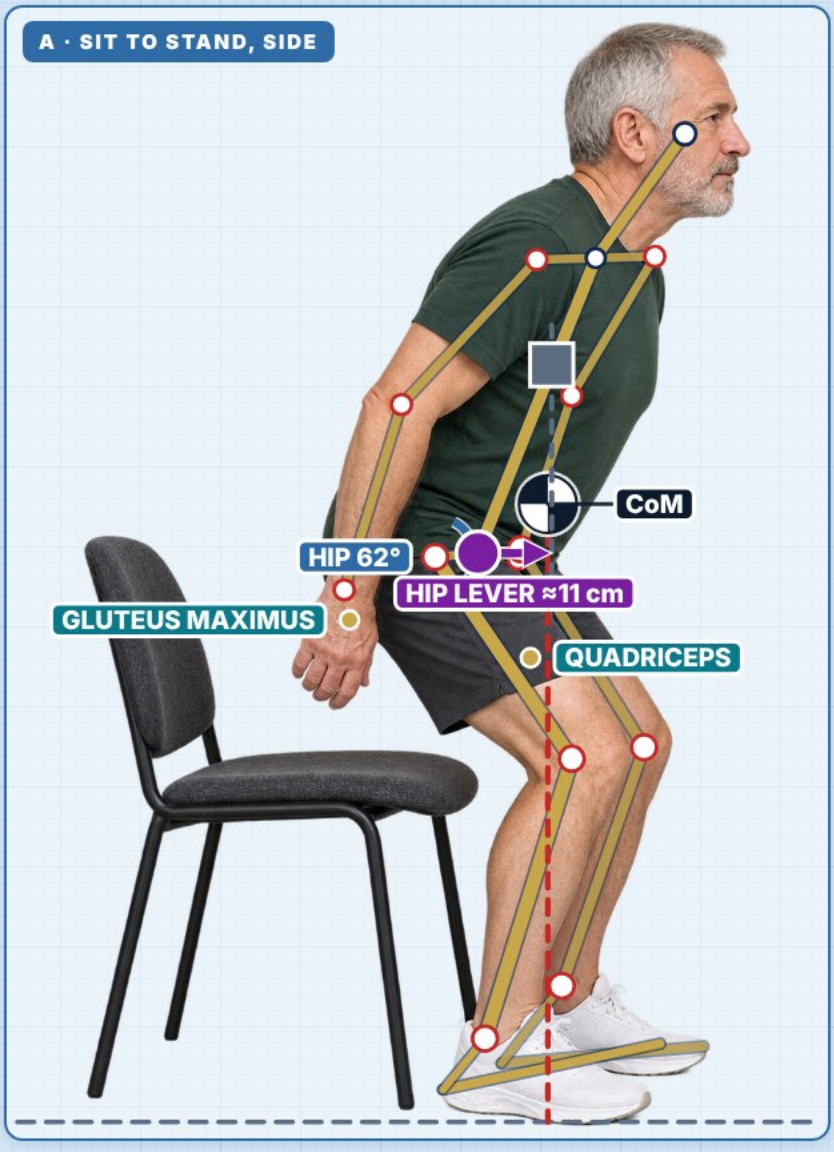
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HIP OSTEOARTHRITIS: WHY EXERCISE IS FIRST-LINE TREATMENT

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EYE-OPENER

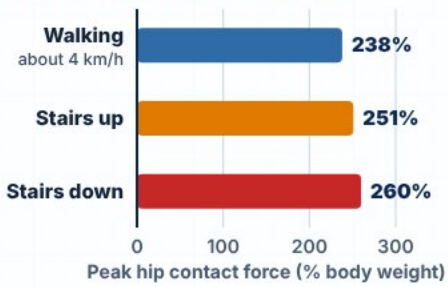
2.4× body weight passes through the hip joint with every ordinary walking step.

238% body weight at about 4 km/h, instrumented hips. Bergmann et al. (2001).

Rising from a chair is hip training

- Hip flexed ≈**62°** with the trunk leaning forward: hip lever ≈**11 cm**, hip moment ≈**44 N·m** for the hip extensors to lift the body.
- Repeated, graded chair rises load the hip muscles in a task that matters for daily independence.

Daily life already loads the hip



Average of 4 patients with instrumented hip implants. Bergmann et al. (2001).

Myth: "Exercise wears out an arthritic hip." High-quality trials show exercise reduces pain and improves function, with benefits lasting months.

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). Hip lever: hip-joint centre to upper-body CoM; moment = upper-body weight × lever, 70 kg adult, static. Educational, not diagnostic.

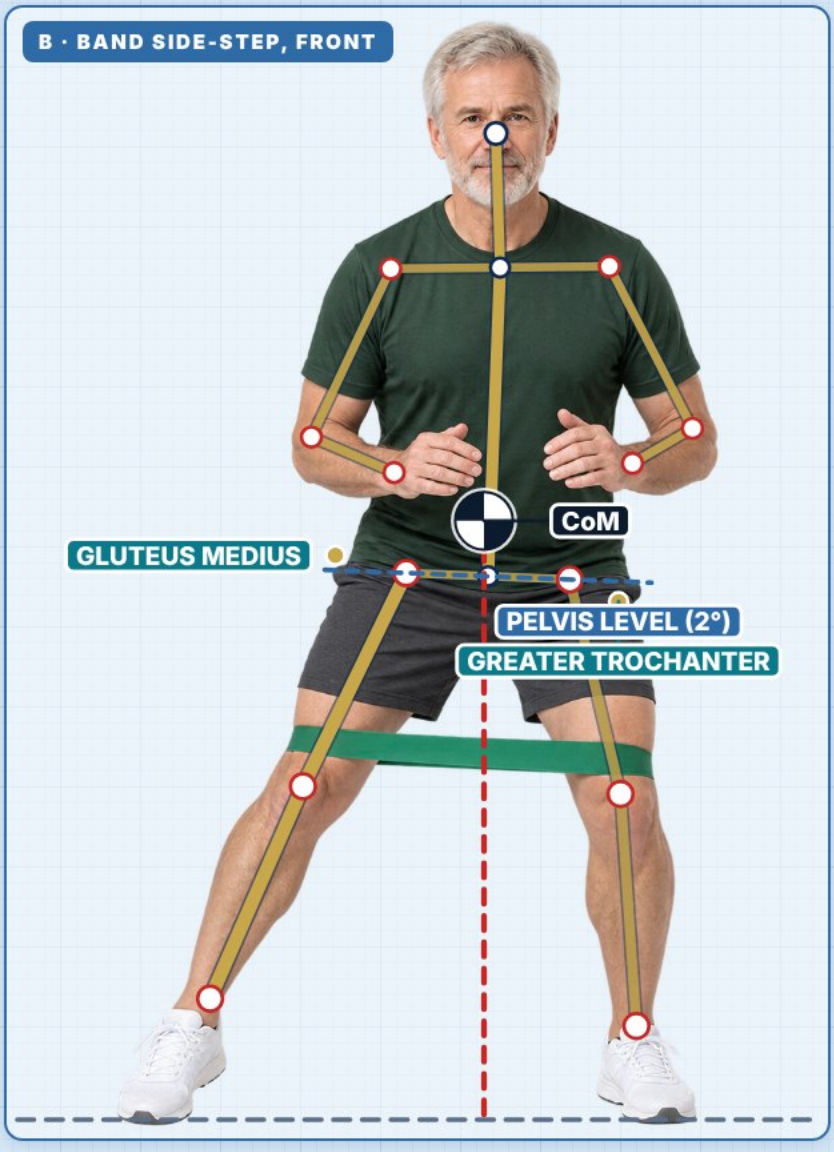
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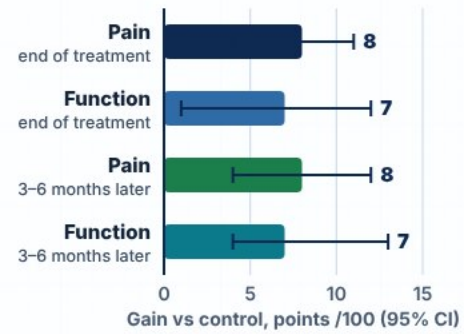
0 / 23 gym-machine exercises loaded replaced hips more than ordinary treadmill walking did.

7 patients with instrumented implants; walking median 303% body weight. Haffer et al. (2022).

Strength for the pelvis

- Side-stepping against a band works the hip abductors (gluteus medius) that keep the pelvis level; here pelvis level (**2°**).
- Muscle activity for this exercise was not measured in these studies; it is one option within a tailored programme.

What exercise adds, in points



0–100 scales; control pain level 29 points. Cochrane review, 10 trials. Fransen et al. (2014).

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C · STATIONARY BIKE, SIDE



EYE-OPENER

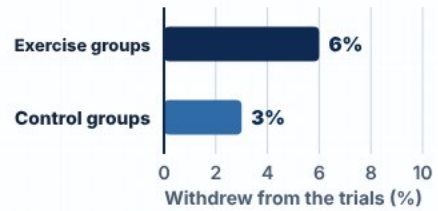
NNT 6 treat six people with exercise and one more gains a meaningful improvement in function.

Number needed to treat for function, end of treatment. Fransen et al. (2014).

Low-impact repetitions

- Seated cycling moves the hip through repeated flexion and extension with body weight supported by the saddle.
- Joint load on the bike was not measured in these studies, so intensity should follow symptoms and be built up gradually.

Exercise is well tolerated



Risk difference 1% (95% CI −1% to 4%), not significant. Fransen et al. (2014).

Key point: pain may rise a little at first; consistent long-term exercise is what helps (NICE, 2022).

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A · Chair rise Strength

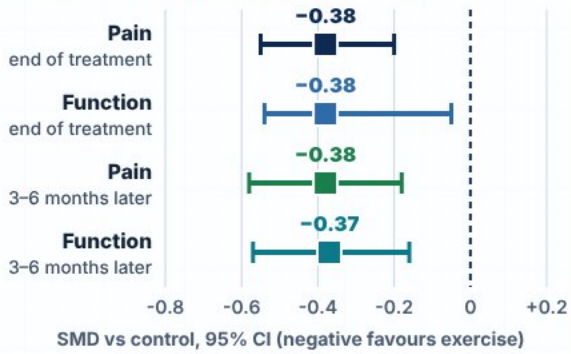


B · Side-step Hip control



C · Bike Low impact

Exercise reduces pain and lifts function



Land-based exercise vs control in hip OA; Cochrane review of 10 trials. Fransen et al. (2014).

Decision pathway

1. **EXPLAIN**
   Exercise is a core treatment offered to everyone with OA (NICE, 2022).
2. **TAILOR**
   Pick strength and aerobic work the person can do: chair rises, band side-steps, cycling.
3. **PROGRESS**
   Build load gradually and keep going: benefits lasted 3–6 months after supervision ended.

NOT RECOMMENDED

Acupuncture, electrotherapy, glucosamine or routine imaging for typical hip OA (NICE, 2022); rest instead of exercise.

SEEK ASSESSMENT IF

A fall then inability to bear weight, a hot painful hip with fever, severe night pain or weight loss, or leg numbness or weakness: seek prompt medical assessment.

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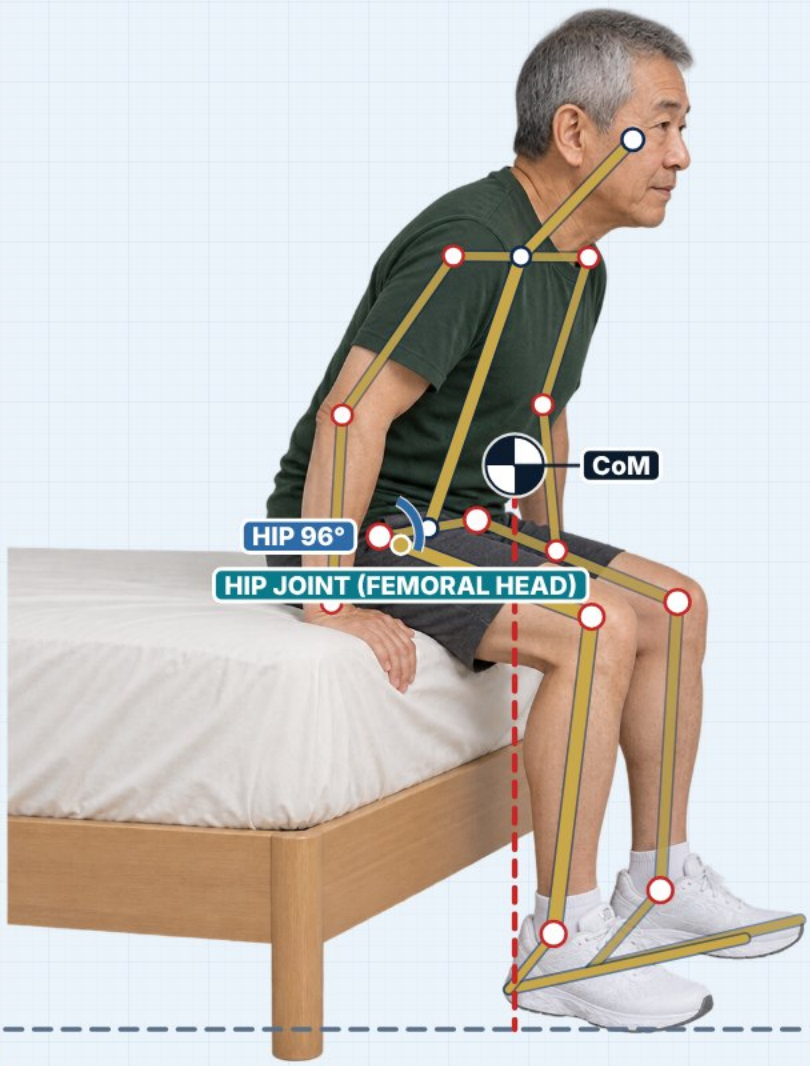
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HIP STIFFNESS IN THE MORNING: WHAT IT TELLS YOU ABOUT THE JOINT

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A · RISING FROM BED, SIDE



EYE-OPENER

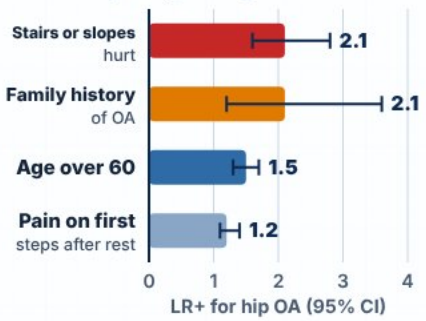
34% of people seeing a clinician for hip pain had hip osteoarthritis on X-ray: most did not.

6 studies, 1110 patients. Metcalfe et al. (2019).

Stiff after rest, easing with use

- Sitting on the bed edge, hip flexed ≈**96°**: the first steps after rest are when an osteoarthritic hip often feels stiff.
- In OA this stiffness is usually brief: 30 minutes or less is part of the clinical diagnosis (NICE, 2022).

The history only nudges the odds



Values near 1 add little; morning stiffness <60 min: LR+ 1.5–1.7 across studies. Metcalfe 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). Educational, not diagnostic.

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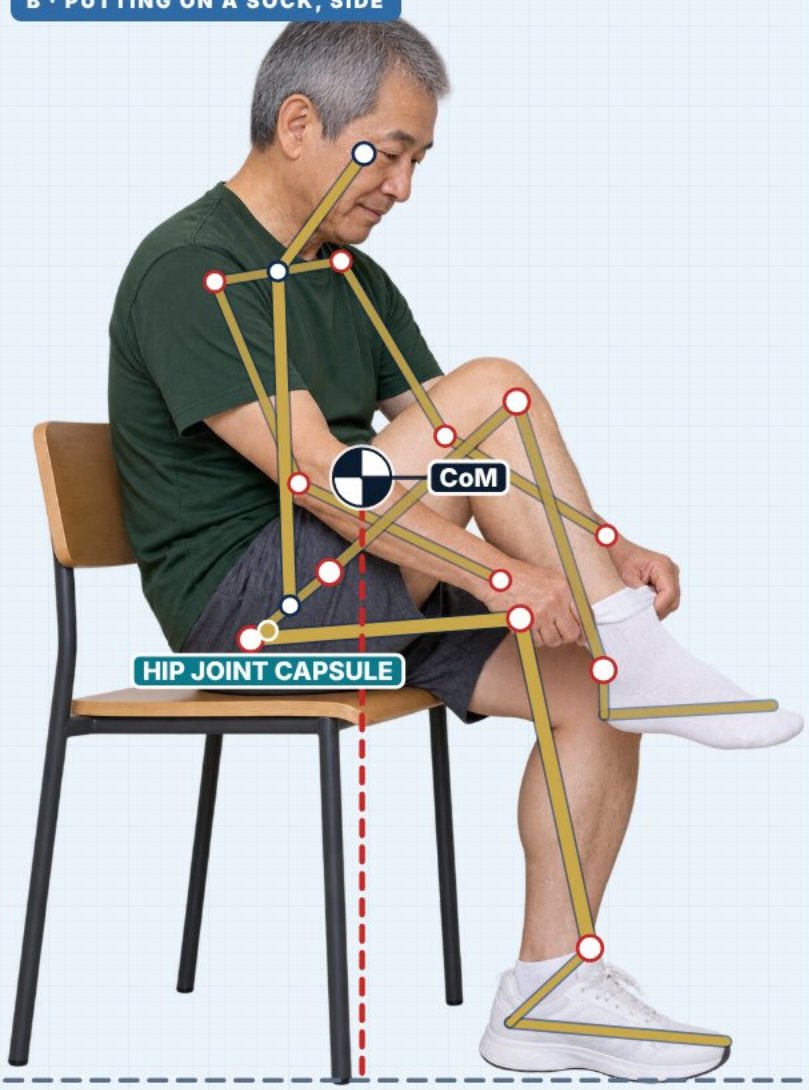
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B · PUTTING ON A SOCK, SIDE



EYE-OPENER

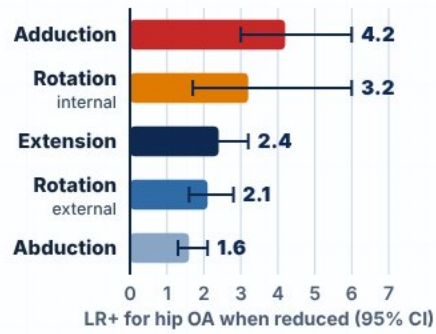
4.2× higher odds of hip OA when passive hip adduction is reduced: the most useful movement sign.

LR+ 4.2 (95% CI 3.0 to 6.0). Metcalfe et al. (2019).

The sock test of daily life

- Pulling the foot up to reach a sock needs deep hip flexion with rotation; difficulty here often reflects a stiffening joint.
- On examination, measurable loss of adduction and rotation carries more diagnostic weight than the stiffness story.

Which lost movement matters most



Passive range tested by a clinician, 6 diagnostic studies. Metcalfe et al. (2019).

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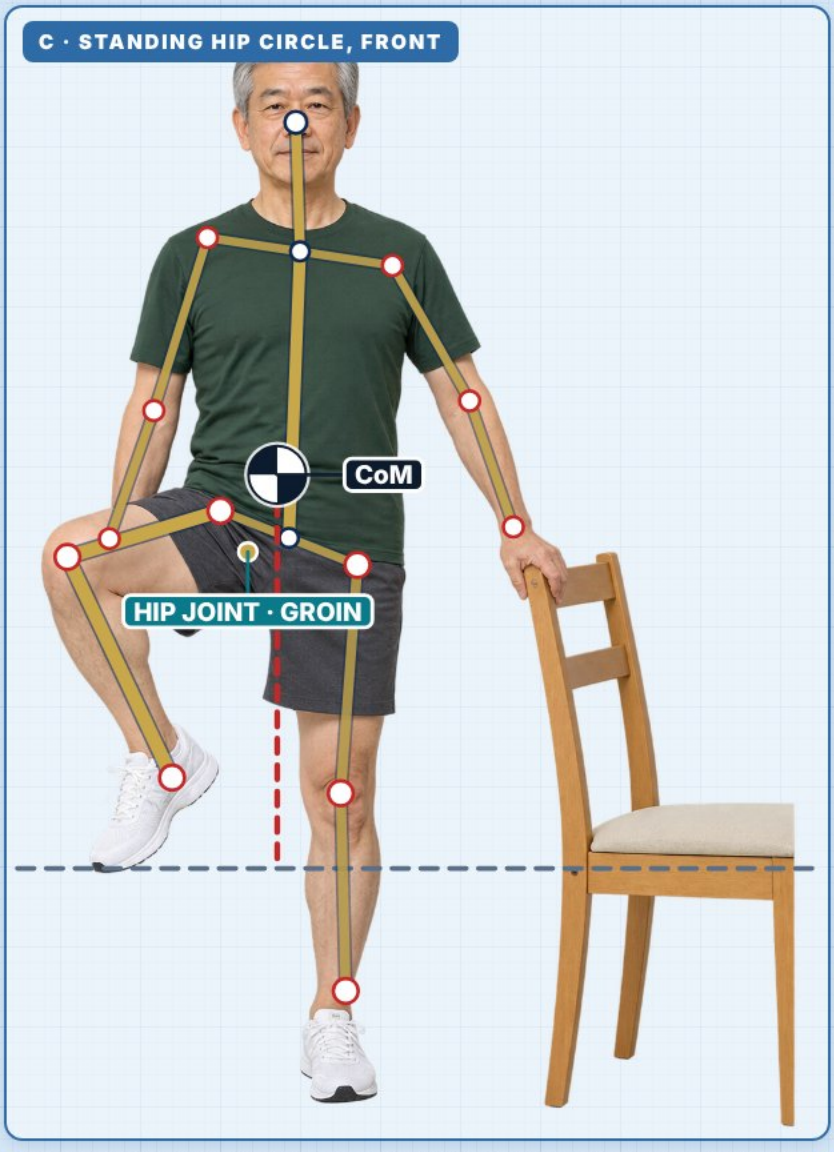
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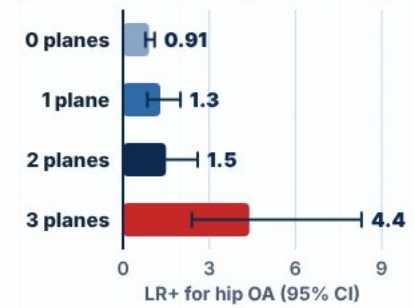
0.25 likelihood ratio when hip adduction is normal: it cuts the odds of OA to about a quarter.

LR− 0.25 (95% CI 0.11 to 0.54). Metcalfe et al. (2019).

Circles find the blocked directions

- A knee circle takes the hip through flexion, abduction and rotation; feeling "blocked" in several directions is typical of OA.
- Gentle range-of-motion work fits an exercise plan but is untested on its own.

More planes restricted, more likely OA



Number of planes with restricted hip movement. Metcalfe et al. (2019).

Myth: "Morning stiffness means the hip is wearing out, so rest it." Alone it is only weakly diagnostic, and exercise, not rest, is advised.

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INTEGRATING PERFORMANCE & REHABILITATION HEALTHCARE PATHWAYS.

HIP STIFFNESS IN THE MORNING: WHAT IT TELLS YOU ABOUT THE JOINT

AN MMSX AUTHORITY | APPLIED BIOMECHANICS LAB EDUCATIONAL ANALYSIS



A · Out of bed Time it

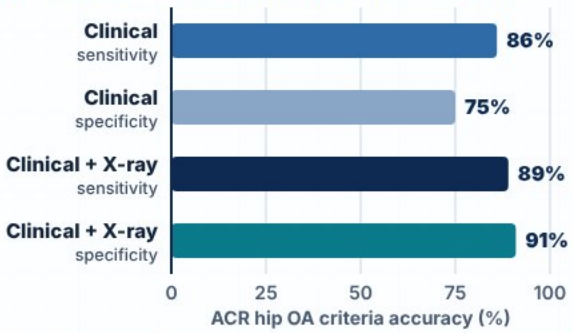


B · Sock Daily task



C · Hip circle All planes

Stiffness is one clue within a combined rule



201 patients with hip pain; clinical rule includes stiffness ≤60 min and age >50. Altman et al. (1991).

Decision pathway

1. **TIME IT**
   Ask how long morning stiffness lasts: 30 minutes or less fits osteoarthritis (NICE, 2022).
2. **TEST MOVEMENT**
   Check passive adduction and rotation: lost movement in several planes points to the joint.
3. **MOVE**
   Start tailored exercise and gentle range-of-motion work, built up gradually.

NOT RECOMMENDED

Resting a stiff hip, or routine imaging to diagnose typical OA in people aged 45 or over (NICE, 2022).

SEEK ASSESSMENT IF

Stiffness lasting well over 30–60 minutes, stiffness in several joints or the spine, a hot swollen joint, fever or rapid worsening: seek assessment.

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Winter, D. A. (2009). *Biomechanics and motor control of human movement* (4th ed.). Wiley. https://doi.org/10.1002/9780470549148

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

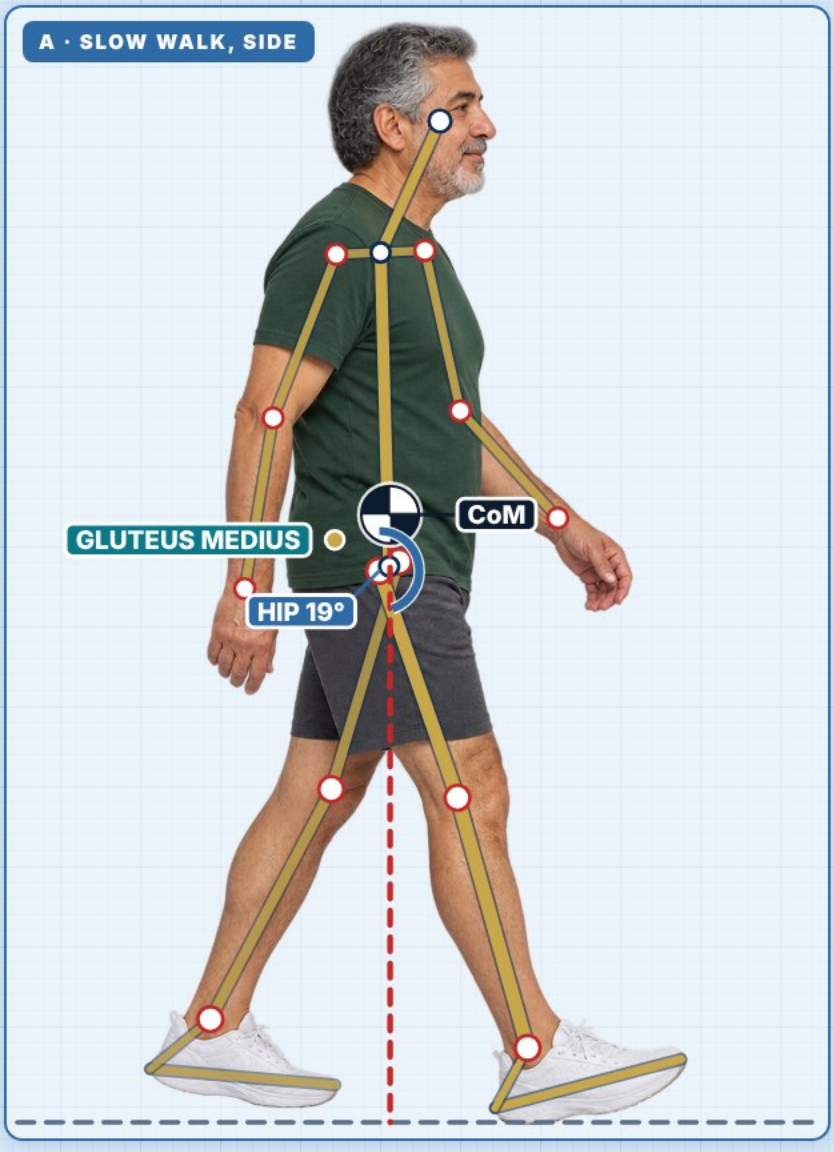
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HIP OSTEOARTHRITIS AND WALKING: HOW LOAD THROUGH THE JOINT CHANGES WITH SPEED

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EYE-OPENER

248% of body weight passed through the hip on average with each walking step in people with hip OA.

10 OA patients with instrumented hip replacements. Damm (2014).

Slow is not load-free

- Short, slow step with the leading hip flexed ≈**19°**: each stance phase still loads the joint through body weight plus the abductor pull that levels the pelvis.
- Slowing down lowers the peak force but never removes it.

Faster walking raises peak force



One patient, telemetric hip implant; values approximate in the source. Bergmann et al. (1993).

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.

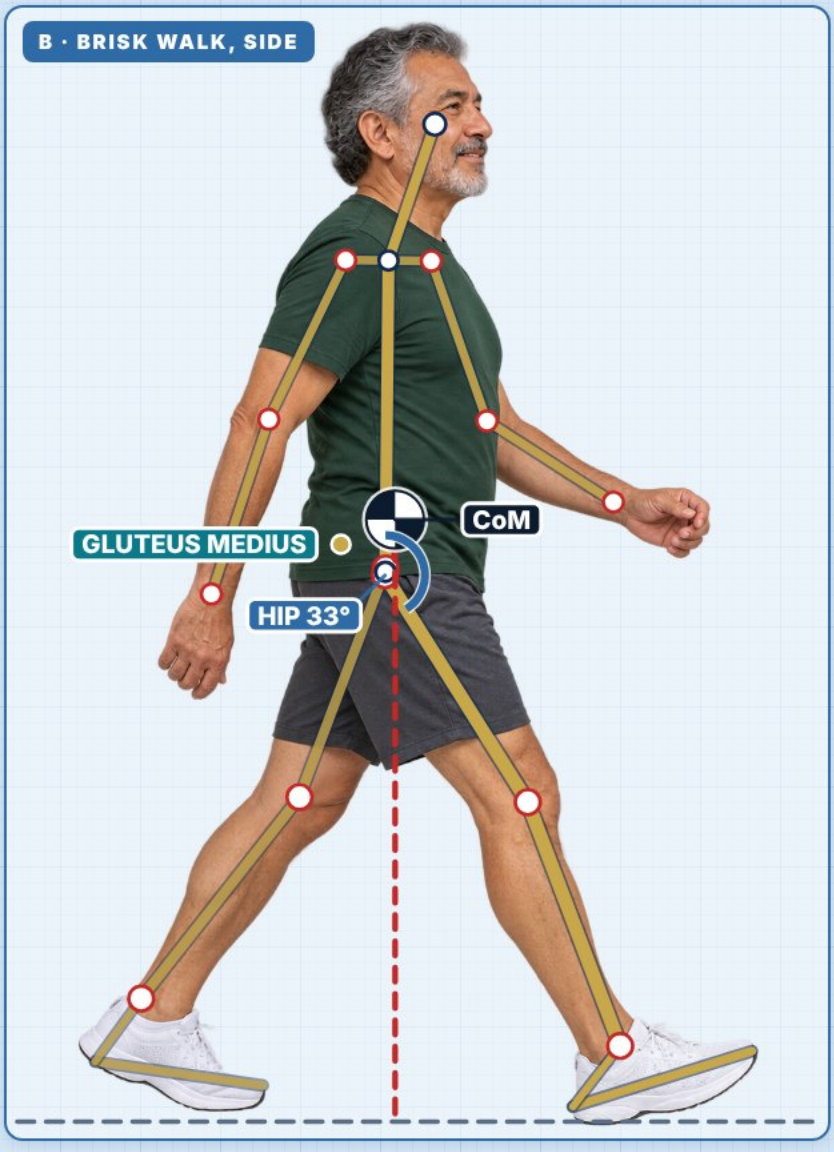
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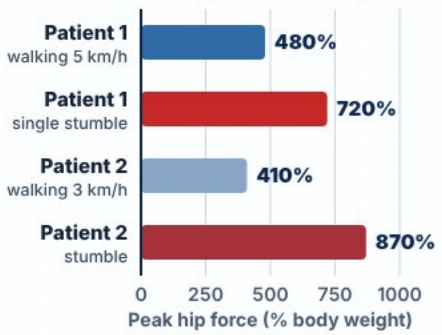
26% slower usual walking speed in people with hip OA, mainly from shorter strides.

Meta-analysis of 30 studies. Constantinou et al. (2014).

Longer stride, higher peaks

- Brisk step: leading hip flexed ≈**33°** against ≈**19°** in the slow walk, so stride and speed rise together.
- Peak joint force climbs with speed, and a stumble produces the highest loads of all.

A stumble beats any walking speed



2 patients with telemetric hip implants; walking values approximate. Bergmann et al. (1993).

Key point: modelling in 8 healthy adults (abstract only) found faster gaits cover distance in fewer steps, so load per metre can fall. Schache 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.

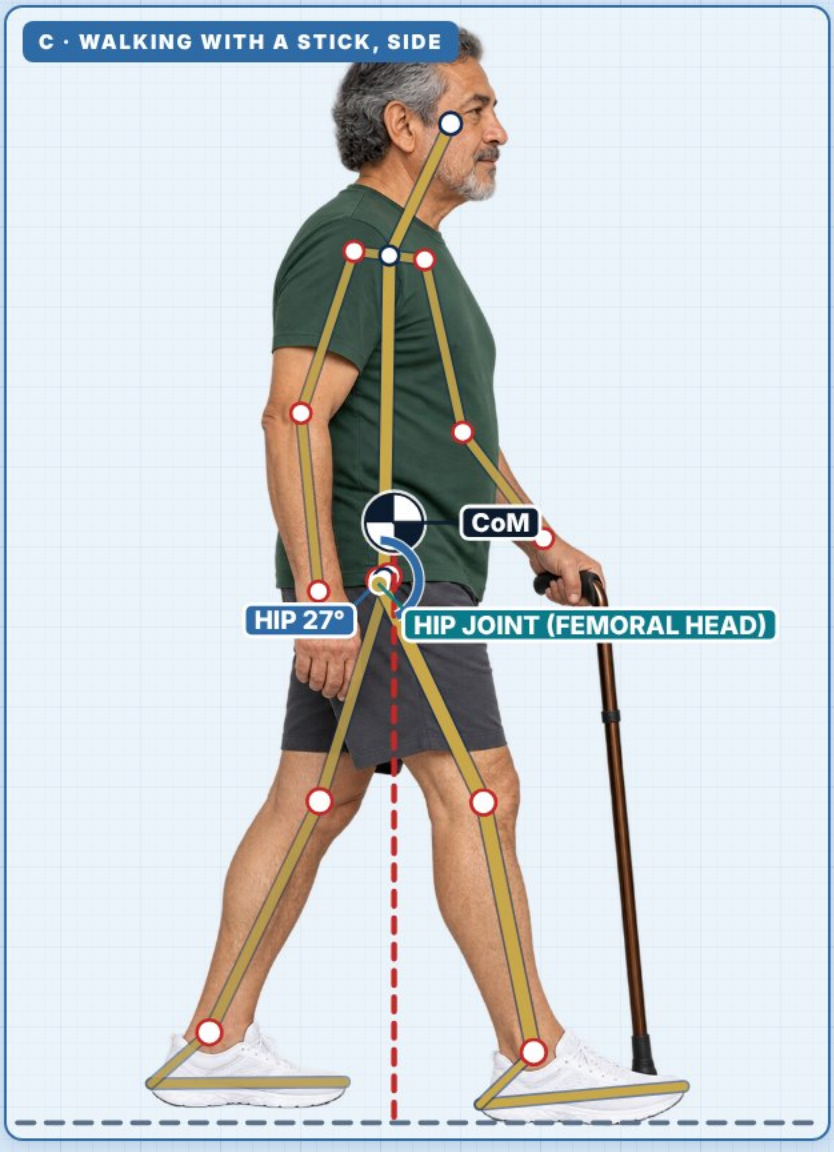
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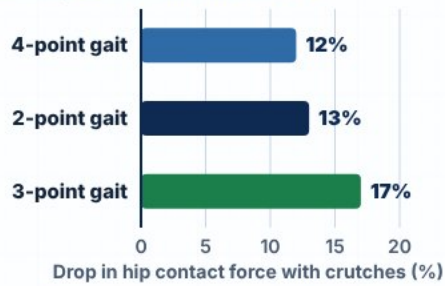
10% weight loss is likely to help more than 5% for people with OA and overweight.

NICE (2022), rec 1.3.5. Walking loads the hip at multiples of body weight.

Share the load with an aid

- Stick planted as the leg steps, leading hip ≈**27°**: part of body weight passes through the aid, so the hip muscles and joint carry less.
- Walking sticks or similar aids are recommended for lower-limb OA (NICE, 2022).

Walking aids unload the hip



10 OA patients with instrumented hips. Crutch data; a single stick was not measured. Damm (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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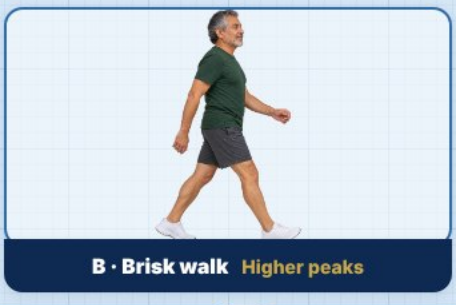
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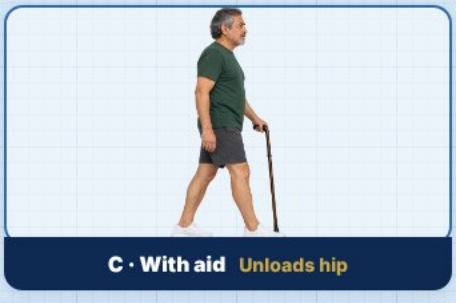
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A · Slow walk Lower peaks



B · Brisk walk Higher peaks



C · With aid Unloads hip

Everyday walking: 2.4 to 4 times body weight



Instrumented hip implants; average, median or approximate values as reported. Bergmann et al. (2001); Damm (2014); Haffer et al. (2022); Bergmann et al. (1993).

Decision pathway

1. **PACE**
   Adjust walking speed to symptoms: slower walking lowers the peak force on the hip.
2. **SUPPORT**
   Use a stick or crutches on painful days; crutches cut hip force by 12–17%.
3. **BUILD**
   Keep walking and exercising, and support weight loss where needed (NICE, 2022).

NOT RECOMMENDED

Giving up walking altogether, or rushing on uneven ground where a stumble can multiply hip load.

SEEK ASSESSMENT IF

A fall then inability to bear weight, a hot painful hip with fever, severe night pain or weight loss, or leg numbness or weakness: seek prompt medical assessment.

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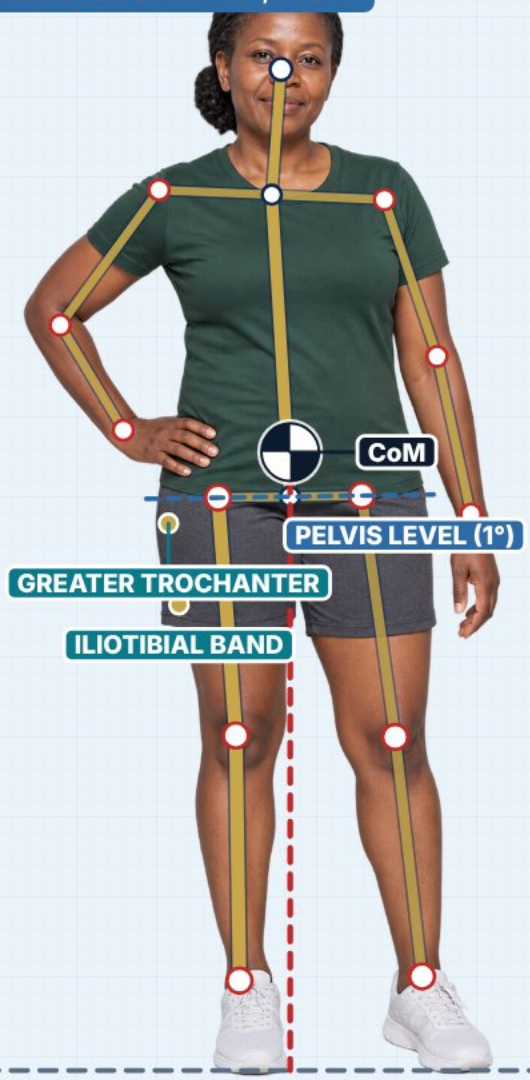
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PAIN ON THE OUTER HIP: GLUTEAL TENDINOPATHY EXPLAINED

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A · HAND ON OUTER HIP, FRONT





OTHER VIEW

EYE-OPENER

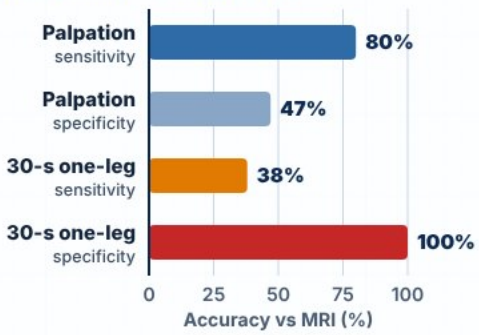
82% of people in a large gluteal tendinopathy trial were women; average age 55.

167 of 204 participants, MRI-confirmed. Mellor et al. (2018).

Tendons on the bony point

- Hand on the greater trochanter, pelvis level (**1°**): gluteus medius and minimus tendons attach here and are the main source of outer hip pain.
- Tenderness here is common but not specific; no tenderness helps rule the condition out (LR− 0.43).

Which clinical test helps?



65 people with lateral hip pain; MRI as reference. Grimaldi 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). Pelvis line joins the two hip landmarks in the front view. Educational, not diagnostic.

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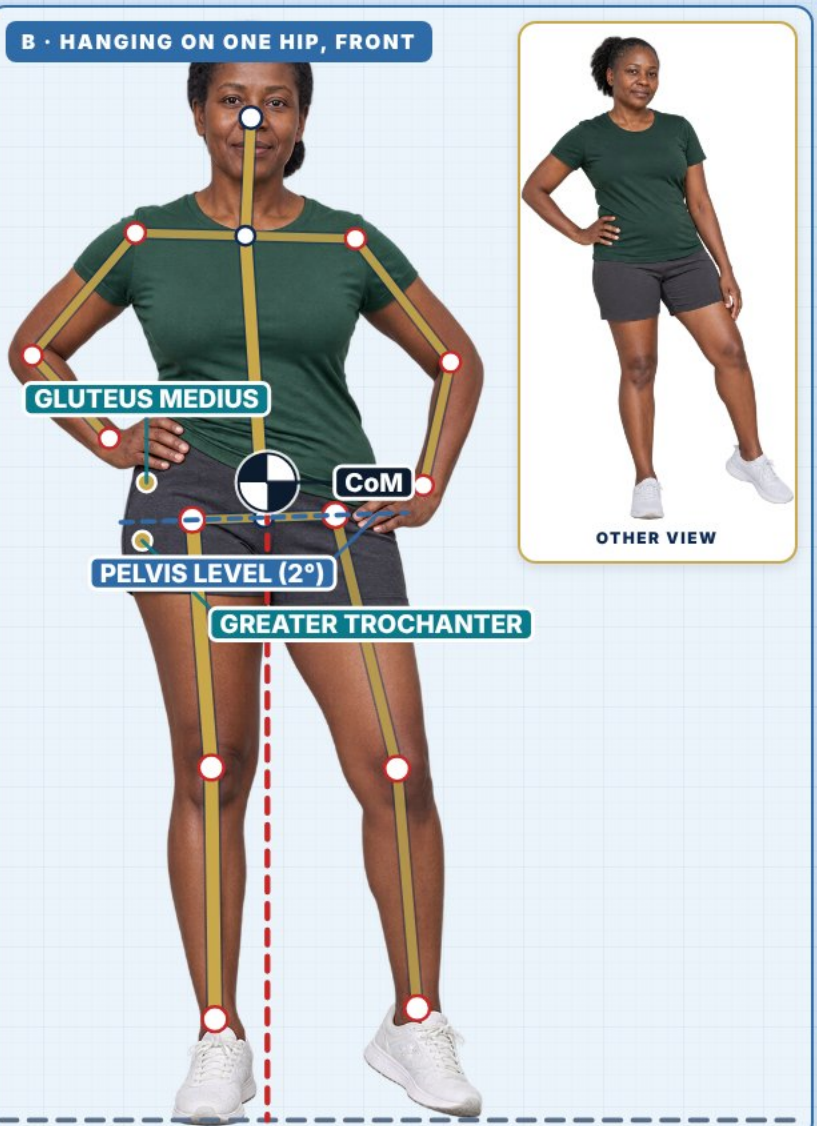
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EYE-OPENER

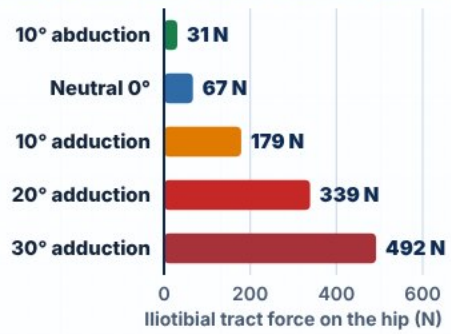
98% probability of gluteal tendinopathy if outer hip pain starts within 30 s of one-leg standing.

From a 50% pre-test probability; specificity 100%. Grimaldi et al. (2017).

Adduction squeezes the tendon

- Letting the hip drift out sideways moves the standing hip into adduction; here pelvis level (**2°**), so the drop is small.
- In adduction the iliotibial band presses the tendons against the trochanter: the compression model of this condition.

More adduction, more compression



Cadaveric specimens with a sensor prosthesis; not directly comparable with living hips. Birnbaum et al. (2010).

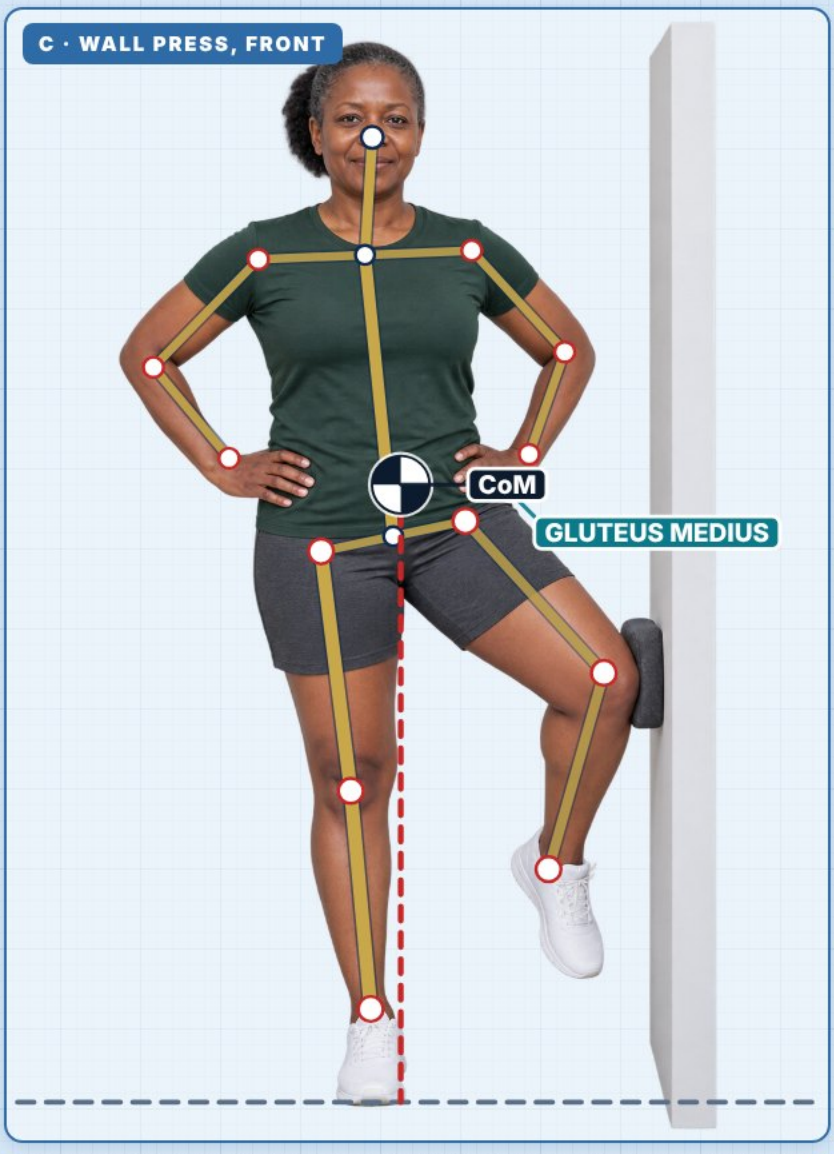
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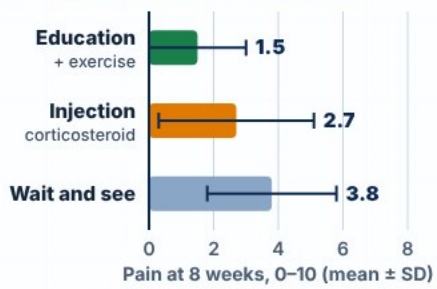
NNT 2 treat two people with education plus exercise and one more succeeds at 8 weeks vs waiting.

Risk difference 49.1% (95% CI 34.6% to 63.5%). Mellor et al. (2018).

Abductor load, no adduction

- Pressing the outer knee into a wall works the hip abductors isometrically while the hip stays out of adduction.
- The trial programme added 4–6 daily home exercises with targeted abductor strengthening.

Pain falls fastest with exercise



Baseline pain 4.8–4.9 in all groups; no difference vs injection at 52 weeks. Mellor et al. (2018).

Myth: "It is bursitis, so an injection fixes it." The tendons are the main problem; exercise won at one year.

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 · Outer hip Locate

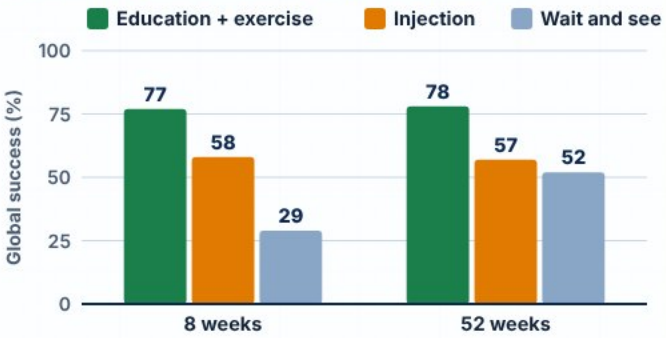


B · On one hip Avoid



C · Wall press Load

Education plus exercise wins at one year



204 people with MRI-confirmed gluteal tendinopathy; percentages from published counts. Mellor et al. (2018).

Decision pathway

1. **EDUCATE**
   Explain tendon compression; avoid hanging on one hip, crossed legs and adduction stretches.
2. **LOAD**
   Start with isometric abductor work such as the wall press, then progress strength and control.
3. **REVIEW**
   An injection may ease pain short term, but global success at one year was higher with exercise.

NOT RECOMMENDED

Relying on an injection alone: at one year 57% succeeded with injection vs 78% with education plus exercise.

SEEK ASSESSMENT IF

Groin pain, painful or stiff hip rotation, night pain unrelated to side-lying, fever, a fall, or leg numbness or weakness: seek assessment.

REFERENCES (APA 7)

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Grimaldi, A., Mellor, R., Nicolson, P., Hodges, P., Bennell, K., & Vicenzino, B. (2017). Utility of clinical tests to diagnose MRI-confirmed gluteal tendinopathy in patients presenting with lateral hip pain. *British Journal of Sports Medicine, 51*(6), 519–524.

Mellor, R., Bennell, K., Grimaldi, A., Nicolson, P., Kasza, J., Hodges, P., Wajswelner, H., & Vicenzino, B. (2018). Education plus exercise versus corticosteroid injection use versus a wait and see approach on global outcome and pain from gluteal tendinopathy: Prospective, single blinded, randomised clinical trial. *BMJ, 361*, k1662. https://doi.org/10.1136/bmj.k1662

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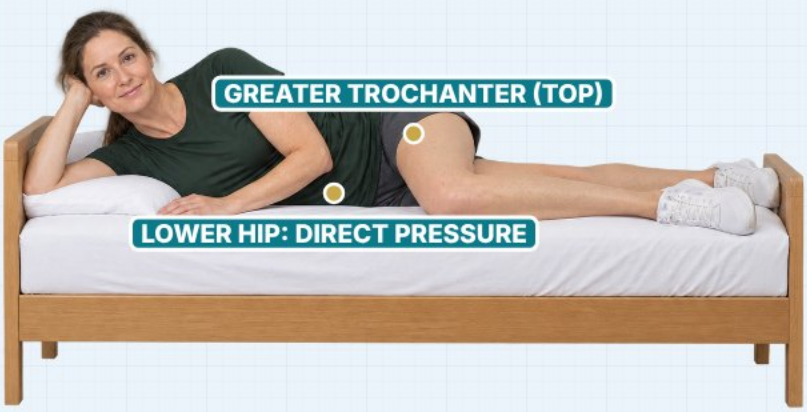
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LYING ON YOUR SIDE WITH OUTER HIP PAIN: POSITIONS THAT COMPRESS THE TENDON

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A · TOP KNEE DROPPED, FRONT





EYE-OPENER

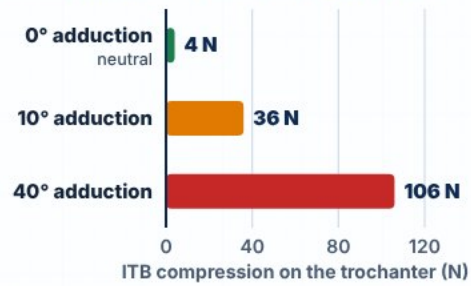
4 to 1 women can outnumber men with gluteal tendon pain by up to four to one.

Reported range 2.4 to 4 : 1. Grimaldi & Fearon (2015).

Two hips under strain

- The lower hip takes direct pressure from the mattress, while the top hip falls into flexion and adduction as the knee drops across.
- Adduction tightens the iliotibial band over the trochanter and compresses the gluteal tendons beneath it.

Adduction multiplies compression



Cadaveric data (Birnbaum and colleagues, 2004) as reported in a review; illustrative. Grimaldi & Fearon (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). Lying pose: skeleton shown for orientation only; no angles measured. Educational, not diagnostic.

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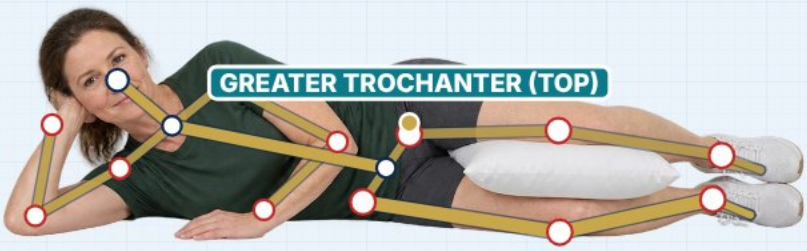
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B · PILLOW BETWEEN KNEES, FRONT





EYE-OPENER

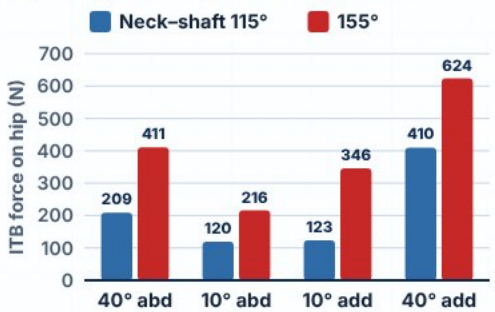
8.5% of women aged 50–79 have outer hip pain on both sides.

3026 adults; a further 15.0% of women on one side. Segal et al. (2007).

A pillow keeps the top hip level

- Pillows between the knees and shins stop the top knee dropping, holding the upper hip nearer neutral instead of adduction.
- Hip shape matters too: the same adducted position pressed harder in some bony configurations.

Hip shape changes the squeeze



Cadaveric specimens, sensor prosthesis at two femoral neck–shaft angles; not directly comparable with living hips. Birnbaum 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). Lying pose: skeleton shown for orientation only; no angles measured. Educational, not diagnostic.

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C · ON THE BACK, SIDE



EYE-OPENER

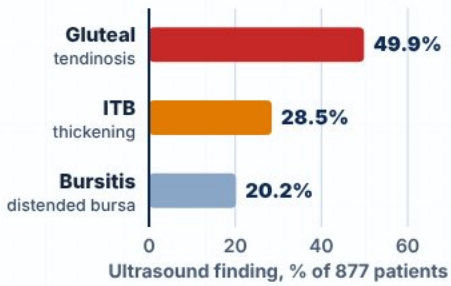
80% success with home training at 15 months, vs 48% after a steroid injection.

229 patients with refractory trochanteric pain; quasi-randomised. Rompe et al. (2009).

On the back: no squeeze

- Lying on the back with a pillow under the knees avoids direct trochanter pressure and hip adduction.
- This follows the compression model; it has not been tested as a treatment on its own.

"Bursitis" is the minority finding



Provisional: from secondary summaries of Long et al. (2013); the 20% bursa figure is also reported by Grimaldi & Fearon (2015).

Myth: "Pull the knee across to stretch the outer hip." Adduction increases compression over the trochanter and is advised against.

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). Lying pose: skeleton shown for orientation only; no angles measured. Educational, not diagnostic.

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INTEGRATING PERFORMANCE & REHABILITATION HEALTHCARE PATHWAYS.

LYING ON YOUR SIDE WITH OUTER HIP PAIN: POSITIONS THAT COMPRESS THE TENDON

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A · Knee dropped Compresses

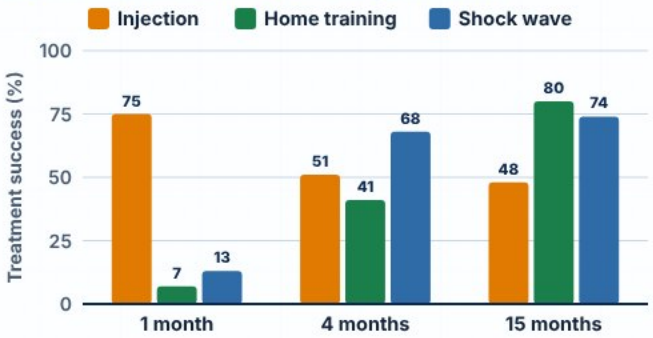


B · Pillow Near neutral



C · On back No pressure

Injection relief fades; loading wins later



229 patients with refractory greater trochanter pain syndrome; quasi-randomised. Rompe et al. (2009).

Decision pathway

1. **POSITION**
   Sleep with pillows between knees and shins, or on the back, so the top knee cannot drop across.
2. **PROTECT**
   Avoid crossed legs, hanging on one hip and adduction stretches through the day.
3. **LOAD**
   Build progressive abductor exercise: education plus exercise gave 77–78% success (Mellor et al., 2018).

NOT RECOMMENDED

Stretching the outer hip by pulling the knee across the body, which adds compression over the trochanter.

SEEK ASSESSMENT IF

Night pain not eased by changing position, fever or feeling unwell, weight loss, a recent fall, groin pain, or leg numbness or weakness: seek assessment.

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Mellor, R., Bennell, K., Grimaldi, A., Nicolson, P., Kasza, J., Hodges, P., Wajswelner, H., & Vicenzino, B. (2018). Education plus exercise versus corticosteroid injection use versus a wait and see approach on global outcome and pain from gluteal tendinopathy: Prospective, single blinded, randomised clinical trial. *BMJ, 361*, k1662. https://doi.org/10.1136/bmj.k1662

Rompe, J. D., Segal, N. A., Cacchio, A., Furia, J. P., Morral, A., & Maffulli, N. (2009). Home training, local corticosteroid injection, or radial shock wave therapy for greater trochanter pain syndrome. *The American Journal of Sports Medicine, 37*(10), 1981–1990. https://doi.org/10.1177/0363546509334374

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CROSSING YOUR LEGS AND OUTER HIP PAIN: WHY HIP ADDUCTION MATTERS

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A · LEGS CROSSED, FRONT





OTHER VIEW

EYE-OPENER

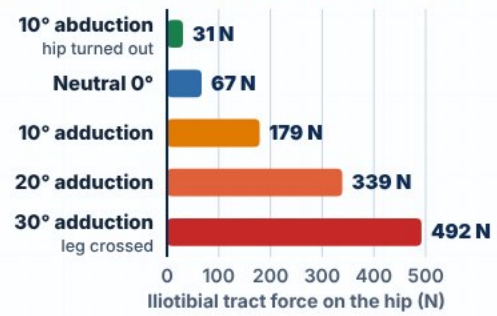
35% of people with low back pain have been reported to have outer hip pain as well.

Upper estimate from two studies cited by Grimaldi & Fearon (2015).

Crossing the thigh = adduction

- With the right thigh crossed over the left knee, the hip moves towards and across the midline: hip adduction, usually combined with flexion.
- Adduction tensions the iliotibial band over the greater trochanter, compressing the gluteal tendons beneath it.

More adduction, more compression



Cadaveric hips with a sensor prosthesis (neck–shaft angle 125°); not directly comparable with living hips. Birnbaum 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). No overlay or angles: pose landmarks are unreliable with the legs crossed. Educational, not diagnostic.

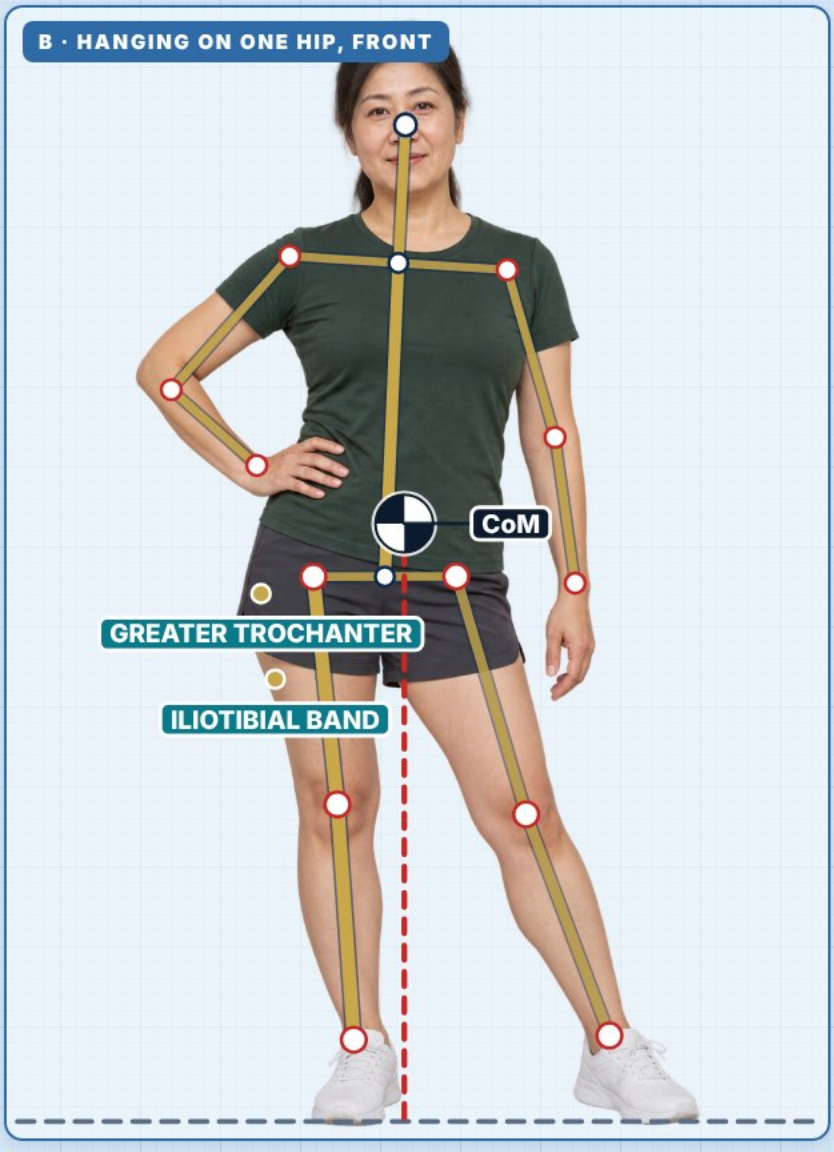
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EYE-OPENER

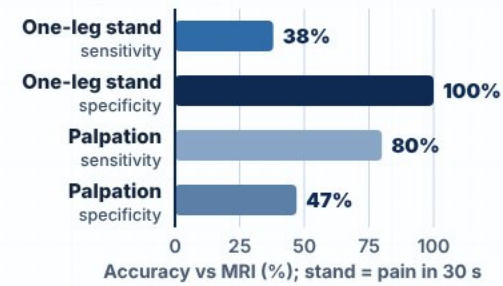
98% likelihood of gluteal tendinopathy if standing 30 s on one leg reproduces the pain (from 50%).

Post-test probability, LR+ about 12. Grimaldi et al. (2017).

Hanging on one hip loads the tendon

- Weight on the right leg with the hip pushed out sideways adducts the standing hip under body weight: tension plus compression.
- Hence single-leg standing is used to provoke gluteal tendon pain.

One-leg standing rules pain in



65 people with lateral hip pain; MRI reference. Grimaldi et al. (2017).

Key point: tests combining adduction with tendon load were among the most specific (FADER-R LR+ 6.6; ADD-R LR+ 5.7).

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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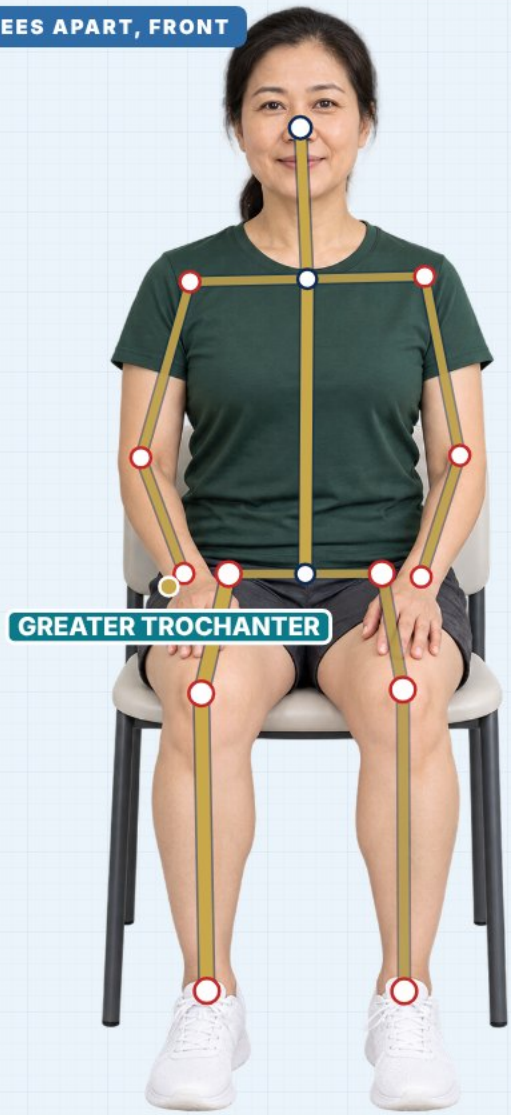
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CROSSING YOUR LEGS AND OUTER HIP PAIN: WHY HIP ADDUCTION MATTERS

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C · KNEES APART, FRONT



EYE-OPENER

3.5× higher odds of a painful outer hip in people with knee osteoarthritis on the same side.

OR 3.47 (95% CI 2.72–4.42), 3026 adults aged 50–79. Segal et al. (2007).

Knees apart: the simple swap

- Feet flat and knees hip-width apart keep the hip near neutral, so the iliotibial band rests lightly over the trochanter.
- Changing daily positions is part of first-line education for gluteal tendinopathy, alongside loading exercise.

Positions to avoid and swap

Sitting, knees crossed or together adduction ± flexion	AVOID
Standing, hanging on one hip adduction in stance	AVOID
Standing with legs crossed adduction	AVOID
Side-lying, top knee dropped flexed + adducted	PILLOW BETWEEN KNEES
Sitting, knees hip-width apart near neutral	PREFER

Education advice for gluteal tendinopathy (categorical, no numbers). Grimaldi & Fearon (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). Skeleton only: no angles are measured from a seated front view. Educational, not diagnostic.

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A · Legs crossed Avoid

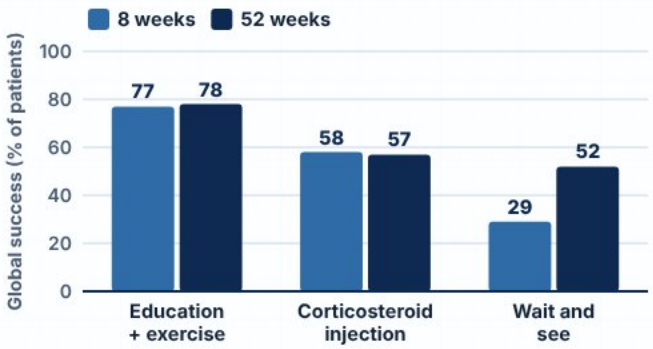


B · Hip hang Avoid



C · Knees apart Prefer

Habits plus loading outperformed injection at one year



LEAP randomised trial in gluteal tendinopathy; % from published counts (e.g. 51/66, 38/65, 20/68 at 8 weeks). Mellor et al. (2018).

Decision pathway

1. **SPOT**
   Notice sustained adduction: crossed legs, knees together or hanging on one hip.
2. **SWAP**
   Sit knees hip-width apart, stand evenly, and use a pillow between the knees in side-lying.
3. **LOAD**
   Build abductor strength and control progressively; education plus exercise comes first.

NOT RECOMMENDED

Repeated stretching across the midline (adduction stretches) or relying on injection alone for long-term relief.

SEEK ASSESSMENT IF

A fall then inability to bear weight, a hot painful hip with fever, severe night pain or weight loss, or leg numbness or weakness: seek prompt medical assessment.

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Birnbaum, K., Prescher, A., & Niethard, F.-U. (2010). Hip centralizing forces of the iliotibial tract within various femoral neck angles. *Journal of Pediatric Orthopaedics B, 19*(2), 140–149. https://doi.org/10.1097/BPB.0b013e328332355e

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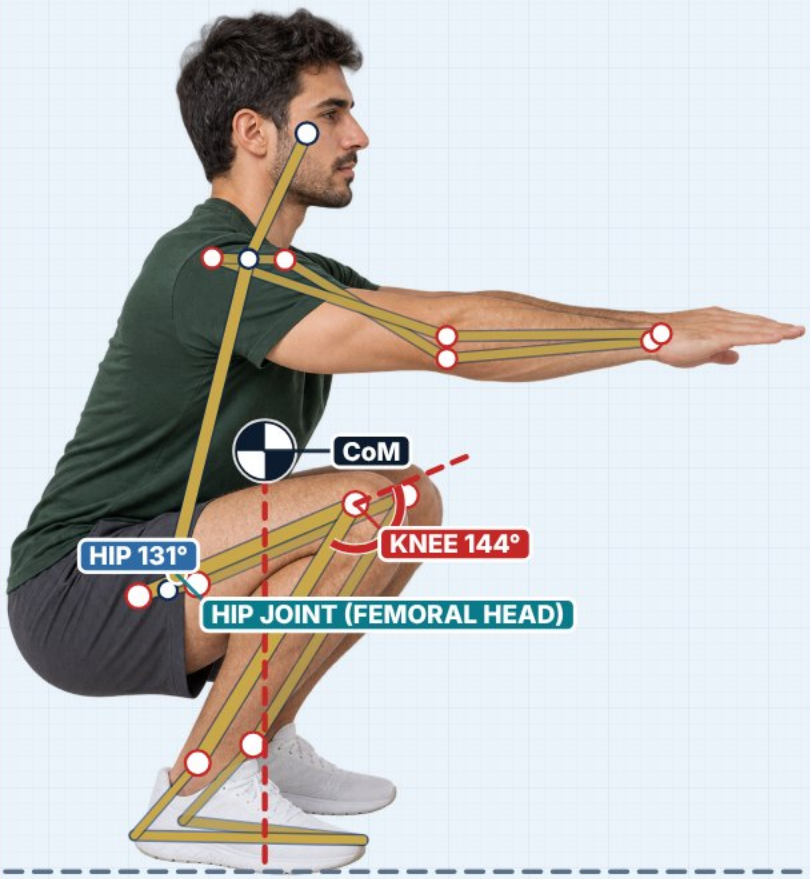
BIOMECHANICS IS A FORCE-GOVERNED DECISION SYSTEM – NOT A POSTURE MODEL.

INTEGRATING PERFORMANCE & REHABILITATION HEALTHCARE PATHWAYS.

HIP IMPINGEMENT (FAI): BONE SHAPE, MOVEMENT AND PAIN

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A · DEEP SQUAT, SIDE



EYE-OPENER

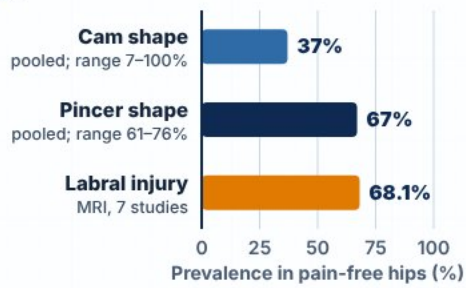
55% of pain-free athletes show a cam-shaped hip on imaging, against 23% of the general population.

54.8% vs 23.1%, asymptomatic hips. Frank et al. (2015).

Deep flexion brings the rim closer

- In this deep squat the hip is ≈**131°** from the trunk line and the knee ≈**144°** flexed: the femoral neck approaches the socket rim.
- FAI syndrome needs a triad: motion-related hip or groin pain, clinical signs and a cam or pincer shape on imaging.

Shape on a scan is common without pain



26 studies, 2114 asymptomatic hips, mean age 25.3 years. Frank 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). Hip: thigh angle from the trunk line (0° = straight); knee: flexion from straight. Educational, not diagnostic.

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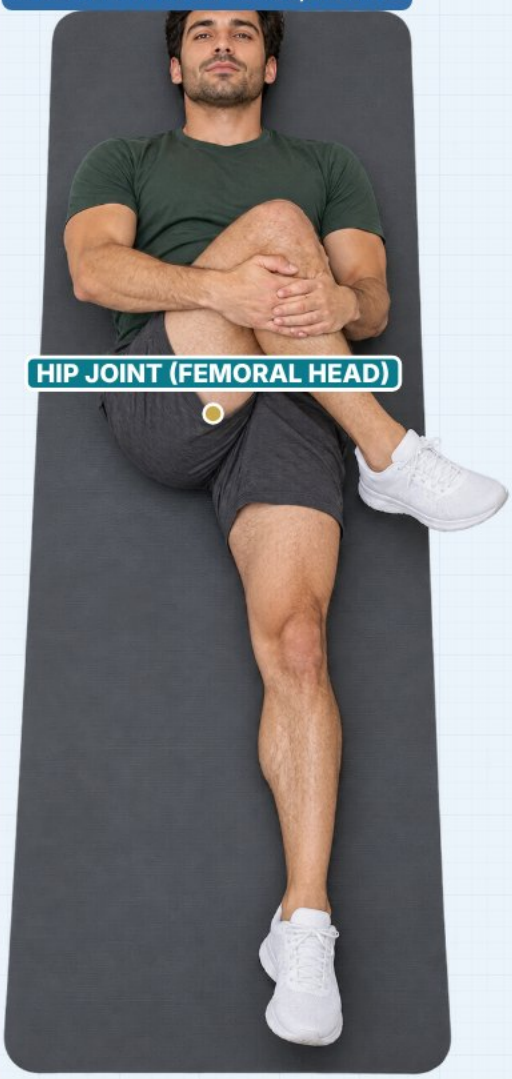
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HIP IMPINGEMENT (FAI): BONE SHAPE, MOVEMENT AND PAIN

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B · KNEE ACROSS BODY, FRONT





EYE-OPENER

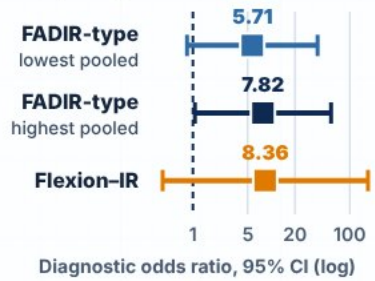
1 of 21 articles on hip impingement tests was judged high quality in a meta-analysis.

21 articles, 9 meta-analysed. Reiman et al. (2015).

Knee to opposite shoulder = FADIR

- Pulling the bent knee across the body combines flexion, adduction and internal rotation: the classic impingement test position.
- Most people with impingement or labral pathology feel pain here, so a pain-free test makes them less likely.

Tests screen; they do not confirm



Odds ratios with confidence intervals reaching or crossing 1 show low precision. Reiman et al. (2015).

Key point: the consensus statement calls this test "sensitive but not specific": a positive result alone is not a diagnosis.

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). No overlay or angles: pose landmarks are unreliable in this top-down lying view. Educational, not diagnostic.

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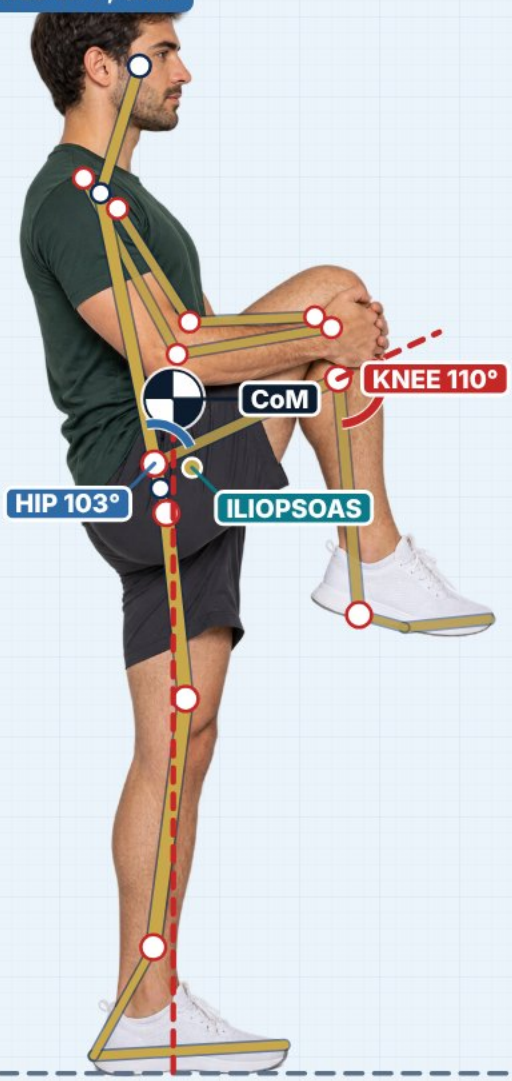
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HIP IMPINGEMENT (FAI): BONE SHAPE, MOVEMENT AND PAIN

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C · HIGH KNEE LIFT, SIDE



EYE-OPENER

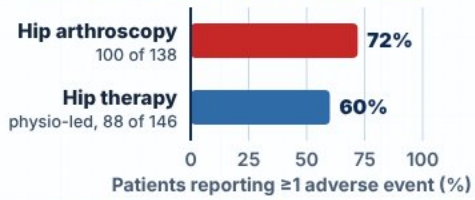
5 of 6 serious adverse events after surgery were judged treatment-related, including one joint infection.

Arthroscopy group, UK FASHIoN trial. Griffin et al. (2018).

Hip flexion in standing

- Lifting the knee to the chest puts the hip ≈**103°** from the trunk line, knee ≈**110°**: active flexion led by the iliopsoas.
- Pain at the front of the hip at end range is a typical impingement symptom; adding inward rotation usually increases it.

Harms differ between treatments



Patient-reported events at 12 months; 147 vs 102 events in total. Griffin et al. (2018).

Myth: "A cam or pincer on the scan means surgery." Shape is common without pain; symptoms and signs must match.

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). Hip: thigh angle from the trunk line (0° = straight); knee: flexion from straight. Educational, not diagnostic.

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HIP IMPINGEMENT (FAI): BONE SHAPE, MOVEMENT AND PAIN

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A · Deep squat Deep flexion

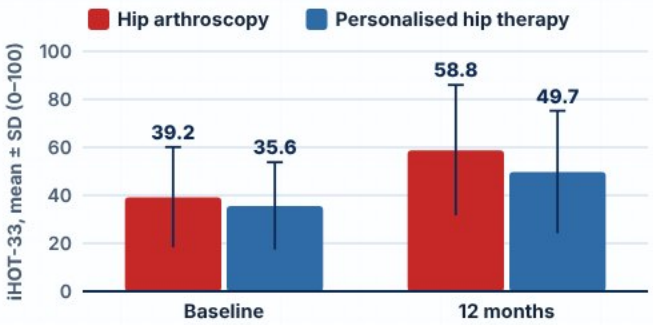


B · Knee across FADIR



C · Knee lift Flexion

Both groups improved; surgery added a modest margin



UK FASHIoN, 348 people with FAI syndrome; adjusted difference 6.8 points (95% CI 1.7–12.0) vs a 6.1-point MCID. Griffin et al. (2018).

Decision pathway

1. **MATCH**
   Diagnose FAI syndrome only when motion-related pain, examination signs and imaging all agree.
2. **MODIFY**
   Adjust depth and direction of deep flexion while rehabilitation builds strength, control and range.
3. **DECIDE**
   Share the choice: physiotherapist-led care or surgery, weighing a modest benefit against more adverse events.

NOT RECOMMENDED

Surgery for a cam or pincer shape on a scan without matching symptoms and examination signs.

SEEK ASSESSMENT IF

Locking or giving way, night or rest pain, pain after trauma, or groin pain with fever, weight loss or inability to bear weight: seek assessment.

REFERENCES (APA 7)

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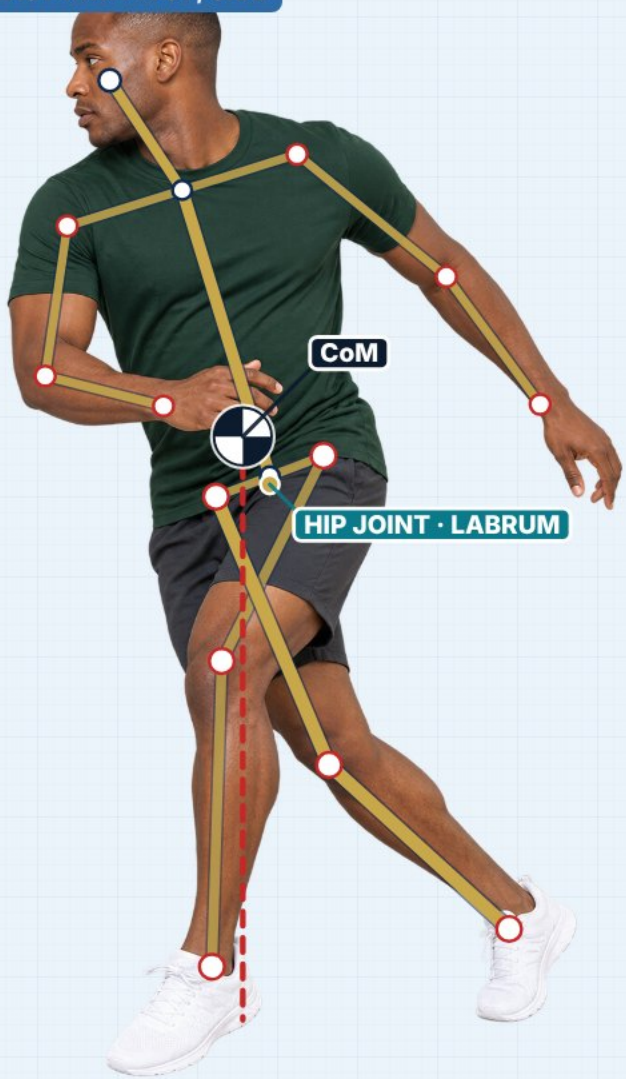
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INTEGRATING PERFORMANCE & REHABILITATION HEALTHCARE PATHWAYS.

HIP LABRAL TEAR: WHEN A SCAN FINDING IS NOT THE WHOLE STORY

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A · TWIST AND PIVOT, SIDE



EYE-OPENER

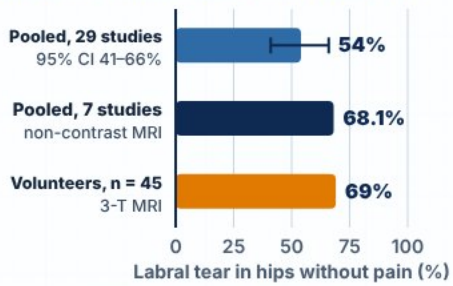
73% of hips in volunteers with no hip pain showed at least one abnormality on high-field MRI.

45 volunteers, 3-T MRI, blinded readers. Register et al. (2012).

Pivoting loads the socket rim

- Turning the trunk over a planted foot rotates the pelvis on the loaded femur, shearing the labrum, the fibrocartilage rim of the socket.
- A tear seen on a scan is a structural finding; it may or may not be the source of symptoms.

Tears are common in pain-free hips



Heerey et al. (2018); Frank et al. (2015); Register et al. (2012).

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). Skeleton only: no angles from a twisted, oblique pose. Educational, not diagnostic.

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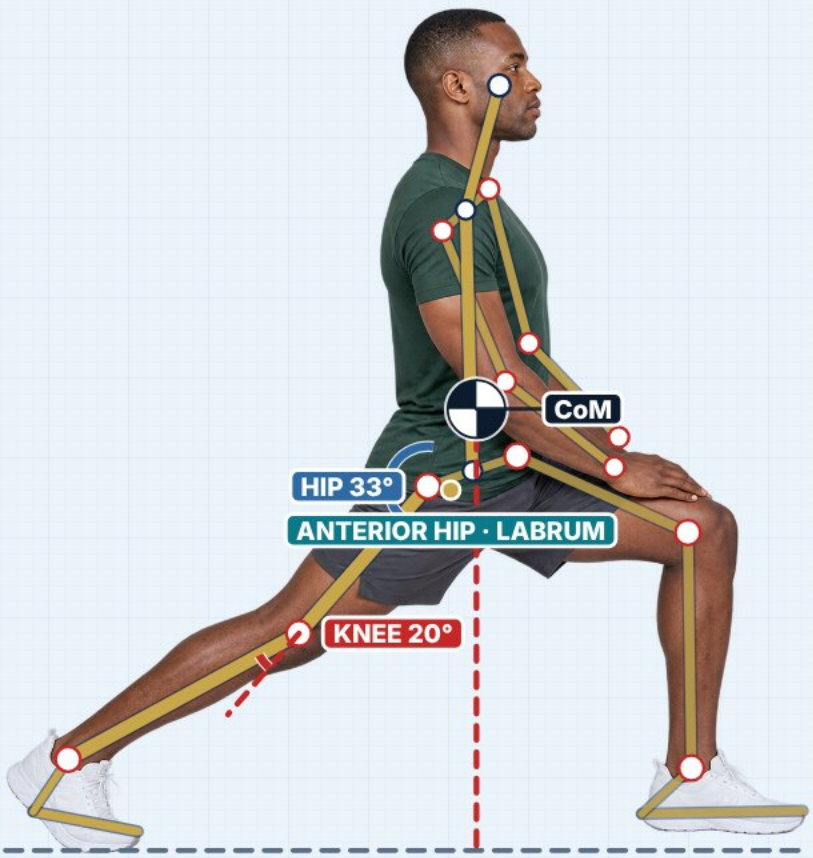
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INTEGRATING PERFORMANCE & REHABILITATION HEALTHCARE PATHWAYS.

HIP LABRAL TEAR: WHEN A SCAN FINDING IS NOT THE WHOLE STORY

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B · LONG LUNGE, SIDE



EYE-OPENER

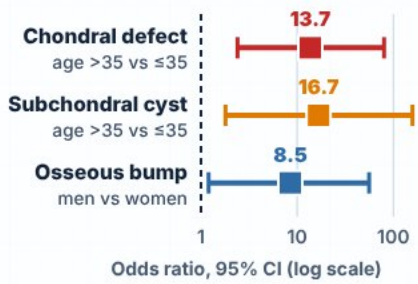
12% of pain-free hips had a cartilage defect, against 64% of painful hips: a sharper pointer than a tear.

Pooled imaging prevalence, 29 studies. Heerey et al. (2018).

Long lunge stretches the front hip

- The rear hip sits ≈**33°** behind the trunk line (extension) with the knee ≈**20°** bent, tensioning the front capsule and labrum.
- Findings on pain-free scans rise with age and differ by sex, so they must be read against the person.

Age and sex shape what a scan shows



Pain-free volunteers, 3-T MRI; wide intervals from a small sample (n = 45). Register et al. (2012).

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). Hip: thigh angle from the trunk line (0° = straight); knee: flexion from straight. Educational, not diagnostic.

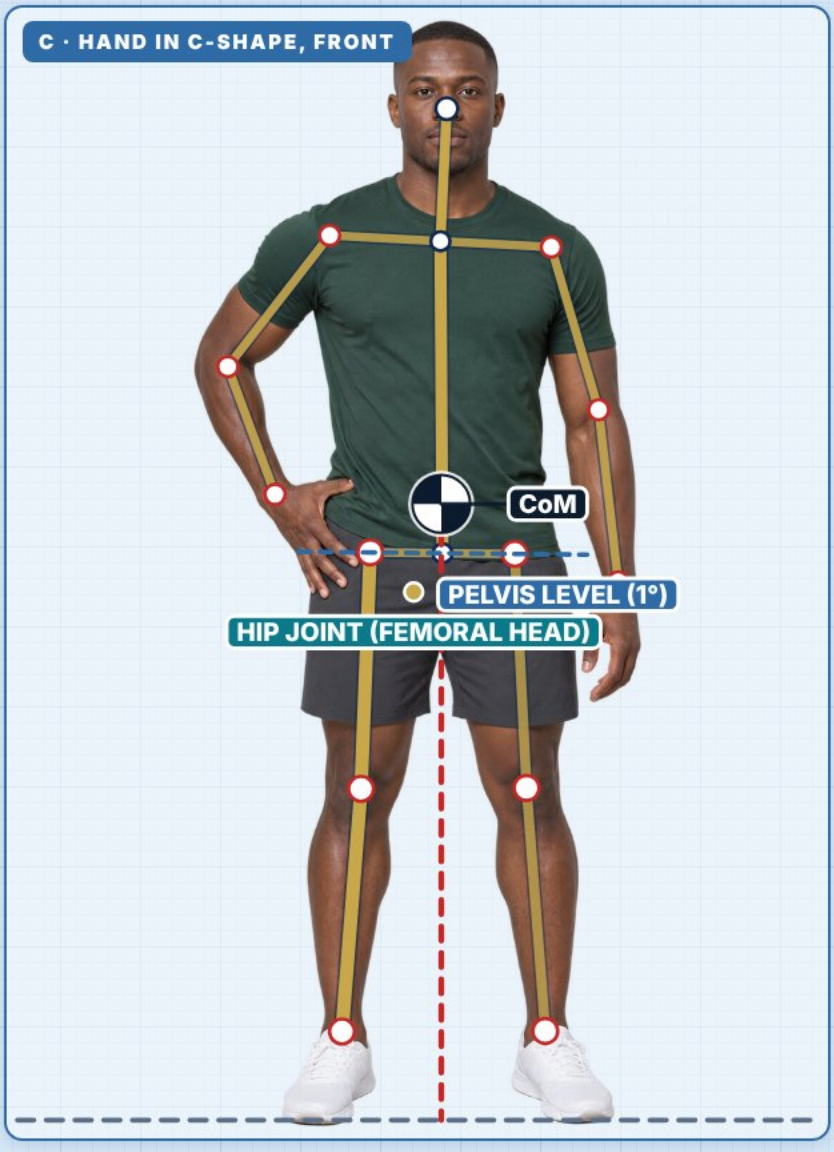
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EYE-OPENER

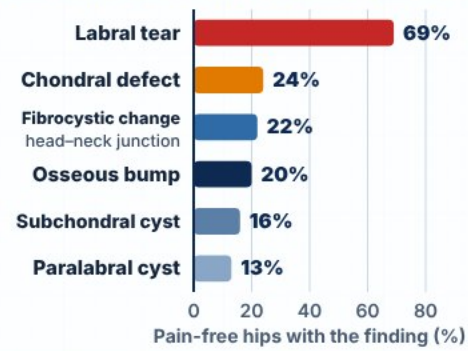
≥94% of people with impingement or labral tears test positive on flexion–adduction–internal rotation.

Pooled sensitivity 0.94 to 0.99. Reiman et al. (2015).

The C-sign: where it hurts matters

- Hand cupping the hip, thumb behind and fingers in front, pelvis level (**1°**): a typical way people locate deep, joint-related pain.
- Clinically relevant hip pain is motion- or position-related groin pain that matches examination findings, not a scan alone.

What MRI finds in hips that do not hurt



45 volunteers with no hip pain; finding counted when 2 of 3 blinded radiologists agreed. Register et al. (2012).

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). Pelvis line joins the two hip landmarks in the front view. Educational, not diagnostic.

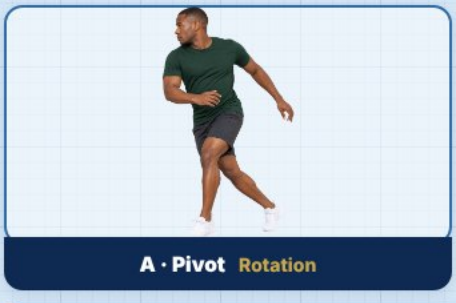
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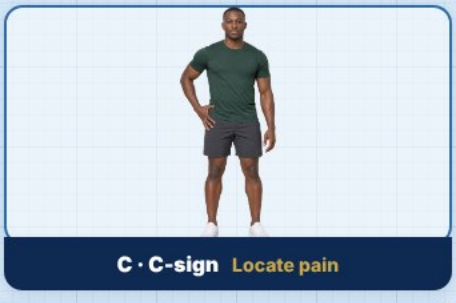
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A · Pivot Rotation

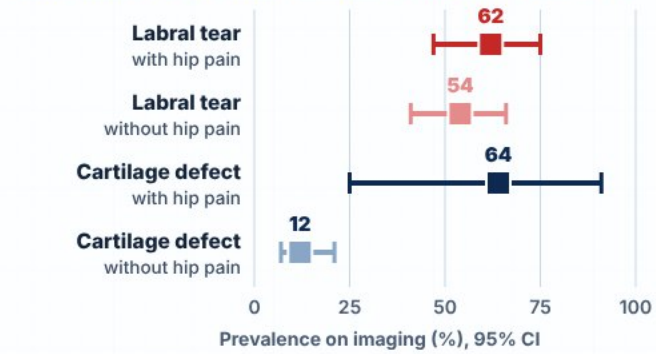


B · Long lunge Extension



C · C-sign Locate pain

Tears barely separate painful from pain-free hips



Meta-analysis of 29 imaging studies; most at moderate to high risk of bias. Heerey et al. (2018).

Decision pathway

1. **LISTEN**
   Note motion- or position-related groin pain and how the person locates it, such as the C-sign.
2. **EXAMINE**
   Use provocation tests to screen; a negative test makes joint pathology less likely, a positive one is not proof.
3. **INTERPRET**
   Read the scan last: treat the person, building strength and control, not the tear alone.

NOT RECOMMENDED

Deciding on treatment from a labral tear on imaging alone, without matching symptoms and examination findings.

SEEK ASSESSMENT IF

True locking, giving way, rapidly worsening pain, pain after a fall or collision, inability to bear weight, or groin pain with fever: seek prompt assessment.

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Heerey, J. J., Kemp, J. L., Mosler, A. B., Jones, D. M., Pizzari, T., Souza, R. B., & Crossley, K. M. (2018). What is the prevalence of imaging-defined intra-articular hip pathologies in people with and without pain? A systematic review and meta-analysis. *British Journal of Sports Medicine, 52*(9), 581. https://doi.org/10.1136/bjsports-2017-098264

Register, B., Pennock, A. T., Ho, C. P., Strickland, C. D., Lawand, A., & Philippon, M. J. (2012). Prevalence of abnormal hip findings in asymptomatic participants: A prospective, blinded study. American Journal of Sports Medicine, 40(12).

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Winter, D. A. (2009). *Biomechanics and motor control of human movement* (4th ed.). Wiley. https://doi.org/10.1002/9780470549148

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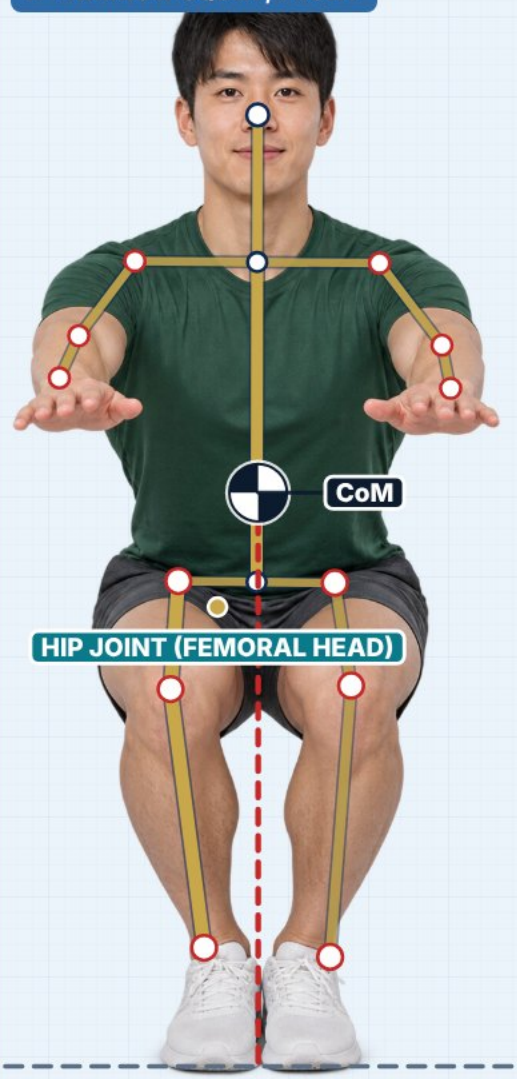
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DEEP SQUAT HIP PAIN: DEPTH, STANCE WIDTH AND HIP SHAPE

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A · NARROW SQUAT, FRONT





EYE-OPENER

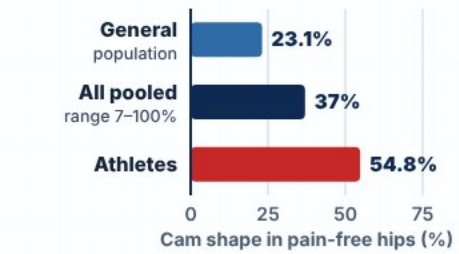
6× more likely hip osteoarthritis when a squat brings on pain at the back of the hip.

LR+ 6.1 (95% CI 1.3–29) in people presenting with hip pain. Metcalfe et al. (2019).

Narrow and toes forward

- Feet close and toes straight: as depth increases the flexed hips also move towards adduction and internal rotation, the impingement direction.
- People with a cam-shaped femoral neck reach the socket rim sooner in this position.

Hip shape differs from person to person



26 studies, 2114 asymptomatic hips. Frank et al. (2015).

Myth: "If deep squats hurt, your mobility is the problem." Bone shape varies, so depth and stance can be individualised.

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). No knee angles: front-view knee projections are not valid in a deep squat. Educational, not diagnostic.

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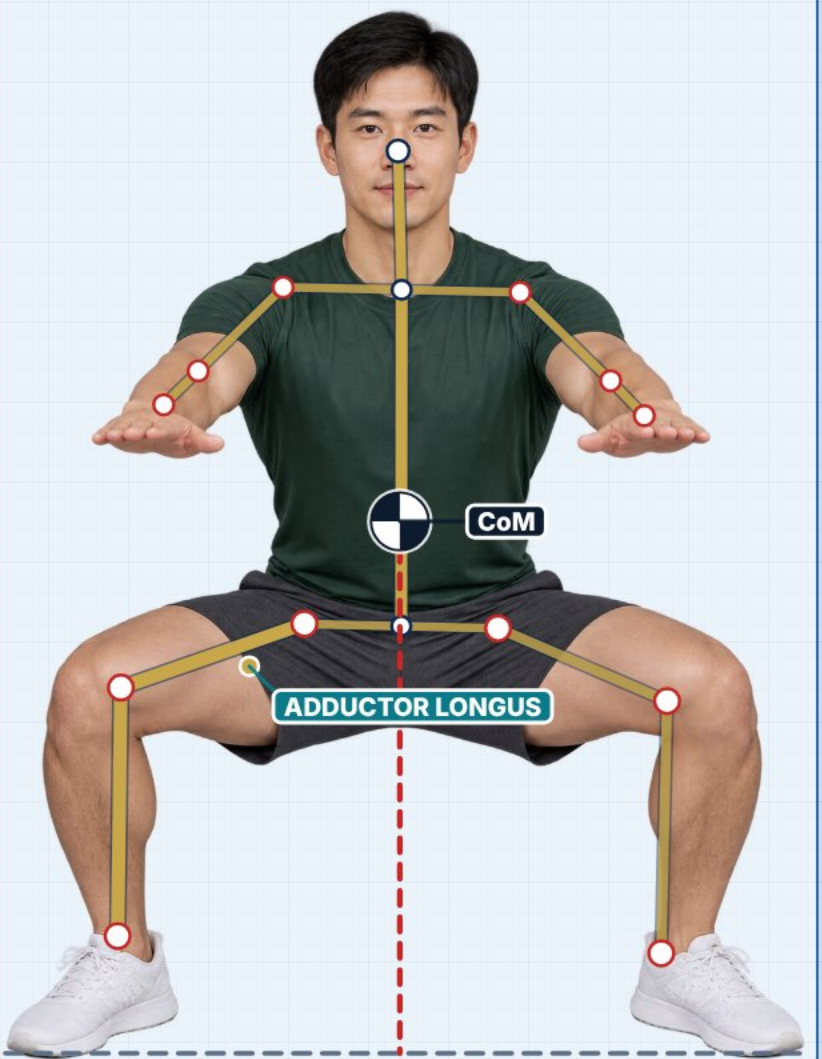
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B · WIDE SQUAT, TOES OUT, FRONT



EYE-OPENER

96% of people with impingement or labral tears felt pain when the bent hip was turned inward.

Flexion–internal rotation test, pooled sensitivity 0.96 (0.81–0.99). Reiman et al. (2015).

Wide stance, toes out

- A wider stance with the feet turned out adds abduction and external rotation, steering the flexed hip away from the impingement direction.
- Any symptom benefit is a mechanical inference: it has not been tested as an outcome.

Two stance combinations to treat with care

	0°	21°	42°
Narrow	tested	tested	LARGE MOMENTS
Hip-width	tested	tested	tested
Wide	LARGE MOMENTS	tested	tested

Foot angle (columns) × stance width (rows)

42 squatters, 9 variations, 3-D motion capture and force plates (categorical summary). Lorenzetti 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). No knee angles: front-view knee projections are not valid in a deep squat. Educational, not diagnostic.

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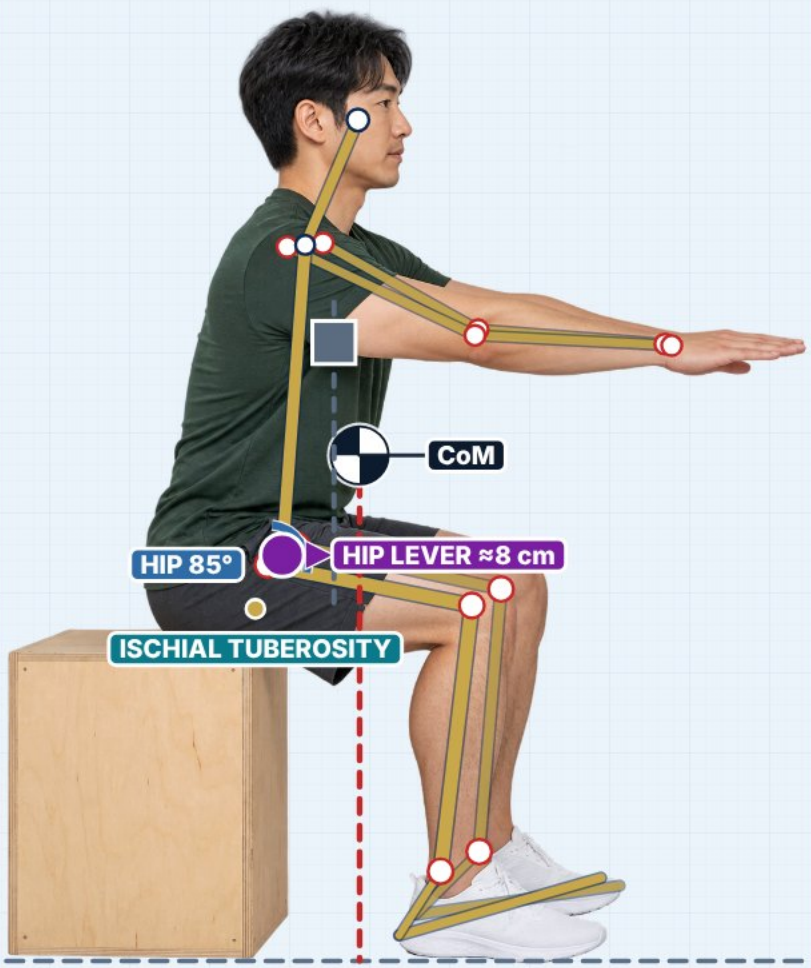
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C · BOX SQUAT, SIDE



EYE-OPENER

0 of 23 machine exercise conditions loaded a replaced hip significantly more than ordinary walking.

Instrumented hip implants, n = 7. Haffer et al. (2022).

Box at parallel: depth with a stop

- Sitting lightly to a box at parallel limits depth to ≈**85°** of hip flexion, with hip lever ≈**8 cm**, hip moment ≈**34 N·m**.
- Temporarily capping depth lets strength work continue while symptoms settle; it is a clinical application, not a trial-tested rule.

Controlled strength work vs walking load

Leg press backrest 10–60°, 50–100% body weight	≤ WALKING
Leg curl and leg extension 20–40 kg	≤ WALKING
Rope-pull hip exercises four directions, 10 kg	≤ WALKING

Hip contact force lower than or not different from walking at 4 km/h; replaced hips and machines, not free squats. Haffer 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). Hip lever: hip-joint centre to upper-body CoM; moment = upper-body weight × lever, 70 kg adult, static. Educational, not diagnostic.

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A · Narrow squat Inward

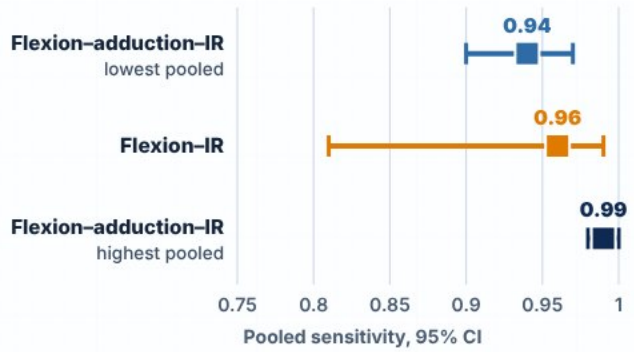


B · Wide, toes out Outward



C · Box squat Depth cap

Turning the bent hip inward provokes most painful hips



Meta-analysis of clinical tests for impingement or labral tear (21 articles, 9 meta-analysed). Reiman et al. (2015).

Decision pathway

1. **CAP**
   Limit depth for now, for example to a box at parallel, and keep strength work going.
2. **ADJUST**
   Vary stance width and foot angle to find a pain-free path.
3. **PROGRESS**
   Lower the box as symptoms allow; build strength, control and range.

NOT RECOMMENDED

Forcing full depth through groin pain; extreme combinations such as narrow stance with feet far out, or wide stance with feet straight.

SEEK ASSESSMENT IF

Groin pain that persists despite reducing depth, catching, locking or giving way, night or rest pain, or pain after a fall: seek assessment.

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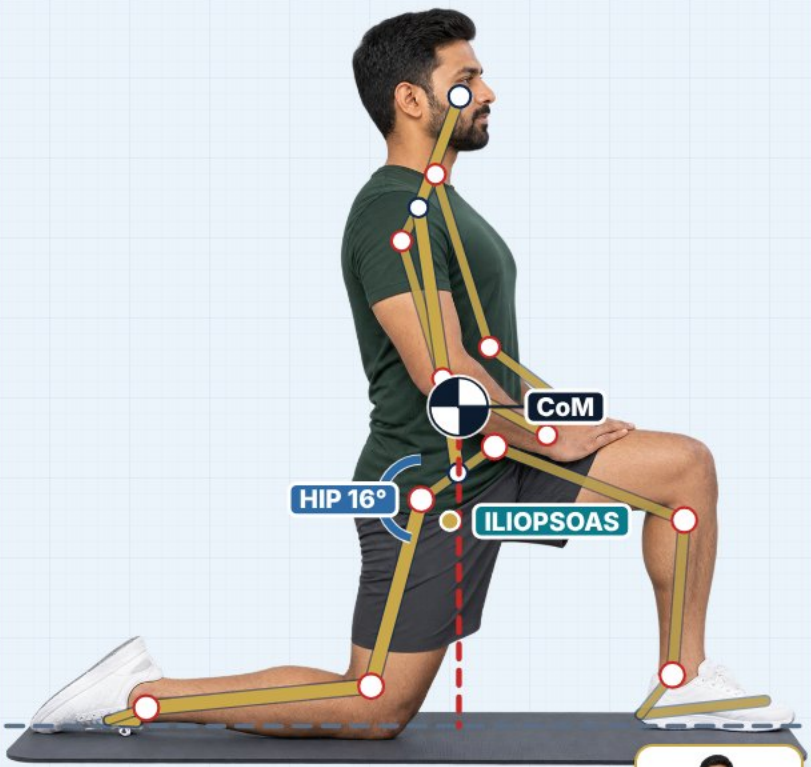
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HIP FLEXOR PAIN: THE ILIOPSOAS AT THE FRONT OF THE HIP

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A · KNEELING HIP STRETCH, SIDE





OTHER VIEW

EYE-OPENER

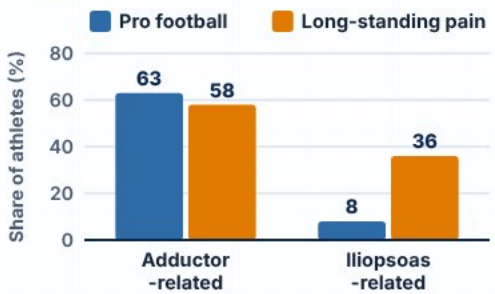
1 in 3 athletes with long-standing groin pain has more than one painful structure, not just one.

33% of 207 athletes. Hölmich (2007).

Iliopsoas: the main hip flexor

- The iliacus and psoas major cross the front of the hip joint; in this half-kneeling stretch the back thigh sits ≈**16°** from the trunk line, close to neutral.
- Iliopsoas-related pain is defined by iliopsoas tenderness, made more likely by pain on resisted hip flexion or on stretching.

Front-of-hip pain is not always iliopsoas



Time-loss hip/groin injuries, men's pro football: Werner et al. (2019). 207 athletes, long-standing groin pain: Hölmich (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). Educational, not diagnostic.

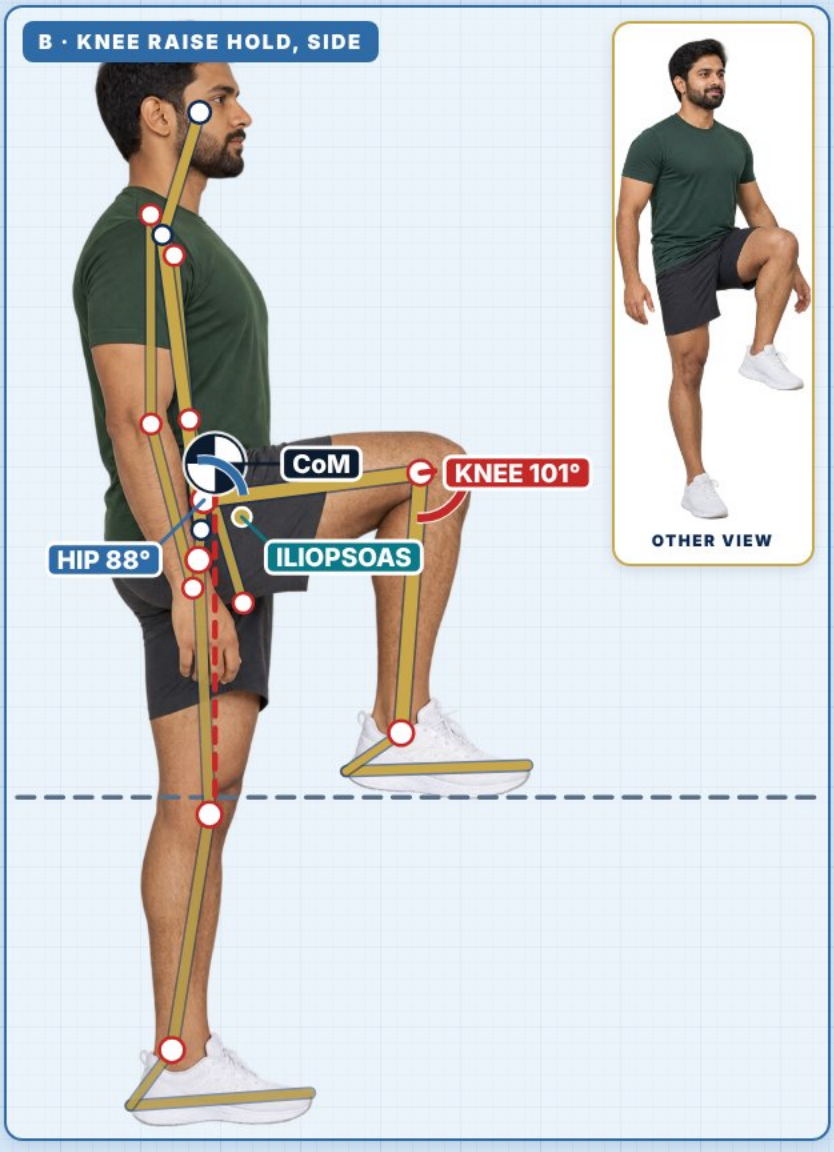
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EYE-OPENER

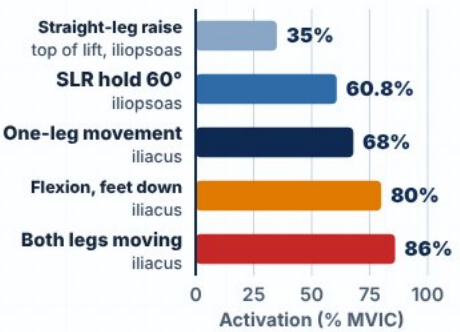
40% of MRI-confirmed hip flexor injuries were in rectus femoris, not the iliopsoas.

16 of 40 injuries in 33 male athletes. Serner et al. (2018).

Holding the knee up is real load

- Knee held at hip height (hip ≈**88°**, knee ≈**101°**): the iliopsoas holds the thigh against gravity.
- Activity rises across 30–60° of hip flexion and with longer levers, so load can be graded by angle and leg length.

How hard the hip flexors work



Review of 9 studies, 109 healthy adults aged 20–40; values from the original studies. Juan 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.

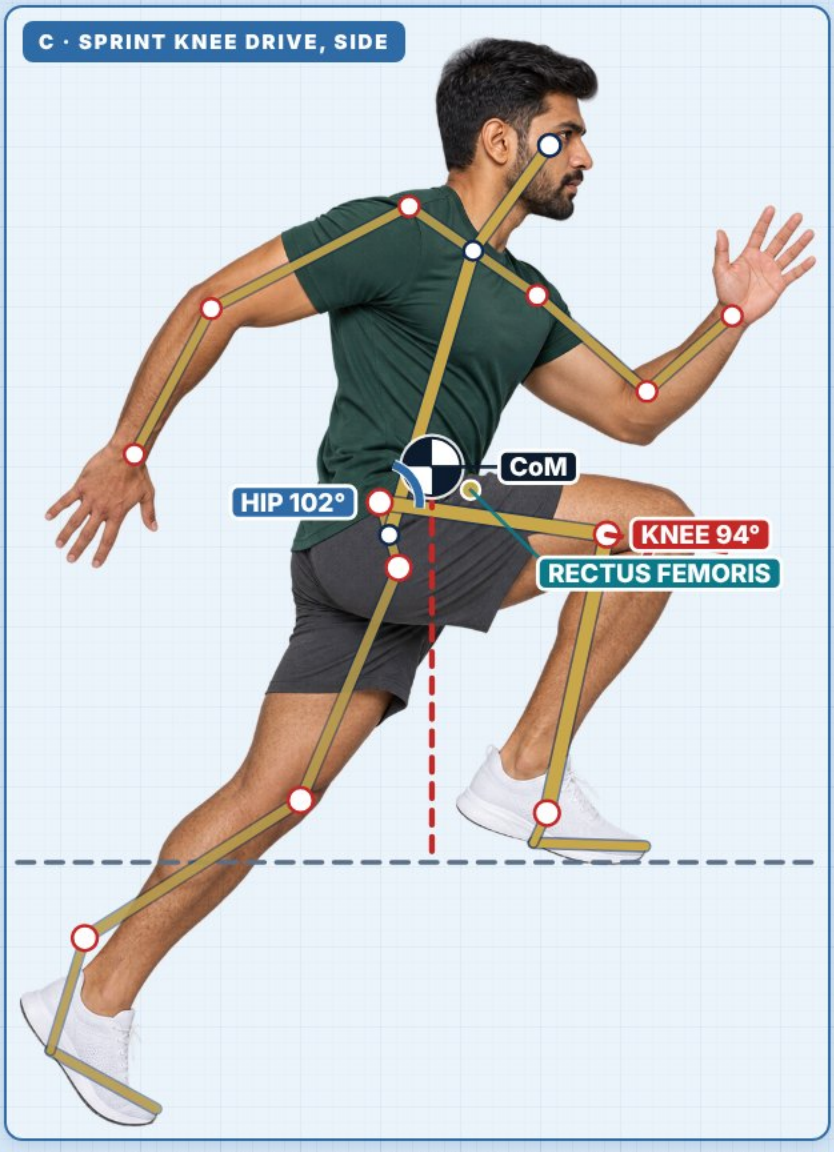
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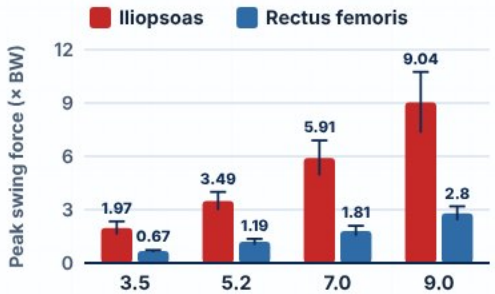
1 in 3 acute groin injuries in athletes are hip flexor injuries.

Serner et al. (2018).

Sprinting multiplies the demand

- The fast knee drive is the iliopsoas's hardest job: modelled force at sprint speed is about 4.6 times the jogging value.
- Return fast running last, after slow, short-lever hip flexor work is pain-free.

Hip flexor force rises with speed



x-axis: running speed (m/s). Mean ± SD, body weights.

9 experienced runners; musculoskeletal model estimates, not direct measures. Dorn et al. (2012).

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 · Stretch Low load

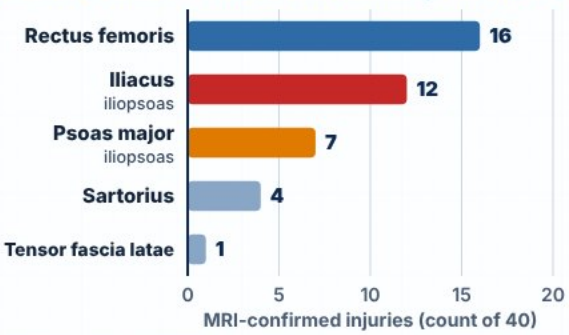


B · Knee hold Graded load



C · Sprint Peak load

Which hip flexor is injured in acute groin injury



33 male athletes, 40 acute hip flexor injuries on MRI. Serner et al. (2018).

Decision pathway

1. **CLASSIFY**
   Examine for adductor, iliopsoas, inguinal, pubic and hip-joint sources; the hip joint should always be considered.
2. **GRADE**
   Start with short levers and small hip angles, then longer levers and sustained holds as pain allows.
3. **PROGRESS**
   Add speed last: the sprint knee drive asks the iliopsoas for far more force than jogging.

NOT RECOMMENDED

Treating front-of-hip pain as a "tight hip flexor" to stretch, without examining the hip joint and other groin sources.

SEEK ASSESSMENT IF

A fall then inability to bear weight, a hot painful hip with fever, severe night pain or weight loss, or leg numbness or weakness: seek prompt medical assessment.

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

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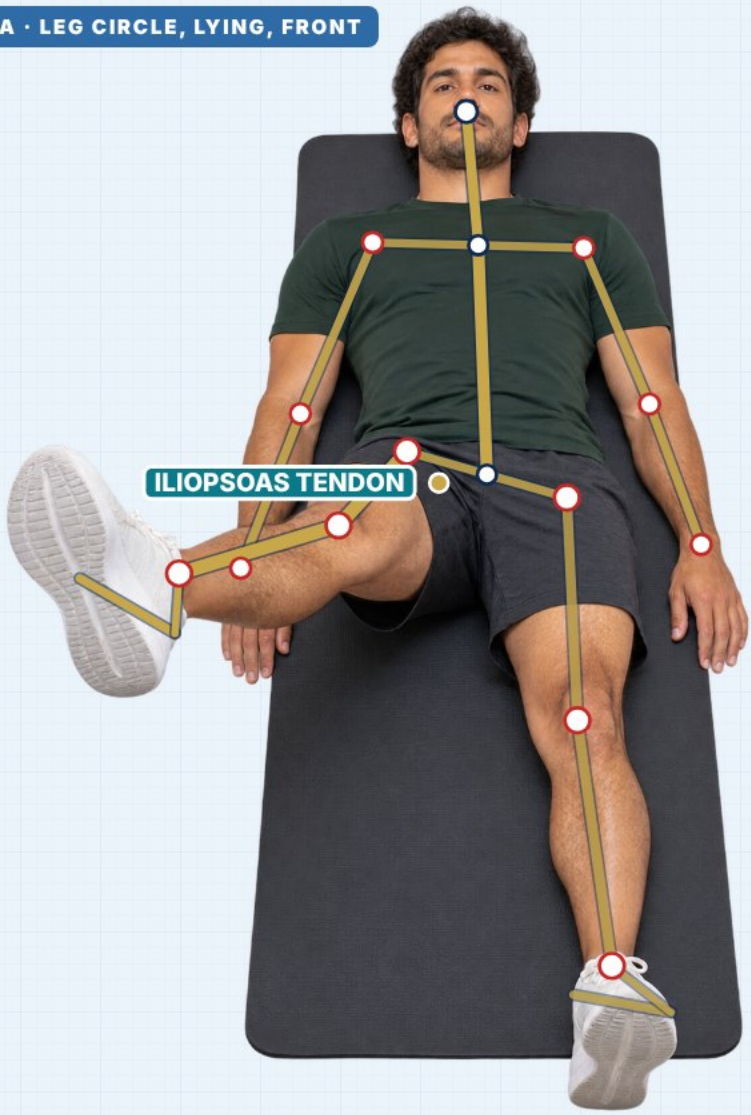
BIOMECHANICS IS A FORCE-GOVERNED DECISION SYSTEM – NOT A POSTURE MODEL.

INTEGRATING PERFORMANCE & REHABILITATION HEALTHCARE PATHWAYS.

SNAPPING HIP: HARMLESS CLICK OR A REASON TO CHANGE LOAD?

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A · LEG CIRCLE, LYING, FRONT



EYE-OPENER

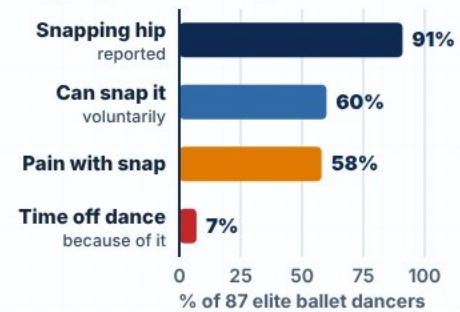
5–10% of the general population have a snapping hip as an incidental finding.

Narrative review citing earlier sources. Walker et al. (2021).

Internal snap: a tendon, not wear

- Circling the lifted leg can make the iliopsoas tendon flick over a structure at the front of the hip: the internal type.
- The snap is often painless; pain and lost activity, not the noise, are what change the plan.

Snapping is common; time off is not



87 unselected elite ballet dancers. Winston et al. (2007).

Myth: "A clicking hip means the joint is wearing out." Most snapping comes from a tendon moving over bone.

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). Lying pose: skeleton only, no angles measured. Educational, not diagnostic.

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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). Pelvis line joins the two hip landmarks in the front view. Educational, not diagnostic.

EYE-OPENER

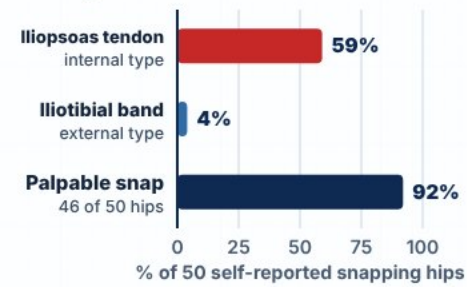
80% of dancers with a snapping hip had it on both sides.

Of 87 elite ballet dancers reporting snapping. Winston et al. (2007).

External snap: the outer hip

- Hand on the outer hip while walking, pelvis level (**1°**): here the iliotibial band can flick over the greater trochanter.
- In dancers this outer-hip type was uncommon on dynamic ultrasound; most snaps were the iliopsoas tendon.

What dynamic ultrasound showed



50 hips in 26 dancers; palpable % is 46/50 (arithmetic). Winston et al. (2007).

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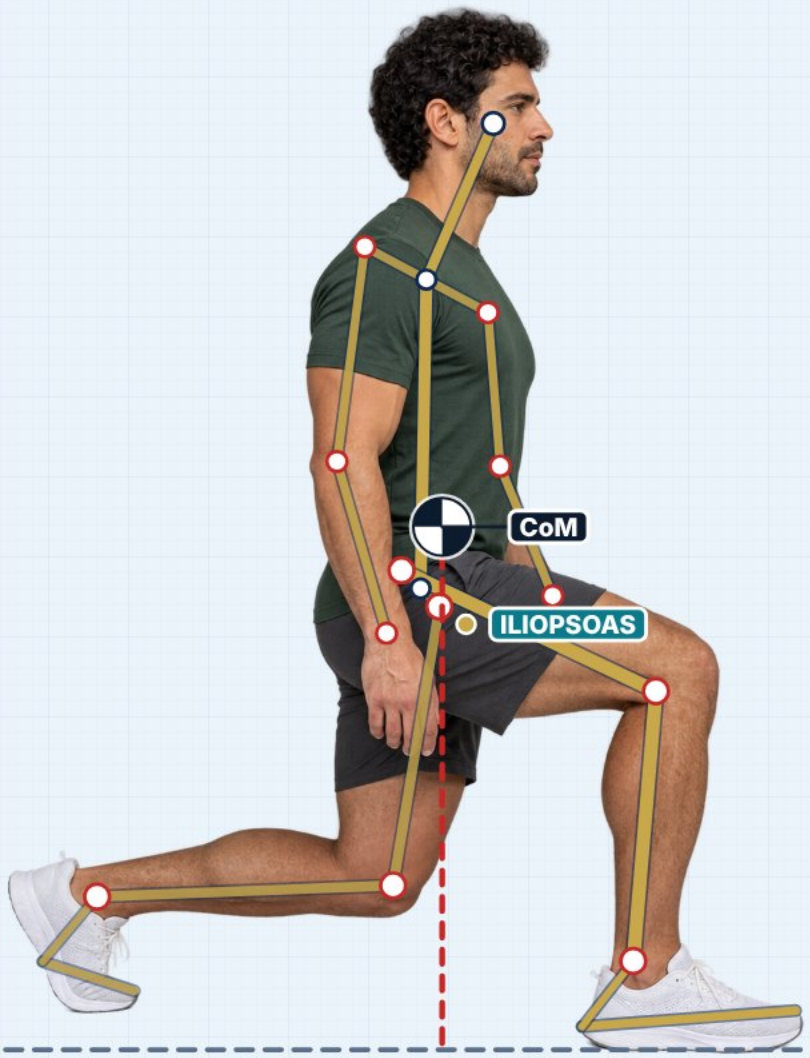
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C · LUNGE TO STAND, SIDE



EYE-OPENER

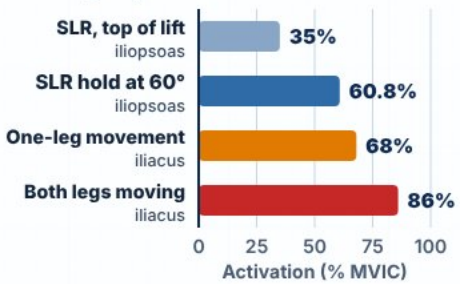
1 in 3 snapping hips had no cause identified on ultrasound; clinical examination still matters.

Winston et al. (2007).

Painful snap? Change the load

- Rising from a lunge moves the hip from extension into flexion, the arc in which an internal snap often occurs.
- Conservative care comes first: grade hip flexor work from low to higher activation and adjust painful ranges.

Grading hip flexor load



Review of 9 studies, 109 healthy adults aged 20–40; values from the original studies. Juan 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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A · Leg circle Internal

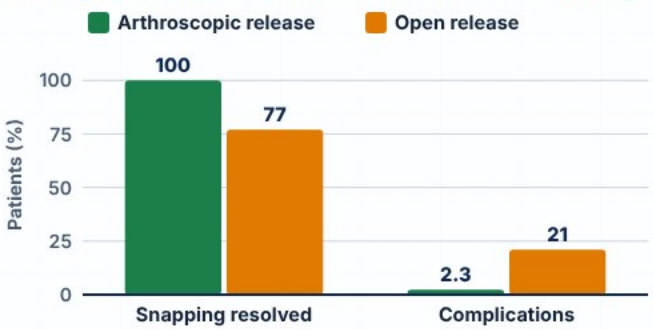


B · Outer hip External



C · Lunge Load

If surgery is needed for painful internal snapping



Systematic review, 11 studies, 248 patients; case series only (level IV), non-randomised. Khan et al. (2013).

Decision pathway

1. **REASSURE**
   A painless click is common and not an injury; most dancers with snapping lost no dance time.
2. **EXAMINE**
   If snapping hurts or limits activity, examine the whole hip, including the joint, not only the tendon.
3. **LOAD, THEN REFER**
   Graded conservative care first; consider surgery only for persistent painful snapping.

NOT RECOMMENDED

Treating a painless click as an injury, or offering surgery before a full course of conservative care.

SEEK ASSESSMENT IF

Snapping becomes painful and limits activity, or catching, locking or giving way; or a fall, fever, night pain or inability to bear weight.

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HIP-RELATED GROIN PAIN IN SPORT: WHAT MAKES IT DIFFERENT

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A · CHANGE OF DIRECTION, FRONT



EYE-OPENER

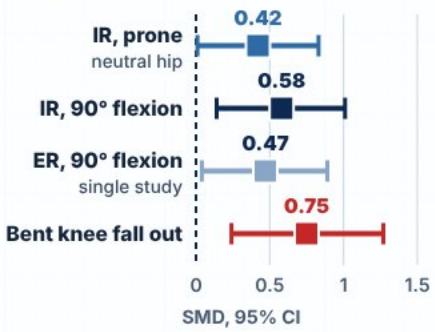
54.8% of pain-free athletes have a cam-shaped hip on imaging, versus 23.1% of the general population.

Review of 26 studies, 2114 asymptomatic hips. Frank et al. (2015).

Cutting loads the hip joint

- Planting and turning combines hip flexion with rotation, the positions that provoke pain from the joint itself (impingement, labrum, synovitis).
- Pain from the hip joint should always be considered in groin pain, alongside adductor, iliopsoas, inguinal and pubic sources.

Painful hips move a little less



Mean differences: only 2.6–3.8° of rotation, or 3.6 cm.

Athletes with vs without hip/groin pain; 17 studies. IR/ER = internal/external rotation. Mosler 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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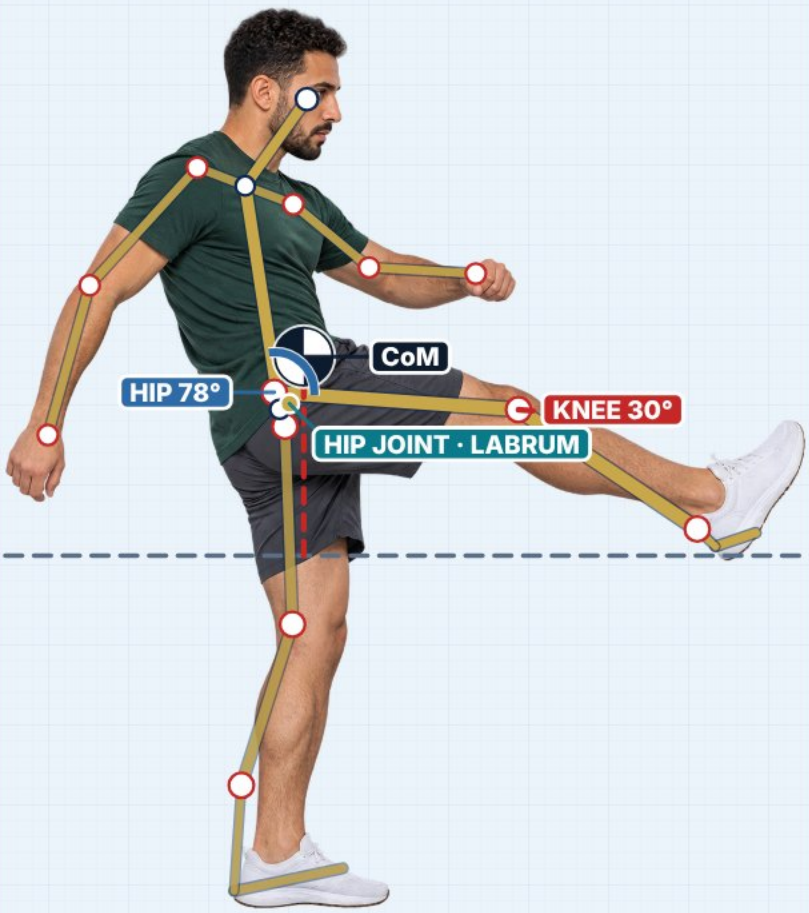
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B · KICK FOLLOW-THROUGH, SIDE



EYE-OPENER

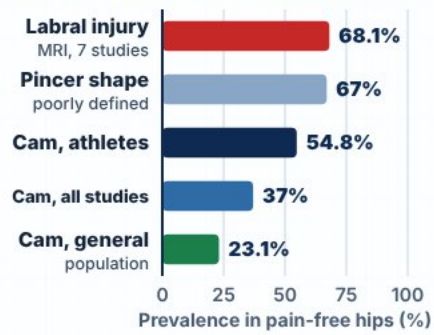
3–4% of time-loss hip and groin injuries in men's pro football were hip-joint related.

Approximate range. Werner et al. (2019).

Shape is not a diagnosis

- The kicking hip swings into deep flexion (≈**78°** from the trunk line here), where a cam shape meets the socket rim.
- Yet cam, pincer and labral findings are common in hips that do not hurt; imaging alone cannot explain the pain.

Findings in people without hip pain



26 studies, 2114 asymptomatic hips, mean age 25.3 years. Frank 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.

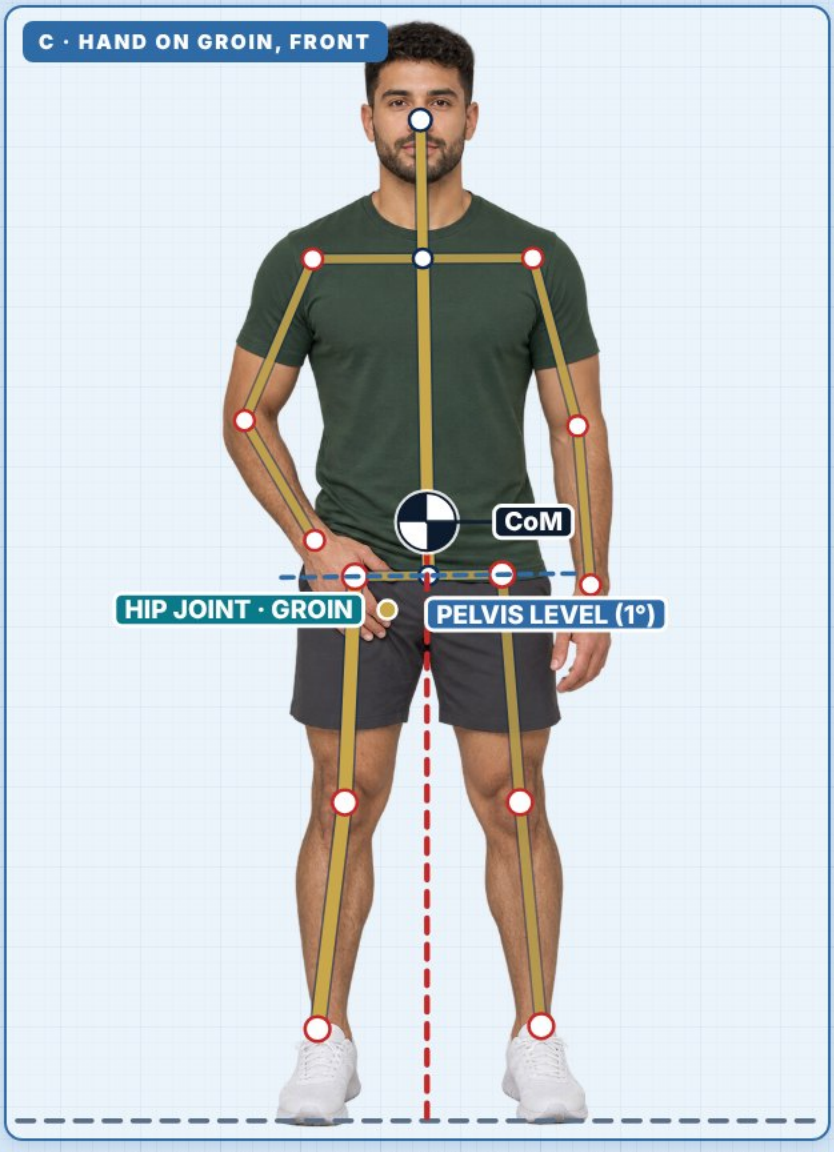
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EYE-OPENER

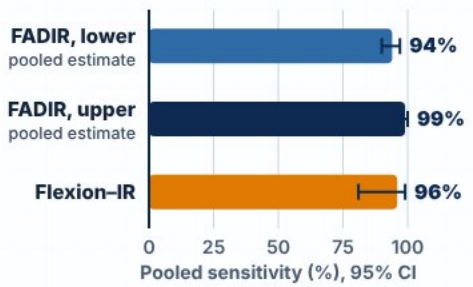
6 days mean lay-off for hip-joint injuries in pro football, versus 16 days for hip and groin overall.

Werner et al. (2019).

Tests rule out, not in

- Hand on the groin crease, pelvis level (1°): examine passive range, FABER and FADIR in every athlete with groin pain.
- A negative FADIR makes joint pathology less likely; a positive test does not confirm it (wide odds-ratio intervals).

FADIR: highly sensitive, so a negative helps



Femoroacetabular impingement / labral tear, meta-analysis. Reiman et al. (2015).

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A · Cutting Rotation

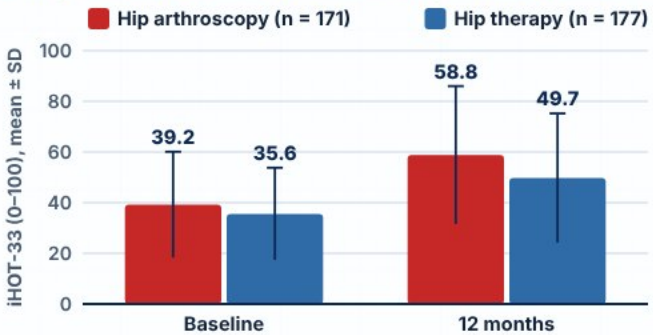


B · Kicking Deep flexion



C · Groin Examine

Surgery vs hip therapy for impingement syndrome



UK FASHIoN RCT; adjusted difference 6.8 points (95% CI 1.7 to 12.0); adverse events 72% vs 60%. Griffin et al. (2018).

Decision pathway

1. **EXAMINE**
   Test hip range, FABER and FADIR in every athlete with groin pain; use negative tests to rule out.
2. **COMBINE**
   Diagnose from symptoms, examination and imaging together, never from a cam or labral finding alone.
3. **TREAT**
   Both hip therapy and arthroscopy improved quality of life; surgery added a modest benefit with more adverse events.

NOT RECOMMENDED

Diagnosing from imaging alone: cam, pincer and labral findings are common in pain-free hips.

SEEK ASSESSMENT IF

Inability to bear weight, night pain or pain after a rise in running load (possible stress fracture); a child or teenager with hip or knee pain and a limp.

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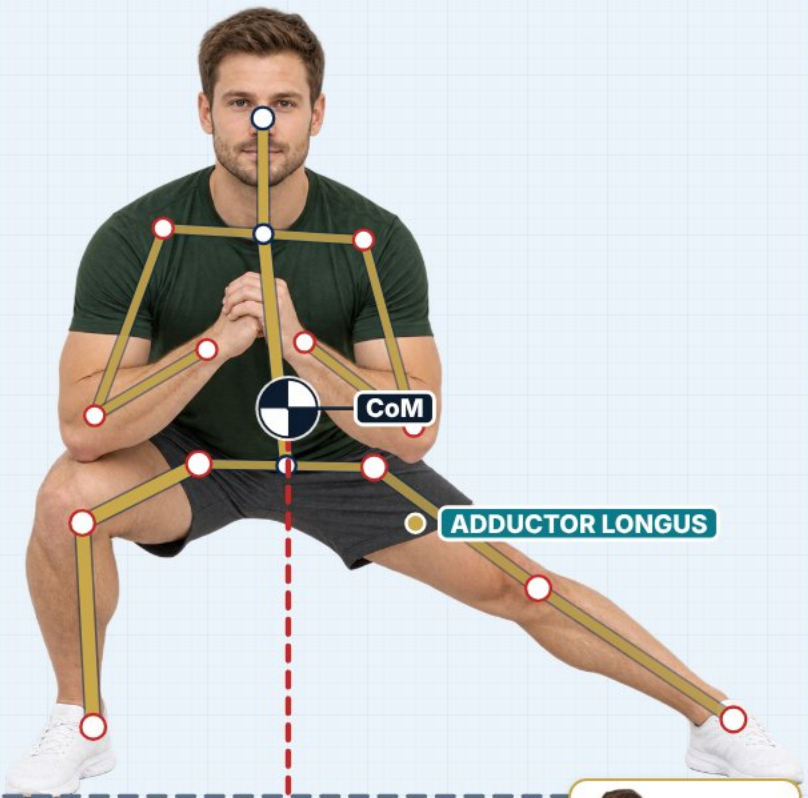
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GROIN PAIN IN FOOTBALLERS: ADDUCTOR, HIP, INGUINAL OR PUBIC?

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A · SIDE LUNGE, FRONT





EYE-OPENER

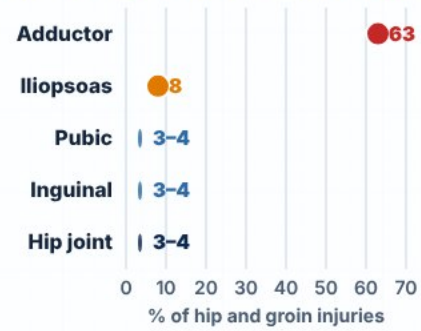
14% of all time-loss injuries in men's professional football are in the hip and groin.

1812 of 12 736 injuries, 47 teams. Werner et al. (2019).

Adductors take the most

- The side lunge stretches and loads the adductors of the straight leg, the commonest source of groin pain in football.
- Adductor-related pain means adductor tenderness plus pain on resisted adduction testing.

Which entity? Pro football injuries



268 team seasons, 2001/02–2015/16; bars show the approximate 3–4% range. Werner 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). Educational, not diagnostic.

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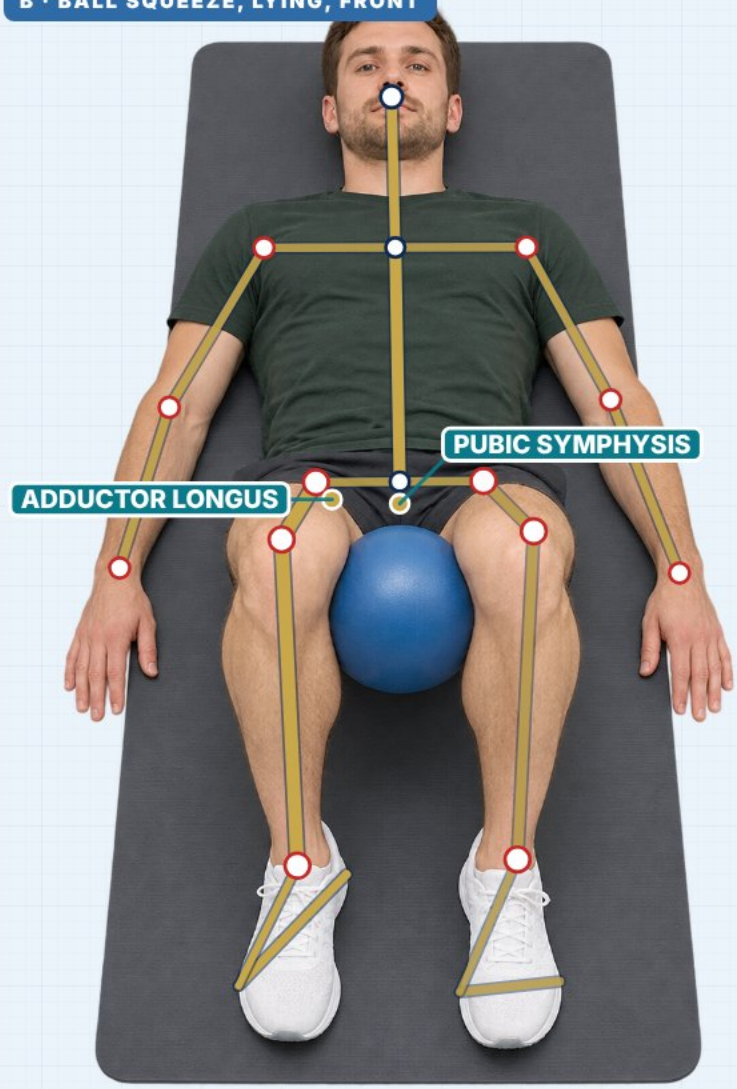
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B · BALL SQUEEZE, LYING, FRONT



EYE-OPENER

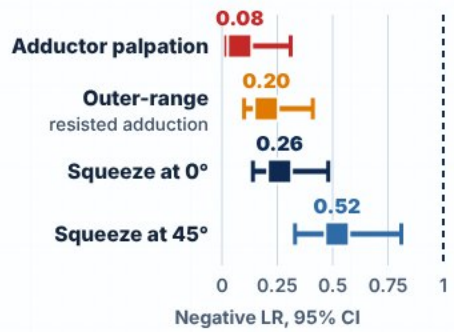
9% chance of an acute adductor injury after pain-free adductor palpation, down from 57%.

81 athletes, MRI reference. Ishøi et al. (2020).

The squeeze test

- Squeezing a ball between the knees tests adductor strength and pain; a weak or painful squeeze is one of the clearest signs of groin pain.
- A pain-free test is more useful than a painful one: it makes an adductor injury less likely.

Which tests rule out best (lower = better)



81 athletes with acute groin injury; pre-test probability 57%. Ishøi et al. (2020).

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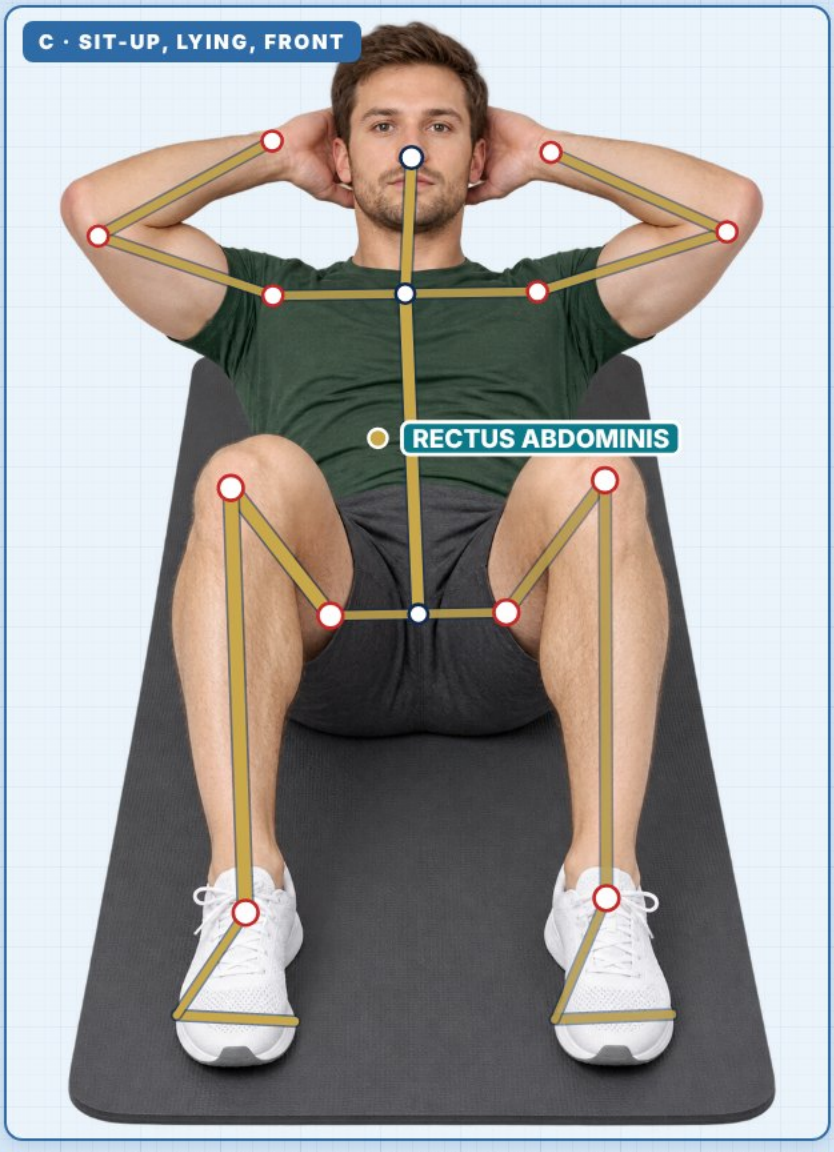
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EYE-OPENER

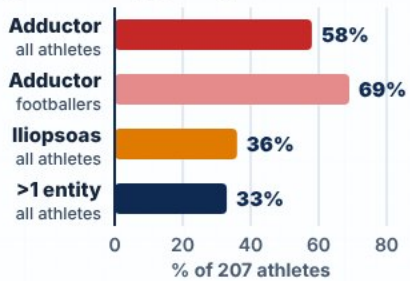
71% is the upper figure for positive groin MRI findings in footballers with no symptoms.

Branci et al. (2015).

Inguinal and pubic: check the midline

- Sit-ups load the abdominal wall where it attaches near the pubic bone and inguinal canal, sources of inguinal- and pubic-related pain.
- Classify by examination: canal tenderness without a hernia, or local tenderness over the pubic symphysis.

Long-standing groin pain: often mixed



Primary entity and overlap, 207 athletes. Hölmich (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). Lying pose: skeleton only, no angles measured. Educational, not diagnostic.

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

INTEGRATING PERFORMANCE & REHABILITATION HEALTHCARE PATHWAYS.

GROIN PAIN IN FOOTBALLERS: ADDUCTOR, HIP, INGUINAL OR PUBIC?

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A · Side lunge Adductor

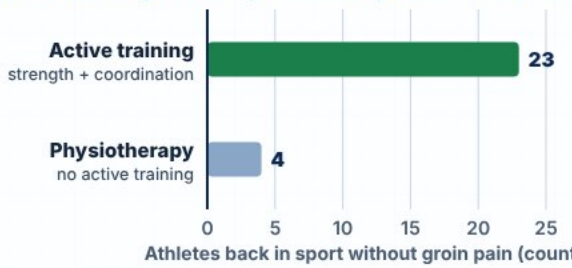


B · Squeeze Test



C · Sit-up Inguinal/pubic

Active training for long-standing adductor pain



68 athletes randomised; 4-month follow-up; OR 12.7 (95% CI 3.4 to 47.2). Group sizes not in the abstract. Hölmich et al. (1999).

Decision pathway

1. **CLASSIFY**
   Name the entity by examination: adductor, iliopsoas, inguinal, pubic or hip; always examine the hip.
2. **STRENGTHEN**
   Long-standing adductor pain: 8–12 weeks of active adductor and pelvic strengthening.
3. **PREVENT**
   Adductor strengthening based on the Copenhagen adduction exercise reduced groin problems (OR 0.59).

NOT RECOMMENDED

Relying on MRI to name the entity, or resting passively and hoping long-standing groin pain settles.

SEEK ASSESSMENT IF

A groin lump on coughing or one that will not go back, testicular pain or swelling, fever, urinary symptoms or inability to bear weight.

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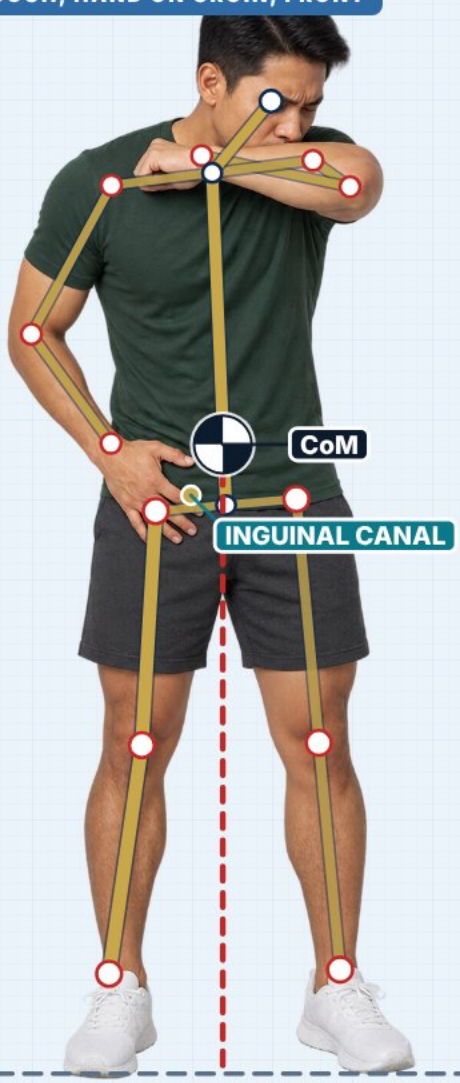
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INTEGRATING PERFORMANCE & REHABILITATION HEALTHCARE PATHWAYS.

SPORTS HERNIA (INGUINAL-RELATED GROIN PAIN): WHAT THE TERM REALLY MEANS

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A · COUGH, HAND ON GROIN, FRONT





OTHER VIEW

EYE-OPENER

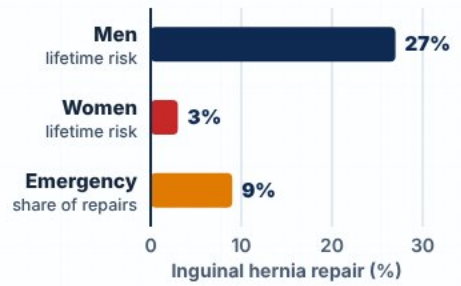
85% of athletes with inguinal disruption had posterior inguinal wall weakness (upper figure).

Consensus statement. Sheen et al. (2014).

Cough pain without a lump

- Pain in the inguinal canal on coughing, with canal tenderness and no palpable hernia, defines inguinal-related groin pain.
- A bulge that appears on coughing is a different problem: a true hernia, which needs a surgical opinion.

A true hernia is a different problem



Population data on inguinal hernia repair. Primatesta & Goldacre (1996).

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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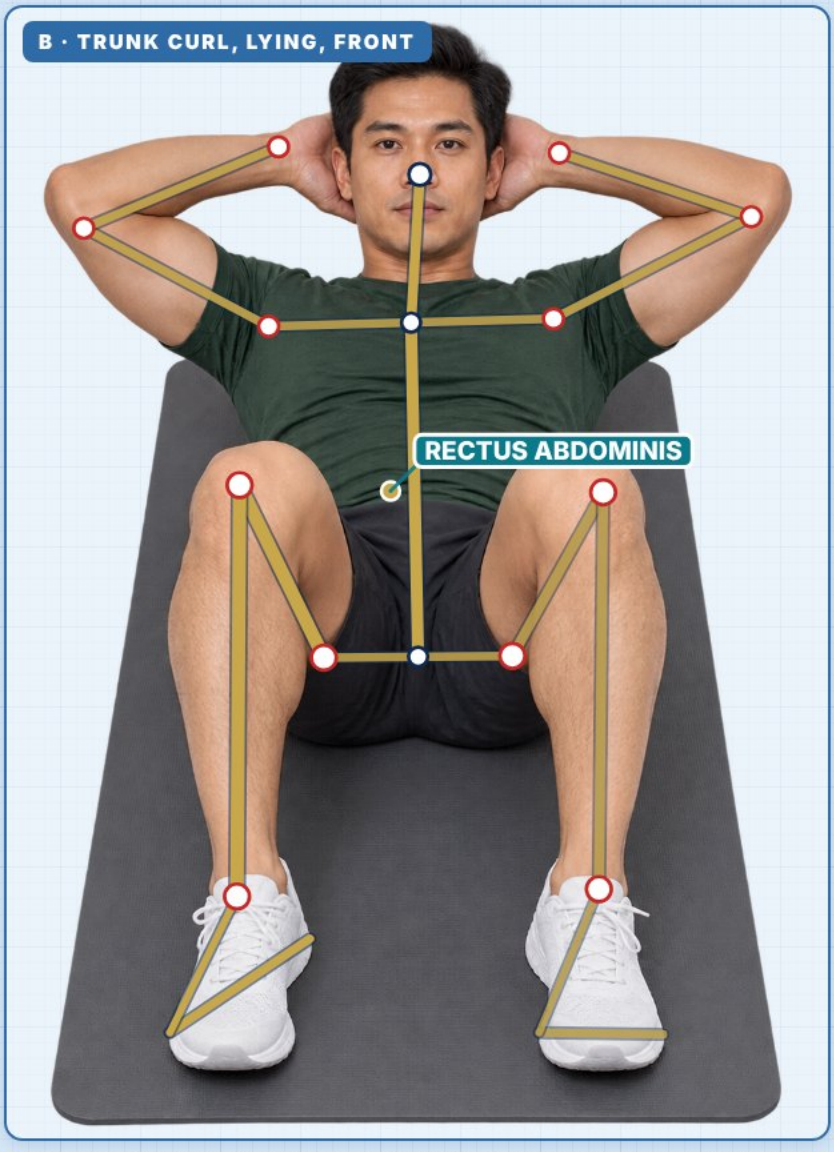
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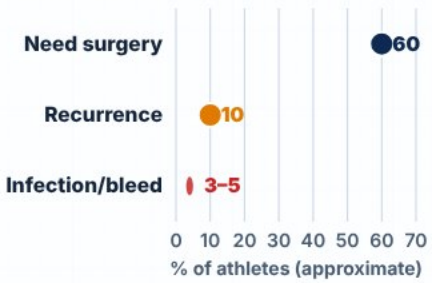
3 of 5 clinical signs are enough to diagnose inguinal disruption; no scan can rule it in or out.

British Hernia Society consensus. Sheen et al. (2014).

Not a hernia: "inguinal disruption"

- Trunk curls pull the abdominal wall on its attachments near the groin; pain here fits inguinal-related groin pain.
- Experts advise against the term "sports hernia" because no true hernia is present.

Consensus figures



Manchester consensus; approximate values. Full return after surgery 4–8 weeks. Sheen et al. (2014).

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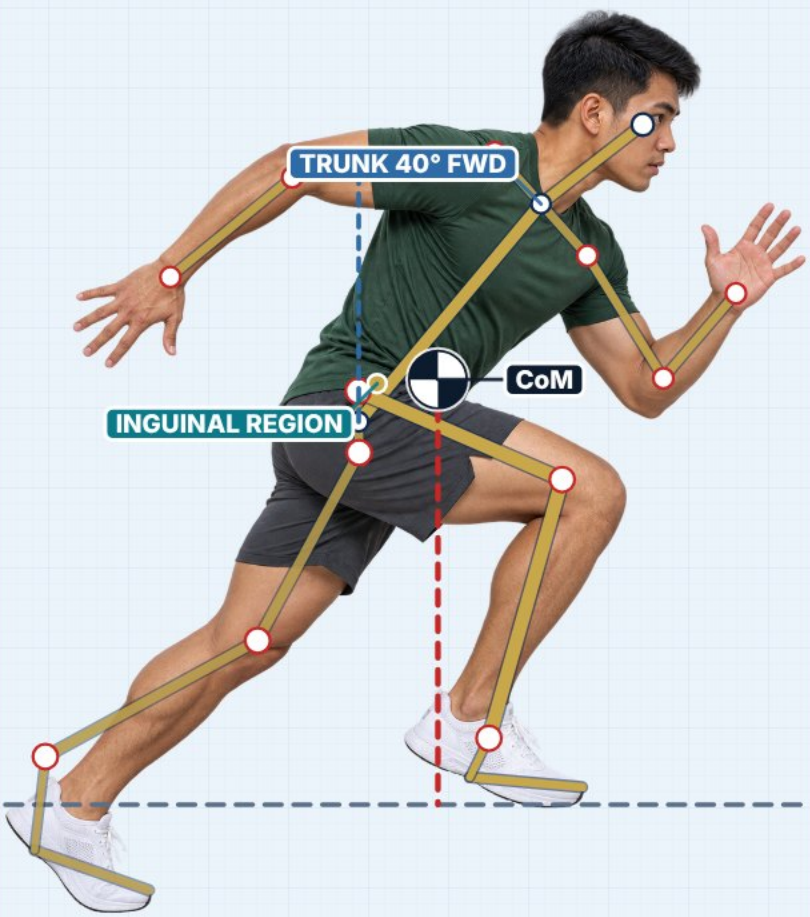
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C · SPRINT START, SIDE



EYE-OPENER

4 wks median return to sport after laparoscopic repair in published surgical series.

28 days; case series. Paajanen et al. (2015).

Acceleration loads the groin

- Sprint starts combine forward trunk lean (≈**40°** here) with a hard knee drive, loading the lower abdominal wall and groin.
- Physiotherapy is the first treatment; surgery is considered when conservative care fails.

Laparoscopic repair in the literature



Systematic review; case series, not comparisons with exercise. Paajanen 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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A · Cough Hernia?

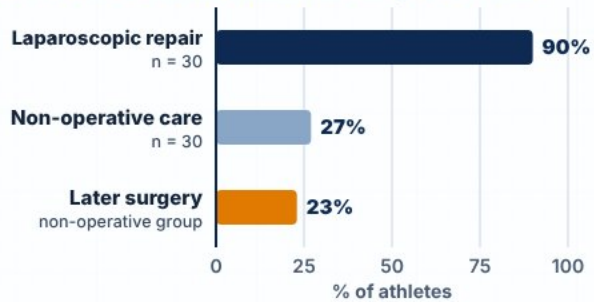


B · Trunk curl Load



C · Sprint Return

Return to sport at 3 months: surgery vs not



60 athletes with 3–6 months of groin pain, randomised. Paajanen et al. (2011).

Decision pathway

1. **CHECK**
   Feel for a hernia: a true lump needs a surgeon; canal tenderness without one is inguinal-related pain.
2. **REHABILITATE**
   Physiotherapy first; surgery is not always required, and MRI mainly excludes other causes.
3. **REFER**
   If conservative care fails, surgical repair is an option; in one trial more athletes returned by 3 months.

NOT RECOMMENDED

Calling the condition a "hernia" when no hernia is present, or operating before trying physiotherapy.

SEEK ASSESSMENT IF

A groin lump that will not go back, sudden severe groin pain with vomiting, testicular pain or swelling, fever or urinary symptoms.

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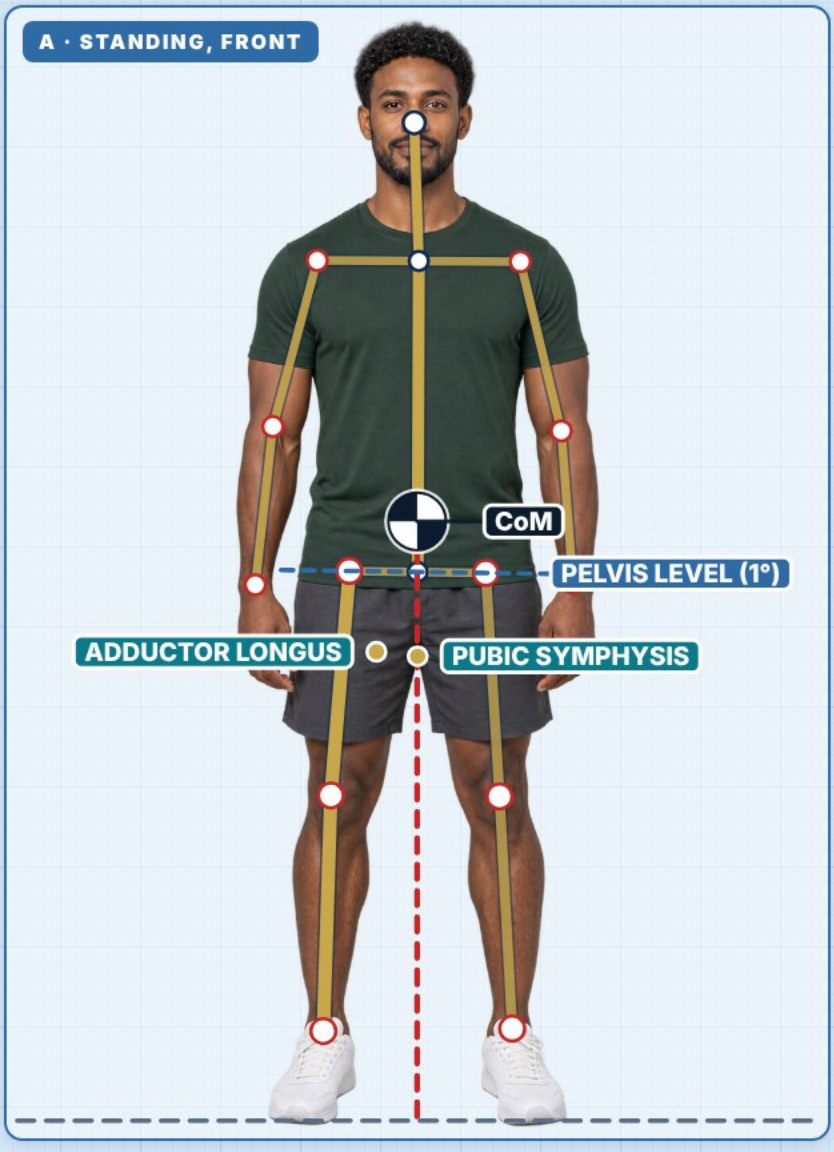
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PUBIC BONE PAIN: OSTEITIS PUBIS AND PUBIC-RELATED GROIN PAIN

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EYE-OPENER

186/195 athletes diagnosed with osteitis pubis across 25 published articles were men.

Systematic review; 9 were women. Choi et al. (2011).

The joint at the front of the pelvis

- The pubic symphysis joins the two pubic bones; adductor and abdominal tendons attach right next to it, so their pull meets here.
- Pubic-related groin pain is defined by local tenderness of the symphysis and adjacent bone on examination (Doha agreement).

Pubic pain is the rarer groin entity



Men's professional football, UEFA Elite Club Injury Study. Werner 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). Pelvis line joins the two hip landmarks in the front view. Educational, not diagnostic.

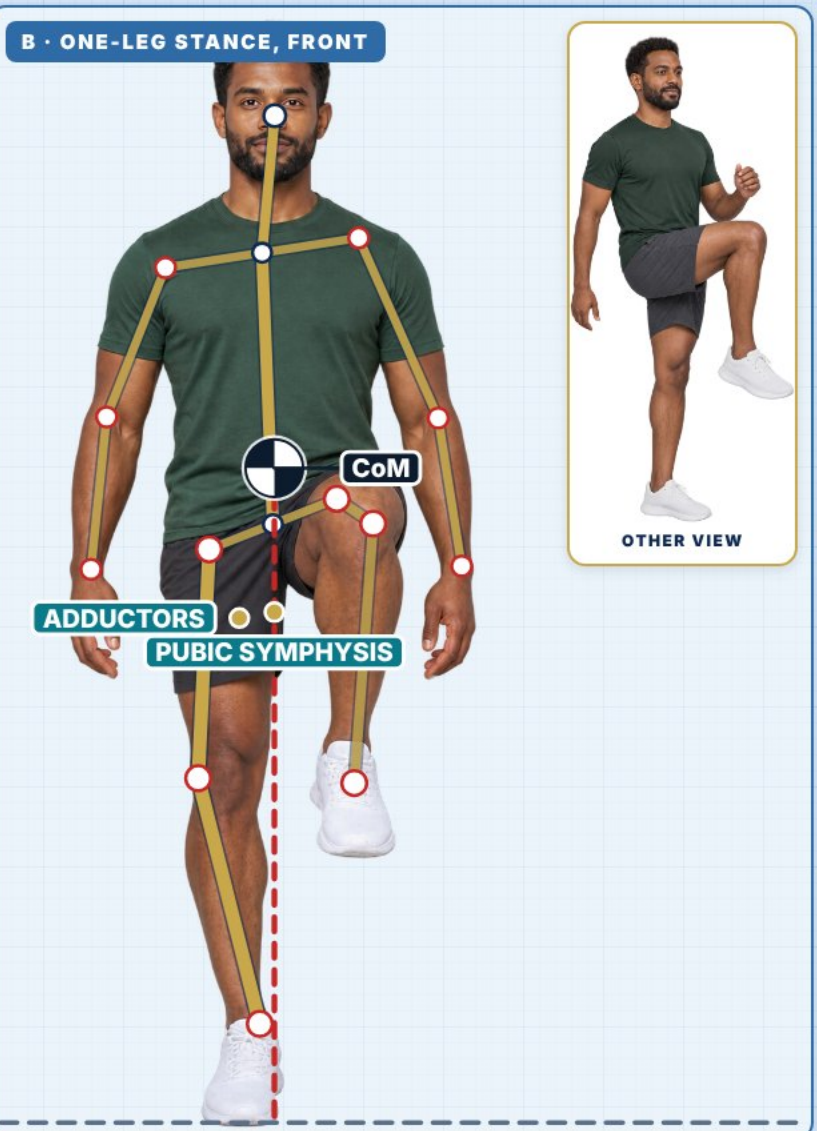
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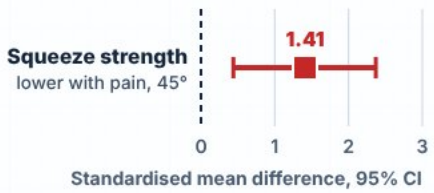
4.3× higher odds of pain on the adductor squeeze test in athletes with hip or groin pain.

OR 4.31 (95% CI 1.86 to 10). Mosler et al. (2015).

One-leg loading meets the symphysis

- Standing on one leg shifts load across the pubic symphysis, and the adductors that steady the pelvis attach beside it.
- Squeeze strength and pain on squeezing are simple markers to track while loading is built back up.

Adductor squeeze strength is lower



Athletes with vs without hip/groin pain; meta-analysis. Mosler et al. (2015).

Key point: these are associations in athletes with hip and groin pain in general, not a test that proves the pubic bone is the source.

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.

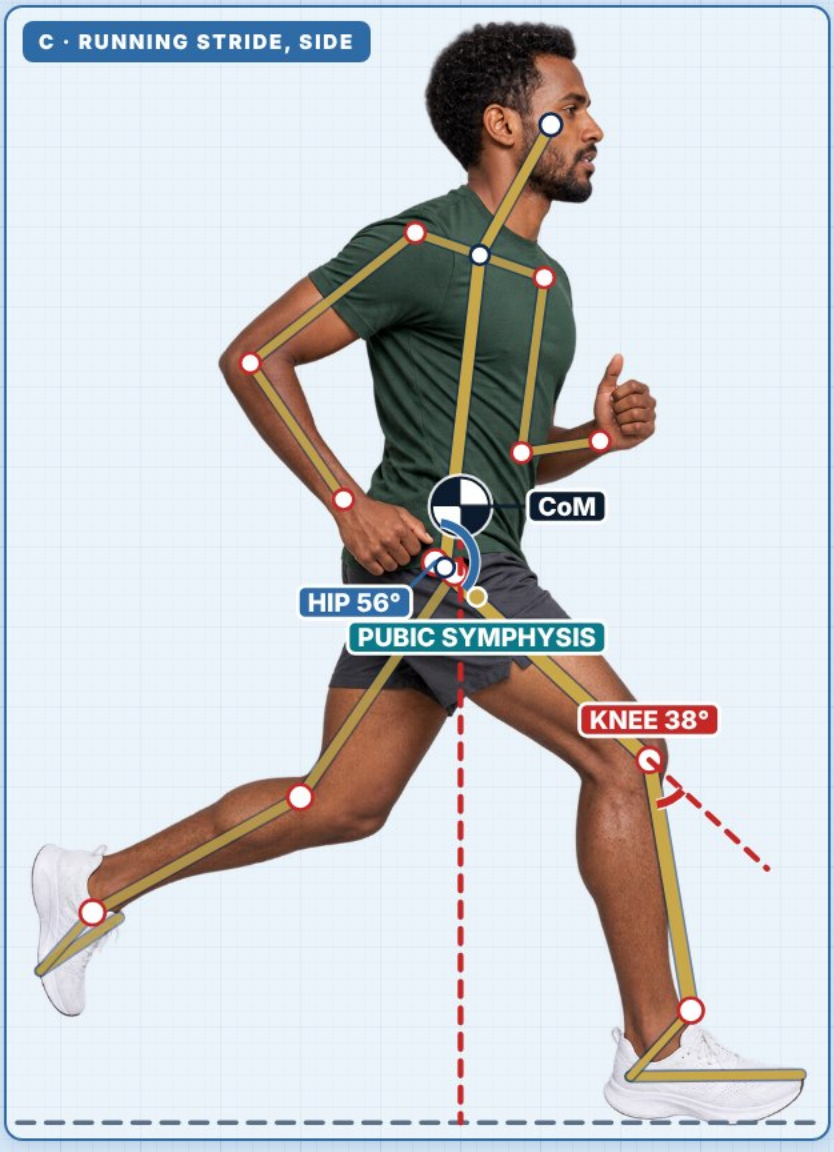
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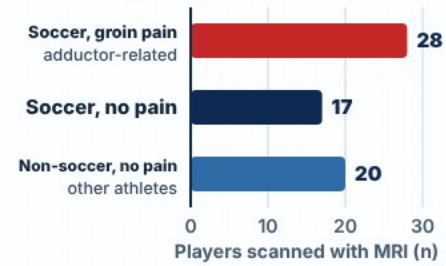
71% of pain-free soccer players had positive MRI findings around the pubic bone and groin.

Up to 71% of 17 asymptomatic players. Branci et al. (2015).

Running and kicking load the pubis

- In this stride the hip is ≈**56°** flexed and the knee ≈**38°**: repeated sprinting and kicking cycle the trunk and adductor pull across the symphysis.
- Bone marrow oedema on MRI is common in footballers and is often a sign of load, not proof of the pain source.

Three groups were compared



Cross-sectional MRI study. Branci et al. (2015).

Myth: "Oedema on the scan proves the pubic bone is the problem." Only central disc protrusion and higher-grade oedema differed with pain.

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.

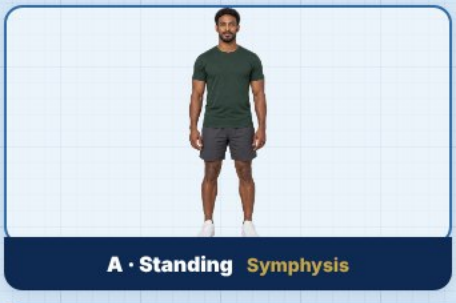
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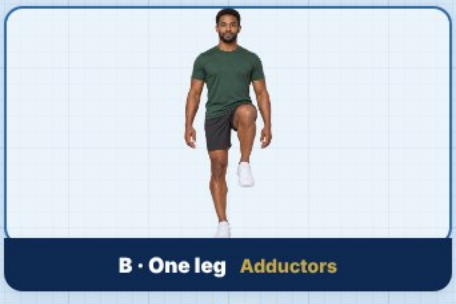
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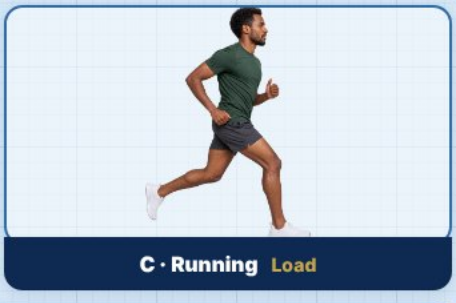
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A · Standing Symphysis

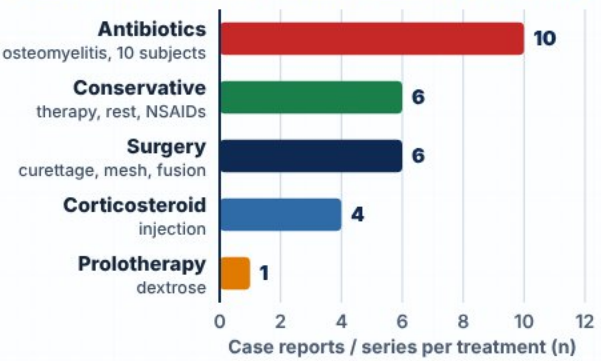


B · One leg Adductors



C · Running Load

Treatment evidence is thin: case reports only



Level 4 evidence only; no comparative studies. Choi et al. (2011).

Decision pathway

1. **EXAMINE**
   Classify by examination: pubic-related pain means local tenderness of the symphysis and adjacent bone.
2. **MONITOR**
   Track squeeze strength and squeeze pain as running and kicking are rebuilt.
3. **LOAD**
   Conservative care is reported most; injections and surgery rest only on case reports.

NOT RECOMMENDED

Treating MRI bone marrow oedema alone; it is common in pain-free footballers.

SEEK ASSESSMENT IF

Pubic pain with fever, feeling unwell or rapidly worsening pain (possible infection), or a suspected pubic ramus stress fracture.

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GLUTE MEDIUS WEAKNESS: HIP DROP AND THE SINGLE-LEG STANCE

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EYE-OPENER

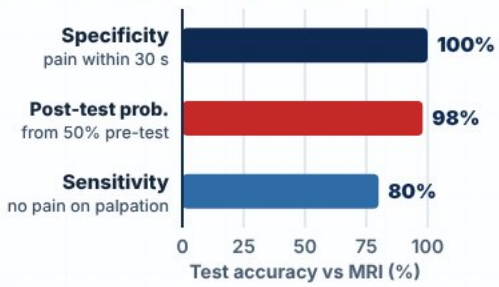
≈12× positive likelihood ratio when 30 s of one-leg standing provokes outer-hip pain.

For MRI-confirmed gluteal tendinopathy. Grimaldi et al. (2017).

One leg, one set of abductors

- Standing on the right leg, gluteus medius and minimus must hold the pelvis level; here the trunk stays within **≈2°** of upright.
- Timing the stance to 30 s turns a simple balance task into a useful test for lateral hip tendon pain.

The 30-second single-leg test



65 people with lateral hip pain; small sample. Grimaldi 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). Trunk lean: shoulder-centre to hip-centre line vs vertical. Educational, not diagnostic.

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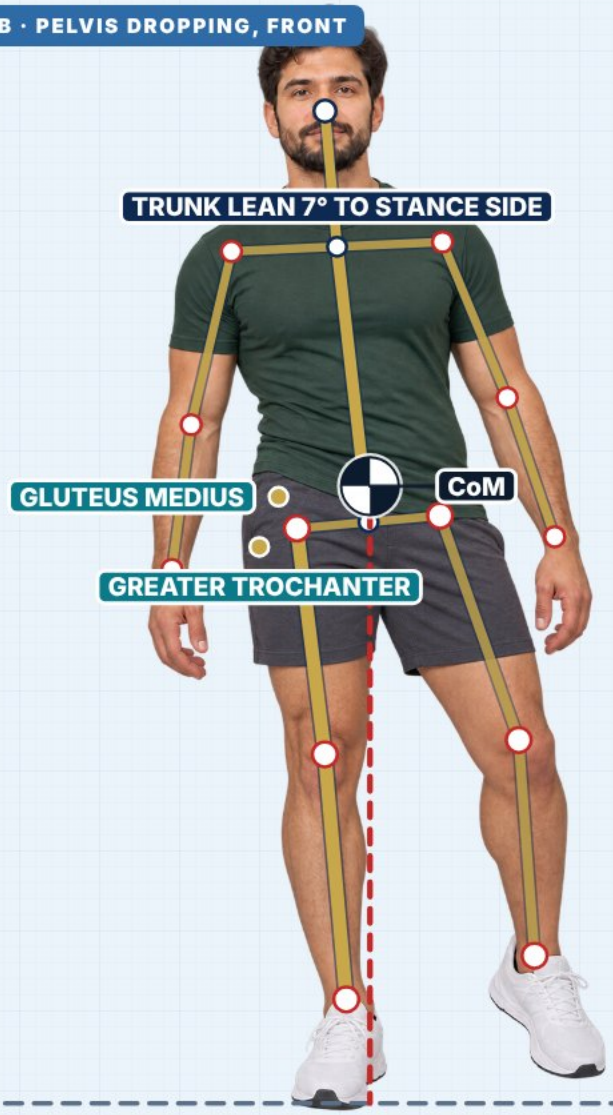
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B · PELVIS DROPPING, FRONT



EYE-OPENER

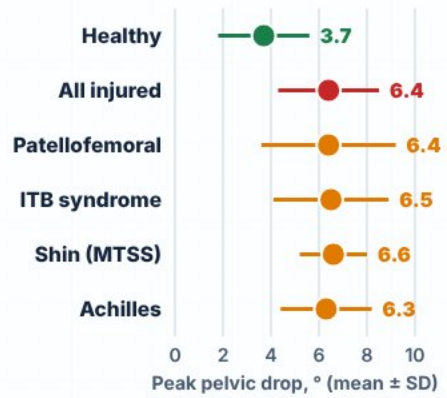
1.87× higher odds of being in the injured group for every extra degree of pelvic drop.

Runners at midstance; OR 1.87 (95% CI 1.41 to 2.49). Bramah et al. (2018).

When the free side sags

- If the abductors cannot hold the load, the pelvis drops on the lifted side or the trunk shifts over the stance leg (≈**7°** here).
- Runners with four common injuries showed only a few degrees more drop than healthy runners; small angles matter.

Pelvic drop in injured runners



72 injured and 36 healthy runners; cross-sectional. 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). Trunk lean: shoulder-centre to hip-centre line vs vertical; pelvis angle not quoted because the lifted-leg hip landmark is unreliable. Educational, not diagnostic.

DOI 10.5281/zenodo.23735806

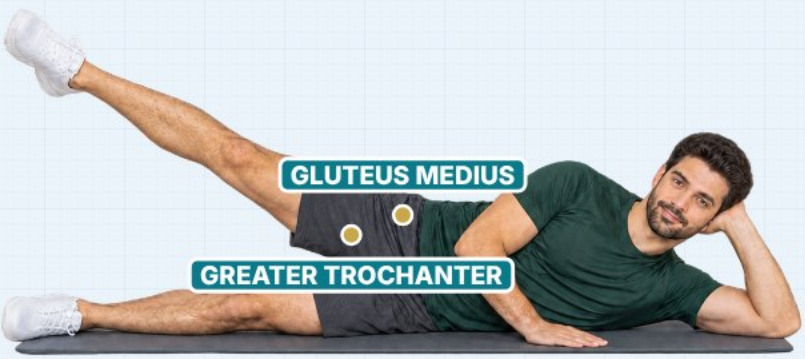
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INTEGRATING PERFORMANCE & REHABILITATION HEALTHCARE PATHWAYS.

GLUTE MEDIUS WEAKNESS: HIP DROP AND THE SINGLE-LEG STANCE

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C · SIDE-LYING ABDUCTION



EYE-OPENER

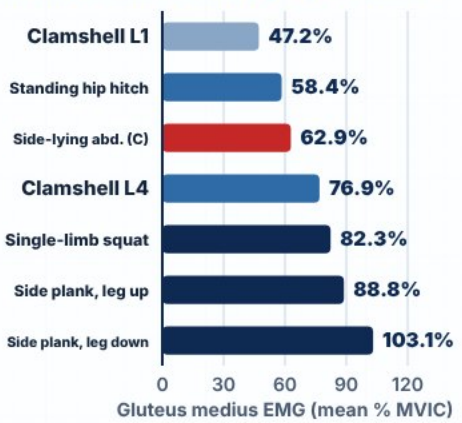
77% of people with gluteal tendinopathy reported success after 8 weeks of education plus exercise.

51 of 66, vs 20 of 68 (29%) with wait-and-see. Mellor et al. (2018).

A moderate, not maximal, exercise

- Lifting the top leg in side-lying works gluteus medius against leg weight; toes forward limits hip flexor take-over.
- Single-leg and side-plank variants demand more, so they suit later stages.

Gluteus medius activity by exercise



26 healthy adults; abduction with dominant leg up/down; means only. Boren 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). No angles are quoted for this lying pose. Educational, not diagnostic.

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A · Level Stance

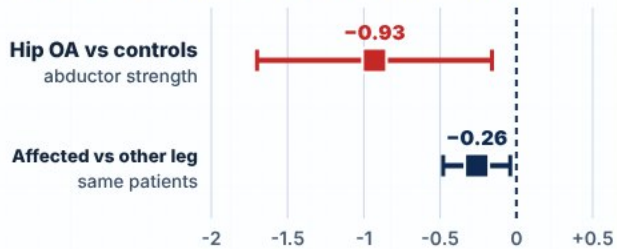


B · Dropping Hip drop



C · Side-lying 62.9% MVIC

Abductors are weaker in hip osteoarthritis



Systematic review and meta-analysis, 22 studies. Marshall et al. (2016).

Decision pathway

1. **TEST**
   Time single-leg stance to 30 s and note any outer-hip pain, pelvic drop or trunk shift.
2. **CHOOSE**
   Start with side-lying or standing work, then progress to single-limb squat and side-plank variants.
3. **REVIEW**
   For gluteal tendinopathy, pair education with progressive exercise rather than relying on injection.

NOT RECOMMENDED

Treating pelvic drop as the cause of every injury; the running evidence is cross-sectional.

SEEK ASSESSMENT IF

New, marked hip drop after surgery, a fall or a sudden "pop", or weakness with back pain, numbness or leg symptoms.

REFERENCES (APA 7)

Boren, K., Conrey, C., Le Coguic, J., Paprocki, L., Voight, M., & Robinson, T. K. (2011). Electromyographic analysis of gluteus medius and gluteus maximus during rehabilitation exercises. *International Journal of Sports Physical Therapy, 6*(3), 206–223.

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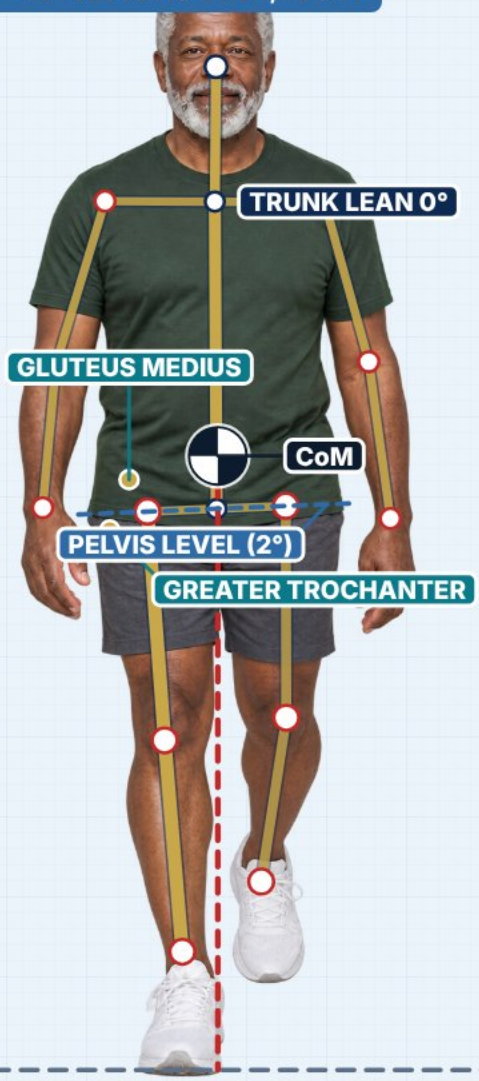
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TRENDELENBURG GAIT: WHAT A DIPPING PELVIS TELLS YOU

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A · LEVEL PELVIS WALK, FRONT





OTHER VIEW

EYE-OPENER

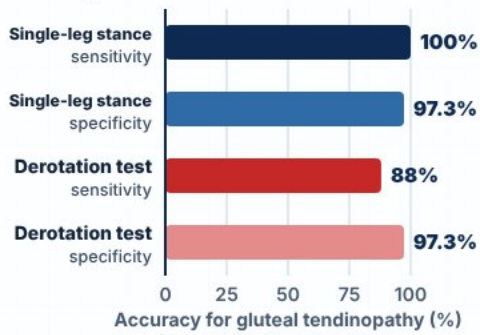
11/24 women with outer-hip pain syndrome had a gluteus medius tear on MRI.

45.8% of a small MRI series. Bird et al. (2001).

A level pelvis in stance

- Right foot in stance: the abductors on that side hold the pelvis level (**2°** here) and the trunk upright (**0°** lean).
- Holding single-leg stance for 30 s, timed, was a strong test for tendon pain in refractory outer-hip pain.

Two simple bedside tests



17 patients with MRI-documented refractory trochanteric pain plus controls; small study. Lequesne 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). Pelvis line joins the two hip landmarks; trunk lean is the shoulder-centre to hip-centre line vs vertical. Educational, not diagnostic.

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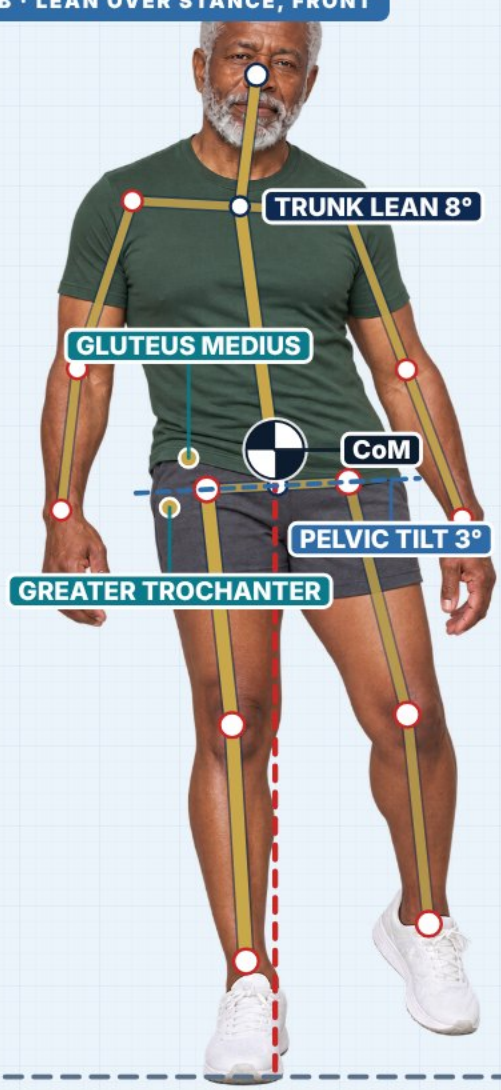
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B · LEAN OVER STANCE, FRONT





OTHER VIEW

EYE-OPENER

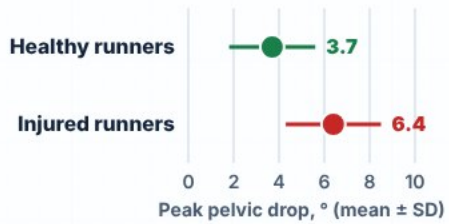
1.87× higher odds of injury group membership per extra degree of pelvic drop in running.

OR 1.87 (95% CI 1.41 to 2.49); running, not walking. Bramah et al. (2018).

Dip or lean: two faces of one sign

- Here the trunk leans ≈**8°** over the stance leg (vs **0°** in A): a compensated Trendelenburg that shortens the body-weight lever arm about the stance hip.
- The pelvis line sits **3°** off level; both a dipping pelvis and a trunk lean point to reduced abductor capacity or tendon pain.

Small angles separate groups



Measured in running, not walking; cross-sectional. Bramah et al. (2018).

Myth: "A positive Trendelenburg sign proves a torn tendon." About one in four people without a tear still test positive.

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). Pelvis line joins the two hip landmarks; trunk lean is the shoulder-centre to hip-centre line vs vertical. Educational, not diagnostic.

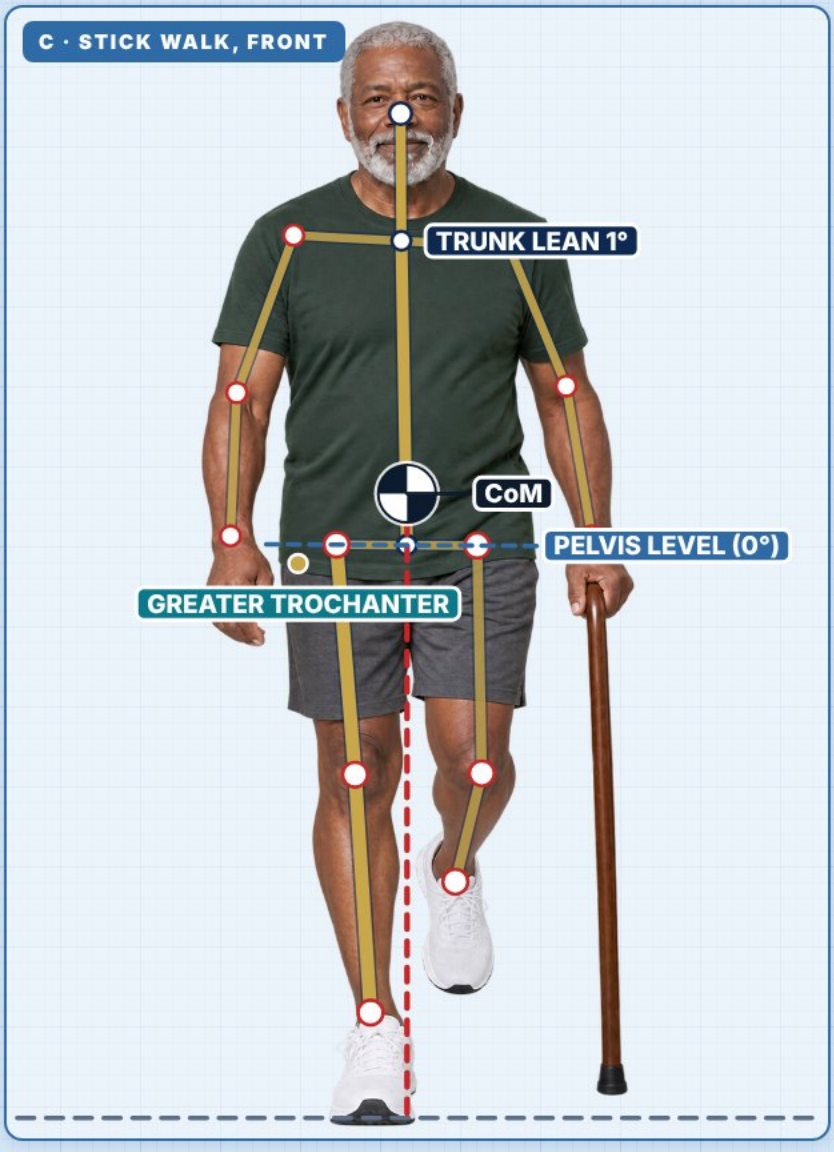
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EYE-OPENER

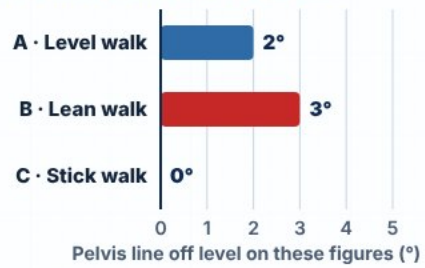
8° → 1° measured trunk lean in Frame B vs this frame, with the stick in the opposite hand.

Measured on these illustrated figures; not study data.

The stick goes in the opposite hand

- Right foot in stance, stick in the left hand: the stick shares the load the right abductors must resist, so the trunk stays near upright (**1°**).
- Held on the painful side, a stick cannot help the abductors in the same way; ask a clinician to set its height.

Pelvis line on the three figures



Measured frame values from pose landmarks; educational, not study data.

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). Pelvis line joins the two hip landmarks; trunk lean is the shoulder-centre to hip-centre line vs vertical. Educational, not diagnostic.

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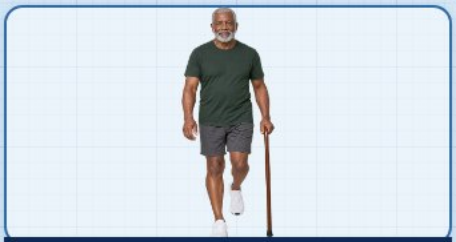
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A · Level Abductors

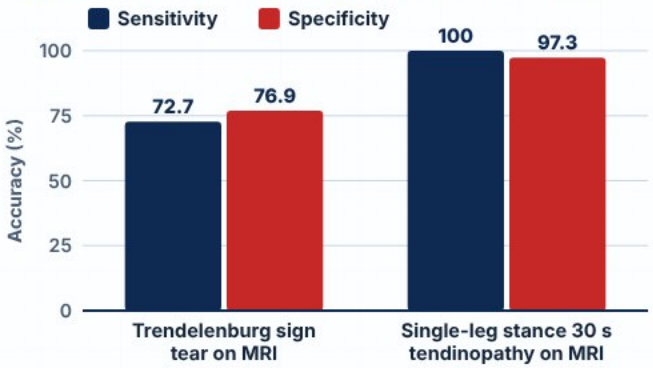


B · Lean Compensated



C · Stick Offloads

Watching the dip is not enough: time the stance



Different patients and reference standards: 24 women with GTPS, Bird et al. (2001); 17 refractory cases, Lequesne et al. (2008).

Decision pathway

1. **WATCH**
   Look for a pelvic dip or a trunk lean over the stance leg during walking.
2. **TEST**
   Time single-leg stance to 30 s and palpate the greater trochanter; do not rely on the visual sign alone.
3. **TREAT**
   For gluteal tendinopathy, use education plus progressive exercise; a stick in the opposite hand can offload painful days.

NOT RECOMMENDED

Calling a tendon torn from a positive Trendelenburg sign alone.

SEEK ASSESSMENT IF

A new Trendelenburg gait after hip replacement, a fall or sudden injury, or with back pain, numbness, progressive weakness or inability to bear weight.

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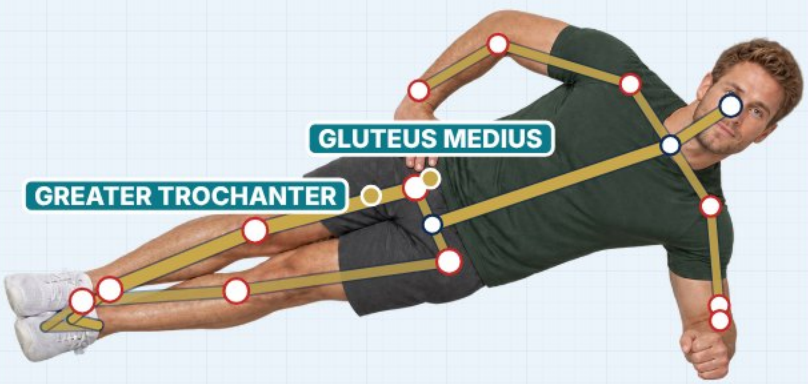
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HIP ABDUCTOR STRENGTH: THE EXERCISE EVIDENCE FOR HIP PAIN

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A · SIDE PLANK, FRONT





EYE-OPENER

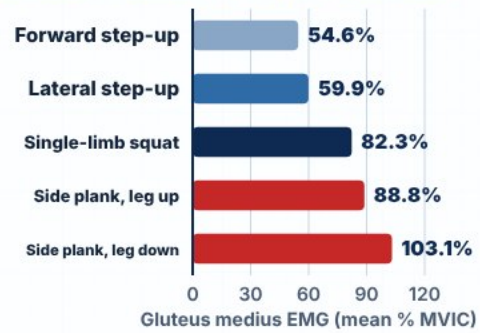
NNT 2 treat two people with education plus exercise for one extra success vs wait-and-see.

Gluteal tendinopathy, 8 weeks; 95% CI 1.6 to 2.9. Mellor et al. (2018).

The side plank: top-tier abductor load

- Body weight is held sideways on the forearm, so the abductors of the lower hip and the top hip both work to keep the pelvis lifted.
- Side-plank variants produced the highest gluteus medius activity of the tested rehabilitation exercises.

Gluteus medius activity by exercise



26 healthy adults; abduction with dominant leg up/down; means only. Boren 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). No angles are quoted for this side-lying pose. Educational, not diagnostic.

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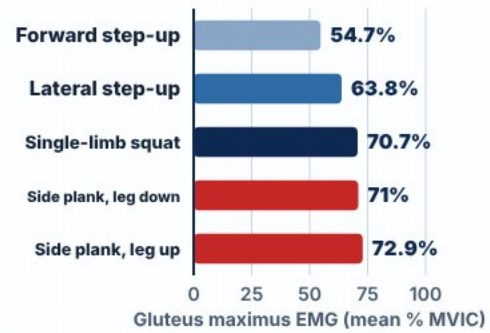
41% of people with hip OA on an active physiotherapy programme reported mild side effects, vs 14% on sham.

19 of 46 vs 7 of 49. Bennell et al. (2014).

Banded steps: plausible, not yet measured

- The band pulls the knees inward, so the abductors must hold them apart; the stance knee here sits ≈**8°** inward of the hip–ankle line.
- No verified muscle-activity data for banded walking were found, so the chart shows gluteus maximus in the measured exercises instead.

Gluteus maximus in the same exercises



26 healthy adults; means only. Boren 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 angle: frontal-plane projection of hip, knee and ankle landmarks (valgus = knee inward). Educational, not diagnostic.

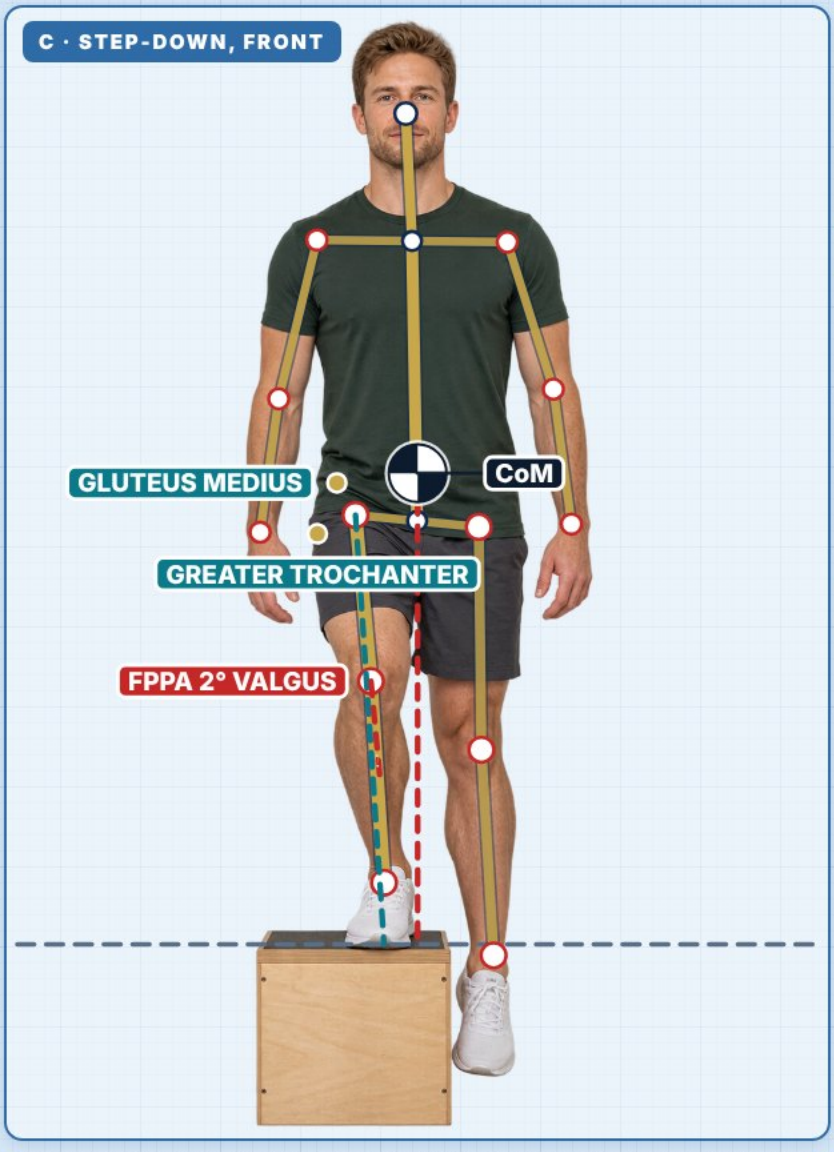
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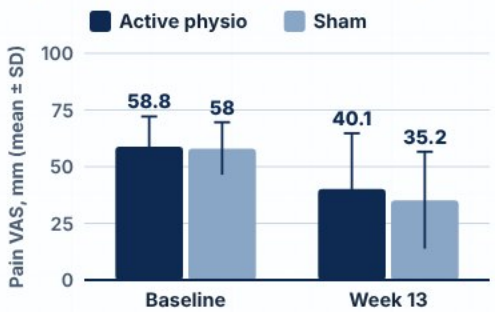
77% of people with gluteal tendinopathy reported success after 8 weeks of education plus exercise.

51 of 66, vs 20 of 68 (29%) with wait-and-see. Mellor et al. (2018).

The diagnosis decides the dose

- Lowering the free heel from a box loads the stance-side abductors to keep the pelvis level; the knee stays ≈**2°** from the hip–ankle line.
- In hip osteoarthritis, a 12-week multimodal physiotherapy programme was not better than sham for pain at 13 weeks.

Hip OA: physiotherapy vs sham pain



102 adults with hip OA; 10 sessions over 12 weeks. Bennell 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). Knee angle: frontal-plane projection of hip, knee and ankle landmarks (valgus = knee inward). Educational, not diagnostic.

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A · Side plank High load



B · Band walk No EMG data



C · Step-down Control

Gluteal tendinopathy: exercise beat wait-and-see



204 adults aged 35–70 with lateral hip pain; 14 sessions over 8 weeks. Mellor et al. (2018).

Decision pathway

1. **DIAGNOSE**
   Separate gluteal tendinopathy from hip osteoarthritis; the evidence for abductor exercise differs between them.
2. **PROGRESS**
   Move from step-ups and side-lying work to single-limb squats and side planks as pain allows.
3. **COMBINE**
   Pair exercise with education; in hip OA place abductor work inside a broader, individual plan.

NOT RECOMMENDED

Assuming abductor exercises fix all hip pain; in hip OA one physiotherapy programme matched sham.

SEEK ASSESSMENT IF

Rest or night pain that does not ease, fever, unexplained weight loss, a fall with inability to bear weight, or rapidly worsening weakness.

REFERENCES (APA 7)

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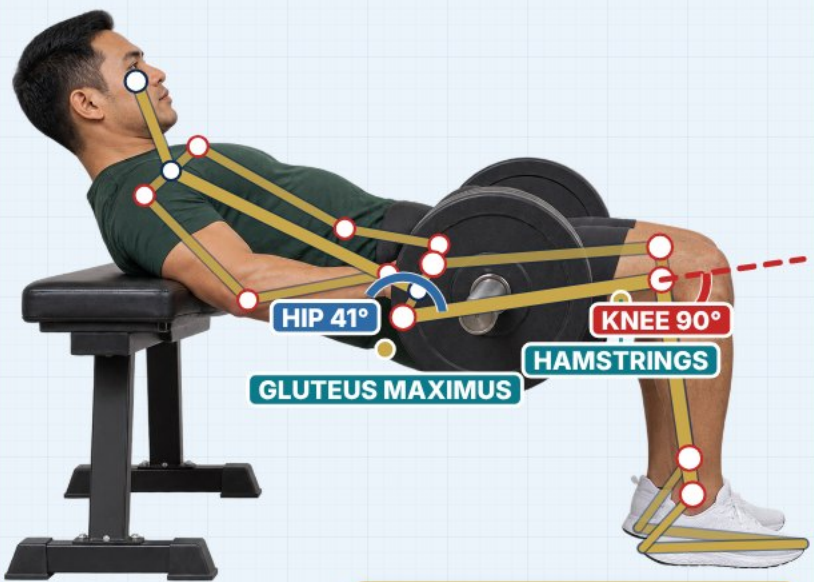
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HIP EXTENSION STRENGTH: GLUTES, HIP THRUSTS AND THE HINGE

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A · BARBELL HIP THRUST, SIDE





OTHER VIEW

EYE-OPENER

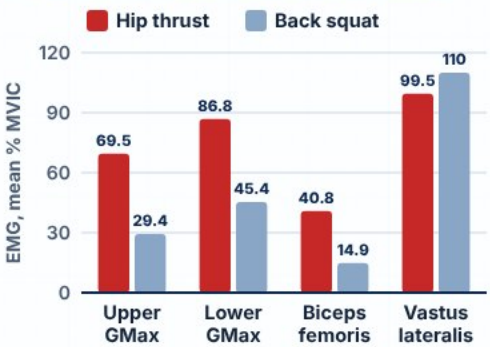
216% peak lower gluteus maximus EMG in the hip thrust: over twice a maximal isometric effort.

Peak % MVIC, 13 trained women. Contreras et al. (2015).

Hip extension with the knee bent

- Upper back on the bench, knee ≈**90°**: the load sits across the hips, and the hip here is still ≈**41°** short of full extension.
- With the knee bent the hamstrings are shortened, so gluteus maximus does more of the hip-extension work.

Hip thrust vs back squat activation



Estimated 10RM loads, 13 trained women; vastus lateralis difference not significant. Contreras 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). Hip angle: trunk line to thigh; knee angle: thigh to shank. Educational, not diagnostic.

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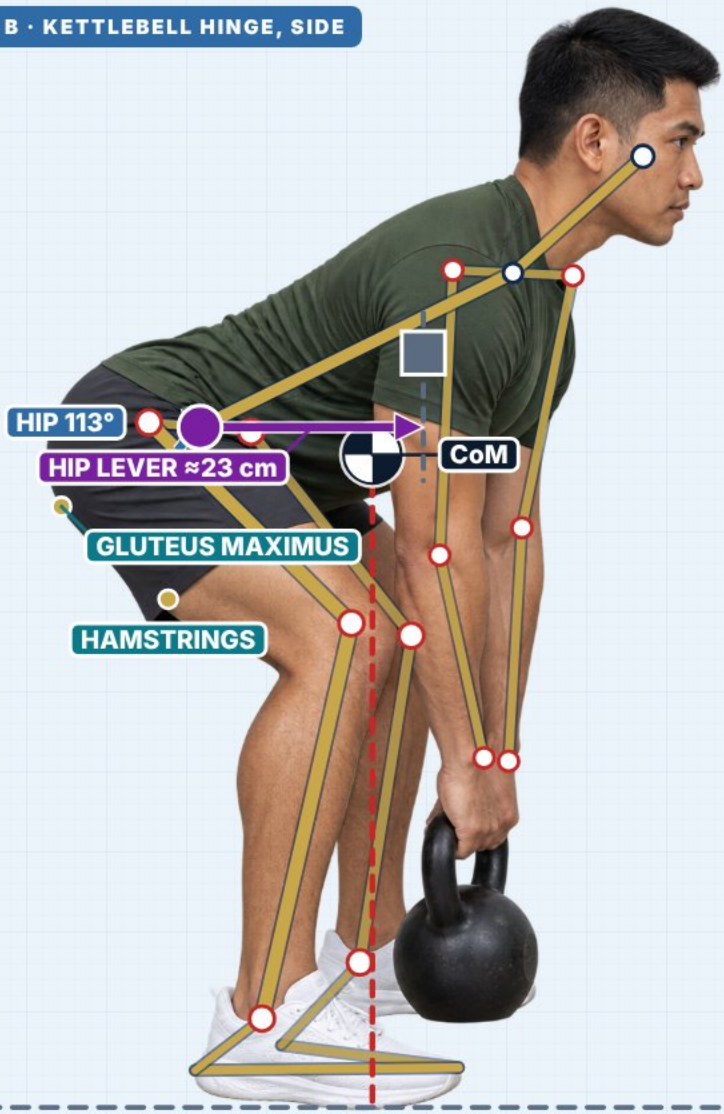
BIOMECHANICS IS A FORCE-GOVERNED DECISION SYSTEM – NOT A POSTURE MODEL.

INTEGRATING PERFORMANCE & REHABILITATION HEALTHCARE PATHWAYS.

HIP EXTENSION STRENGTH: GLUTES, HIP THRUSTS AND THE HINGE

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B · KETTLEBELL HINGE, SIDE



EYE-OPENER

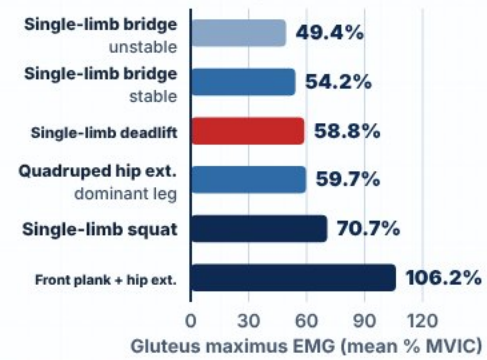
95 N·m static hip-extensor demand from the upper body alone here, before the kettlebell is added.

Measured on this figure, 70 kg adult; not study data.

The hinge: trunk forward, hips back

- Hip flexed ≈**113°**, knee ≈**58°**; hip lever ≈**23 cm**, hip moment ≈**95 N·m**. The kettlebell adds to this moment.
- Gluteus maximus and hamstrings share the work; single-leg versions raise demand without heavy loads.

Gluteus maximus in graded exercises



26 healthy adults; means only. Boren 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). Hip lever: hip-joint centre to upper-body CoM; moment = upper-body weight × lever, 70 kg adult, static. Hip angle: trunk line to thigh. Educational, not diagnostic.

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C · SINGLE-LEG BRIDGE, SIDE



EYE-OPENER

0 kg difference in deadlift strength gain between 9 weeks of hip thrusts and 9 weeks of squats.

0 ± 2 kg (95% CI −4 to 3). Plotkin et al. (2023).

Single-leg bridge: a graded start

- One foot down, the other leg straight: the stance-side gluteus maximus and hamstrings lift and hold the pelvis.
- A stable single-limb bridge reached about 54% MVIC, a moderate load before the deadlift or hip thrust.

Strength gains were lift-specific



Untrained adults, 9 weeks; hip thrust n = 18, squat n = 16. Plotkin et al. (2023).

Key point: each group got strongest in the lift it trained, yet both transferred equally to the hinge.

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). No angles are quoted for this lying pose. Educational, not diagnostic.

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A · Hip thrust High EMG

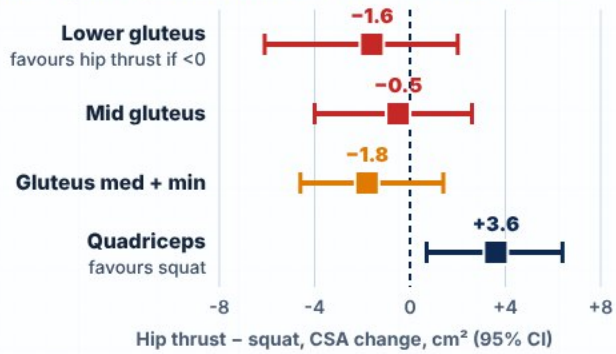


B · Hinge ≈23 cm lever



C · 1-leg bridge Start here

Similar glute growth from hip thrusts or squats



9 weeks, 15–17 sessions; untrained adults. Plotkin et al. (2023).

Decision pathway

1. **START**
   Use single-leg bridges and deadlifts for moderate gluteus maximus demand while symptoms settle.
2. **BUILD**
   Add hip thrusts, squats or hinges by goal and tolerance; both grew the glutes.
3. **SPECIFY**
   Train the lift you need to be strong in; strength gains were lift-specific.

NOT RECOMMENDED

Choosing exercises by EMG alone; higher activation did not mean more muscle growth.

SEEK ASSESSMENT IF

Hinging or bridging brings back pain spreading below the knee, numbness, pins and needles, leg weakness or sharp groin pain on loading.

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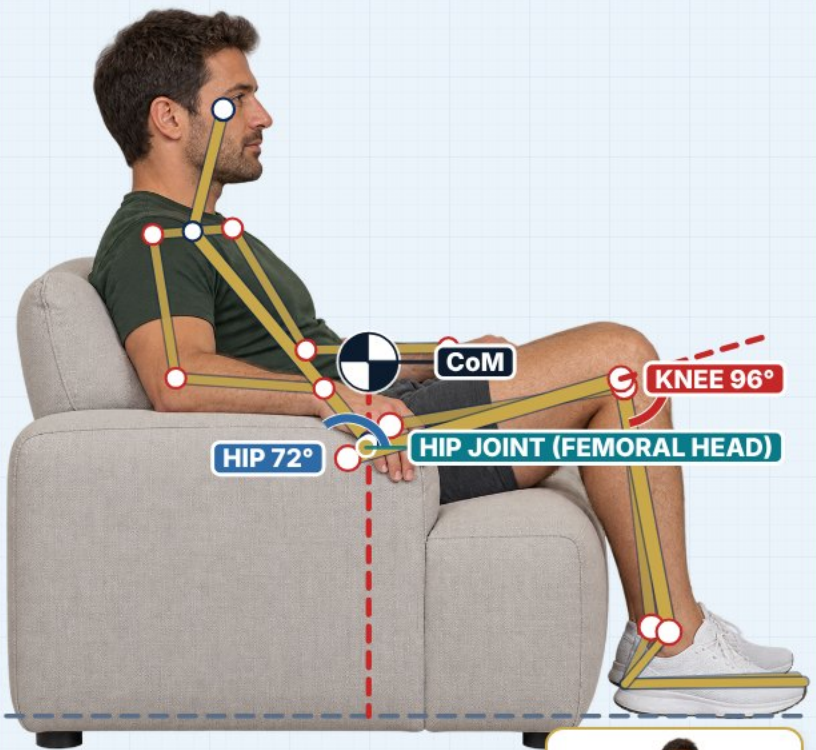
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INTEGRATING PERFORMANCE & REHABILITATION HEALTHCARE PATHWAYS.

SITTING AND HIP PAIN: FLEXION, PRESSURE AND TOLERANCE

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A · LOW SOFT SOFA, SIDE





OTHER VIEW

EYE-OPENER

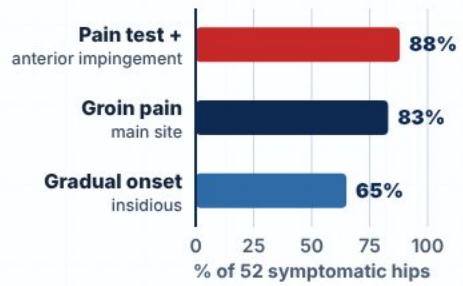
3.1 yrs average wait from first symptoms to a diagnosis of hip impingement, after 4.2 health providers.

51 patients, mean age 35. Clohisy et al. (2009).

A low sofa holds the hip flexed

- Knees above hips: hip ≈**72°** and knee ≈**96°** flexion with the trunk reclined; leaning forward to rise takes the hip deeper.
- In symptomatic hip impingement, total hip flexion averaged only 97°, so deep seats can sit near the end of available range.

What symptomatic impingement looks like



Prospective cohort, 51 patients (52 hips); mean flexion 97°. Clohisy et al. (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). Educational, not diagnostic.

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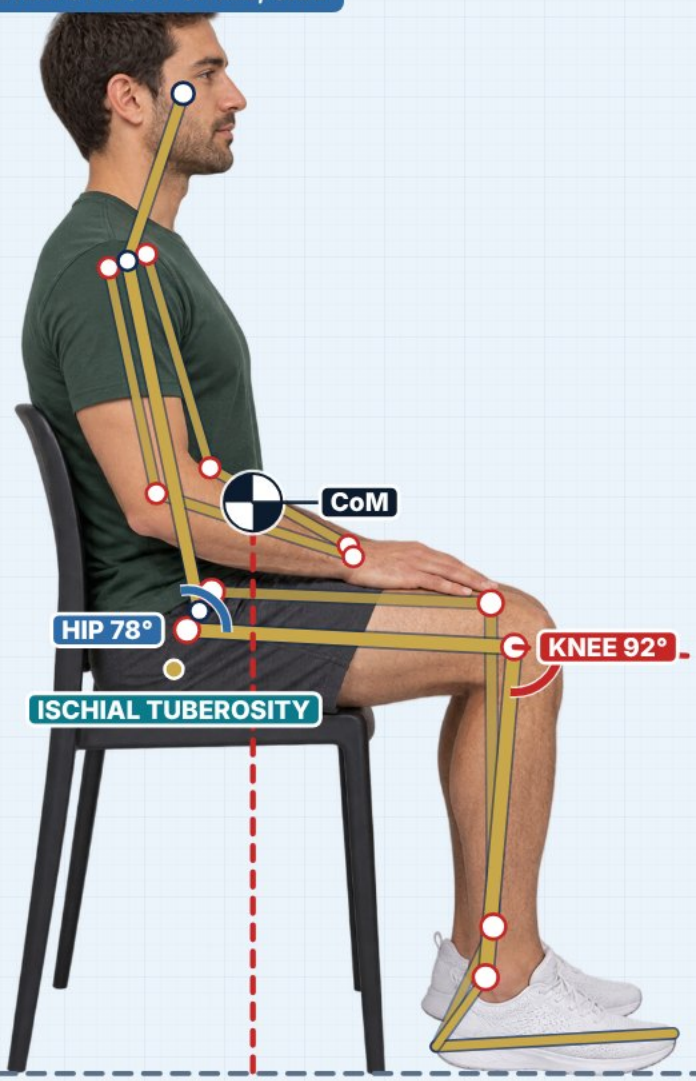
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B · FIRM UPRIGHT CHAIR, SIDE



EYE-OPENER

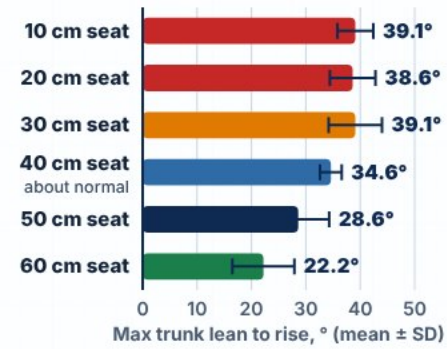
13% of people with hip impingement had already had unsuccessful surgery elsewhere before the hip was diagnosed.

51 patients with symptomatic impingement. Clohisy et al. (2009).

Higher, firmer seats ease the rise

- Hips slightly above knees: hip ≈**78°** flexion here with the trunk upright: an easier start than a deep sofa.
- Raising the seat from 40 to 60 cm cut forward lean and the peak hip extensor moment (about 1.7 times higher at 40 cm).

Lower seats need more forward lean



8 healthy young adults; trunk lean was reported, not hip angle. Yoshioka 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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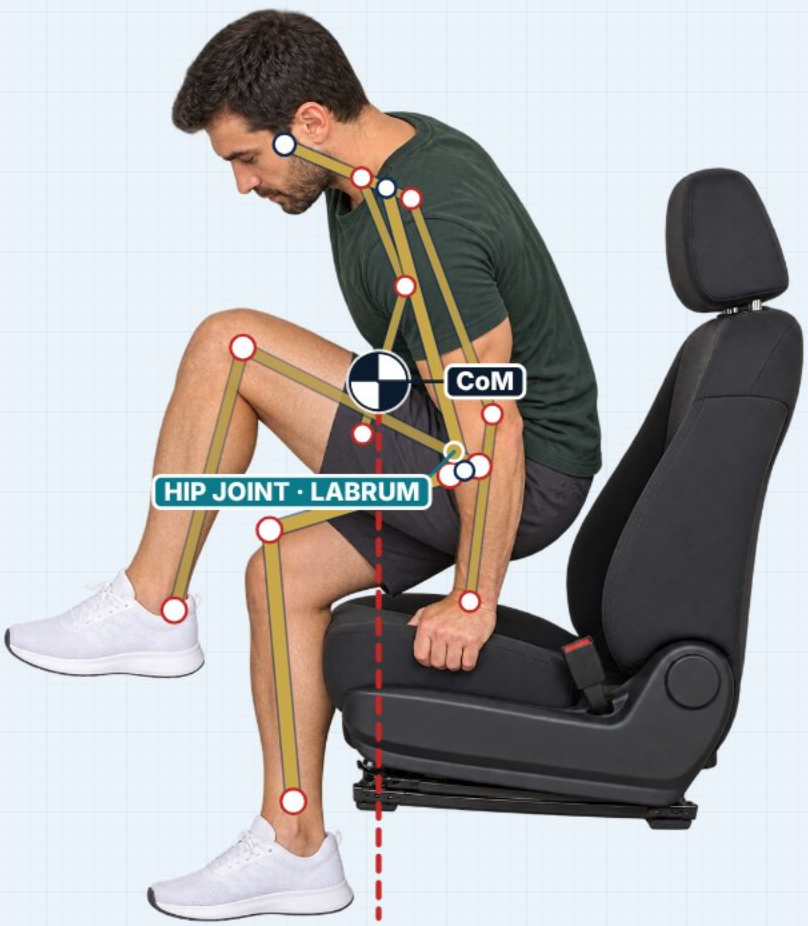
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C · GETTING INTO A CAR, SIDE



EYE-OPENER

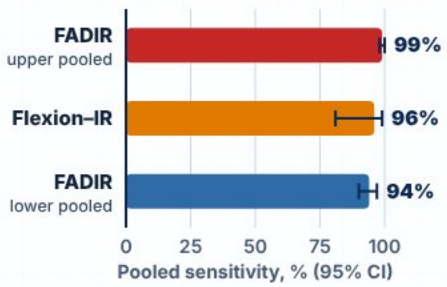
9° average inward rotation left with the hip bent, in 52 hips with symptomatic impingement.

Internal rotation in flexion. Clohisy et al. (2009).

Car entry mirrors a clinical test

- Lifting the leg in with the trunk bent combines deep flexion, adduction and inward rotation: the FADIR test position.
- Pain here is common in joint-related hip pain, but the test screens rather than confirms: a negative result helps rule out.

Provocation tests: sensitive screens



FAI or labral tear; systematic review, 9 studies meta-analysed. Reiman et al. (2015).

Myth: "Sitting is rest, so it cannot be what hurts." Deep sitting is sustained end-range flexion; change the seat, not only the activity.

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). Car-entry pose: skeleton and CoM only, no angles measured. Educational, not diagnostic.

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A · Low sofa Deep flexion



B · Firm chair Easier



C · Car entry FADIR-like

A positive test does not confirm the cause



Wide intervals crossing or near 1: weak at ruling in. Systematic review, 21 articles. Reiman et al. (2015).

Decision pathway

1. **ADJUST**
   Use a firmer, higher seat with hips level with or above the knees, a cushion and regular breaks.
2. **STRENGTHEN**
   Pair seat changes with progressive hip strengthening rather than avoiding sitting altogether.
3. **ASSESS**
   If groin pain with deep flexion persists for months despite load changes, seek a specialist hip assessment.

NOT RECOMMENDED

Labelling the cause of sitting pain from a single provocation test or an imaging finding alone.

SEEK ASSESSMENT IF

A fall then inability to bear weight, a hot painful hip with fever, severe night pain or weight loss, or leg numbness or weakness: seek prompt medical assessment.

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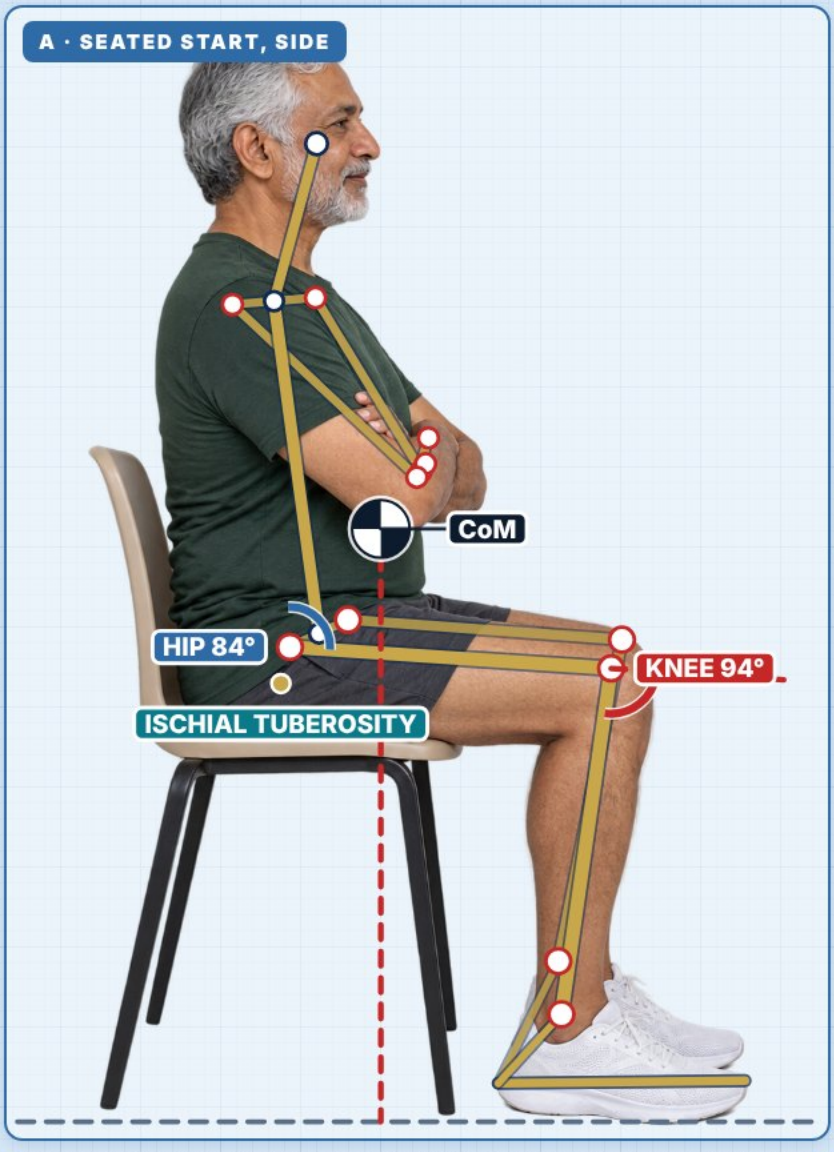
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GETTING UP FROM A CHAIR: THE HIP STRENGTH TEST OF DAILY LIFE

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EYE-OPENER

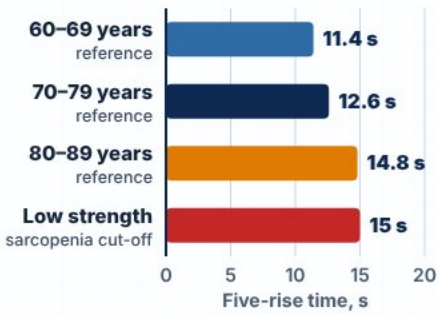
1.9× higher odds of falling in older adults with sarcopenia, which slow chair rises help define.

Prospective studies, OR 1.89 (95% CI 1.33–2.68). Yeung et al. (2019).

Five rises, arms crossed

- Sitting tall, feet behind the knees: hip ≈**84°** and knee ≈**94°** flexion, the start of the five-times sit-to-stand test.
- Timing five rises and comparing with age references turns a daily task into a quick strength screen.

Slower than average above…



Meta-analysis, 14 studies, adults ≥60: Bohannon (2006). Cut-off >15 s: Cruz-Jentoft 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). Educational, not diagnostic.

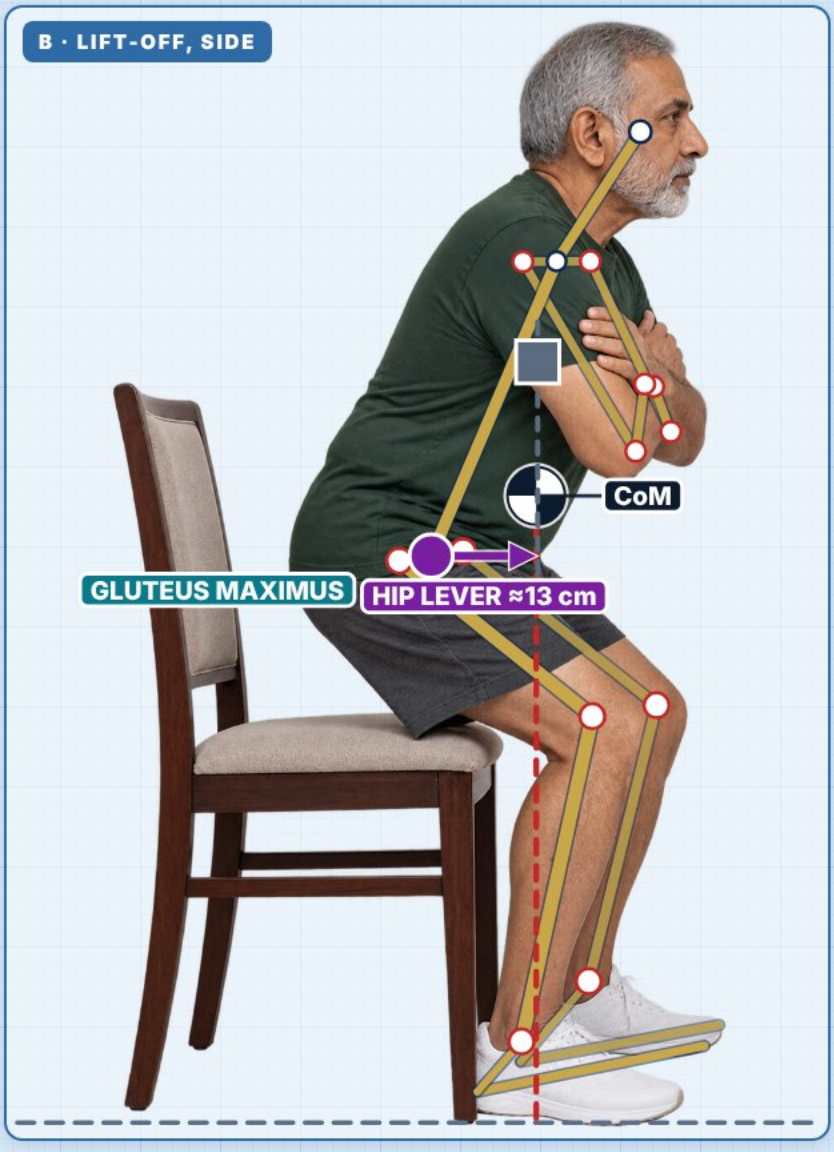
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EYE-OPENER

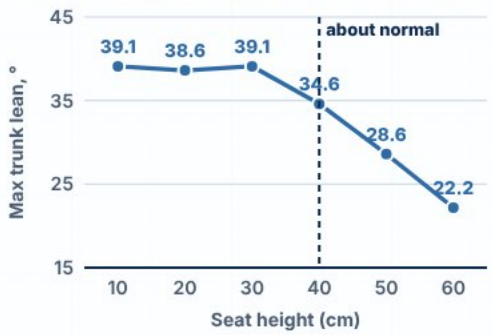
1.7× more peak hip extensor effort to rise from a 40 cm seat than from a 60 cm one.

8 healthy young adults. Yoshioka et al. (2014).

Lift-off is the hip's job

- Trunk forward, seat just cleared: upper-body mass sits ahead of the hip, hip lever ≈**13 cm**, hip moment ≈**55 N·m** to hold.
- Raising the seat cuts the forward lean needed; lowering it towards about 40 cm scales the task up.

Lower seats need more forward lean



8 healthy young adults; peak hip and knee moments unchanged from 10 to 40 cm. Yoshioka 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). Hip lever: hip-joint centre to upper-body CoM; moment = upper-body weight × lever, 70 kg adult, static. Educational, not diagnostic.

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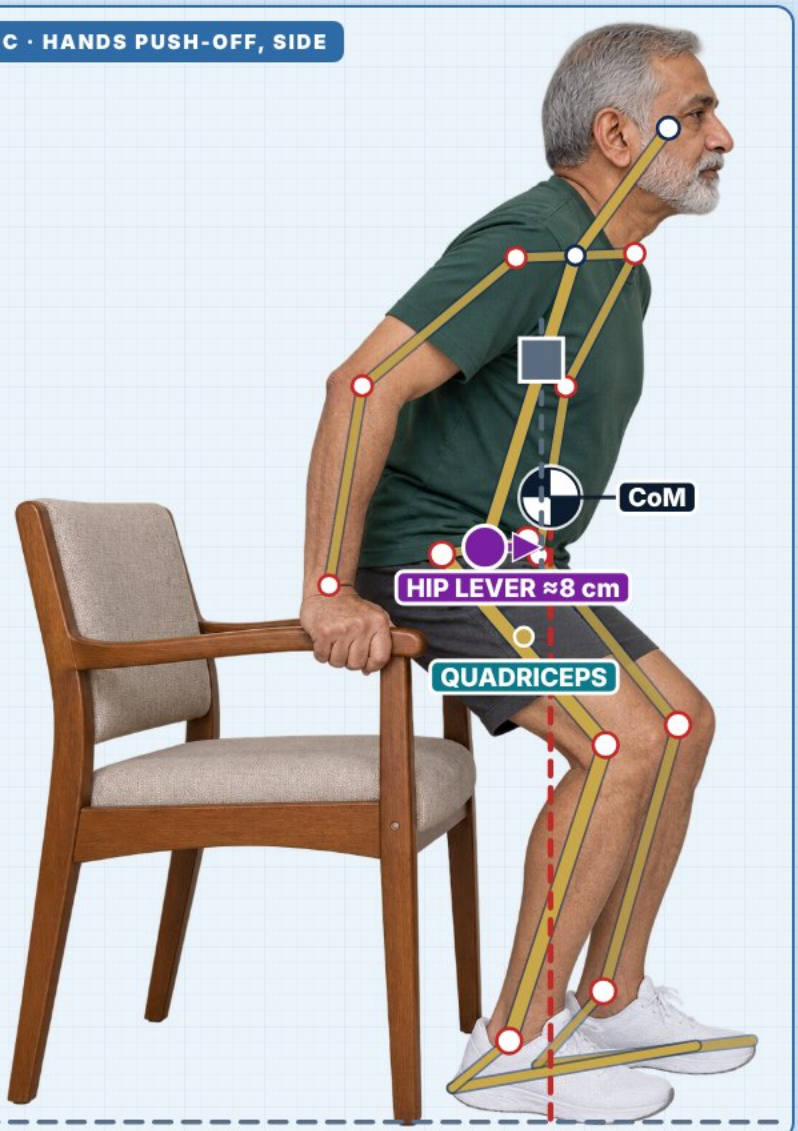
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C · HANDS PUSH-OFF, SIDE



EYE-OPENER

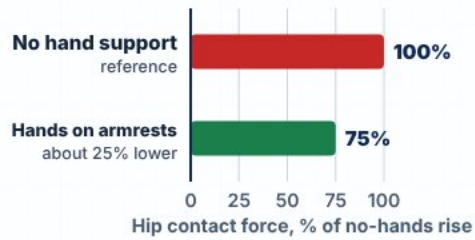
15–160% higher hip load when patients changed position without physiotherapy instruction.

Instrumented hip implants. Schwachmeyer (2015).

Hands are a dose dial, not cheating

- Pushing on the armrests: the static hip lever ≈**8 cm**, hip moment ≈**31 N·m** omits the share the arms carry.
- Hand support offloads a painful or recently operated hip; rising without hands is the progression.

Hand support cuts hip load by about 25%



Thesis series, 7 patients with instrumented hip implants; relative values only. Schwachmeyer (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). Hip lever: hip-joint centre to upper-body CoM; moment = upper-body weight × lever, 70 kg adult, static. Arm support not modelled. Educational, not diagnostic.

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A · Seated Test start

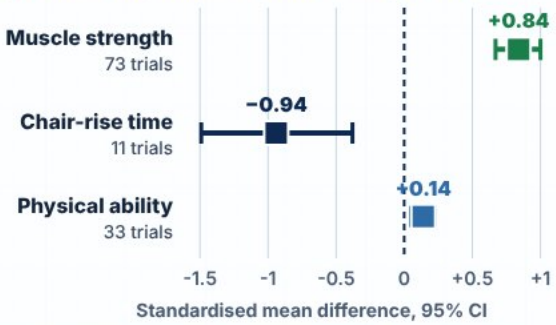


B · Lift-off Hip effort



C · Hands Offload

Strength training makes chair rising faster



Chair-rise time: negative = faster. Cochrane review, 121 trials, 6700 older adults. Liu & Latham (2009).

Decision pathway

1. **MEASURE**
   Time five rises with arms crossed and compare with age references; over 15 s indicates low strength.
2. **SCALE**
   Start from a higher seat or with hand support, then lower the seat and remove the hands.
3. **TRAIN**
   Progressive resistance training improves strength and chair rising in older adults.

NOT RECOMMENDED

Labelling hand support as cheating, or simply observing a slow chair-rise time without starting training.

SEEK ASSESSMENT IF

A new inability to rise without the arms, strength lost over weeks, new or repeated falls, or weakness with weight loss, fever or numbness.

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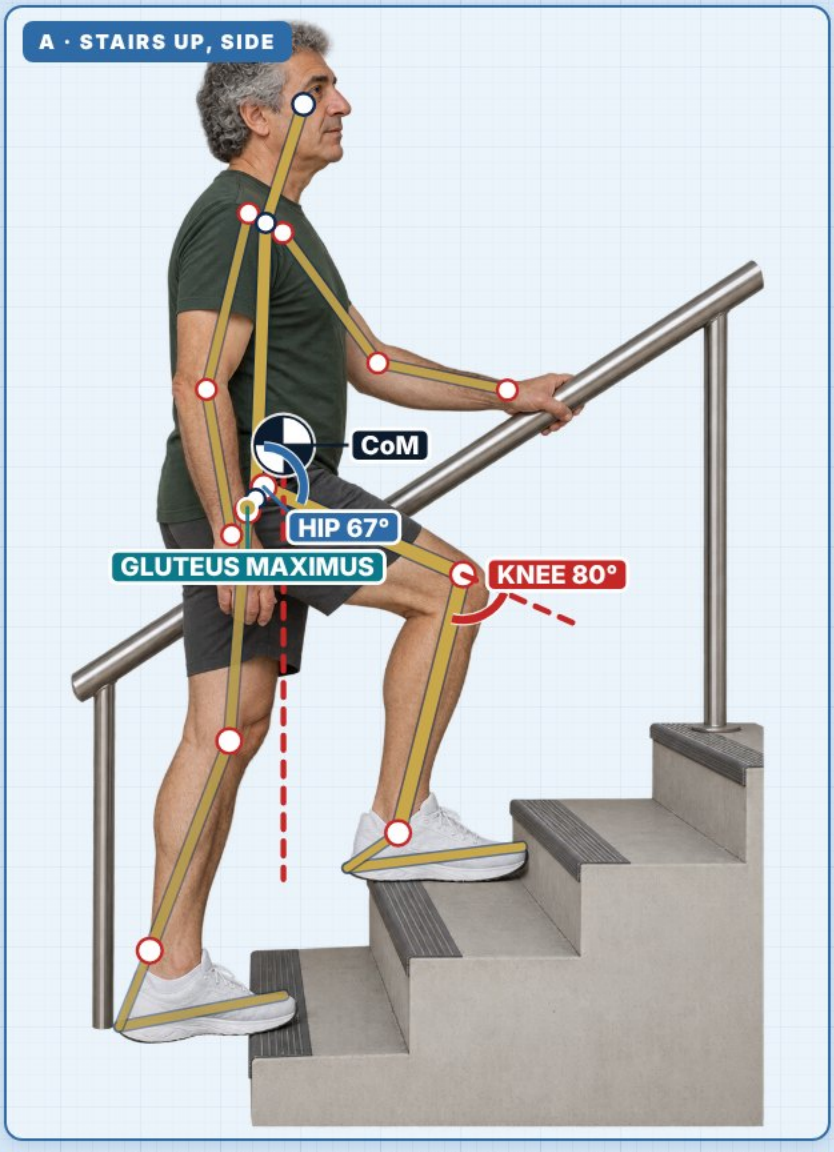
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INTEGRATING PERFORMANCE & REHABILITATION HEALTHCARE PATHWAYS.

STAIRS AND HIP PAIN: WHY GOING UP AND DOWN FEEL DIFFERENT

AN MMSX AUTHORITY | APPLIED BIOMECHANICS LAB EDUCATIONAL ANALYSIS



EYE-OPENER

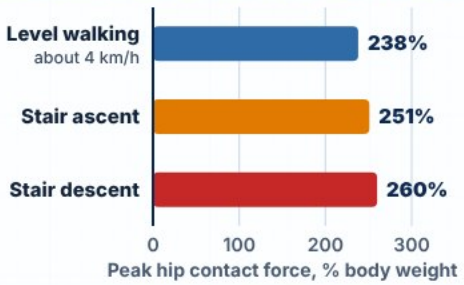
83% larger: the highest twisting torques on the hip in daily tasks, compared with normal walking.

Instrumented hip implants. Bergmann et al. (2001).

Going up: lift and twist

- Leading foot on the step above: hip ≈**67°** and knee ≈**80°** flexion as the extensors lift the body concentrically.
- Average twisting torque on the hip was 23% larger going upstairs than in level walking.

Both stair directions load the hip more



4 patients with telemetric hip implants; "average patient" values. Bergmann et al. (2001).

Myth: "Going down is easier because gravity does the work." The muscles must brake the body, and hip contact force was highest on descent.

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). Stairs: no floor line drawn. Educational, not diagnostic.

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B · STAIRS DOWN, SIDE



EYE-OPENER

120% of maximal knee extensor strength was needed by older adults to walk downstairs.

84 healthy adults aged 60–88. Samuel et al. (2011).

Going down: braking the body

- Stepping down, the hip and knee extensors lengthen under load (eccentric work) to control the descent.
- In hip osteoarthritis, descent showed more trunk lean and altered hip moments, pointing to abductor function.

Hip OA changes how people step down

HIP OA vs HEALTHY, STAIR DESCENT

▲	Trunk lean towards stance side
▼	Sagittal hip range of motion
▼	Peak hip extension moment
▼	Peak external rotation moment
▲	Hip adduction moment impulse

15 people with hip OA vs 15 controls, 3-D motion analysis; unadjusted, no values in abstract. Hall 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). Descending pose: CoM only, no angles measured. Educational, not diagnostic.

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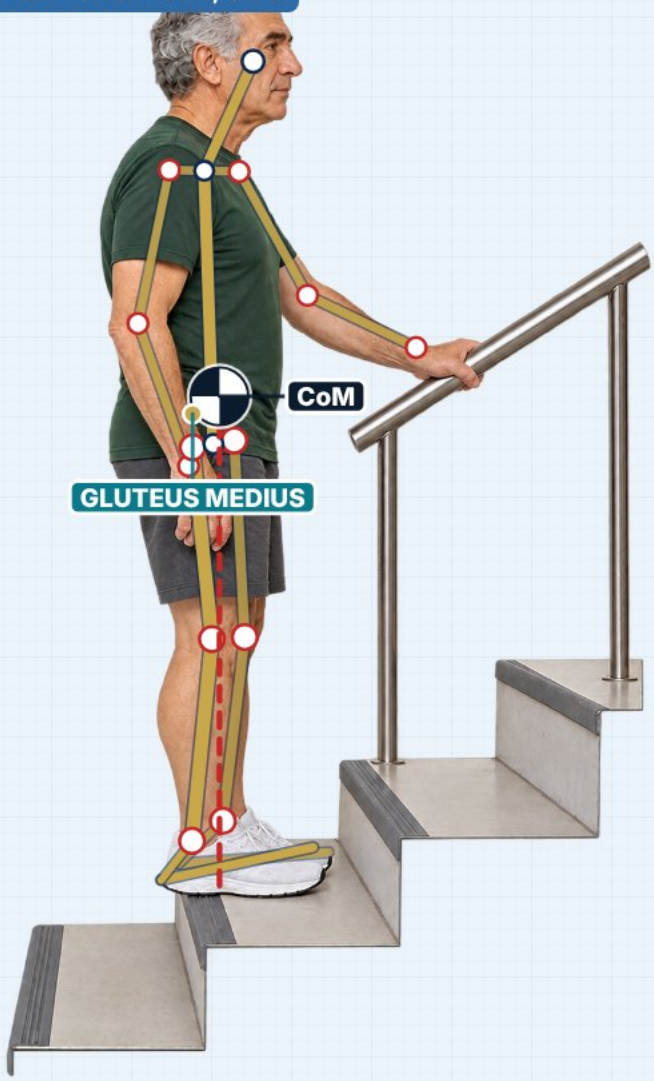
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C · STEP-TO PATTERN, SIDE



EYE-OPENER

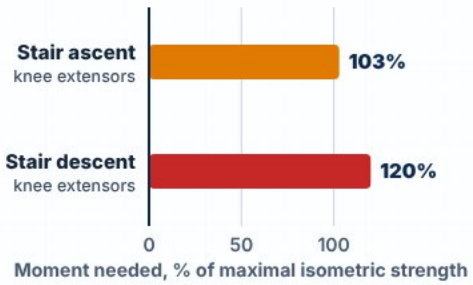
1 in 6 people with hip OA treated with exercise gains a pain benefit they would not otherwise have had.

Number needed to treat 6. Cochrane review, 10 RCTs. Fransen et al. (2014).

Step-to: one step at a time

- Both feet on each step with a hand on the rail cuts the demand per step; lead up with the stronger leg, down with the painful one.
- This is task scaling from the load data; no trial in this evidence set tests the rule itself.

Stairs leave little strength in reserve



84 healthy adults aged 60–88; hip demand high but slightly lower (no % given). Samuel 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). Stairs: skeleton and CoM only, no angles measured. Educational, not diagnostic.

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A · Up Lift + twist

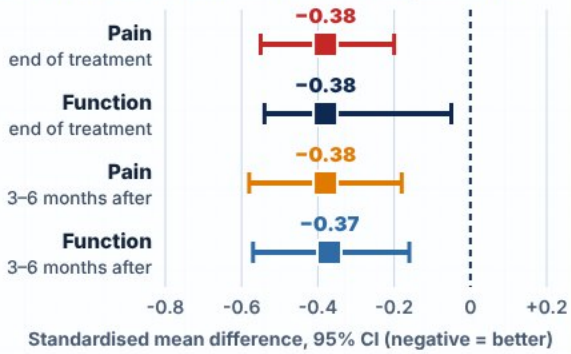


B · Down Brake



C · Step-to Scale down

Exercise for hip OA: a moderate, lasting benefit



Cochrane review, 10 RCTs; about 7–8 points better on a 0–100 scale. Fransen et al. (2014).

Decision pathway

1. **SCALE**
   Use the rail and, when painful, a step-to pattern: stronger leg first going up, painful leg first going down.
2. **STRENGTHEN**
   Train hip abductors and extensors, including slow, controlled lowering for the descent.
3. **PROGRESS**
   Return to step-over-step stairs as strength and pain allow; exercise benefit persisted for months.

NOT RECOMMENDED

Avoiding stairs altogether, or assuming going down must be easier because gravity does the work.

SEEK ASSESSMENT IF

Sudden inability to climb stairs or bear weight after a fall, pain at rest and at night, fever, or rapidly worsening groin pain.

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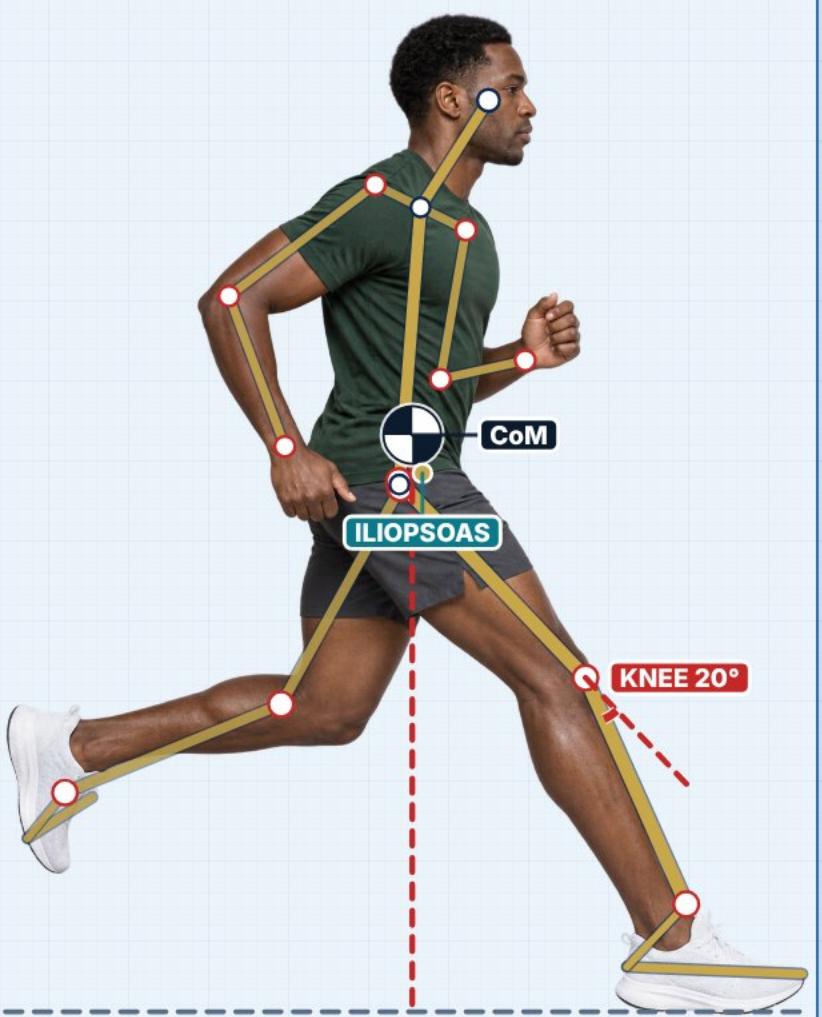
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HIP PAIN IN RUNNERS: LOAD, CADENCE AND STRIDE

AN MMSX AUTHORITY | APPLIED BIOMECHANICS LAB EDUCATIONAL ANALYSIS

A · OVERSTRIDE, SIDE



EYE-OPENER

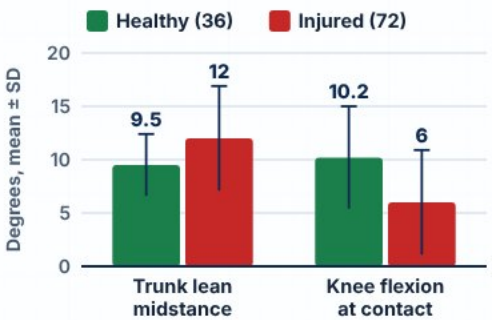
44.6% average prevalence of running-related injury across studies: close to one runner in two.

Systematic review; prevalence 44.6% ± 18.4. Kakouris et al. (2021).

Overstriding: a straighter knee

- Foot reaching well ahead of the body with the front knee near straight (≈**20°** flexion in this frame).
- Injured runners landed with less knee flexion than healthy runners; each extra degree went with lower odds of injury (OR 0.87).

Injured runners: more lean, straighter knee



Cross-sectional: association, not cause. 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). Educational, not diagnostic.

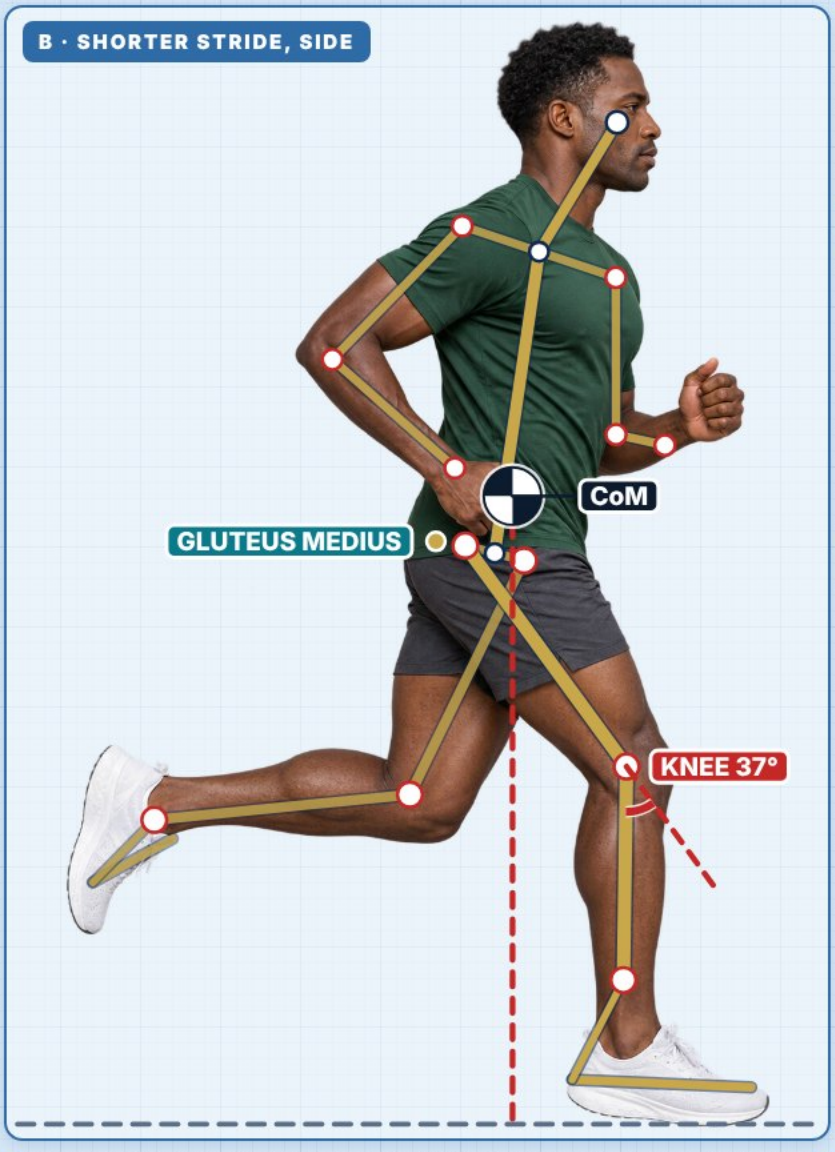
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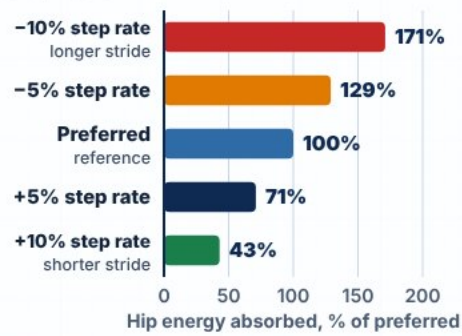
−11% peak gluteus medius force in stance when runners took 10% more steps per minute at the same speed.

30 recreational runners; model estimates. Lenhart et al. (2014).

Shorter, quicker steps

- Foot landing closer under the hips with more knee bend: ≈**37°** here vs ≈**20°** in Frame A.
- Raising step rate 5–10% at the same speed lowered hip energy absorption, hip adduction and vertical CoM excursion.

Quicker steps, less hip energy absorbed



Relative change, arithmetic from table means (large SDs); 45 runners, speed held constant. 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.

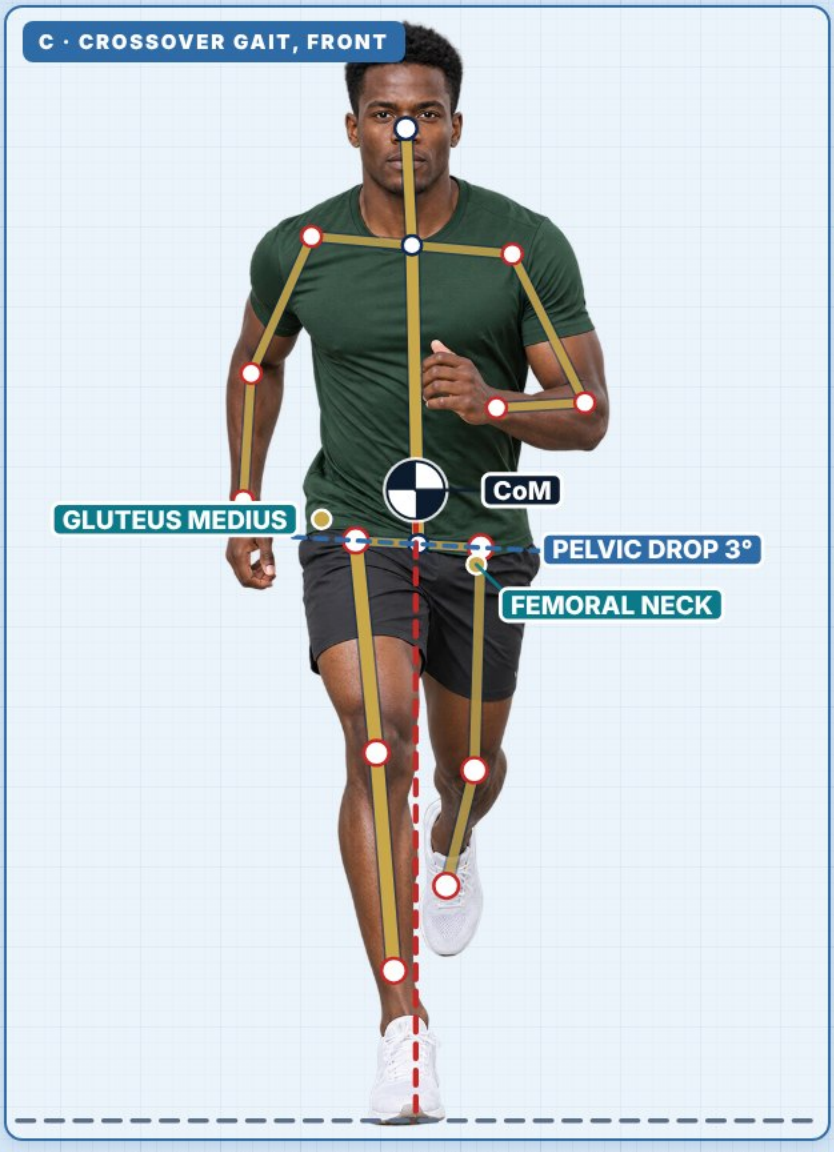
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2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Pelvis line joins the two hip landmarks in the front view. Educational, not diagnostic.

EYE-OPENER

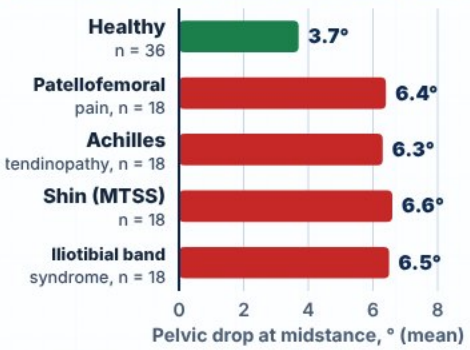
+87% higher odds of being an injured runner with each extra degree of pelvic drop at midstance.

OR 1.87 per degree (95% CI 1.41–2.49); cross-sectional. Bramah et al. (2018).

Frontal-plane control

- Feet landing near the midline, pelvis ≈3° off level in this frame; a dropping pelvis loads the stance-side hip abductors.
- Pelvic drop was similar across four different running injuries, so it may be a shared pattern, not injury-specific.

Pelvic drop: the same across injuries



72 injured and 36 healthy runners; cross-sectional. Bramah et al. (2018).

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A · Overstride Higher load

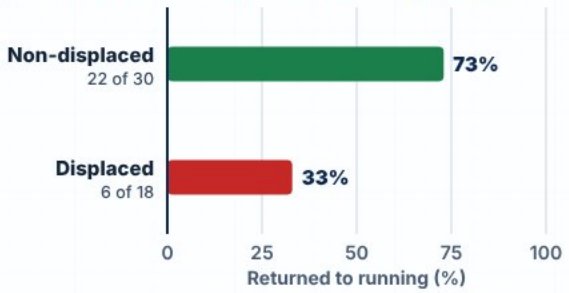


B · Short stride Lower load



C · Crossover Control

Femoral neck stress fracture: catch it early



48 runners; percentages calculated from published counts. Neubauer et al. (2016).

Decision pathway

1. **SHORTEN**
   Raise step rate by 5–10% at the same speed to land closer under the hips.
2. **CONTROL**
   Train hip abductor strength and pelvic control alongside progressive hip strengthening.
3. **MONITOR**
   Track deep groin pain run by run; pain that builds each run needs imaging before running on.

NOT RECOMMENDED

Running through deep groin pain that worsens with each run without imaging to exclude a femoral neck stress fracture.

SEEK ASSESSMENT IF

Deep groin pain building during each run, pain at night or at rest, pain on hopping, or a limp after running.

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HIP MOBILITY: ROTATION RANGE AND WHAT IT MEANS FOR FUNCTION

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A · 90/90 SIT, FRONT



EYE-OPENER

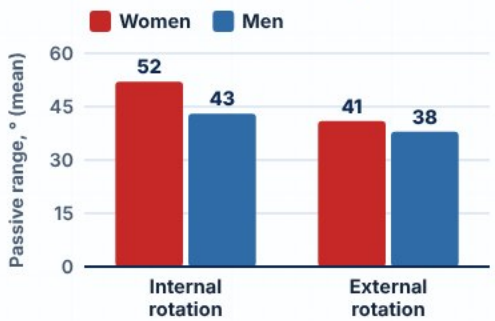
34–71° normal internal rotation range among healthy adult women alone: "normal" is a wide band.

Mean ± 2 SD, 761 healthy participants. Svenningsen et al. (1989).

90/90: both rotations at once

- The front hip turns out (external rotation) while the back hip turns in (internal rotation), so one position works both directions.
- Healthy adults averaged more internal than external rotation, and women more than men; compare sides and change over time.

Healthy adult hip rotation by sex



761 healthy Norwegian participants, passive goniometry. Svenningsen et al. (1989).

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). Floor-sitting pose: no skeleton or angles measured. Educational, not diagnostic.

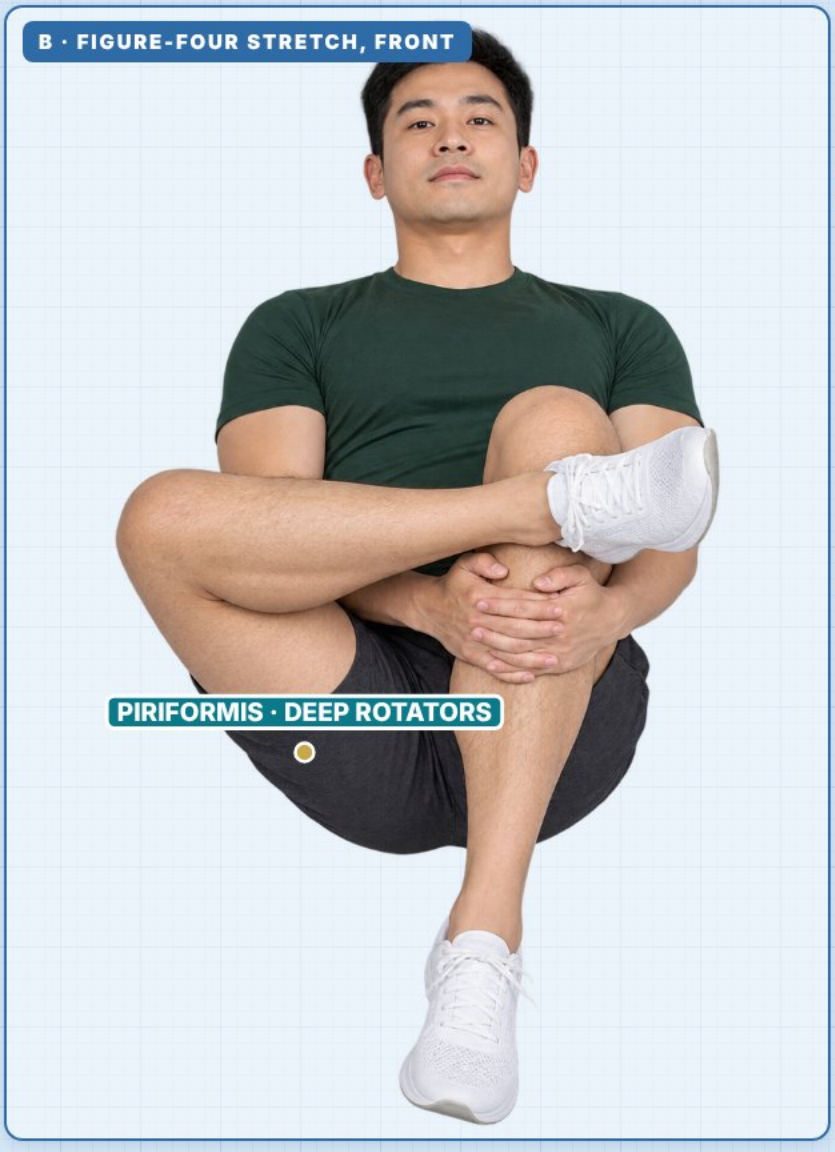
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EYE-OPENER

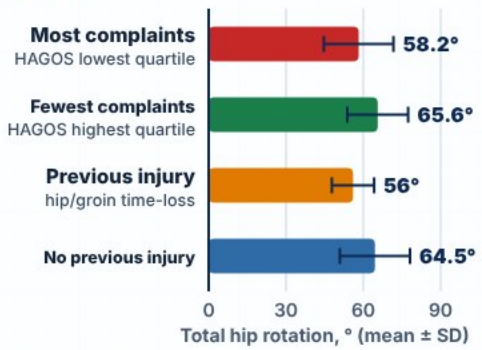
−7° less internal rotation in pro footballers with a past hip or groin injury: 21° vs 28°.

21.1 vs 28.3° (arithmetic). Tak et al. (2016).

Figure-four: an outward-rotation stretch

- Lying on the back, ankle over the opposite knee: the crossed hip is flexed and turned out, stretching the deep rotators behind it.
- In footballers, lower rotation went with symptoms and past injury, independent of cam bone shape; association only.

Less rotation with symptoms or past injury



60 professional footballers, cross-sectional screening. Tak 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). Lying pose seen from the feet: no skeleton or angles measured. Educational, not diagnostic.

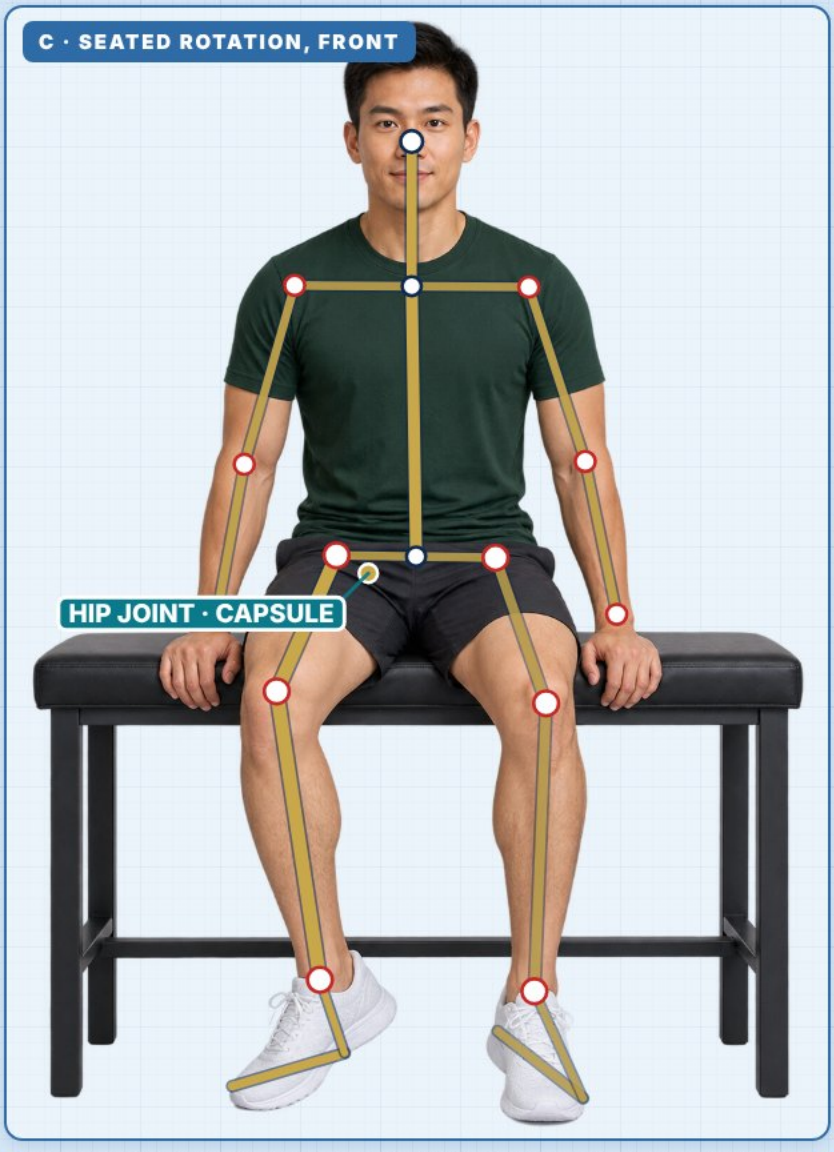
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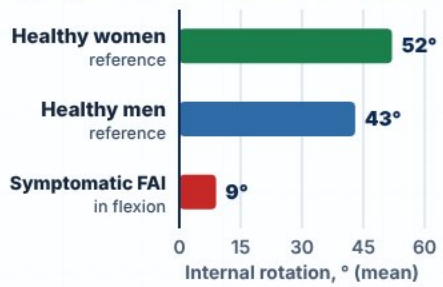
<15° of internal rotation is one of the two clinical routes used to classify hip osteoarthritis.

With ESR ≤45 mm/h or flexion ≤115°. Altman et al. (1991).

Seated rotation: measure, both sides

- Sitting with hips and knees at 90°, turning the foot out rotates the hip in; this is how rotation is usually measured.
- Loss of internal rotation is one of the earliest signs of joint conditions such as osteoarthritis and impingement.

Impingement: a fraction of normal



Cross-study illustration, different positions and methods; not a statistical comparison. Svenningsen et al. (1989); Clohisy et al. (2009).

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A · 90/90 Both ways

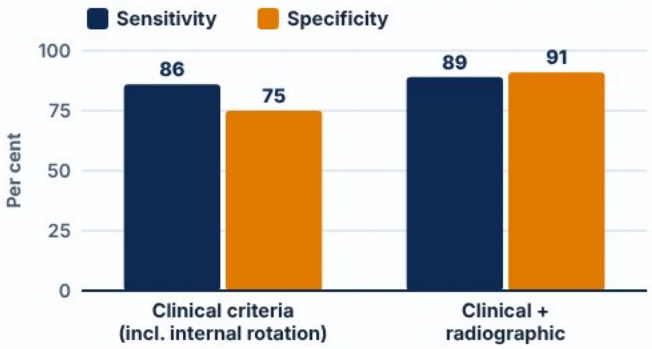


B · Figure-four Turn out



C · Seated Measure

Internal rotation in the hip OA classification rule



201 patients with hip pain; classification criteria, not a stand-alone diagnostic test. Altman et al. (1991).

Decision pathway

1. **MEASURE**
   Measure internal rotation at 90° of flexion on both sides and track it over time.
2. **COMPARE**
   Compare with the other side and the person's own history, not a single textbook number.
3. **MOVE**
   Use rotation work within an exercise programme, as one component rather than a stand-alone cure.

NOT RECOMMENDED

Forcing end-range rotation into pain in a hip with suspected impingement or osteoarthritis.

SEEK ASSESSMENT IF

Rapid loss of rotation with severe pain, fever, night pain or inability to bear weight, or a history of steroid or heavy alcohol use.

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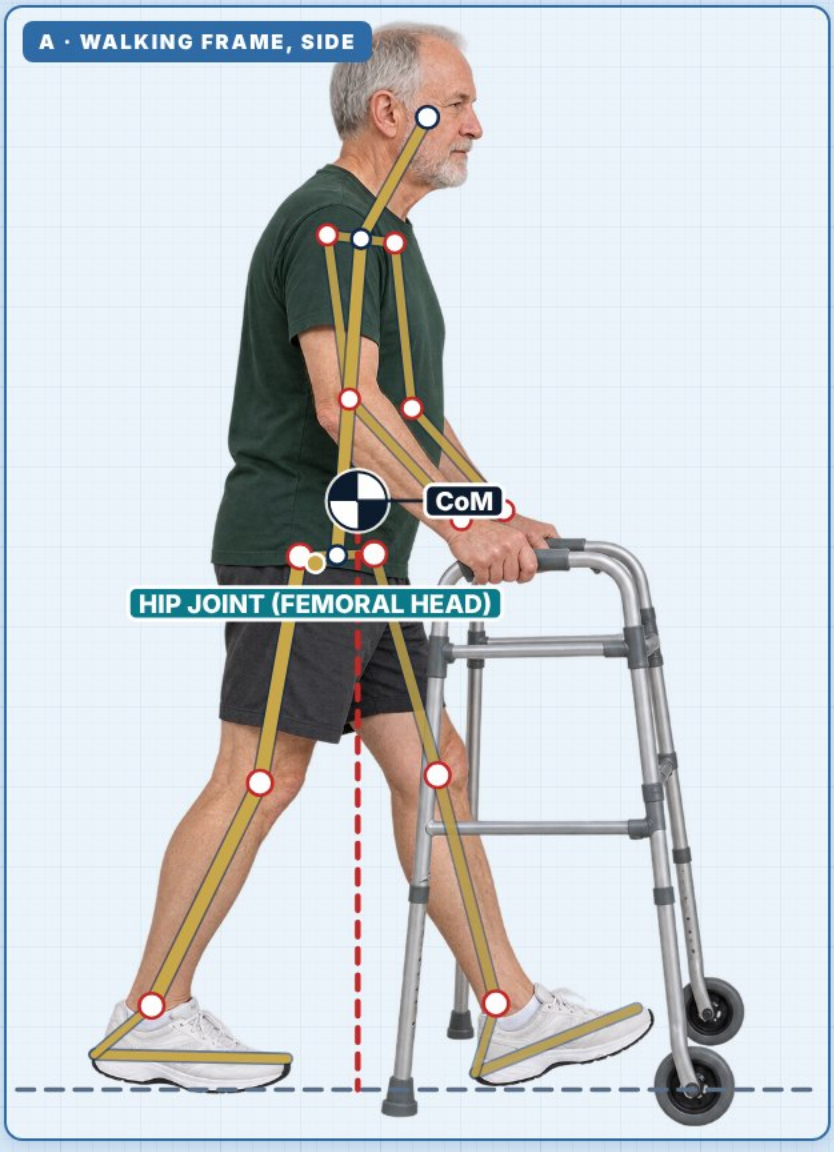
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INTEGRATING PERFORMANCE & REHABILITATION HEALTHCARE PATHWAYS.

HIP REPLACEMENT: RECOVERY MILESTONES AND SAFE MOVEMENT

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EYE-OPENER

303% of body weight passes through a hip implant at each step of ordinary walking.

Median peak, treadmill at 4 km/h, instrumented implants. Haffer et al. (2022).

Walking is the first loading test

- Walking with a frame shares load through the arms early on; most gains in pain and function after hip arthroplasty came in the first three months.
- In patients with telemetric implants, seated gym machines loaded the hip less than ordinary walking did.

Implant load: machines vs walking



7 patients, mean 17.4 months after surgery; ranges of medians across 20–40 kg loads. Haffer et al. (2022); Lenguerrand 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.

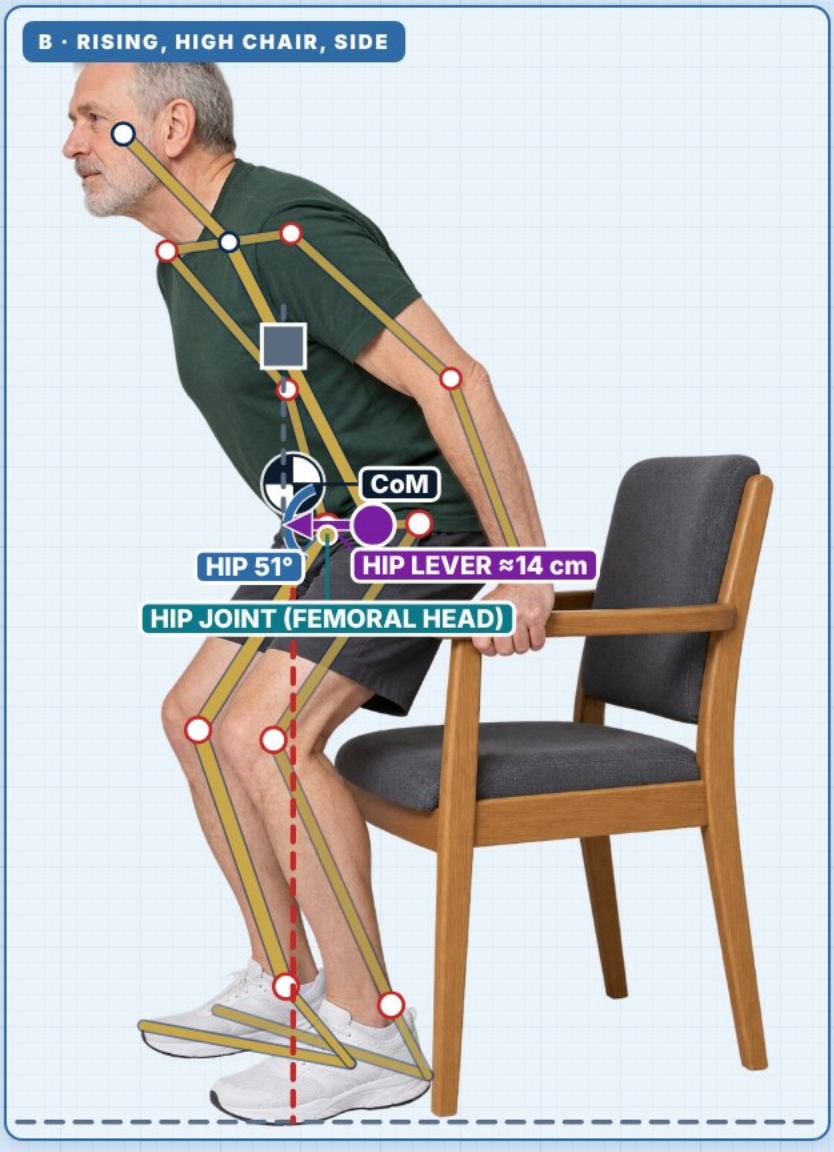
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EYE-OPENER

≈25% less force through the new hip when you push on the armrests or thighs to stand up.

Hand support vs none, rising from or sitting onto a chair. Schwachmeyer (2015).

High chair, hands on the armrests

- Rising here needs hip flexion ≈**51°**, hip lever ≈**14 cm**, hip moment ≈**57 N·m**; a higher seat and an arm push both reduce the demand.
- In a trial of 265 patients, those without extra movement restrictions reached everyday milestones sooner.

Fewer restrictions, earlier milestones

Side-sleeping	Sooner	p < 0.001
Riding in a car	More often	p < 0.026
Return to work	Sooner	p < 0.001
Satisfied with pace	Higher	p < 0.001

Unrestricted vs restricted; p-values only reported

RCT, 265 patients (303 hips); restrictions added about USD 655 per patient. Peak 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). Hip lever: hip-joint centre to upper-body CoM; moment = upper-body weight × lever, 70 kg adult, static. Educational, not diagnostic.

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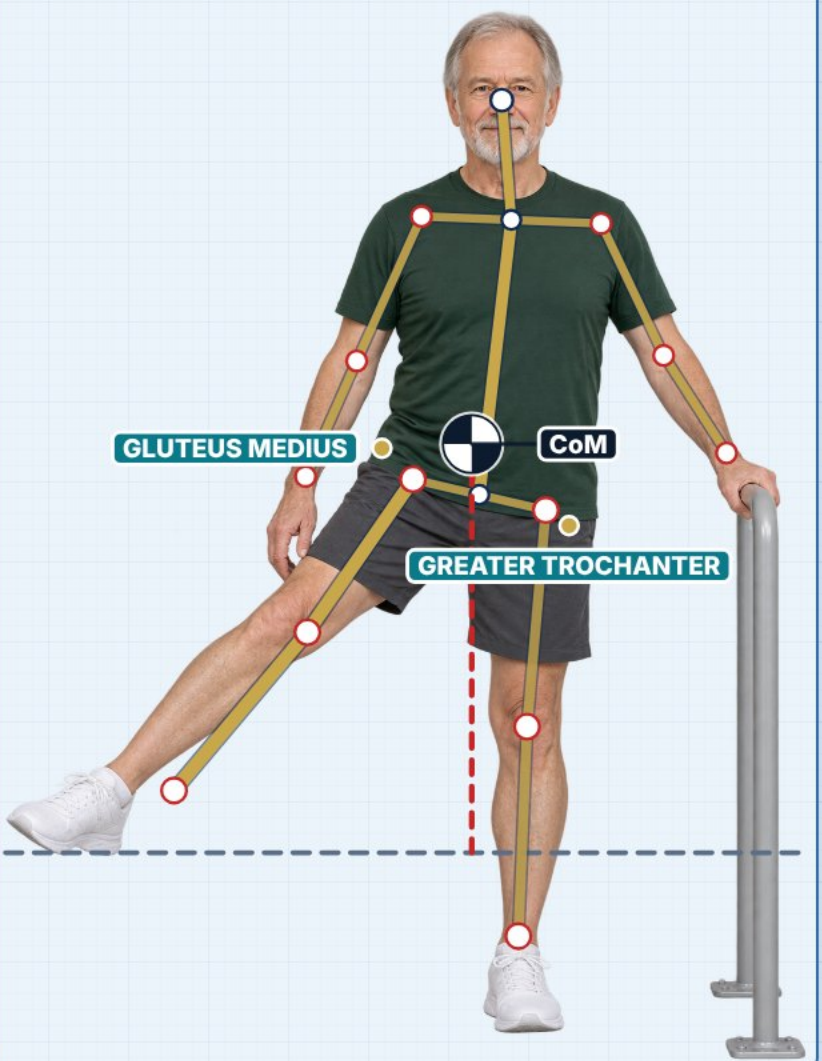
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C · LEG OUT TO SIDE, FRONT



EYE-OPENER

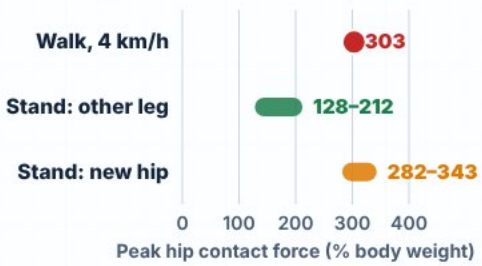
1/303 hips dislocated in a trial comparing extra movement restrictions with none.

One dislocation in the whole cohort (0.33%). Peak et al. (2005).

Which leg stands matters most

- Moving the operated leg out to the side while standing on the other leg loaded the implant less than walking.
- Standing on the operated leg while the other leg worked reached 282–343% of body weight, at or above walking.

Standing cable exercise: hip load



Ranges across adduction to abduction/extension pulls; 7 patients with instrumented implants. Haffer 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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A · Walking Frame first

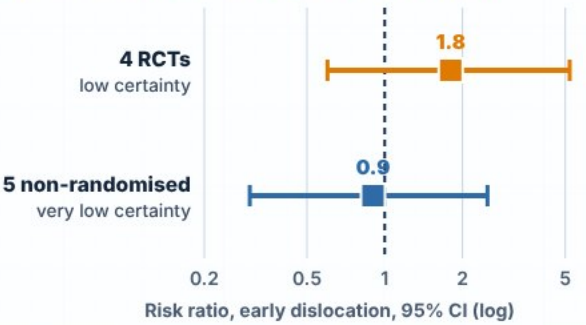


B · Rising Use armrests



C · Side lift Stance leg

Hip precautions vs none: early dislocation



Posterior-approach THA for primary OA, 8835 participants; RR > 1 favours no precautions. Wide intervals: follow the surgical team. Korfitsen et al. (2023).

Decision pathway

1. **PLAN**
   Agree a rehabilitation plan before discharge (NICE); add supervised help if daily activities stay difficult.
2. **MOVE**
   Walk early with an aid, rise from a high chair using the armrests, and follow your surgical team.
3. **PROGRESS**
   Add strength work: seated machines loaded the implant less than walking.

NOT RECOMMENDED

Assuming strict precautions suit everyone: pooled trials found no clear difference in early dislocation.

SEEK ASSESSMENT IF

A clunk with a shortened or turned leg or inability to bear weight; a hot, red or leaking wound or fever; calf swelling, chest pain or breathlessness.

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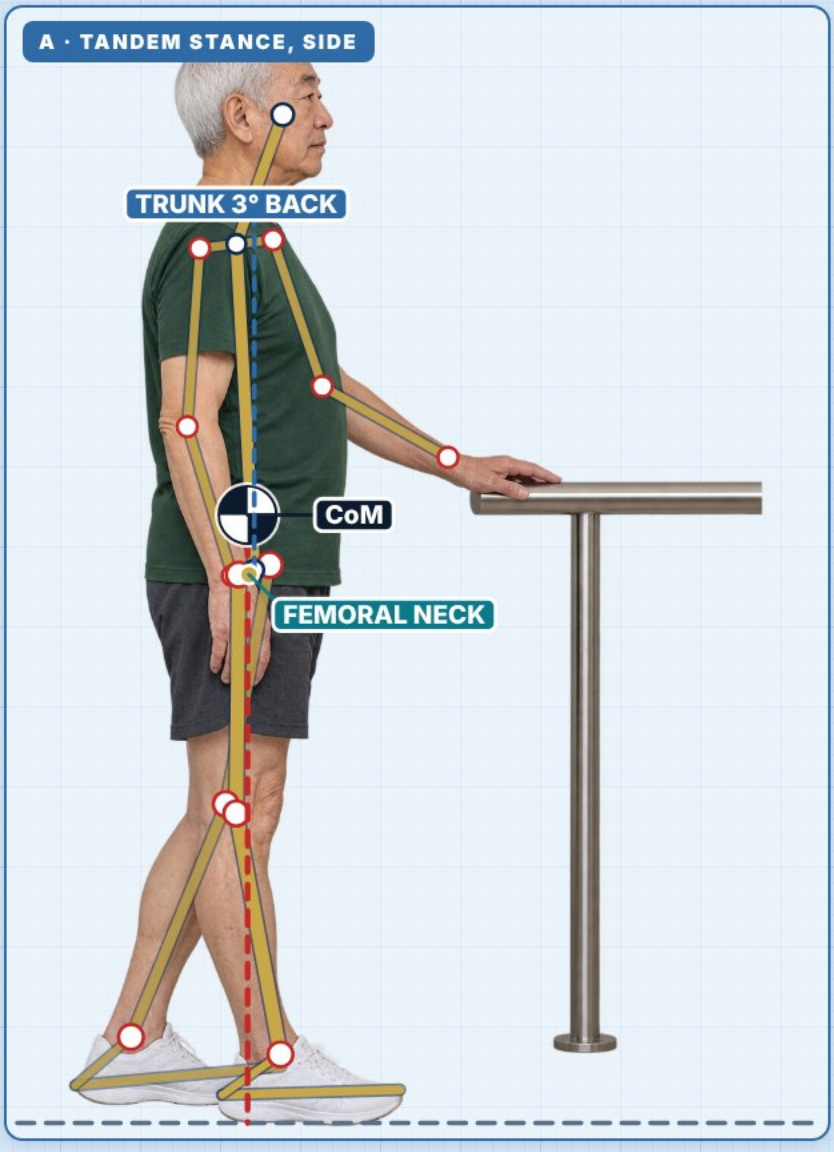
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HIP FRACTURE IN OLDER ADULTS: FALLS, STRENGTH AND RECOVERY

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EYE-OPENER

101 000 UK hip fractures a year projected for 2020, up from about 70 000–75 000 in 2011.

Rounded figures from an official press release. NICE (2011).

Balance is trainable

- Heel-to-toe stance beside a rail, trunk upright (≈**3°**): a narrow base that challenges balance with support close by.
- Most hip fractures follow a low-energy fall, usually breaking the femoral neck or trochanteric region; fewer falls means fewer fractures.

Exercise cuts the rate of falls



Community-dwelling older people, Cochrane review; < 1 = fewer falls. Sherrington 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.

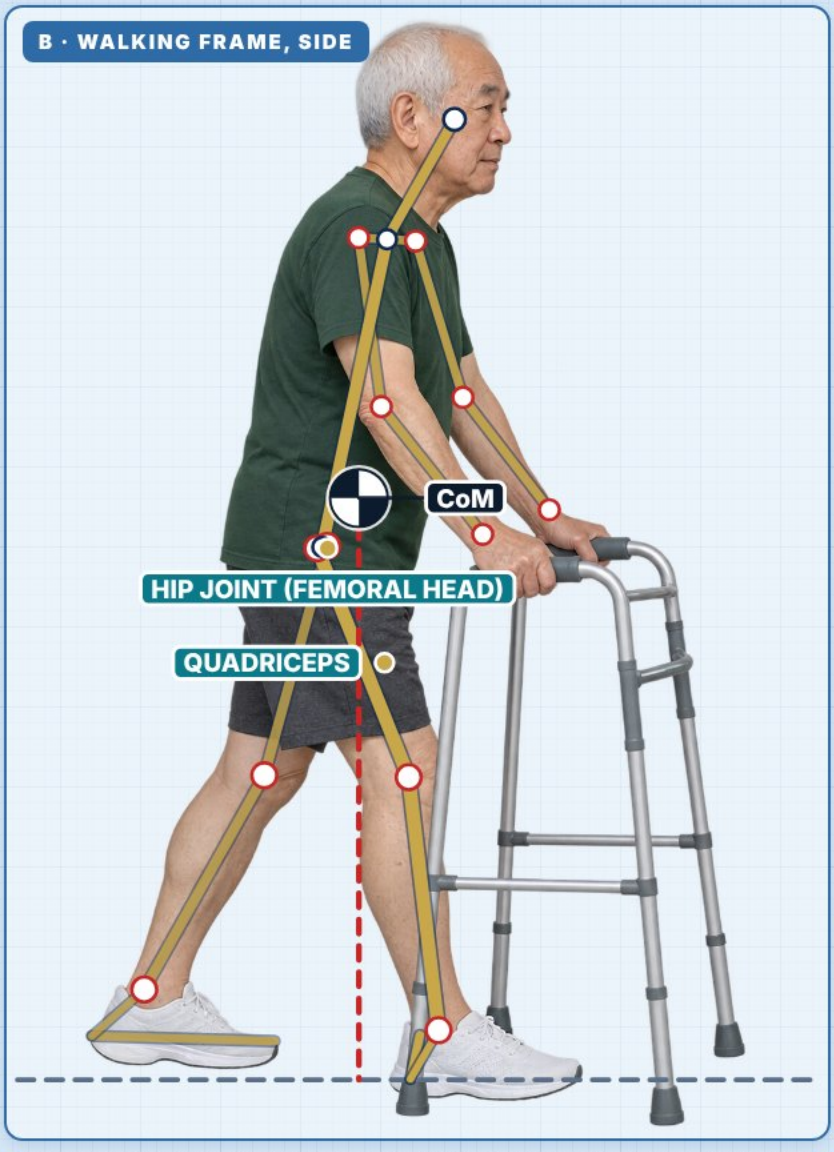
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EYE-OPENER

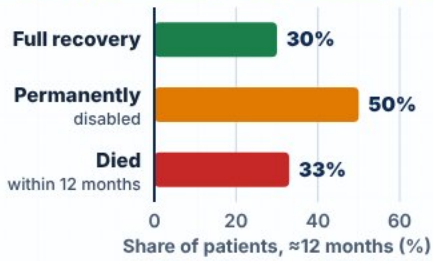
Day 1 NICE advises physiotherapy and getting up from the day after hip-fracture surgery, not bed rest.

With surgery on the day of, or after, admission. NICE (2011).

Early walking, with support

- A walking frame lets the operated hip take load early while the arms share the work and steady balance.
- Rehabilitation goals are set early by a multidisciplinary team, within a ward-based Hip Fracture Programme.

What happens after a hip fracture (UK)



Rounded headline figures from an official press release, not trial data; categories overlap. National Institute for Health and Care Excellence [NICE] (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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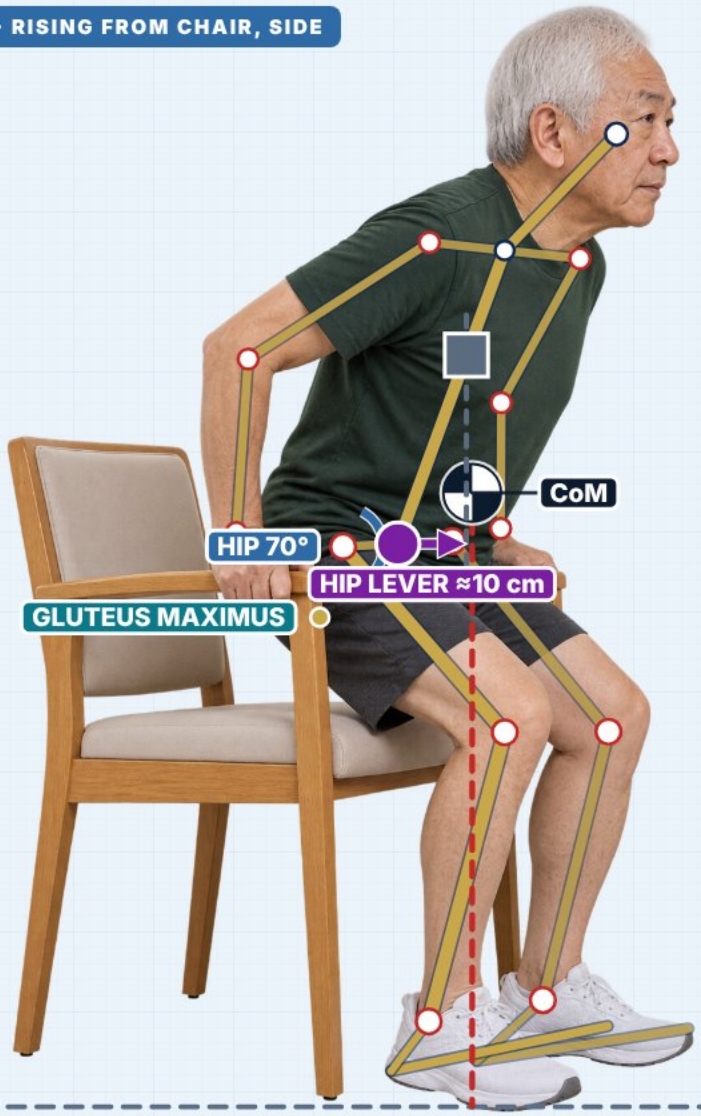
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C · RISING FROM CHAIR, SIDE



EYE-OPENER

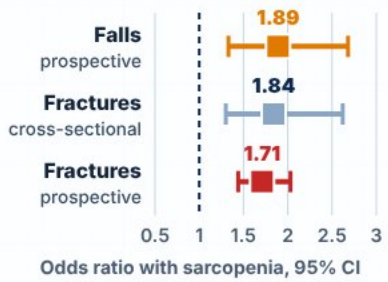
£2bn a year in UK medical and social care costs for hip fractures (2011 estimate).

Rounded figure from an official press release. NICE (2011).

The chair rise is a strength test

- Rising here needs hip flexion ≈**70°**, hip lever ≈**10 cm**, hip moment ≈**40 N·m**; pushing on the armrests shares the load.
- Low muscle mass and strength (sarcopenia) was associated with both falls and fractures across 33 studies of older adults.

Weak muscles, more falls and fractures



33 studies, 45 926 older adults; associations, not causes. Yeung 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). Hip lever: hip-joint centre to upper-body CoM; moment = upper-body weight × lever, 70 kg adult, static. Educational, not diagnostic.

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A · Tandem stance Balance

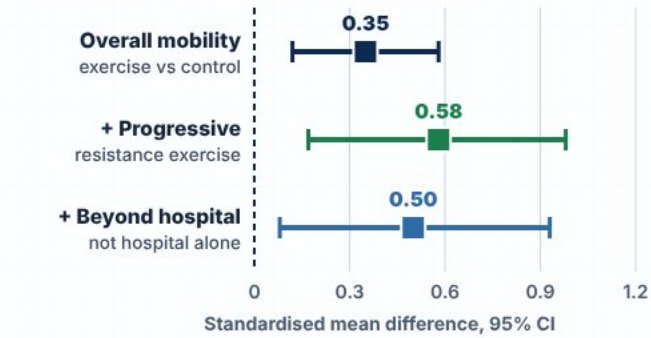


B · Frame walk Day 1



C · Chair rise Strength

Structured exercise after hip fracture



13 trials, 1903 participants; "+" rows are the added change in SMD for that programme feature. Diong et al. (2016).

Decision pathway

1. **OPERATE & MOBILISE**
   Surgery on the day of or after admission, then physiotherapy and getting up from the next day.
2. **REBUILD**
   Continue structured exercise after discharge and include progressive resistance work for larger mobility gains.
3. **PREVENT**
   Practise balance and functional exercise, such as tandem stance and chair rises, to cut further falls.

NOT RECOMMENDED

Prolonged bed rest, or stopping exercise at discharge: hospital-only programmes gave smaller mobility gains.

SEEK ASSESSMENT IF

After a fall: hip or groin pain, inability to bear weight, or a shortened, outwardly turned leg needs emergency assessment, even if the first X-ray looks normal.

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HIP PAIN IN WOMEN IN MIDLIFE: TENDONS, HORMONES AND LOAD

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EYE-OPENER

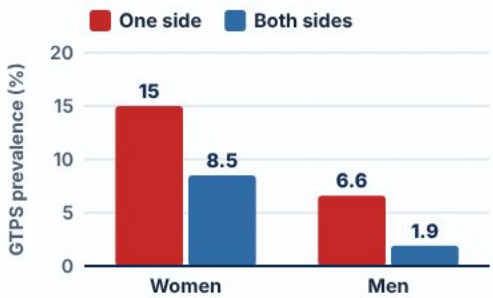
82% of people in a large gluteal tendon pain trial were women, average age about 55.

167 of 204 participants, aged 35–70; calculated from counts. Mellor et al. (2018).

One-leg loading and the outer hip

- Standing on one leg, the gluteus medius and minimus hold the pelvis level; their tendons attach to the greater trochanter.
- Gluteal tendon pain (GTPS) is typically aggravated by side-lying, stairs and prolonged single-leg loading.

Outer hip pain, adults aged 50–79



3026 adults, Multicenter Osteoarthritis Study. GTPS = greater trochanteric pain syndrome. Segal 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). Educational, not diagnostic.

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B · GLUTE BRIDGE, SIDE





OTHER VIEW

EYE-OPENER

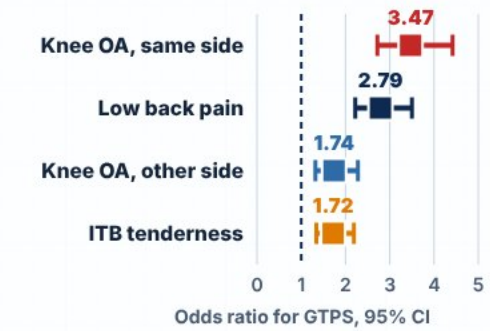
1.10 odds ratio, not significant: body weight was not linked to outer hip pain (BMI ≥30 vs <25).

95% CI 0.80–1.52. Segal et al. (2007).

Strength without side-lying load

- Progressive gluteal work, such as the bridge, was part of the education-plus-exercise programme that outperformed injection.
- Outer hip pain clustered with knee osteoarthritis and low back pain: a whole-limb picture, though these are associations, not causes.

What travels with outer hip pain



Cross-sectional, 3026 adults aged 50–79; ITB = iliotibial band. Segal 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). No pose overlay or angles in lying positions, where landmarks are unreliable. Educational, not diagnostic.

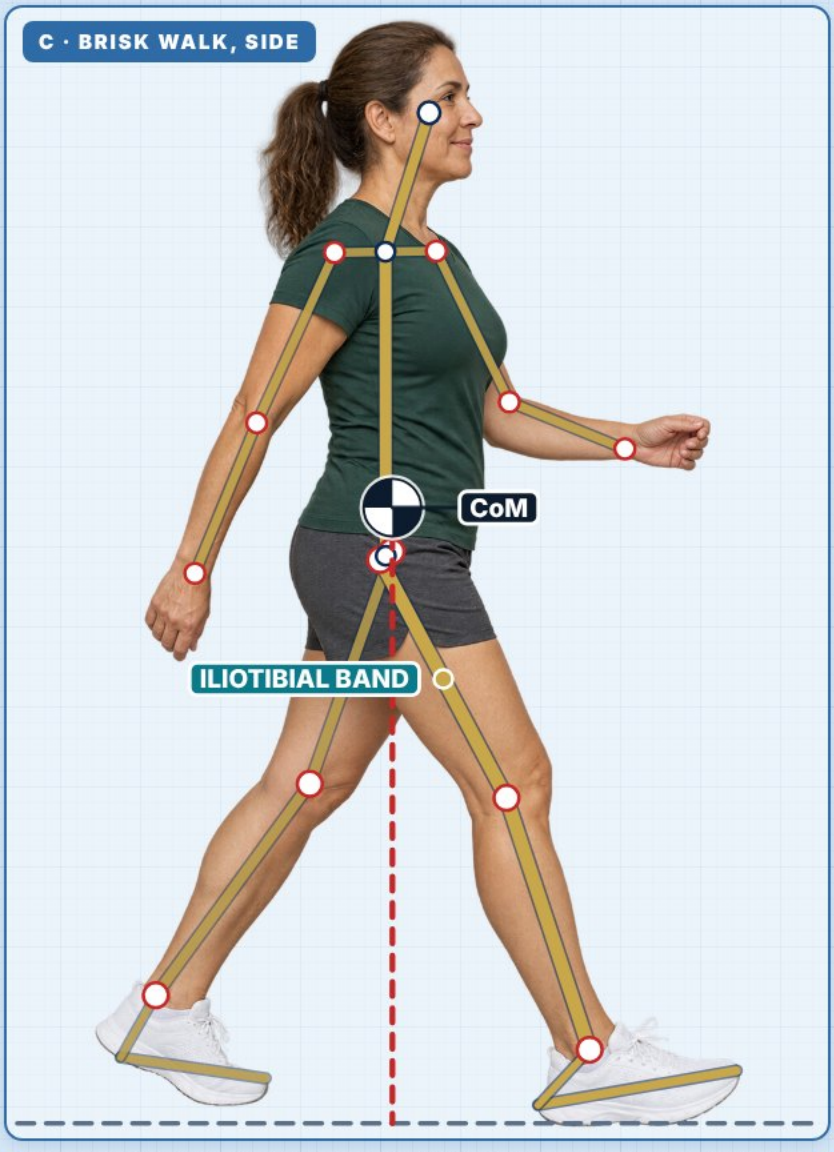
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EYE-OPENER

3× Women in midlife and later were over three times as likely as men to have outer hip pain.

Odds ratio 3.37 (95% CI 2.67–4.25), adults aged 50–79. Segal et al. (2007).

Education about load comes first

- Load education plus 14 exercise sessions over 8 weeks gave the lowest pain scores at 8 weeks.
- Tenderness of the iliotibial band, on the outer thigh, was also linked to outer hip pain.

Pain after 8 weeks of care



204 people aged 35–70 with gluteal tendinopathy; pain as reported in the trial. Mellor et al. (2018).

Hormones? In a trial of 132 postmenopausal women, every arm improved; hormone therapy helped only in a BMI <25 subgroup (Cowan et al., 2022).

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A · One-leg stance Load

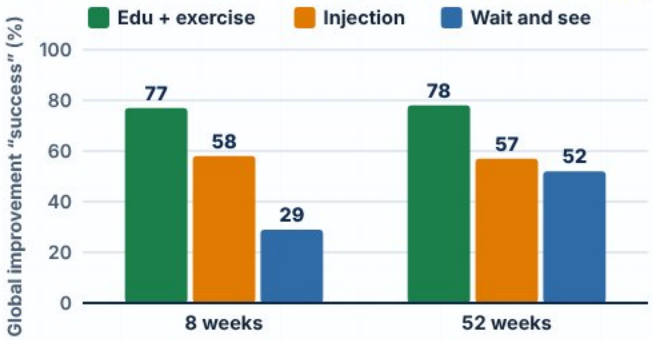


B · Bridge Strength



C · Brisk walk Progress

Education plus exercise beat injection and waiting



LEAP RCT, 204 people (167 women); percentages calculated from published counts. Mellor et al. (2018).

Decision pathway

1. **EDUCATE**
   Explain tendon load and pace the usual aggravators: side-lying, stairs and prolonged standing on one leg.
2. **STRENGTHEN**
   Progress gluteal exercise and walking over about 8 weeks.
3. **CHECK THE CHAIN**
   Look for knee osteoarthritis and low back pain; hormone therapy is not an established treatment for outer hip pain.

NOT RECOMMENDED

Relying on one corticosteroid injection: at one year, 57% improved after injection versus 78% after education plus exercise.

SEEK ASSESSMENT IF

Fever or a hot swollen hip, night pain not linked to side-lying, unexplained weight loss, pain after a fall with osteoporosis, or groin pain with lost rotation.

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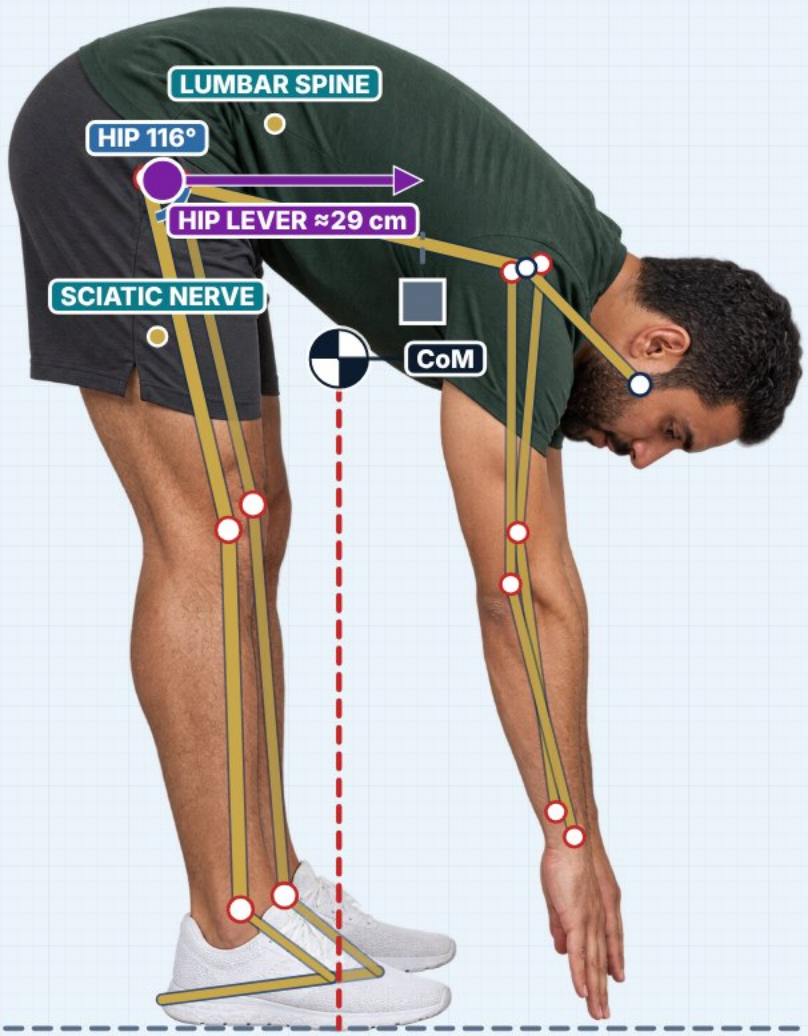
BIOMECHANICS IS A FORCE-GOVERNED DECISION SYSTEM – NOT A POSTURE MODEL.

INTEGRATING PERFORMANCE & REHABILITATION HEALTHCARE PATHWAYS.

HIP PAIN THAT IS NOT THE HIP: LOWER BACK AND NERVE REFERRAL

AN MMSX AUTHORITY | APPLIED BIOMECHANICS LAB EDUCATIONAL ANALYSIS

A · FORWARD BEND, SIDE



EYE-OPENER

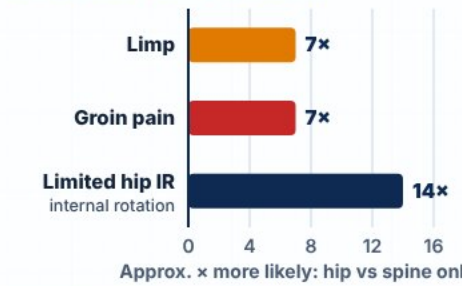
29 cm horizontal lever from hip to upper-body mass when reaching for the floor: a big load on back and hip.

Measured on this figure; hip moment ≈118 N·m for a 70 kg adult.

Buttock pain on bending is not specific

- Bending to the floor (hip flexion ≈**116°** from the trunk line) loads both the lumbar spine and the hip; pain here fits either source.
- Groin pain, a limp and a stiff hip in rotation pointed far more strongly to the hip than to the spine.

Clues that point to the hip



97 patients with lower-limb pain; likelihood of a hip or hip-plus-spine disorder vs spine only. Brown 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). Hip lever: hip-joint centre to upper-body CoM; moment = upper-body weight × lever, 70 kg adult, static. Educational, not diagnostic.

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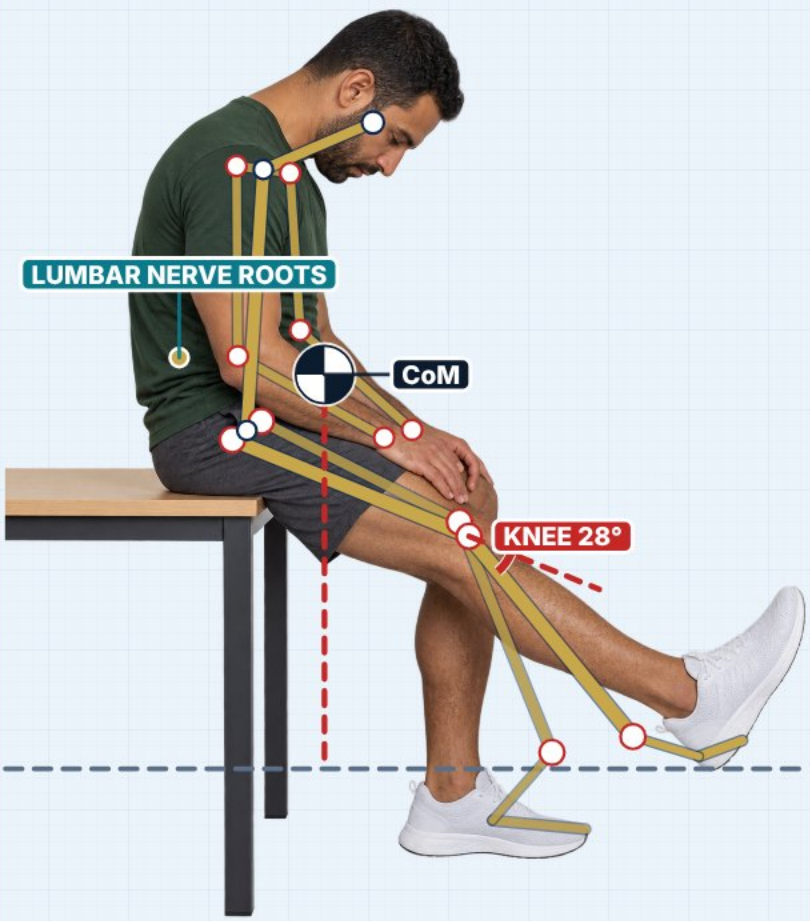
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B · SLUMP SITTING, SIDE



EYE-OPENER

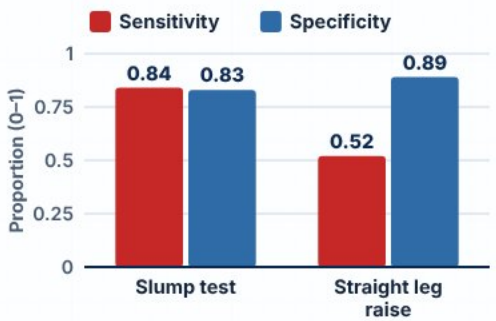
2.8× higher odds of painful outer hip (GTPS) in adults who also had low back pain.

Odds ratio 2.79 (95% CI 2.22–3.50), 3026 adults aged 50–79. Segal et al. (2007).

The slump test tensions the nerve

- Slumped trunk, chin down, knee straightening (≈**28°** short of straight here): reproducing leg pain suggests a nerve-related source.
- The slump test was more sensitive and the straight leg raise slightly more specific, so they complement each other.

Nerve tension tests for disc herniation



75 patients, 38 with MRI-confirmed herniation; values read from a translated abstract, interpret cautiously. Majlesi 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.

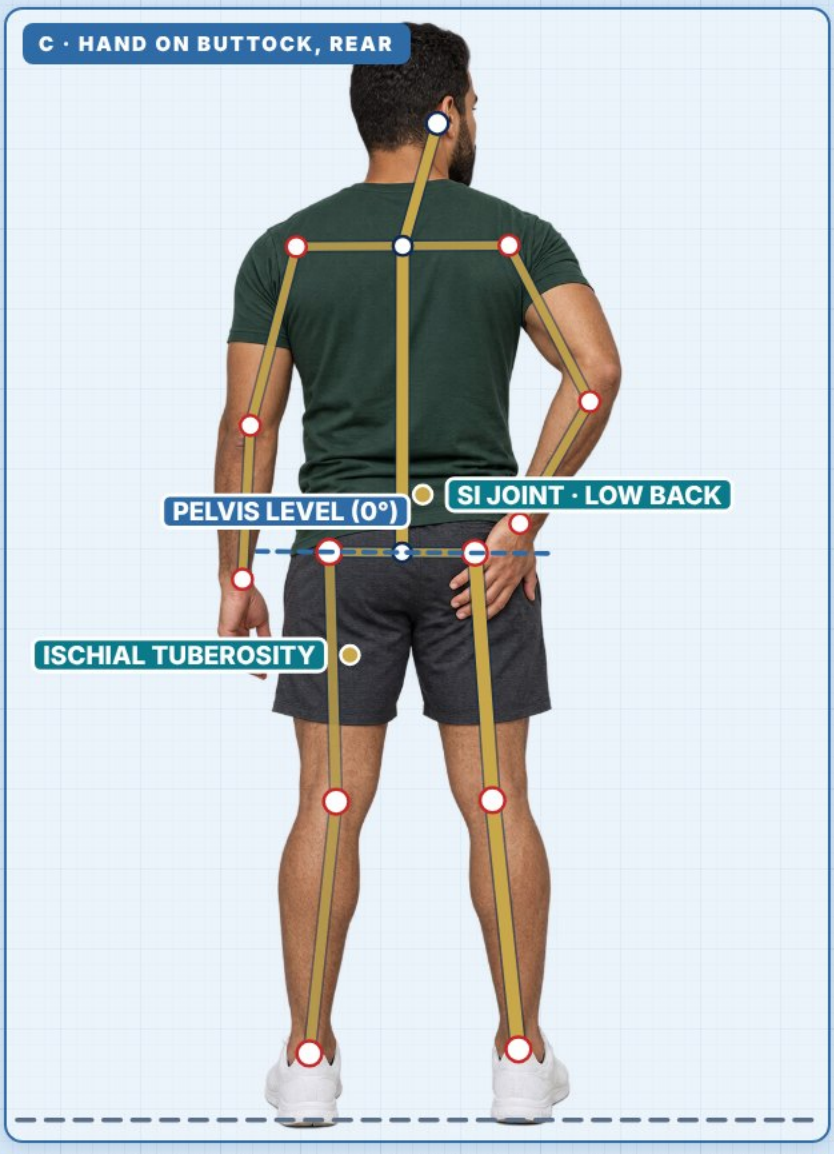
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2-D estimates from pose landmarks on an illustrated figure; CoM from de Leva (1996) segment parameters; cm for a 1.70 m adult (Winter, 2009). Pelvis line joins the two hip landmarks in the rear view. Educational, not diagnostic.

EYE-OPENER

0.52 sensitivity of the straight leg raise: it missed about half of MRI-confirmed disc herniations.

Translated abstract; interpret cautiously. Majlesi et al. (2008).

Buttock pain: back, SI joint or hip

- Hand on the buttock, pelvis level (**0°**): this area can hurt from the lumbar spine, sacroiliac joint, nerve roots or the hip itself.
- Back pain and outer hip pain often occur together, so examine both regions rather than choosing one by default.

Back pain travels with outer hip pain



Cross-sectional, 3026 adults aged 50–79; associations, not causes. ITB = iliotibial band. Segal et al. (2007).

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A · Bend Non-specific

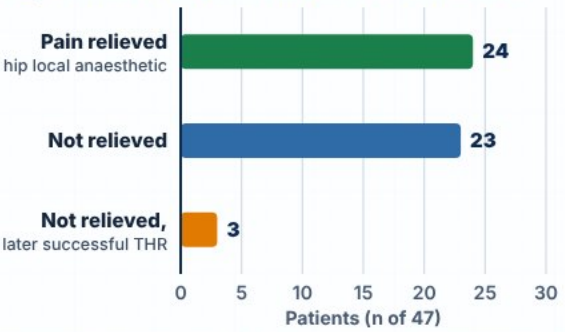


B · Slump Nerve test



C · Buttock Both regions

A diagnostic hip injection: joint or referred?



10-year single-centre series, hip OA with thigh pain of uncertain origin; reported sensitivity 88%, specificity 100%. THR = hip replacement. Faraj et al. (2003).

Decision pathway

1. **EXAMINE BOTH**
   Check hip internal rotation, gait and groin pain, and test the lumbar spine in the same visit.
2. **TEST THE NERVE**
   Use the slump and straight leg raise together; a positive slump test suggests a nerve-related source.
3. **CLARIFY**
   If the source stays uncertain, specialist assessment may include a diagnostic hip injection; treat each source found.

NOT RECOMMENDED

Labelling buttock pain as a worn hip, or as back pain, without examining both regions.

SEEK ASSESSMENT IF

Saddle numbness, new bladder or bowel disturbance or progressive leg weakness; or pain with fever, weight loss, past cancer or constant night pain.

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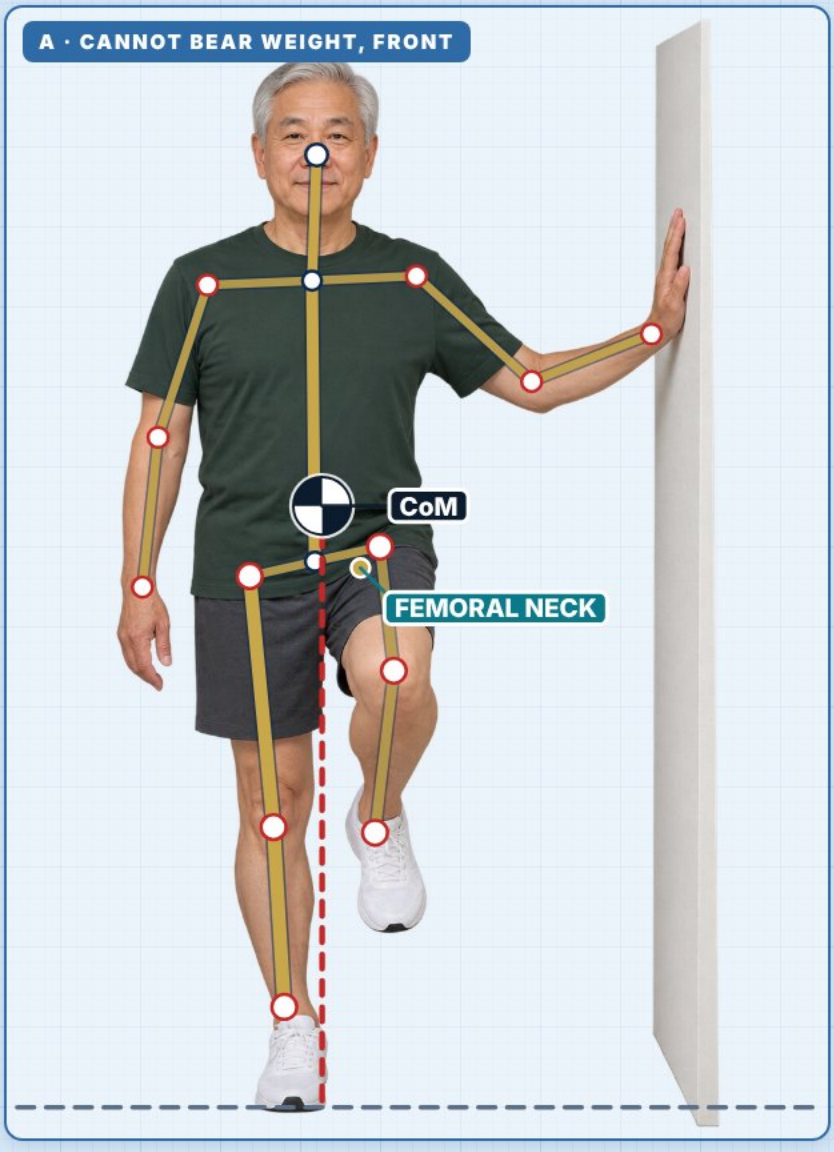
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HIP RED FLAGS: WHEN HIP OR GROIN PAIN NEEDS URGENT MEDICAL CARE

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EYE-OPENER

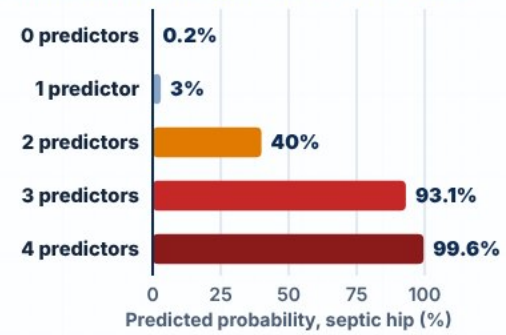
57% of adults with an infected joint had a fever: no fever does not rule out infection.

Sensitivity of fever for septic arthritis, 14 studies. Margaretten et al. (2007).

Not bearing weight is a red flag

- Holding the leg off the floor and leaning on a wall is not a load problem to exercise through; it needs medical assessment.
- In a child, fever plus refusing to bear weight sharply raises the chance of an infected hip, as the chart shows.

Child with an irritable hip: is it septic?



Fever, non-weight-bearing, ESR ≥40 mm/h, white cells >12 000/mm³; 0 = <0.2%. 282 children; paediatric rule. Kocher et al. (1999).

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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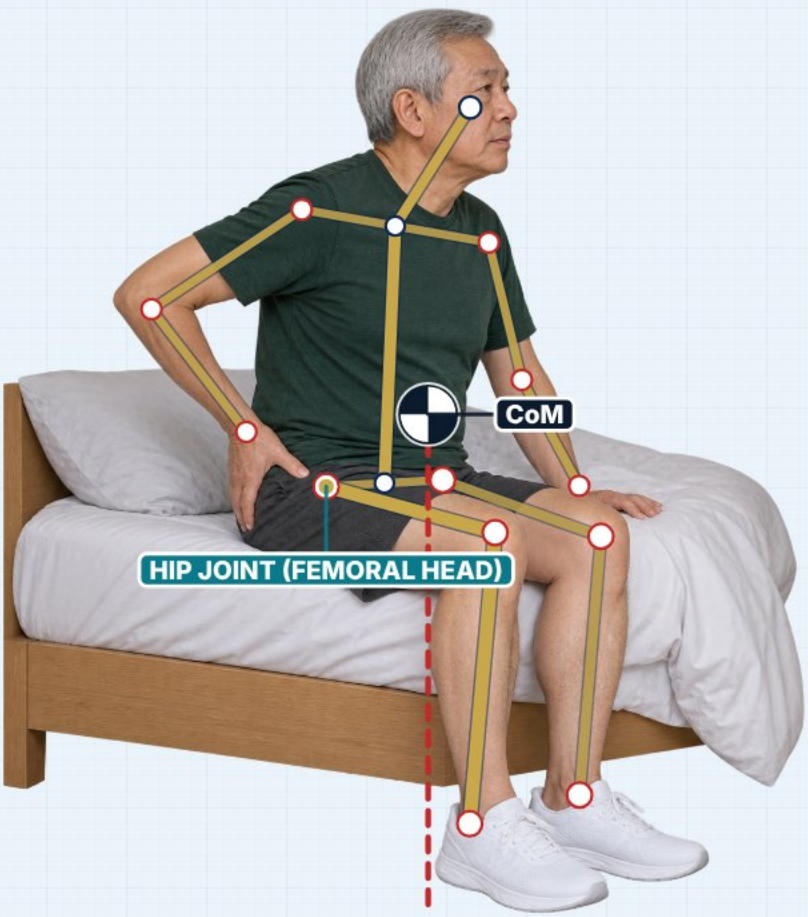
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B · NIGHT PAIN IN BED, SIDE



EYE-OPENER

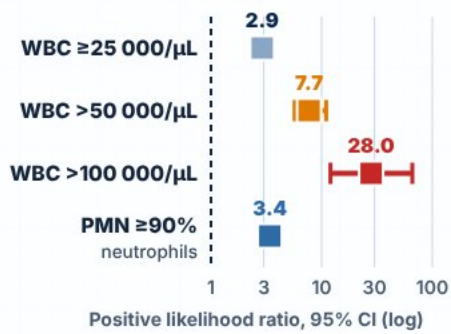
27% of adults with septic arthritis reported sweats, and only 19% rigors: their absence proves little.

Sensitivities, 6242 patients, 653 with septic arthritis. Margaretten et al. (2007).

Night pain with feeling unwell

- Constant night pain, especially with sweats, fever, weight loss or a history of cancer, needs medical review (general clinical guidance).
- A hot, painful hip needs joint aspiration: a very high joint-fluid white-cell count strongly supports infection.

Joint-fluid tests for infection



WBC = synovial white cells; LR >10 strongly raises the probability. Systematic review, 14 studies. 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). Skeleton only: angles are not estimated in this oblique seated view. Educational, not diagnostic.

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C · AFTER A FALL, FRONT



EYE-OPENER

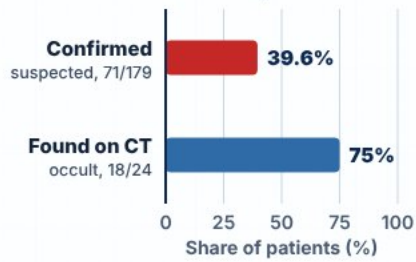
1 in 3 older adults die within 12 months of a hip fracture, and about half are left permanently disabled.

Rounded UK figures from an official press release. NICE (2011).

A normal X-ray is not the end

- After a fall, hip or groin pain and inability to stand need urgent assessment, even if the first X-ray looks normal.
- In one series, CT detected 18 of 24 occult fractures; MRI found 3 that CT had missed.

Fractures the first X-ray missed



Older adults with suspected hip fracture; secondary summary of two studies. BestBETs (n.d.).

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). Skeleton only: angles are not estimated in floor-sitting poses. Educational, not diagnostic.

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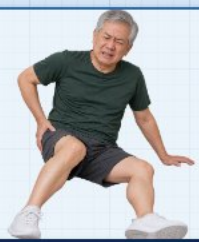
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A · No weight Fracture?

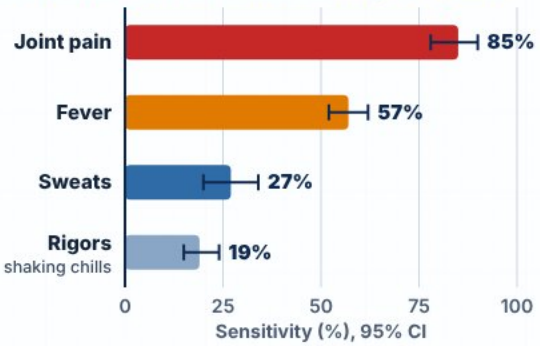


B · Night pain Infection?



C · Fall Urgent

Septic arthritis: how often each sign appears



Systematic review, 14 studies, 6242 patients (653 septic). Risk rises with diabetes, rheumatoid arthritis or a joint prosthesis. Margaretten et al. (2007).

Decision pathway

1. **AFTER A FALL**
   Cannot bear weight: urgent assessment; MRI if X-rays are normal but doubt persists.
2. **HOT HIP**
   Hot, painful hip, fever or not: same-day review and joint aspiration.
3. **RUNNER'S GROIN**
   Groin pain building with running: image first; 73% of non-displaced vs 33% of displaced stress fractures ran again.

NOT RECOMMENDED

Exercising through a red flag, or reassuring because of no fever or a normal first X-ray.

SEEK ASSESSMENT IF

Urgently: no weight-bearing after a fall; a hot, swollen hip; a child who limps or will not stand; constant night pain, weight loss or past cancer.

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