MMSx AUTHORITY · APPLIED BIOMECHANICS LAB

Elbow, Forearm, Wrist and Hand Rehabilitation

50 Evidence-Based Biomechanics Analyses

50 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.

DOI 10.5281/zenodo.23735910

Version 1 · 28 October 2026 · CC BY 4.0

Online edition: mmsxauthority.org/edu/analysis/arm/

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

ARM PAIN REHAB CHALLENGE

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Mehta, N. (2026). Elbow, Forearm, Wrist and Hand Rehabilitation: 50 Evidence-Based Biomechanics Analyses. MMSx Authority Applied Biomechanics Lab. https://doi.org/10.5281/zenodo.23735910

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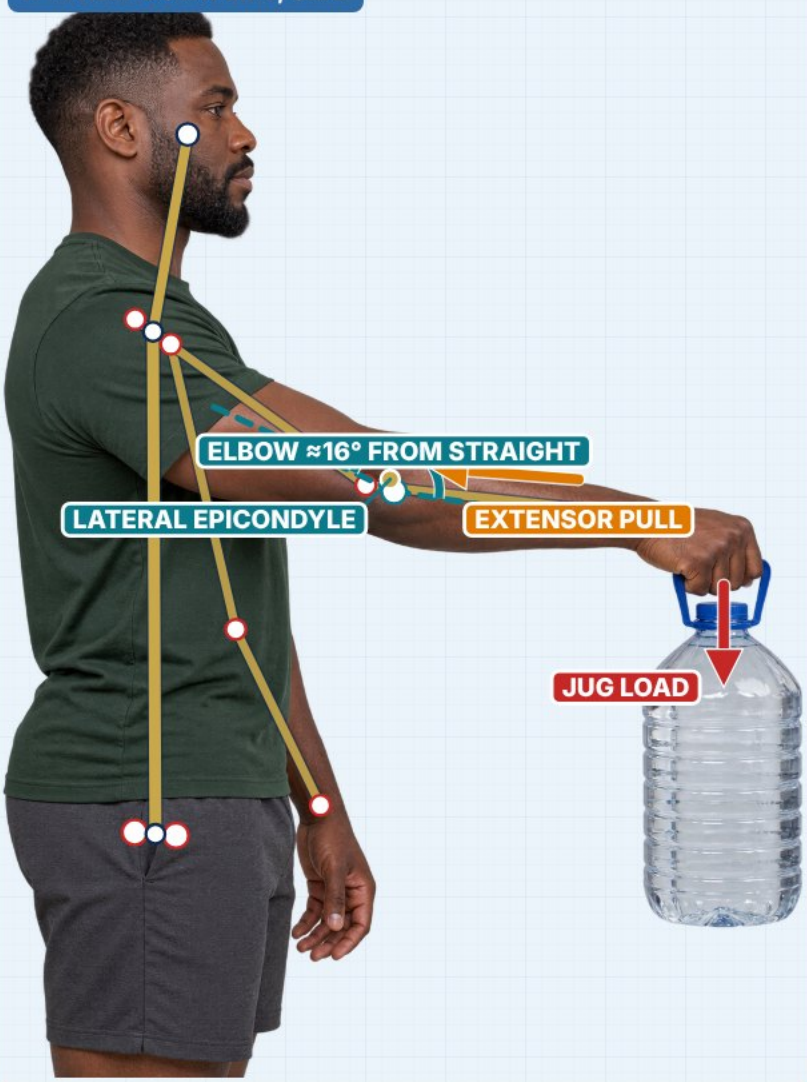
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TENNIS ELBOW: WHY THE OUTER ELBOW HURTS WHEN YOU GRIP AND LIFT

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A · PALM-DOWN LIFT, SIDE



EYE-OPENER

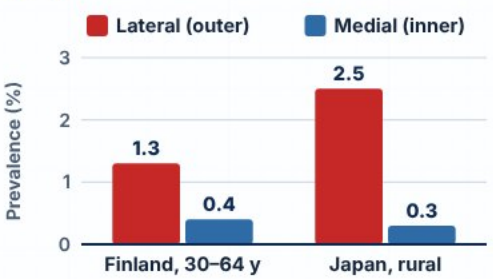
5.6× higher odds of tennis elbow when arm work is both forceful and repetitive.

Adjusted OR, 95% CI 1.9–16.5. Shiri et al. (2006).

A long lever on the wrist

- Palm-down lift with the elbow ≈**16°** from straight: the jug hangs at the end of the forearm, and the wrist extensors must hold the wrist level against it.
- Those extensors, chiefly ECRB, arise from the lateral epicondyle, which is where grip-and-lift pain is felt.

The outer elbow is affected far more often



Population samples: Finland n = 4,783 (Shiri et al., 2006); Japan n = 1,777 (Otoshi et al., 2015).

2-D estimates from pose landmarks on an illustrated figure (head-to-hip framing); lengths scaled to a 1.70 m adult (Winter, 2009). Elbow angle from manually placed shoulder, elbow and wrist landmarks. Educational, not diagnostic.

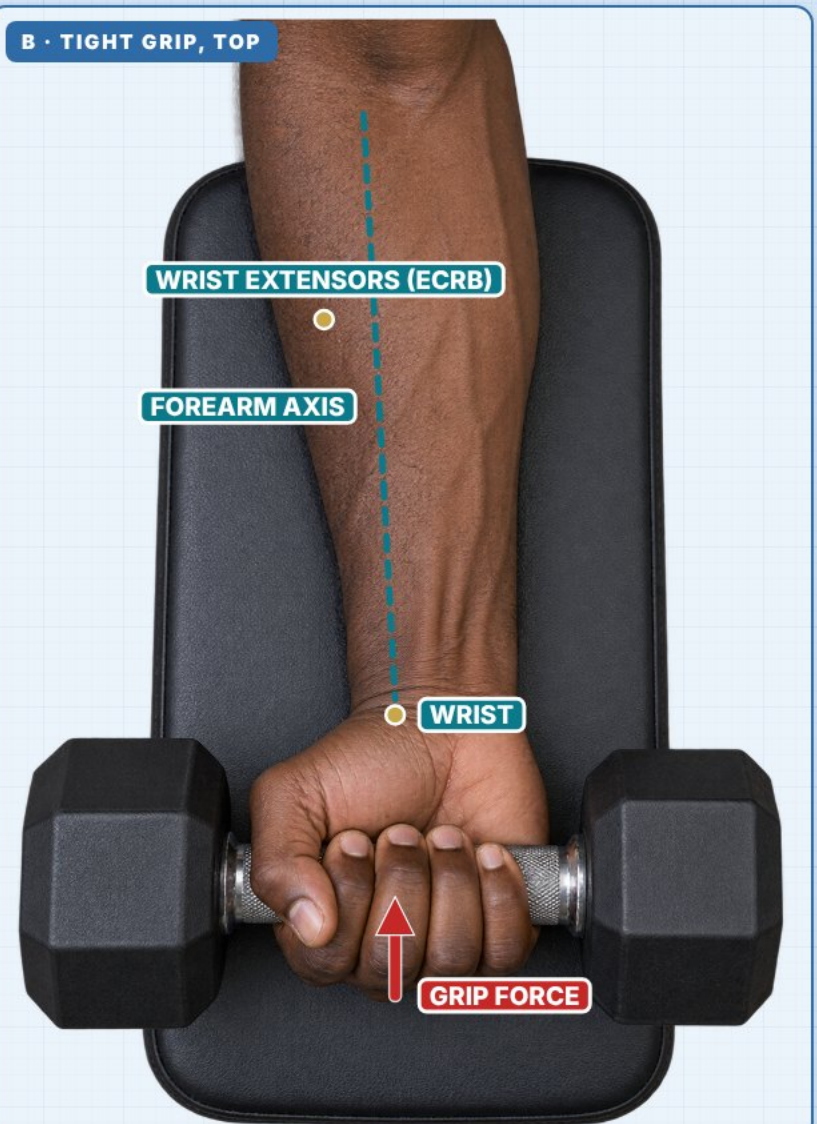
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TENNIS ELBOW: WHY THE OUTER ELBOW HURTS WHEN YOU GRIP AND LIFT

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EYE-OPENER

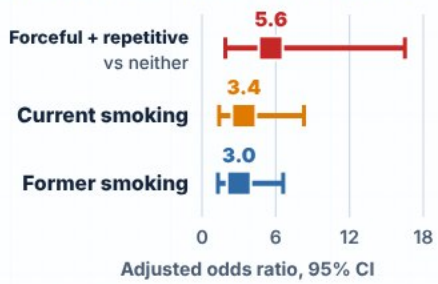
1.3% of adults aged 30–64 have definite tennis elbow at any one time.

Finnish population sample, n = 4,783. Shiri et al. (2006).

Gripping loads the extensors too

- A hard grip needs the wrist extensors to co-contract, holding the wrist slightly extended so the finger flexors can generate force.
- So every firm grip, not only lifting, pulls on the common extensor origin at the outer elbow.

Force plus repetition carries the risk



Finnish adults 30–64; possible or definite (work) and definite (smoking) lateral epicondylitis. Shiri et al. (2006).

Angles from landmarks placed on an illustrated figure (2-D, camera-plane); approximate. Grip direction and forearm axis drawn on the figure for teaching. Educational, not diagnostic.

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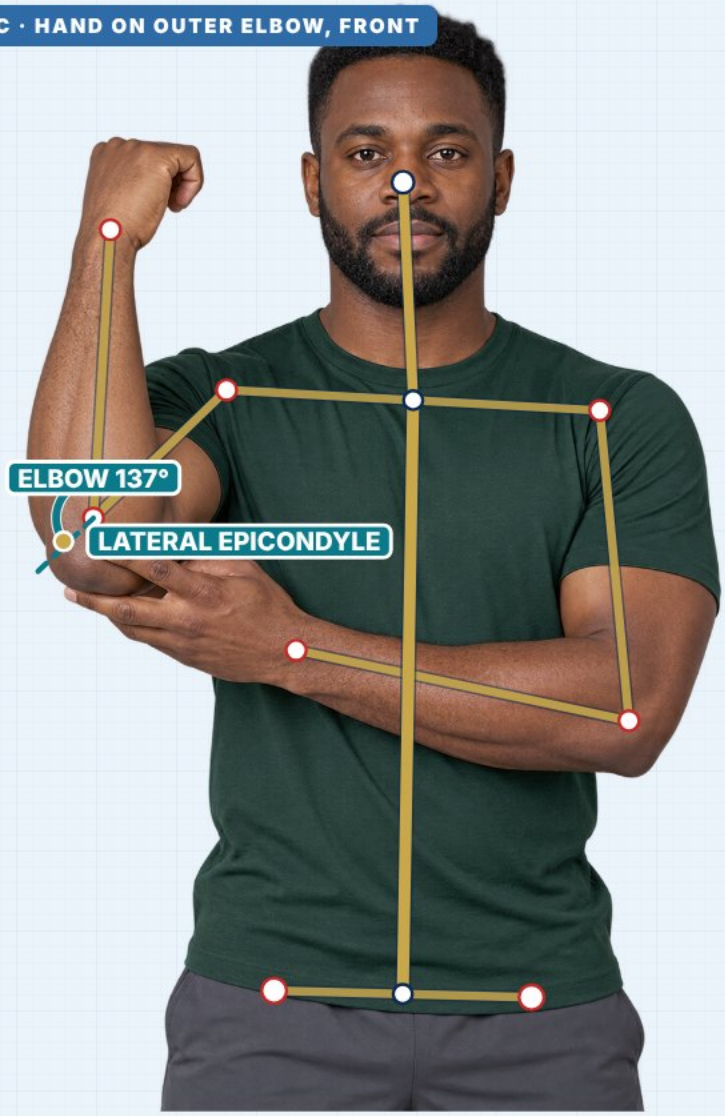
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C · HAND ON OUTER ELBOW, FRONT



EYE-OPENER

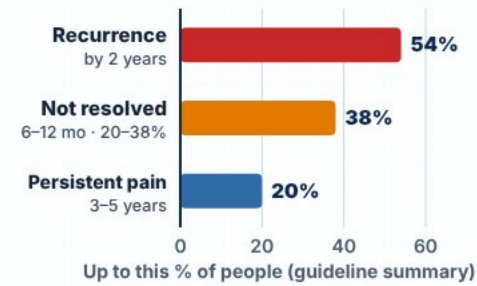
90% recovered or much improved by one year with "wait and see" alone.

56 of 62 people. Bisset et al. (2006).

Finding the painful spot

- Pain sits on or just below the lateral epicondyle, at the common extensor origin, and is provoked by gripping or resisted wrist and middle-finger extension.
- Most cases settle over months, but recurrence is common, so loading is planned.

Slow to settle, quick to return



Upper values of earlier studies summarised in the JOSPT guideline. Lucado et al. (2022).

Myth: "Rest it until it is better." The guideline recommends progressive wrist-extensor loading (Grade B).

2-D estimates from pose landmarks on an illustrated figure (head-to-hip framing); lengths scaled to a 1.70 m adult (Winter, 2009). Elbow angle from pose landmarks in the front view. Educational, not diagnostic.

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A · Lift Long lever

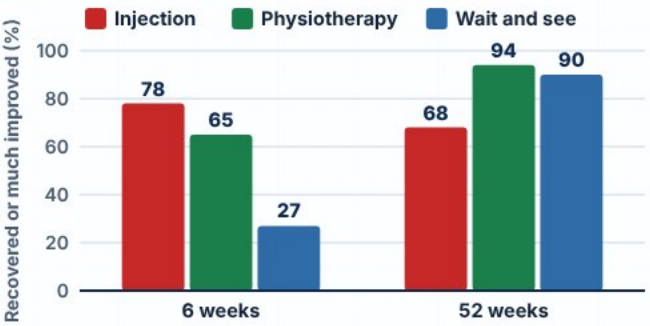


B · Grip Co-contraction



C · Locate Epicondyle

Injection helps early, then loses its lead



198 adults, tennis elbow ≥ 6 weeks; physiotherapy = mobilisation with movement + exercise. Bisset et al. (2006).

Decision pathway

1. **MODIFY**
   Lift palm-up or closer to the body and spread hard gripping while pain settles.
2. **LOAD**
   Progress isometric, then slow concentric and eccentric wrist-extensor exercise (guideline Grade B).
3. **TRACK**
   Measure pain-free grip; build it gradually for work or sport demands.

NOT RECOMMENDED

Complete rest, or relying on a steroid injection, which gave worse one-year results than physiotherapy.

SEEK ASSESSMENT IF

Chest or left-arm pain, a hot swollen joint with fever, deformity after a fall, worsening numbness or weakness, or a tight swollen forearm: seek prompt assessment.

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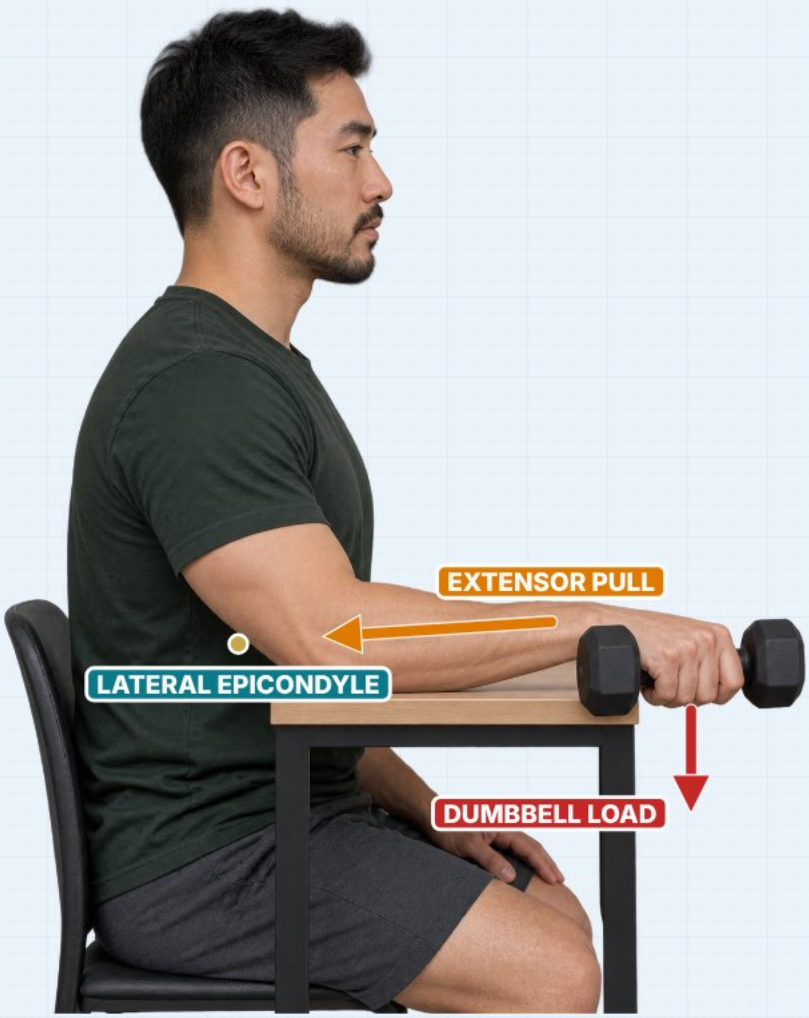
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TENNIS ELBOW IS NOT INFLAMMATION: WHAT THE TENDON IS REALLY DOING

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A · WRIST-LEVEL HOLD, SIDE



EYE-OPENER

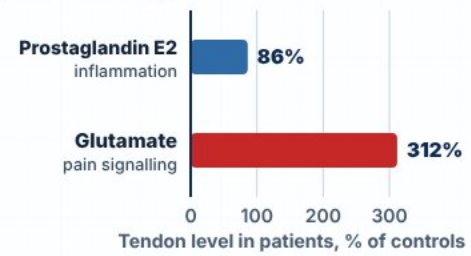
33 mm³ more poorly organised (hypoechoic) tendon tissue on ultrasound in the painful elbow.

Mean difference, 95% CI 8.4–57.6. Heales et al. (2015).

A failed-healing tendon, not a fire

- Holding the dumbbell level loads the wrist extensors isometrically; their tendon, chiefly ECRB, arises from the lateral epicondyle.
- In tennis elbow that tendon shows degenerative, failed-healing change, so "epicondylitis" is a misleading name.

Inflammatory marker normal, glutamate high



Microdialysis in the ECRB tendon at rest, 4 patients vs 4 controls; patient mean as % of control mean (PGE2 not significant; glutamate $p < 0.001$). Alfredson et al. (2000).

2-D estimates from pose landmarks on an illustrated figure (head-to-hip framing); lengths scaled to a 1.70 m adult (Winter, 2009). Force directions drawn on the figure for teaching. Educational, not diagnostic.

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B · SLOW LOWERING, SIDE



2-D estimates from pose landmarks on an illustrated figure (head-to-hip framing); lengths scaled to a 1.70 m adult (Winter, 2009). Wrist angle from manually placed forearm and hand landmarks. Educational, not diagnostic.

EYE-OPENER

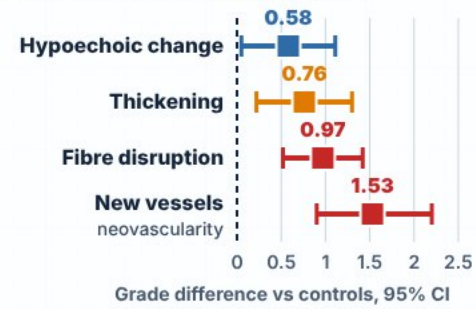
1 in 10 people gain an extra good result from slow-lowering rather than lifting-only training.

Number needed to treat 10, 3 months, n = 120. Peterson et al. (2014).

Structure that has changed

- Lowering the dumbbell slowly (wrist flexion ≈**53°**) lengthens the extensors under load: eccentric work, which tendon rehabilitation uses to rebuild capacity.
- Painful tendons show disrupted fibres, thickening and new vessels, not the swelling and pus of acute inflammation.

Painful tendons look different



29 people with one painful elbow vs 32 pain-free controls; ultrasound grade differences. Heales et al. (2015).

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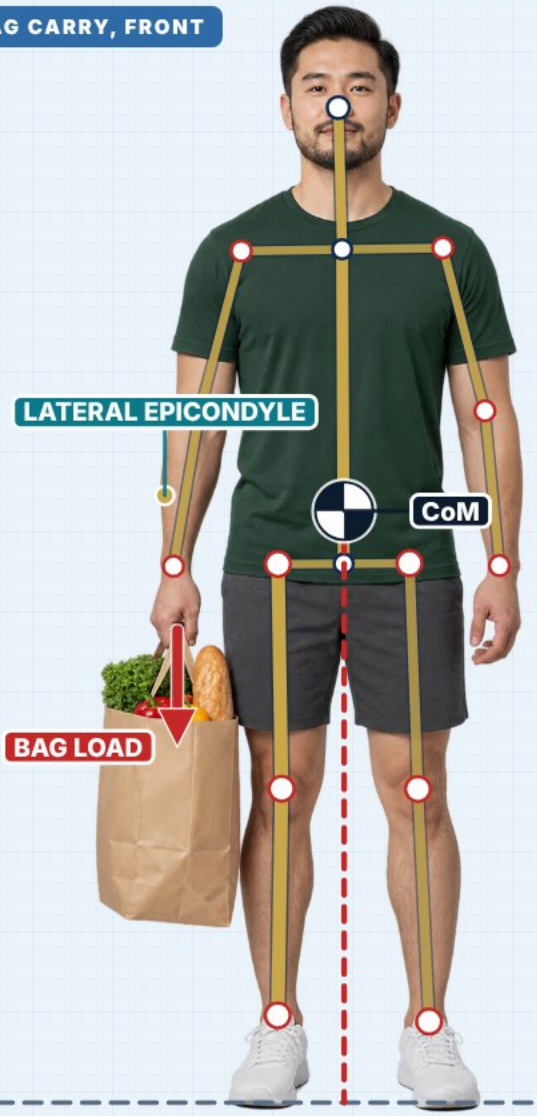
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C · BAG CARRY, FRONT



EYE-OPENER

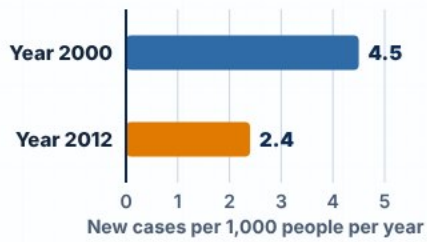
3.2% of cases went to surgery in 2012, up from 1.1% in 2000, as diagnoses fell.

Secondary summary in Lucado et al. (2022).

Everyday grip still counts

- A carried bag hangs from a sustained grip; the wrist extensors co-contract to steady the wrist, loading the same tendon origin.
- Because the problem is tendon capacity, not inflammation, the plan is to grade load, not to suppress swelling.

Diagnosed less often, operated on more



Age- and sex-adjusted annual incidence; secondary summary of earlier data in the JOSPT guideline. Lucado et al. (2022).

Myth: "Anti-inflammatories cure tennis elbow." The guideline advises against anti-inflammatory gel phonophoresis (Grade C).

2-D estimates from pose landmarks on an illustrated figure; CoM (if shown) from de Leva (1996); cm for a 1.70 m adult (Winter, 2009). Skeleton and CoM from pose landmarks; load arrow drawn for teaching. Educational, not diagnostic.

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A · Hold Isometric

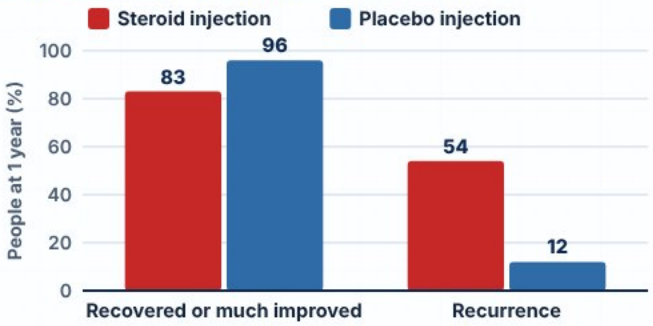


B · Lower Eccentric



C · Carry Daily grip

Suppressing "inflammation" backfired



165 adults, tennis elbow > 6 weeks; 1-year recovery RR 0.86 (99% CI 0.75–0.99). Coombes et al. (2013).

Decision pathway

1. **UNDERSTAND**
   Treat it as a tendon that has lost load capacity, not an inflamed joint.
2. **LOAD**
   Start with level wrist holds, then slow lowering; the guideline grades progressive loading B.
3. **GRADE**
   Build carrying and gripping in steps the tendon tolerates the next day.

NOT RECOMMENDED

Relying on steroid injection or anti-inflammatory gels; one-year recovery was lower and recurrence higher after steroid.

SEEK ASSESSMENT IF

A red, hot, swollen elbow with fever is not tendinopathy; also deformity, numbness or weakness: seek prompt assessment.

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GOLFER'S ELBOW: INNER ELBOW PAIN FROM GRIPPING, THROWING AND LIFTING

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A · GOLF IMPACT, SIDE



EYE-OPENER

0.4% of adults aged 30–64 have definite golfer's elbow: about a third of the tennis-elbow rate.

Finnish population sample, n = 4,783. Shiri et al. (2006).

The inner elbow in the swing

- At impact the club pulls the hands along the shaft; the forearm flexors and pronators grip and rotate against it from the medial epicondyle.
- Amateurs drove the trail-arm pronator above a maximal manual test, about twice the professionals' level.

Amateurs overwork the trail arm



Trail arm, mean %MMT; 10 amateur vs 10 professional golfers without elbow pain (p = 0.04 and 0.08). Farber et al. (2009).

Angles from landmarks placed on an illustrated figure (2-D, camera-plane); approximate. Pose skeleton omitted (twisted swing pose); club-pull arrow drawn along the shaft for teaching. Educational, not diagnostic.

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B · WRIST-FLEXION CURL, SIDE



EYE-OPENER

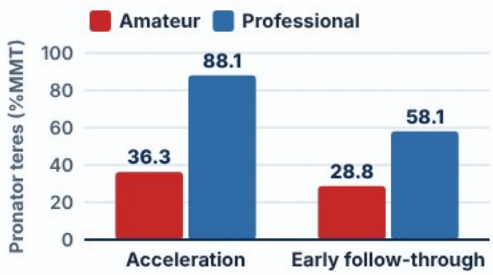
1.9% of US manual workers had golfer's elbow; most were not golfers.

Pooled worker cohorts, n = 1,824. Thiese et al. (2016).

Loading the flexor–pronator origin

- A palm-up curl (wrist flexion ≈**40°**) works the wrist flexors that share the common flexor origin on the medial epicondyle.
- No medial-elbow trial was found: graded loading here is borrowed from tennis-elbow evidence, not tested for golfer's elbow.

Professionals share the work to the lead arm



Lead arm, mean %MMT; same 20 golfers (p = 0.03 and 0.06). Farber et al. (2009).

2-D estimates from pose landmarks on an illustrated figure (head-to-hip framing); lengths scaled to a 1.70 m adult (Winter, 2009). Wrist angle from manually placed forearm and hand landmarks. Educational, not diagnostic.

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C · HAND ON INNER ELBOW, FRONT



EYE-OPENER

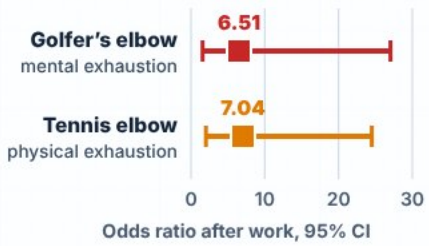
8 of 10 workplace stress factors studied were linked with golfer's elbow.

Significant trends or associations. Thiese et al. (2016).

Finding the painful spot

- Pain sits on the medial epicondyle, the bony inner point, and is provoked by resisted wrist flexion, forearm pronation and gripping.
- Tingling in the ring and little fingers points instead to the ulnar nerve, which runs just behind it.

Exhaustion after work tracks with pain



Largest odds ratio per condition, pooled US worker cohorts; association, not cause, wide CIs. Thiese et al. (2016).

Myth: "Golfer's elbow only happens to golfers." Population and workplace samples find it mainly in forceful manual work.

2-D estimates from pose landmarks on an illustrated figure (head-to-hip framing); lengths scaled to a 1.70 m adult (Winter, 2009). Anatomy callout placed on the figure for teaching. Educational, not diagnostic.

DOI 10.5281/zenodo.23735910

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

INTEGRATING PERFORMANCE & REHABILITATION HEALTHCARE PATHWAYS.

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A · Swing Trail arm

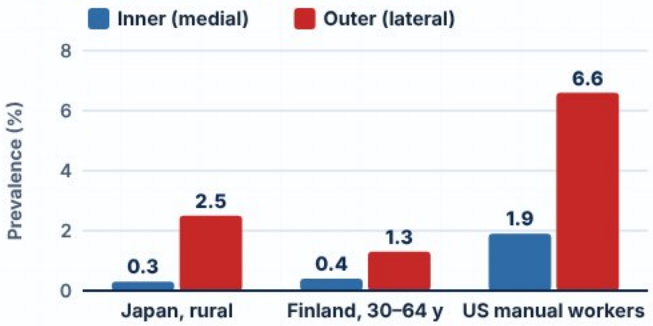


B · Curl Flexor load



C · Locate Inner point

The inner elbow is the rarer site



Japan n = 1,777 (Otoshi et al., 2015); Finland n = 4,783 (Shiri et al., 2006); US n = 1,824 (Thiese et al., 2016).

Decision pathway

1. **MODIFY**
   Ease hard gripping, throwing and swing volume while pain settles; review the trail-arm action.
2. **LOAD**
   Graded wrist-flexion and pronation work, borrowed from tennis-elbow loading (untested for the inner elbow).
3. **SUPPORT**
   Plan recovery around exhausting work days; fatigue is associated with symptoms.

NOT RECOMMENDED

Playing or throwing through pain; treating tennis-elbow trial results as proof for the inner elbow.

SEEK ASSESSMENT IF

Ring- or little-finger tingling, a "pop" or instability when throwing, pain in a young thrower, or a hot swollen elbow.

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Farber, A. J., Smith, J. S., Kvitne, R. S., Mohr, K. J., & Shin, S. S. (2009). Electromyographic analysis of forearm muscles in professional and amateur golfers. *The American Journal of Sports Medicine, 37*(2), 396–401. https://doi.org/10.1177/0363546508325154

Otoshi, K., Takegami, M., Sekiguchi, M., Onishi, Y., Yamazaki, S., Otani, K., Shishido, H., Fukuhara, S., Kikuchi, S., & Konno, S. (2015). Chronic hyperglycemia increases the risk of lateral epicondylitis: The Locomotive Syndrome and Health Outcome in Aizu Cohort Study (LOHAS). *SpringerPlus, 4*, Article 407. https://doi.org/10.1186/s40064-015-1204-3

Shiri, R., Viikari-Juntura, E., Varonen, H., & Heliövaara, M. (2006). Prevalence and determinants of lateral and medial epicondylitis: A population study. *American Journal of Epidemiology, 164*(11), 1065–1074. https://doi.org/10.1093/aje/kwj325

Thiese, M. S., Hegmann, K. T., Kapellusch, J., Merryweather, A., Bao, S., Silverstein, B., Tang, R., & Garg, A. (2016). Psychosocial factors related to lateral and medial epicondylitis: Results from pooled study analyses. *Journal of Occupational and Environmental Medicine, 58*(6), 588–593. https://doi.org/10.1097/JOM.0000000000000701

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TENNIS ELBOW INJECTIONS VERSUS EXERCISE: WHAT THE LONG-TERM EVIDENCE SHOWS

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2-D estimates from pose landmarks on an illustrated figure; CoM (if shown) from de Leva (1996); cm for a 1.70 m adult (Winter, 2009). Pose skeleton omitted (forearm resting on the thigh); band direction drawn for teaching. Educational, not diagnostic.

EYE-OPENER

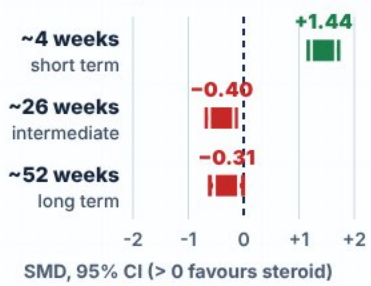
54% relapsed within a year after a steroid injection, against 12% after a placebo injection.

165 adults. Coombes et al. (2013).

Exercise works the tendon, slowly

- The band resists wrist extension, so the extensors that arise from the lateral epicondyle work against a graded, adjustable load.
- Exercise builds tendon capacity over weeks; a steroid quietens pain for weeks but the advantage then reverses.

The steroid advantage reverses



Corticosteroid vs no intervention, lateral epicondylalgia; systematic review of 41 RCTs (2,672 participants). Coombes et al. (2010).

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B · HAMMER ROTATION, SIDE



EYE-OPENER

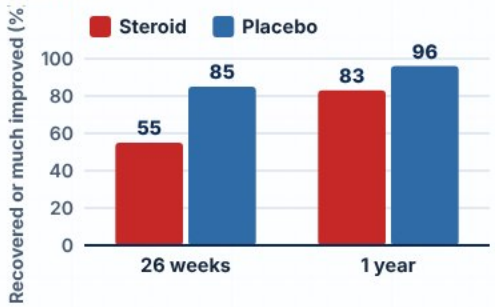
1 in 991 injected participants in the review had a tendon rupture.

Serious adverse event, 0.1%. Coombes et al. (2010).

Rotation adds a lever

- Tipping the hammer sideways turns the forearm against the head's weight on a long handle: a graded rotation load for the forearm muscles.
- Choke down the handle to shorten the lever, or slide out to lengthen it, as tolerance improves.

Placebo beat steroid at 6 and 12 months



165 adults, tennis elbow > 6 weeks; RR 0.79 (99% CI 0.62–0.99) at 26 weeks, 0.86 (0.75–0.99) at 1 year. Coombes et al. (2013).

2-D estimates from pose landmarks on an illustrated figure (head-to-hip framing); lengths scaled to a 1.70 m adult (Winter, 2009). Hammer lever and weight direction drawn on the figure for teaching. Educational, not diagnostic.

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C · SOFT-BALL SQUEEZE, FRONT



EYE-OPENER

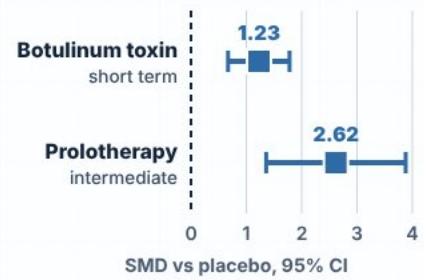
47/65 early injection successes in one trial later came back as pain.

Regression after initial success. Bisset et al. (2006).

Grip is part of the plan

- Squeezing a soft ball loads the finger and wrist flexors while the extensors co-contract to steady the wrist, a low-load start for grip.
- Progress squeeze time and firmness by symptom response, aiming at pain-free grip for daily tasks.

Other injections: big effects, thin evidence



Single or few small trials, not proof of superiority. Coombes et al. (2010).

Myth: "The injection fixed it." Relief at 4 weeks is real, but by 6–12 months outcomes are worse than without it.

2-D estimates from pose landmarks on an illustrated figure (head-to-hip framing); lengths scaled to a 1.70 m adult (Winter, 2009). Grip direction drawn on the figure for teaching. Educational, not diagnostic.

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A · Extend Band load

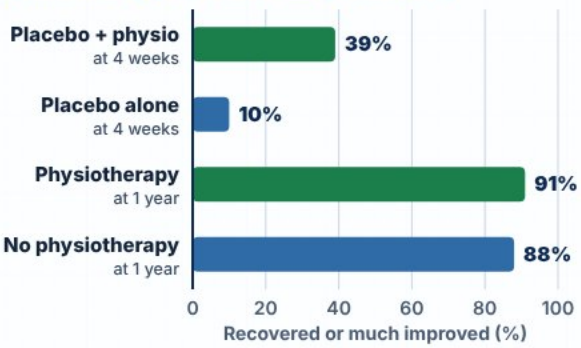


B · Rotate Lever



C · Squeeze Grip

Physiotherapy speeds early recovery



8 sessions (elbow manipulation + exercise); 4 weeks RR 4.00 (99% CI 1.07–15.00); 1 year RR 1.04 (0.90–1.19). Coombes et al. (2013).

Decision pathway

1. **CHOOSE**
   Make exercise the core plan; the guideline grades loading B and makes no injection recommendation (Lucado et al., 2022).
2. **LOAD**
   Progress band wrist extension, hammer rotation and grip by next-day symptoms.
3. **EXPECT**
   Plan for weeks to months; most people recover by a year with or without injection.

NOT RECOMMENDED

Steroid injection for lasting relief: worse at 6–12 months, with more relapses, than placebo.

SEEK ASSESSMENT IF

Skin thinning, sudden loss of grip, or a red, hot, swollen elbow with fever after an injection: seek urgent review.

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Bisset, L., Beller, E., Jull, G., Brooks, P., Darnell, R., & Vicenzino, B. (2006). Mobilisation with movement and exercise, corticosteroid injection, or wait and see for tennis elbow: Randomised trial. *BMJ, 333*(7575), 939–944. https://doi.org/10.1136/bmj.38961.584653.AE

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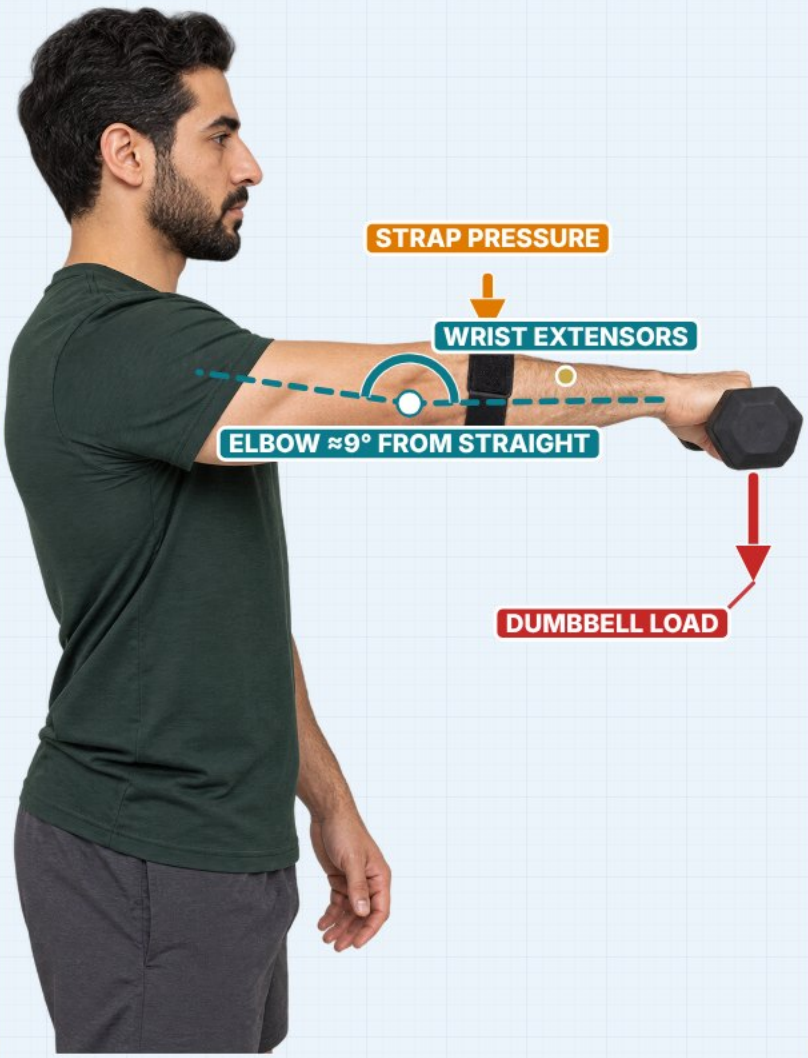
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COUNTERFORCE STRAPS AND BRACES FOR ELBOW PAIN: DO THEY REDUCE TENDON LOAD?

AN MMSX AUTHORITY | APPLIED BIOMECHANICS LAB EDUCATIONAL ANALYSIS

A · LIFT WITH STRAP, SIDE



EYE-OPENER

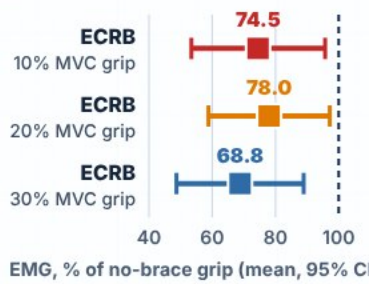
42 kPa better pressure-pain tolerance after a brace, and after no brace alike.

Immediate change, 95% CI 16.5–68.0; n = 34. Bisset et al. (2014).

What the strap is meant to do

- With the arm ≈**9°** from straight and the palm down, the wrist extensors hold the dumbbell level; the strap presses over them below the elbow.
- The idea is to dampen force reaching the lateral epicondyle. EMG data exist only for a dynamic brace, not this simple strap.

A dynamic brace, not a strap, lowered ECRB EMG



Dynamic extensor brace (adds a wrist-extension force) vs same grip without it; wrist neutral; people with tennis elbow. EDC similar. Faes et al. (2006).

2-D estimates from pose landmarks on an illustrated figure (head-to-hip framing); lengths scaled to a 1.70 m adult (Winter, 2009). Elbow angle from manually placed shoulder, elbow and wrist landmarks. Educational, not diagnostic.

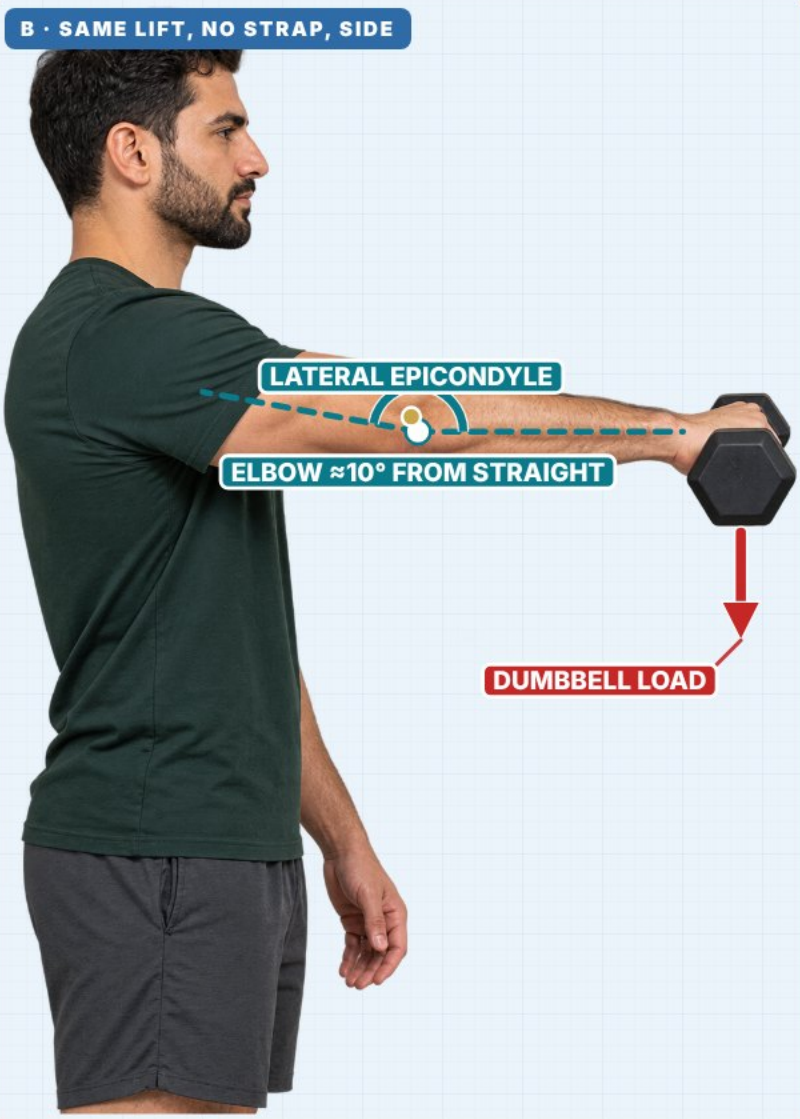
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EYE-OPENER

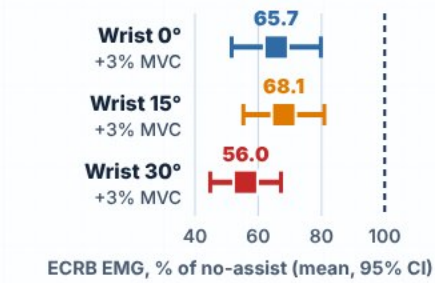
3% of maximal force, pushed into wrist extension from outside, cut extensor activity in almost all conditions.

Faes et al. (2006).

Unloading needs a real push

- Without support the extensors carry the full wrist moment from the dumbbell, transmitted to the lateral epicondyle.
- Muscle activity fell clearly only once an external extension force of about 3% of maximum was added: a dose–response, not a squeeze effect.

A 3% push helped at every wrist angle



Extension force of 3% MVC added during a 10% MVC grip. Dynamic-brace study, not a counterforce strap. Faes et al. (2006).

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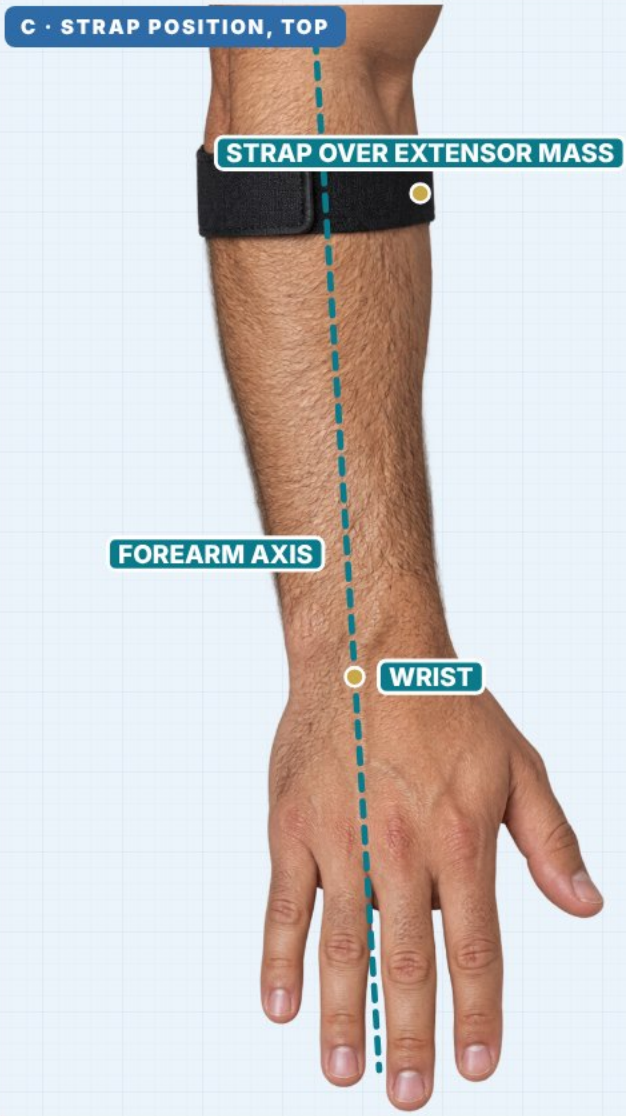
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Angles from landmarks placed on an illustrated figure (2-D, camera-plane); approximate. Forearm axis and callouts placed on the figure for teaching. Educational, not diagnostic.

EYE-OPENER

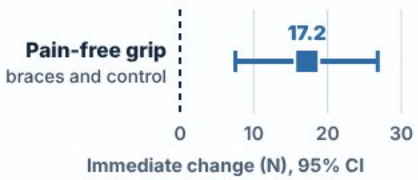
0 significant differences between two counterforce braces and no brace, on any outcome.

Randomised crossover, n = 34. Bisset et al. (2014).

Where the strap sits

- The band wraps the upper forearm over the wrist-extensor muscle bellies; two finger-widths below the elbow crease is common practice, not a graded rule.
- A strap that is too tight can press on nerves: loosen it if the hand tingles.

Grip improved with or without a brace



Affected side, after two counterforce braces and a no-brace control; no difference between conditions. Bisset et al. (2014).

Myth: "The strap takes the load off the tendon." Immediate gains were no greater than with no brace at all.

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A · Strap Pressure

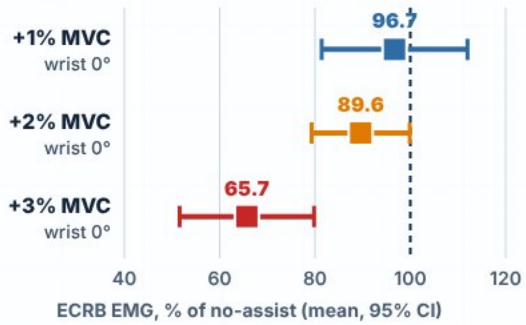


B · No strap Full load



C · Position Below elbow

Only a real extension push unloads ECRB



External extension force added at 10% MVC grip, wrist neutral; dynamic extensor brace study, not a counterforce strap. Faes et al. (2006).

Decision pathway

1. **OPTIONAL**
   A strap may be worn during activity for short-term relief (Grade F); long-term value unproven (Grade D; Lucado et al., 2022).
2. **LOAD**
   Keep progressive wrist-extensor loading as the core treatment; a strap does not replace it.
3. **CHECK**
   Judge any strap by pain-free grip during your own tasks, and keep it comfortably loose.

NOT RECOMMENDED

Relying on a strap instead of loading, or wearing it so tight that the hand swells or tingles.

SEEK ASSESSMENT IF

Numbness, tingling or hand swelling that persists after removing the strap, or a hot swollen elbow: seek assessment.

REFERENCES (APA 7)

Bisset, L. M., Collins, N. J., & Offord, S. S. (2014). Immediate effects of 2 types of braces on pain and grip strength in people with lateral epicondylalgia: A randomized controlled trial. *Journal of Orthopaedic & Sports Physical Therapy, 44*(2), 120–128. https://doi.org/10.2519/jospt.2014.4744

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Faes, M., van Elk, N., de Lint, J. A., Degens, H., Kooloos, J. G. M., & Hopman, M. T. E. (2006). A dynamic extensor brace reduces electromyographic activity of wrist extensor muscles in patients with lateral epicondylalgia. *Journal of Orthopaedic & Sports Physical Therapy, 36*(3), 170–178. https://doi.org/10.2519/jospt.2006.36.3.170

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ISOMETRIC AND HEAVY SLOW LOADING FOR ELBOW TENDINOPATHY: BUILDING THE DOSE

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A · ISOMETRIC WRIST HOLD, SIDE



EYE-OPENER

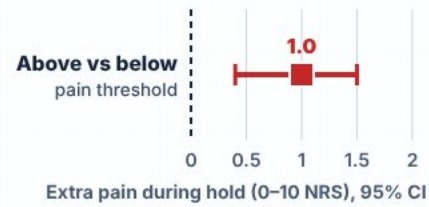
30 min later, holds pushed above the pain threshold still hurt more than gentler ones.

p = 0.043; 24 people, 10 × 15 s holds. Coombes et al. (2016).

Start with a tolerable hold

- Forearm supported, elbow ≈**79°** flexed, wrist level: the extensors hold the dumbbell still, loading the tendon without movement.
- Set the load below the pain threshold; a single session gave no immediate change in pain-free grip, so the benefit comes from repetition.

Holding above the pain threshold hurt more



Isometric wrist extension at +20% vs −20% of each person's pain threshold; p = 0.002. Coombes et al. (2016).

2-D estimates from pose landmarks on an illustrated figure (head-to-hip framing); lengths scaled to a 1.70 m adult (Winter, 2009). Elbow angle from manually placed shoulder, elbow and wrist landmarks. Educational, not diagnostic.

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EYE-OPENER

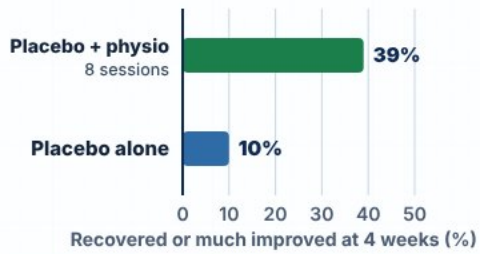
10% more people responded to slow-lowering (eccentric) training than to lifting-only training.

Number needed to treat 10, 3 months, n = 120. Peterson et al. (2014).

Carry: grip under real load

- With the elbow ≈**6°** from straight, the dumbbell hangs from a sustained grip, and the wrist extensors co-contract to keep the wrist steady.
- Carries bridge isolated wrist work and daily tasks; no load data exist for this frame, so dose it by symptoms.

Exercise-based physio quadrupled early recovery



Elbow manipulation + therapeutic exercise; RR 4.00 (99% CI 1.07–15.00); n = 165. Coombes et al. (2013).

2-D estimates from pose landmarks on an illustrated figure; CoM (if shown) from de Leva (1996); cm for a 1.70 m adult (Winter, 2009). Elbow angle from manually placed shoulder, elbow and wrist landmarks; pose skeleton omitted for clarity. Educational, not diagnostic.

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C · BENCH ROW, SIDE



EYE-OPENER

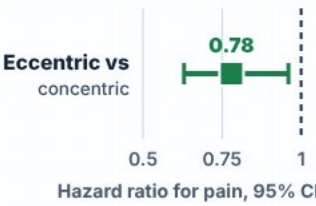
R = 0.56 link between fear of movement and pain during hard holds.

Kinesiophobia vs suprathreshold pain, p = 0.005. Coombes et al. (2016).

Row: a pulling grip

- The row bends the elbow to ≈**125°** while the hand grips the dumbbell, adding a whole-arm pull to the grip demand.
- Add it once holds and slow wrist work are tolerated; keep slow lowering, which outperformed lifting-only work over 3 months.

Slow lowering beat lifting-only



120 adults, tennis elbow > 3 months; 3 months daily graded home exercise; strength gain greater too (p < 0.02). Peterson et al. (2014).

Myth: "Isometrics switch off tendon pain at once." In tennis elbow one session did not change pain-free grip or pressure pain.

2-D estimates from pose landmarks on an illustrated figure; CoM (if shown) from de Leva (1996); cm for a 1.70 m adult (Winter, 2009). Elbow angle from manually placed shoulder, elbow and wrist landmarks; pose skeleton omitted (bent-over pose). Educational, not diagnostic.

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INTEGRATING PERFORMANCE & REHABILITATION HEALTHCARE PATHWAYS.

ISOMETRIC AND HEAVY SLOW LOADING FOR ELBOW TENDINOPATHY: BUILDING THE DOSE

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A · Hold Isometric

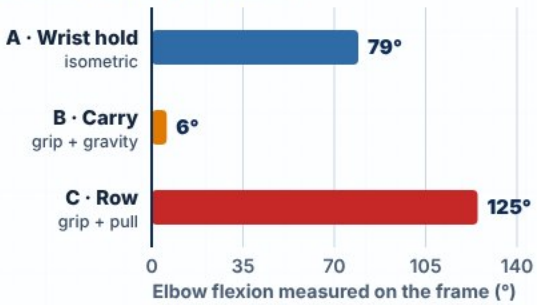


B · Carry Grip load



C · Row Pull

One tendon, three positions



Measured frame values (2-D, approximate); no load or EMG data were found for these frames.

Decision pathway

1. **HOLD**
   Isometric wrist-extension holds kept below the pain threshold, about 10 × 15 s.
2. **SLOW**
   Progress to slow lifting and lowering of the wrist (Grade B; Lucado et al., 2022); stress the lowering.
3. **APPLY**
   Add carries, then rows, raising load only when next-day symptoms stay settled.

NOT RECOMMENDED

Prolonged complete rest, or pushing holds well above the pain threshold.

SEEK ASSESSMENT IF

Rapid swelling, locking, night pain unrelated to load, or progressive weakness or numbness: seek prompt assessment.

REFERENCES (APA 7)

Coombes, B. K., Bisset, L., Brooks, P., Khan, A., & Vicenzino, B. (2013). Effect of corticosteroid injection, physiotherapy, or both on clinical outcomes in patients with unilateral lateral epicondylalgia: A randomized controlled trial. *JAMA, 309*(5), 461–469. https://doi.org/10.1001/jama.2013.129

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

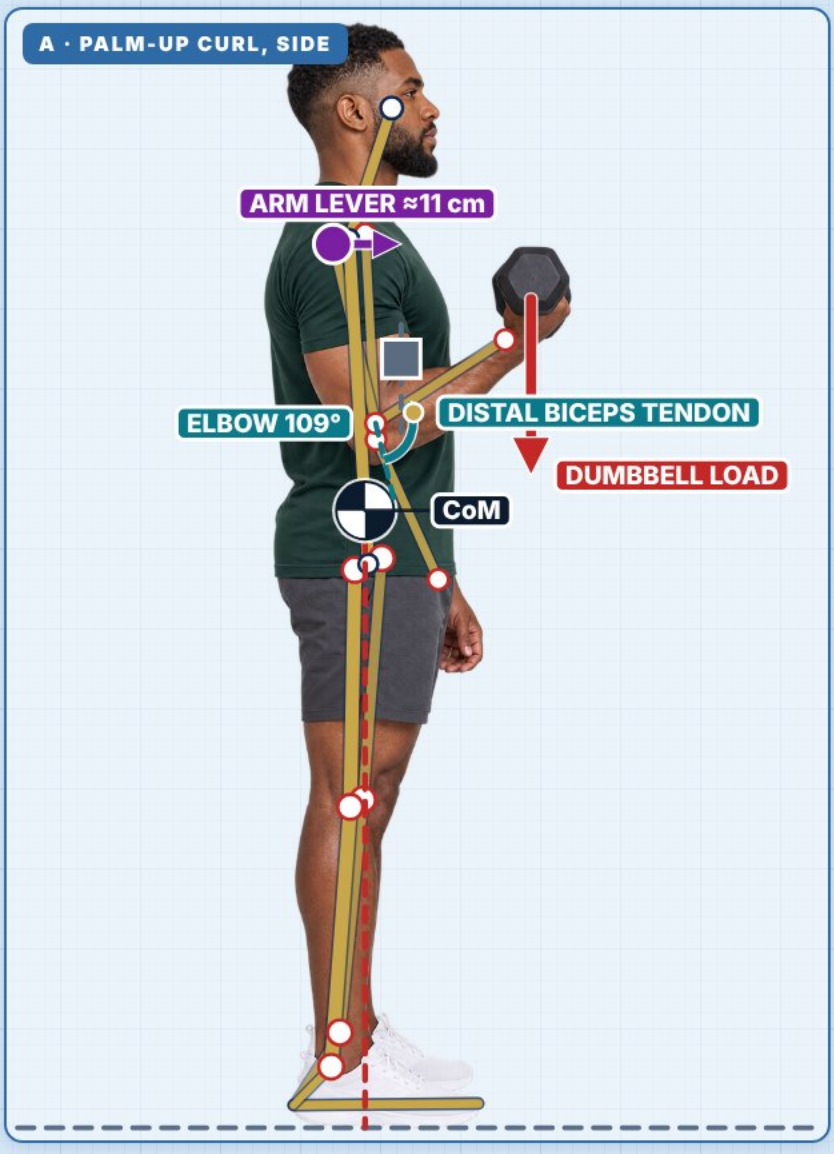
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DISTAL BICEPS TENDON PAIN: FRONT-OF-ELBOW LOAD IN CURLS AND CARRYING

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EYE-OPENER

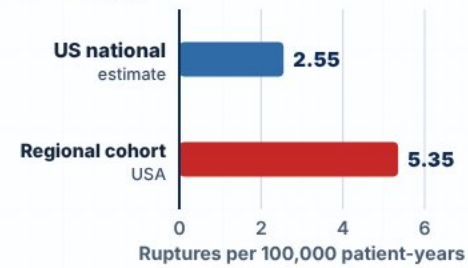
95% of people with a complete distal biceps rupture are men.

US national estimate (96% in the regional cohort). Kelly et al. (2015).

Palm up: the biceps does two jobs

- In this curl the elbow is flexed ≈**109°** with the palm up, so the biceps both bends the elbow and holds the forearm turned up (supination).
- Both demands pull on one tendon, which inserts on the radial tuberosity just below the front of the elbow crease.

Complete rupture: rare, but not vanishingly so



Large population database; mean age 46.3 years. Kelly et al. (2015).

2-D estimates from pose landmarks on an illustrated figure; CoM (if shown) from de Leva (1996); cm for a 1.70 m adult (Winter, 2009). Arm lever: shoulder joint to arm CoM; moment = arm weight × lever, 70 kg adult, static. Dumbbell 10 kg (illustrative load). Educational, not diagnostic.

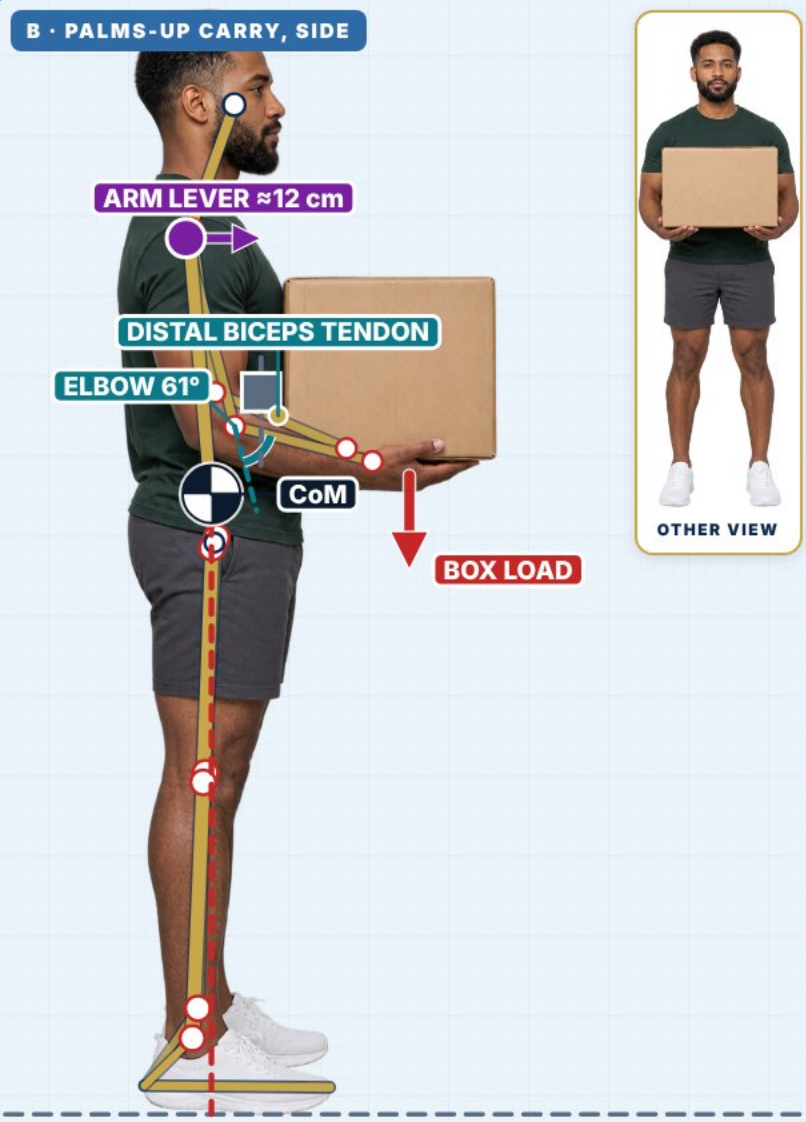
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EYE-OPENER

37% of palm-up turning strength is lost when a ruptured tendon is not repaired.

Supination 62.6% of the other arm, non-operative. Cuzzolin et al. (2021).

Carrying keeps the tendon working

- Holding a box palms up with the elbows ≈**61°** flexed is a sustained isometric: the load hangs ≈**30 cm** in front of the shoulder.
- Unlike a curl, there is no rest between repetitions, so a sensitive tendon can ache during a long carry.

How bent is the elbow in each task?



Measured on Frames A–C (2-D, camera plane); 0° = straight elbow.

2-D estimates from pose landmarks on an illustrated figure; CoM (if shown) from de Leva (1996); cm for a 1.70 m adult (Winter, 2009). Arm lever: shoulder joint to arm CoM; moment = arm weight × lever, 70 kg adult, static. Box 10 kg, 5 kg per hand (illustrative load). Educational, not diagnostic.

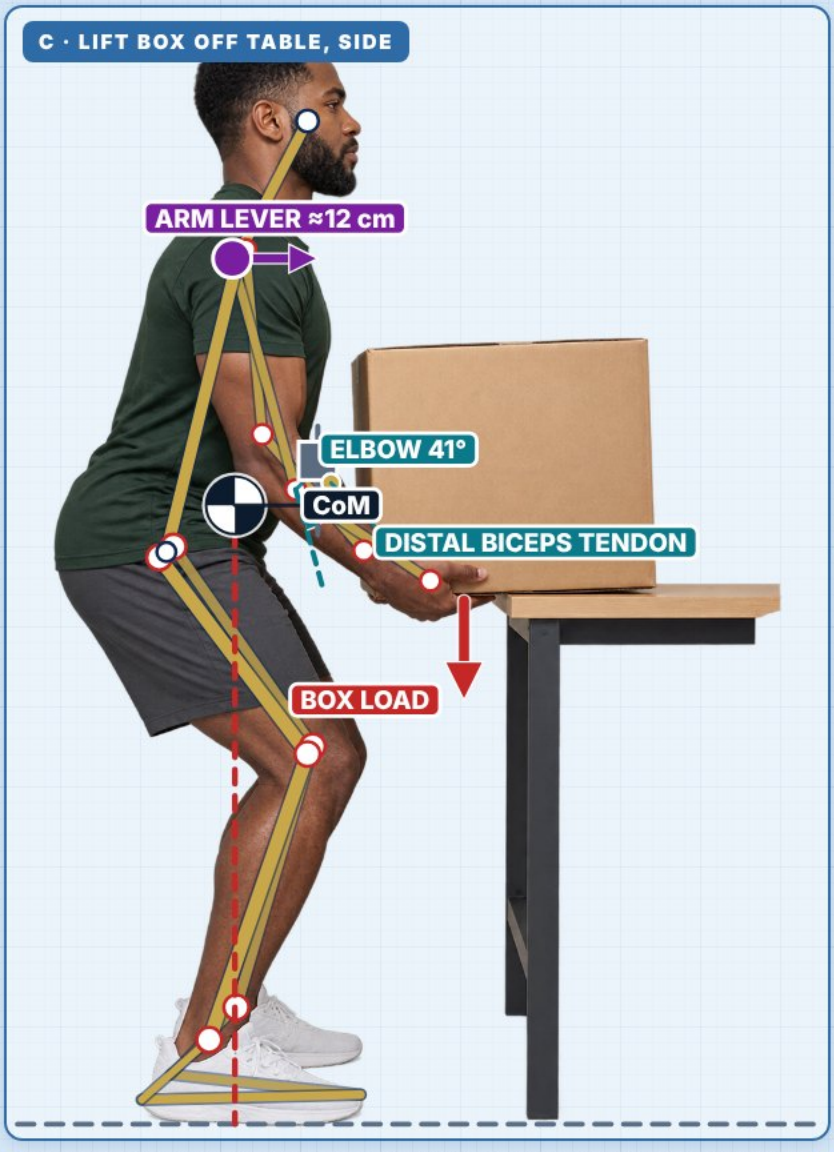
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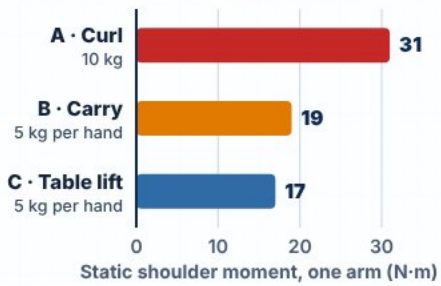
46.3 years: the mean age at complete distal biceps rupture, mid-career rather than late life.

Median 46 years. Kelly et al. (2015).

Breaking the box free

- Lifting from the table, the elbow is only ≈**41°** flexed with the palms up, so the tendon takes the first pull of the lift in a more lengthened position.
- The hands sit ≈**27 cm** in front of the shoulder; sliding the box close first shortens that lever.

Static shoulder demand in each task



Measured on Frames A–C: arm weight (de Leva, 1996) plus illustrative hand load, 70 kg adult, static.

Myth: "The biceps is mainly an elbow bender." Without it, supination strength falls far more than flexion strength (Cuzzolin et al., 2021).

2-D estimates from pose landmarks on an illustrated figure; CoM (if shown) from de Leva (1996); cm for a 1.70 m adult (Winter, 2009). Arm lever: shoulder joint to arm CoM; moment = arm weight × lever, 70 kg adult, static. Box 10 kg, 5 kg per hand (illustrative load). Educational, not diagnostic.

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A · Curl Palm up



B · Carry Sustained



C · Lift Lengthened

Supination shows what the biceps tendon does



Meta-analysis, 53 studies, 1,380 patients; both differences $p < 0.001$. Cuzzolin et al. (2021).

Decision pathway

1. **MODIFY**
   Use a neutral (hammer) grip and hold loads close to the body while pain settles.
2. **LOAD**
   Grade elbow flexion, then resisted supination, as front-of-elbow pain allows (expert principle).
3. **TRACK**
   Compare palm-up turning strength with the other arm before heavy carrying.

NOT RECOMMENDED

Pushing through heavy palm-up lifting or carrying on a painful, weak elbow.

SEEK ASSESSMENT IF

A sudden "pop", front-of-elbow bruising, a changed biceps contour or weak palm-up turning: possible rupture, seek urgent assessment.

REFERENCES (APA 7)

Cuzzolin, M., Secco, D., Guerra, E., Altamura, S. A., Filardo, G., & Candrian, C. (2021). Operative versus nonoperative management for distal biceps brachii tendon lesions: A systematic review and meta-analysis. *Orthopaedic Journal of Sports Medicine, 9*, Article 23259671211037311. https://doi.org/10.1177/23259671211037311

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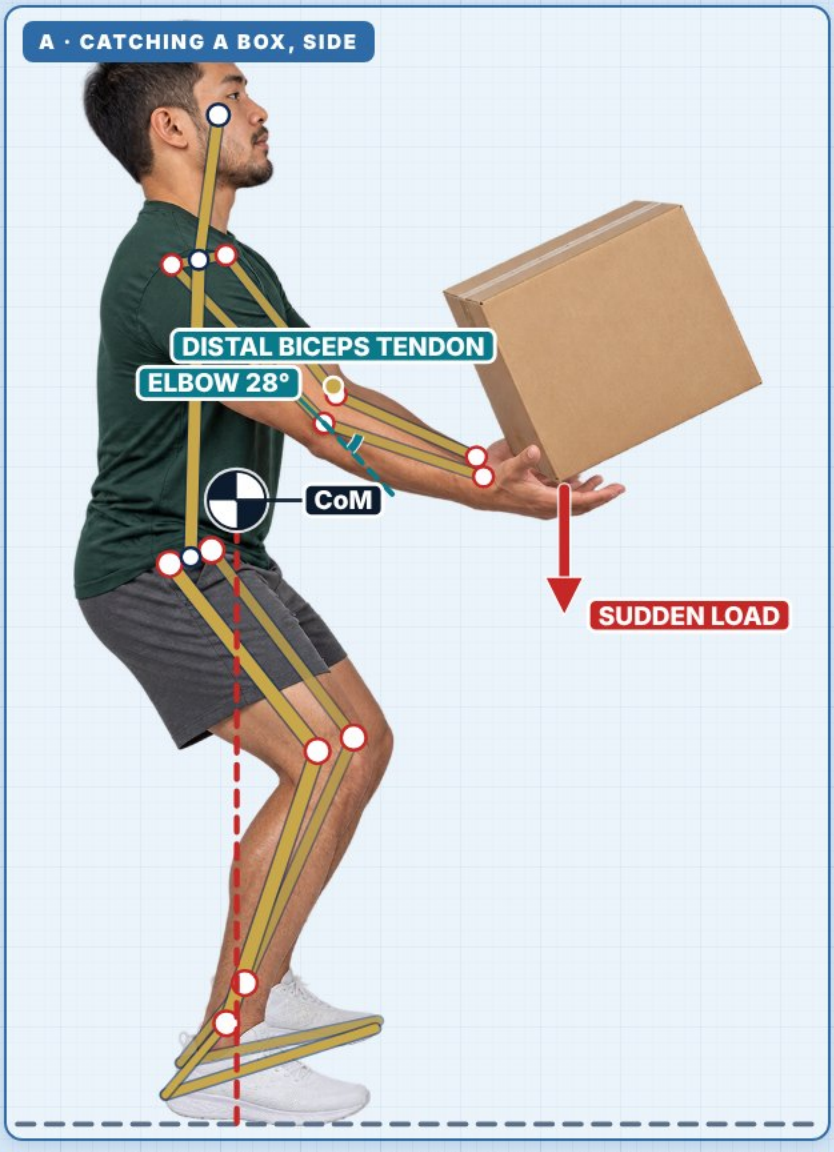
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DISTAL BICEPS RUPTURE: THE "POP", THE POPEYE SIGN AND URGENT ASSESSMENT

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EYE-OPENER

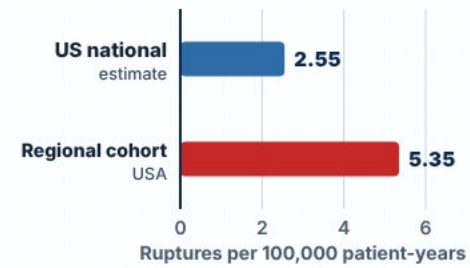
46.3 years: mean age at rupture. This is a mid-life tendon injury, not only an athlete's.

Median 46 years. Kelly et al. (2015).

A sudden eccentric pull

- Catching a falling box palms up, the elbows are dragged to ≈**28°** from straight while the biceps is contracting to resist: a forced lengthening load.
- That combination of a bent, palm-up elbow being pulled straight is the typical mechanism for tearing the tendon off the radius.

Who ruptures: mostly middle-aged men



Large population database. Kelly et al. (2015).

2-D estimates from pose landmarks on an illustrated figure; CoM (if shown) from de Leva (1996); cm for a 1.70 m adult (Winter, 2009). Elbow angle from pose landmarks in the side view. Educational, not diagnostic.

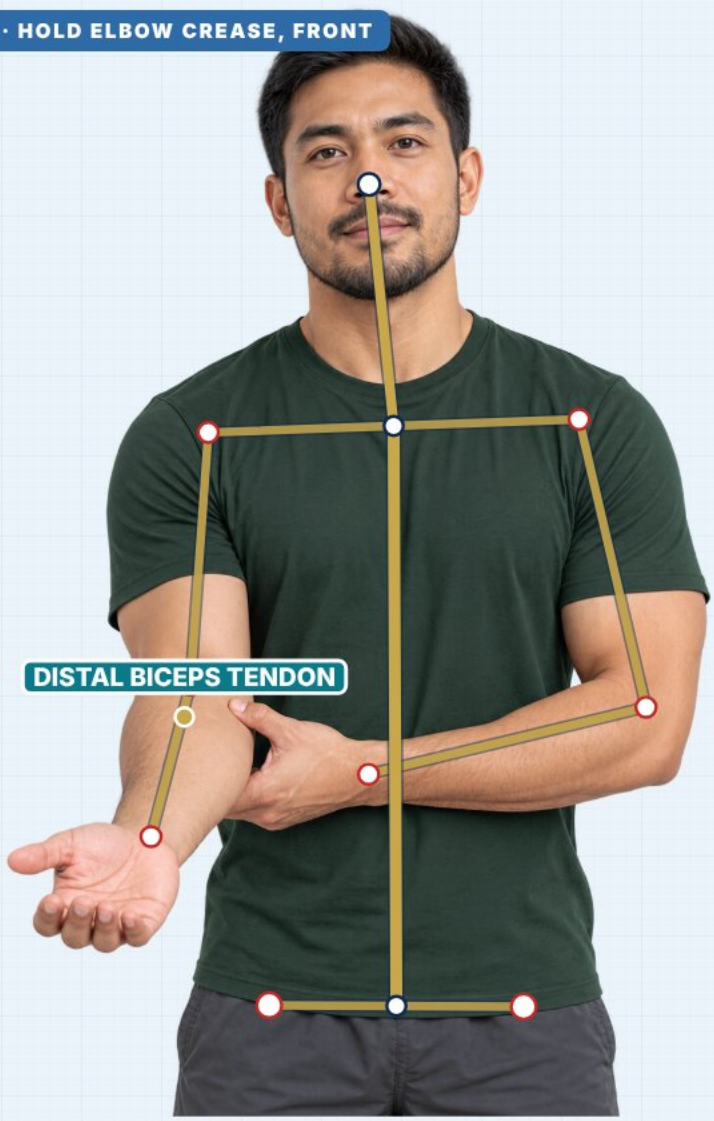
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EYE-OPENER

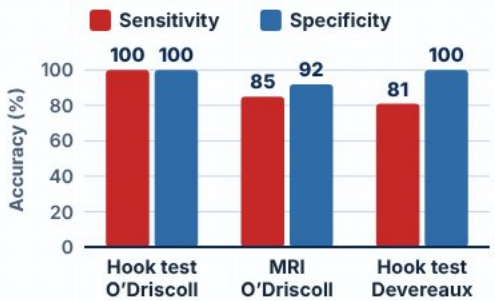
95% of people with a complete distal biceps rupture are men.

US national estimate. Kelly et al. (2015).

The hook test at the crease

- With the elbow bent and the palm up, the examiner tries to hook a finger under the tendon cord in the front of the elbow crease.
- An intact cord can be hooked; when it cannot, a complete rupture is likely and imaging and specialist review follow.

A simple test, high reported accuracy



Secondary summary: values as tabulated in a BestBETs appraisal (Annison, 2020) of O'Driscoll (2007) and Devereaux & ElMaraghy (2013, n = 48).

2-D estimates from pose landmarks on an illustrated figure (head-to-hip framing); lengths scaled to a 1.70 m adult (Winter, 2009). Anatomy marker placed on the figure for teaching. Educational, not diagnostic.

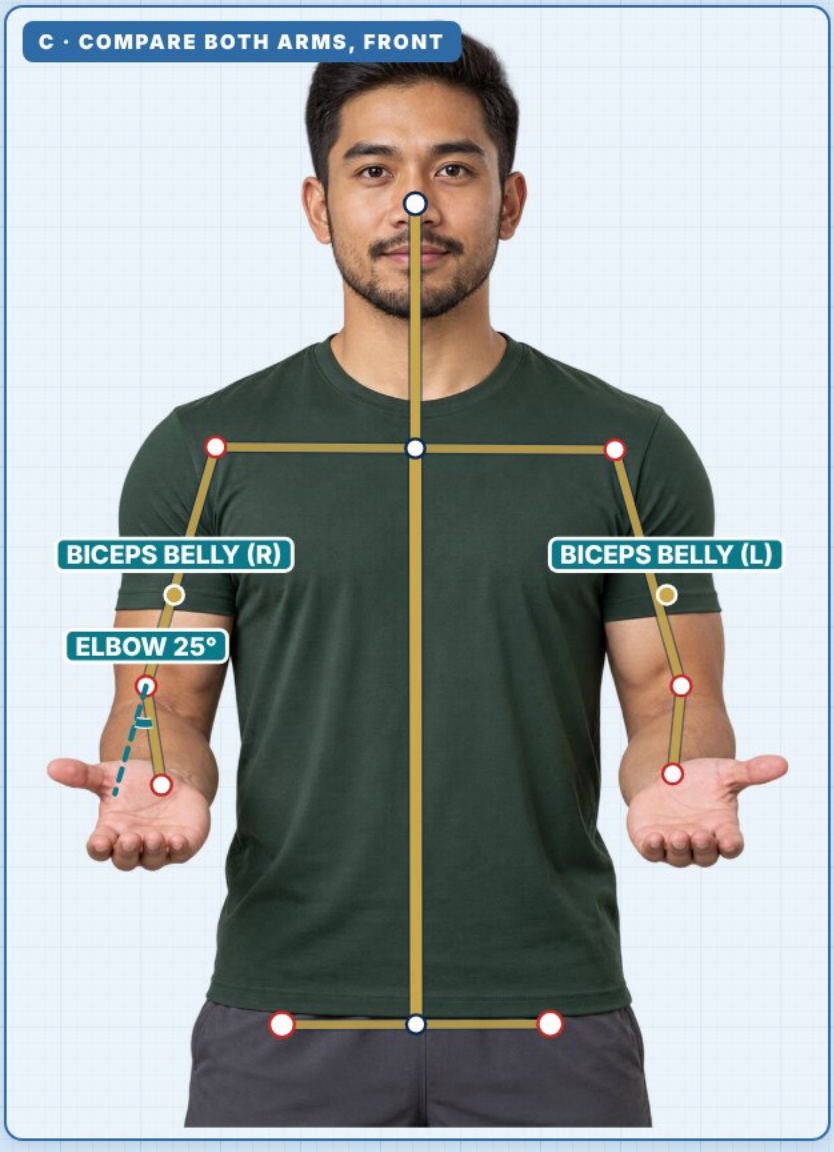
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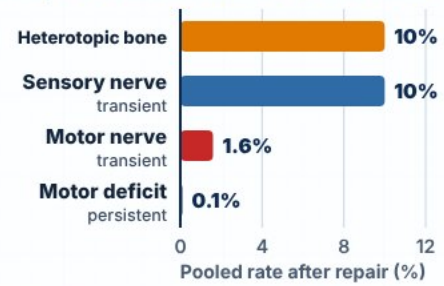
83% of elbow-bending strength remains even when a rupture is not repaired.

Non-operative flexion, % of the other arm. Cuzzolin et al. (2021).

Look for the Popeye sign

- Palms up, elbows ≈**25°** flexed: compare both biceps. After rupture the muscle belly can retract towards the shoulder as a bulge ("reverse Popeye").
- Add bruising in the crease and weak palm-up turning, and the picture points to a complete tear.

Surgery risks are mostly transient



Systematic review and meta-analysis. Cuzzolin et al. (2021).

Myth: "I can still bend it, so it isn't torn." Other flexors keep bending strength; the loss shows in supination.

2-D estimates from pose landmarks on an illustrated figure (head-to-hip framing); lengths scaled to a 1.70 m adult (Winter, 2009). Elbow angle from pose landmarks in the front view. Educational, not diagnostic.

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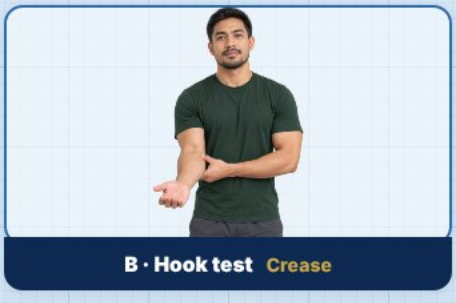
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A · Catch Eccentric pull

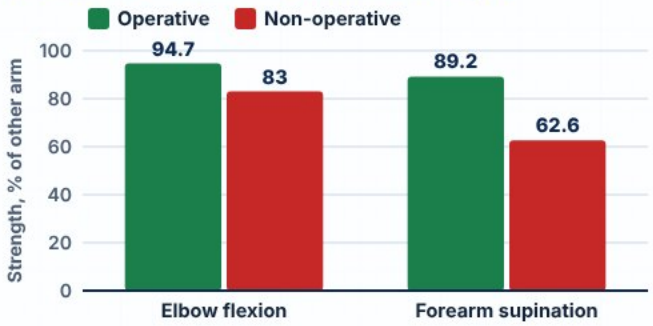


B · Hook test Crease



C · Compare Contour

Repair keeps more supination strength



53 studies, 1,380 patients; both $p < 0.001$; DASH and MEPI also favoured surgery. Cuzzolin et al. (2021).

Decision pathway

1. **STOP**
   After a "pop" with the elbow bent under load, stop lifting and protect the arm.
2. **REFER**
   Seek early specialist assessment so operative and non-operative options can be weighed together.
3. **REHAB**
   Follow a physiotherapy-led programme on either route, rebuilding flexion and supination strength gradually.

NOT RECOMMENDED

Waiting weeks to see if it settles; the treatment decision is best made early.

SEEK ASSESSMENT IF

A felt or heard "pop", sudden front-of-elbow pain and bruising, a changed biceps contour, weak palm-up turning or a positive hook test: seek urgent assessment.

REFERENCES (APA 7)

Annison, D. (2020). *Is the hook test accurate and reliable in detecting distal bicep tendon rupture?* [Best evidence topic report]. BestBETs. https://www.bestbets.org/?p=6554

Cuzzolin, M., Secco, D., Guerra, E., Altamura, S. A., Filardo, G., & Candrian, C. (2021). Operative versus nonoperative management for distal biceps brachii tendon lesions: A systematic review and meta-analysis. *Orthopaedic Journal of Sports Medicine, 9*, Article 23259671211037311. https://doi.org/10.1177/23259671211037311

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O'Driscoll, S. W., Goncalves, L. B., & Dietz, P. (2007). The hook test for distal biceps tendon avulsion. *The American Journal of Sports Medicine, 35*(11), 1865–1869. https://doi.org/10.1177/0363546507305016

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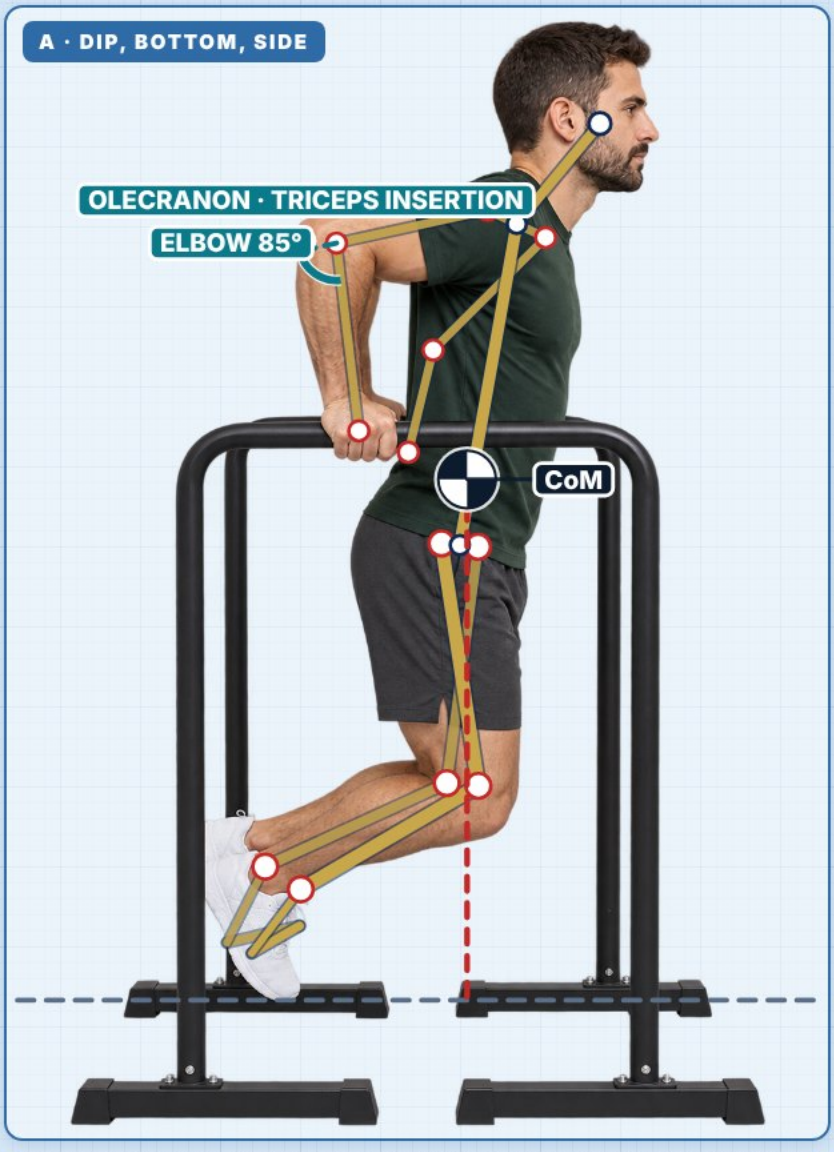
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TRICEPS TENDON PAIN: BACK-OF-ELBOW LOAD IN PRESSING AND DIPS

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EYE-OPENER

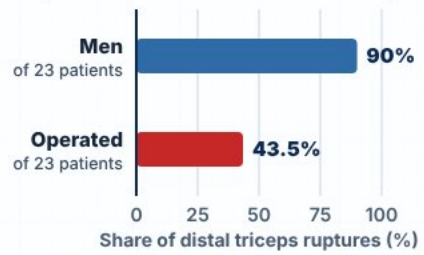
57.7 years: mean age at distal triceps rupture, older than the typical biceps rupture.

Slovak regional series, 2014–2023. Sekáč et al. (2024); biceps: Kelly et al. (2015).

Deep elbow bend under body weight

- At the bottom of the dip the elbow is flexed ≈**85°** with the elbows behind the body, so the triceps must start extension from a long, stretched position.
- Its tendon pulls on the olecranon at the point of the elbow, where back-of-elbow pain is felt.

Who ruptures, and who needs surgery



23 patients, Slovakia, 2014–2023; surgery followed MRI confirmation of tears over 50% of fibres. Sekáč et al. (2024).

2-D estimates from pose landmarks on an illustrated figure; CoM (if shown) from de Leva (1996); cm for a 1.70 m adult (Winter, 2009). Elbow angle from pose landmarks, wrist placed manually on the hand. Educational, not diagnostic.

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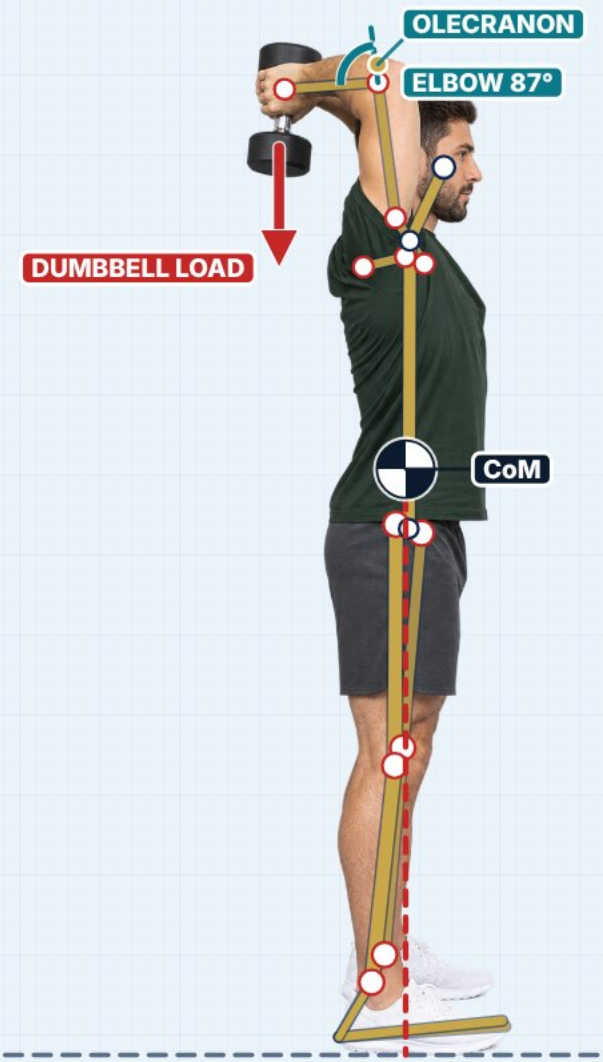
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B · OVERHEAD EXTENSION, SIDE



EYE-OPENER

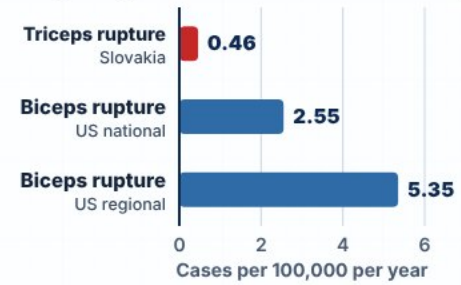
45% of body weight is carried along the forearm at the elbow in a standard push-up.

Peak axial force, averaged. Donkers et al. (1993).

Overhead: the triceps on full stretch

- With the arm overhead and the elbow flexed ≈**87°**, the long head of triceps is lengthened across both shoulder and elbow.
- Lowering the dumbbell behind the head is therefore a demanding, stretched-position load for a sensitive tendon.

Triceps rupture is far rarer than biceps



Different populations and methods: order of magnitude only. Sekáč et al. (2024); Kelly et al. (2015).

Key point: no triceps load data exist here for dips or overhead work; angles show position, not tendon force.

2-D estimates from pose landmarks on an illustrated figure; CoM (if shown) from de Leva (1996); cm for a 1.70 m adult (Winter, 2009). Elbow angle from pose landmarks, wrist placed manually on the hand. Educational, not diagnostic.

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DOI 10.5281/zenodo.23735910

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INTEGRATING PERFORMANCE & REHABILITATION HEALTHCARE PATHWAYS.

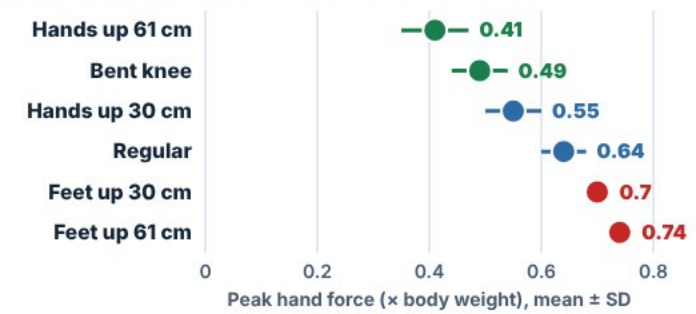
TRICEPS TENDON PAIN: BACK-OF-ELBOW LOAD IN PRESSING AND DIPS

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C · PUSH-UP, BOTTOM, SIDE



A push-up ladder grades the load



Peak ground reaction force at the hands. Wurm et al. (2010).

EYE-OPENER

+42% valgus torque at the elbow in a one-handed push-up simulating a fall.

Versus the standard push-up. Donkers et al. (1993).

Push-ups load the elbow more than expected

- At the bottom the elbow is flexed ≈**106°**; the triceps must resist a torque that tends to bend the elbow further.
- Changing body angle grades the force through the hands (inset), a simple way to dose triceps and elbow load.

Peak elbow torques in a standard push-up



Converted from N·cm (2305.9, 1241, 315.4). Donkers et al. (1993).

2-D estimates from pose landmarks on an illustrated figure; CoM (if shown) from de Leva (1996); cm for a 1.70 m adult (Winter, 2009). Elbow angle from pose landmarks in the side view. Educational, not diagnostic.

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A · Dip Deep bend

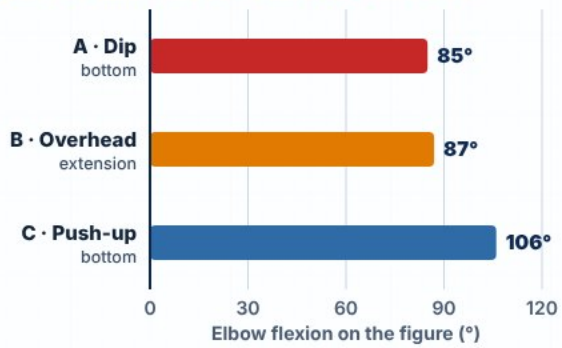


B · Overhead Long head



C · Push-up Graded

Depth is a dial: elbow flexion by exercise



Measured on Frames A–C (2-D, camera plane); 0° = straight elbow. Position only, not tendon force.

Decision pathway

1. **MODIFY**
   Reduce dip depth and volume and pause overhead extensions while the back of the elbow is sensitive.
2. **LOAD**
   Climb the push-up ladder from hands elevated to regular, then feet elevated, as pain allows (expert principle).
3. **RETURN**
   Reintroduce dips and heavier pressing last, building depth before load.

NOT RECOMMENDED

Deep weighted dips or heavy overhead extensions through back-of-elbow pain.

SEEK ASSESSMENT IF

A "pop" at the back of the elbow, a gap above the olecranon or inability to straighten the elbow against gravity: seek urgent assessment.

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DOI 10.5281/zenodo.23735910

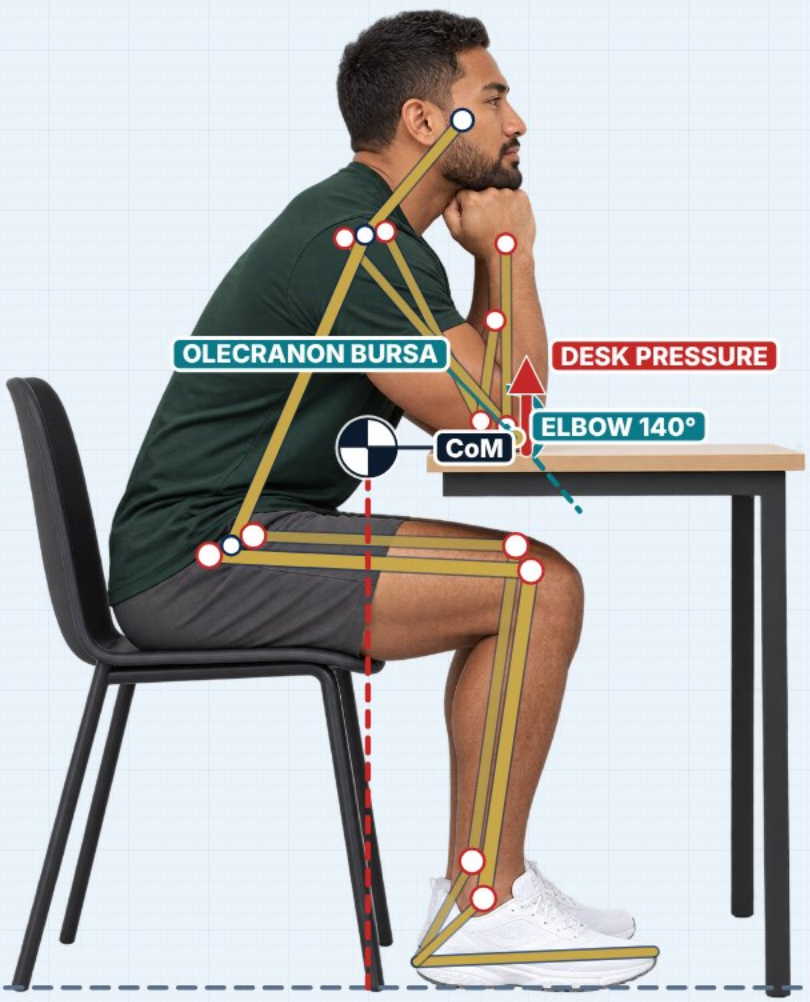
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OLECRANON BURSITIS: SWELLING AT THE POINT OF THE ELBOW

AN MMSX AUTHORITY | APPLIED BIOMECHANICS LAB EDUCATIONAL ANALYSIS

A · LEANING ON ELBOWS, SIDE



EYE-OPENER

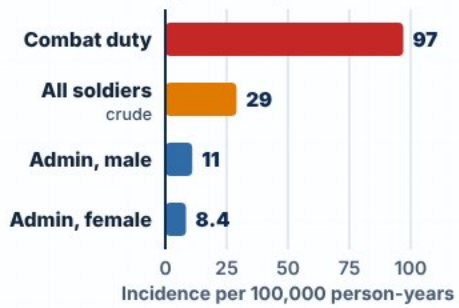
24% of olecranon bursitis cases in a military population were septic (infected).

2,692 cases, 2005–2015; 32% in combat soldiers. Schermann et al. (2017).

Body weight through a small point

- Leaning on the desk with the elbows flexed ≈**140°**, the head and trunk rest on the olecranon, compressing the bursa between bone and desk.
- Repeated pressure and friction are a recognised provocation; the bursa sits just under the skin, with little to protect it.

Pressure-heavy duties, more bursitis



Military population, 2005–2015. Schermann et al. (2017).

2-D estimates from pose landmarks on an illustrated figure; CoM (if shown) from de Leva (1996); cm for a 1.70 m adult (Winter, 2009). Elbow angle from pose landmarks in the side view. Educational, not diagnostic.

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B · POINT OF ELBOW, REAR



2-D estimates from pose landmarks on an illustrated figure (head-to-hip framing); lengths scaled to a 1.70 m adult (Winter, 2009). Elbow angle from manually placed elbow and wrist landmarks in the rear view. Educational, not diagnostic.

EYE-OPENER

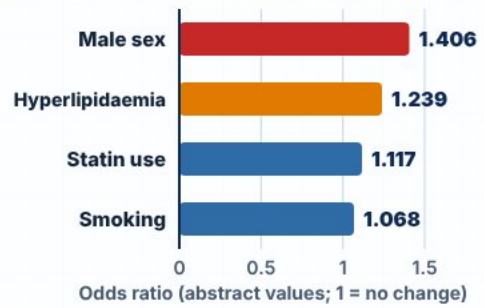
17.6 weeks: mean symptom duration of olecranon bursitis in the military cohort.

Schermann et al. (2017).

Why the point of the elbow swells

- With the elbow flexed ≈**132°** the olecranon is the most prominent point, and the superficial bursa over it takes direct knocks and pressure.
- Irritated, it fills with fluid as a soft, fluctuant swelling; infection is a separate, more urgent problem.

Modest associations in a large study



10,301 cases, 44,608 controls; abstract values used throughout (results tables differ slightly). Shemesh et al. (2024).

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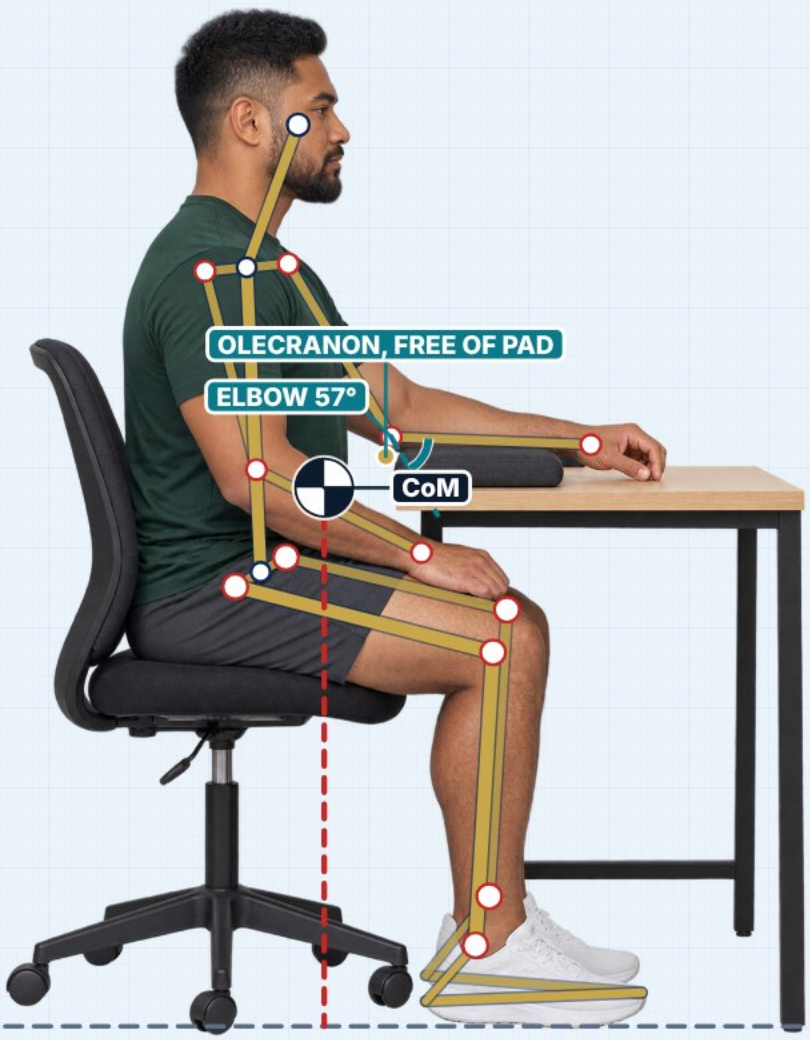
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C · ELBOW OFF-LOADED, SIDE



EYE-OPENER

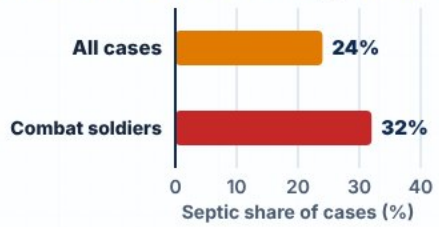
19% of military bursitis cases were referred to a specialist.

Schermann et al. (2017).

Take the pressure off

- Here the forearm rests on a soft pad with the elbow ≈**57°** flexed, so the point of the elbow hangs free and the bursa is not compressed.
- Off-loading, compression and time are the first-line approach for non-infected bursitis.

Infection is common enough to check



Septic cases presented earlier in service (13 vs 17 weeks after recruitment). Schermann et al. (2017).

Myth: "Drain it and inject steroid for a quick fix." Steroid injection was linked to more complications and skin atrophy (Sayegh & Strauch, 2014).

2-D estimates from pose landmarks on an illustrated figure; CoM (if shown) from de Leva (1996); cm for a 1.70 m adult (Winter, 2009). Elbow angle from manually placed elbow and wrist landmarks (far arm on the pad). Educational, not diagnostic.

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A · Lean Pressure



B · Point Bursa



C · Pad Off-load

Treatment evidence: direction of effect

Comparison	Direction	p
Surgery vs non-surgical clinical resolution	▼ less likely	0.0476
Surgery vs non-surgical overall complications	▲ more	0.0117
Surgery persistent drainage	▲ more	0.0194
Surgery bursal infection	▲ more	0.0060
Steroid injection (aseptic) complications	▲ more	0.0458
Steroid injection (aseptic) skin atrophy	▲ more	0.0261

Systematic review, 29 studies, 1,278 patients, mostly level IV; no pooled rates reported. Sayegh & Strauch (2014).

Decision pathway

1. **PROTECT**
   Stop leaning on the elbow; pad desks, armrests and kneeling-type tasks so the point of the elbow hangs free.
2. **SETTLE**
   For non-infected bursitis use compression and time; non-surgical care resolved more often than surgery.
3. **CHECK**
   Watch daily for redness, heat or fever, which change the plan to same-day medical assessment.

NOT RECOMMENDED

Routine steroid injection, or surgery as a first step, for non-infected bursitis.

SEEK ASSESSMENT IF

Spreading redness, heat, marked tenderness, fever or feeling unwell, or a skin break over the elbow: possible infection, seek same-day assessment.

REFERENCES (APA 7)

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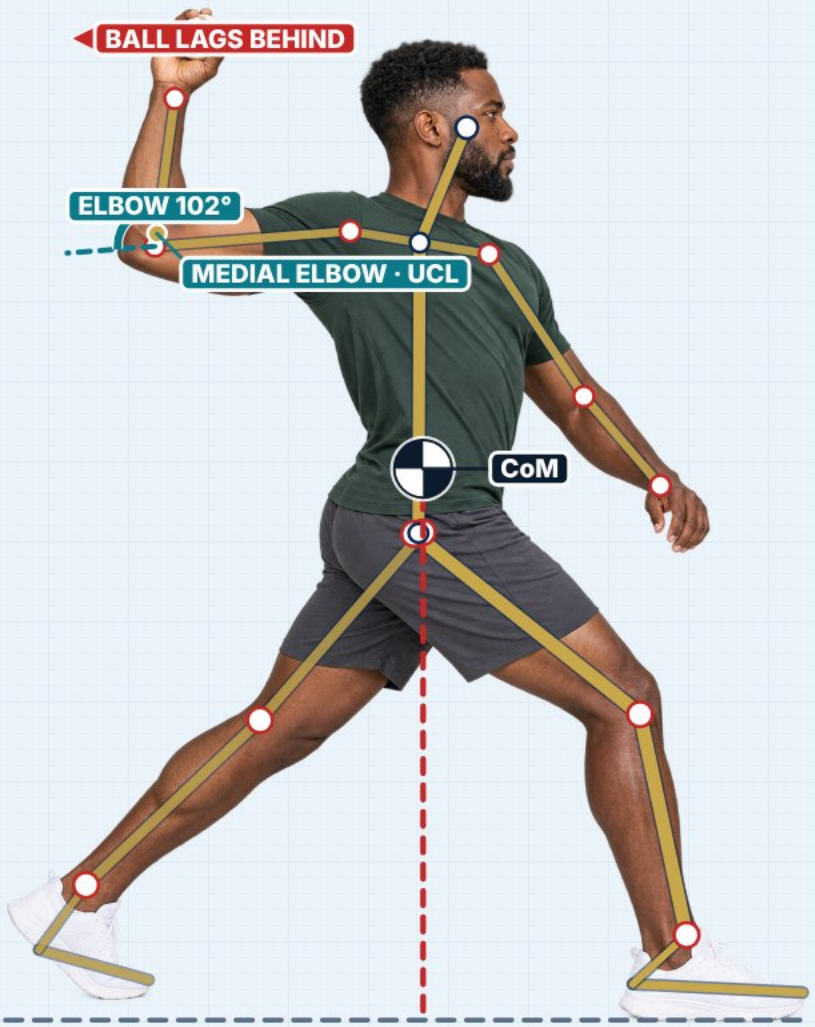
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THROWER'S ELBOW: VALGUS LOAD AND THE ULNAR COLLATERAL LIGAMENT

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A · ARM COCKING, SIDE



EYE-OPENER

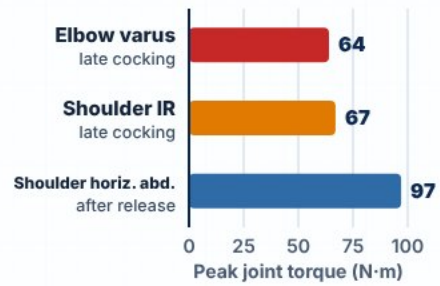
61% of minor-league pitchers with UCL reconstruction had it in high school or college.

Survey of professional players. Conte et al. (2015).

The ball pulls the forearm back

- In arm cocking the elbow is flexed ≈**102°** as the trunk drives forward and the ball lags behind, pushing the elbow into valgus (opening the inner side).
- The ulnar collateral ligament on the medial elbow is the main restraint, helped by the forearm flexor–pronator muscles.

Peak torques in the adult pitch



26 skilled adult pitchers; elbow varus torque = torque resisting valgus. Fleisig et al. (1995).

2-D estimates from pose landmarks on an illustrated figure; CoM (if shown) from de Leva (1996); cm for a 1.70 m adult (Winter, 2009). Elbow angle from pose landmarks in the side view. Educational, not diagnostic.

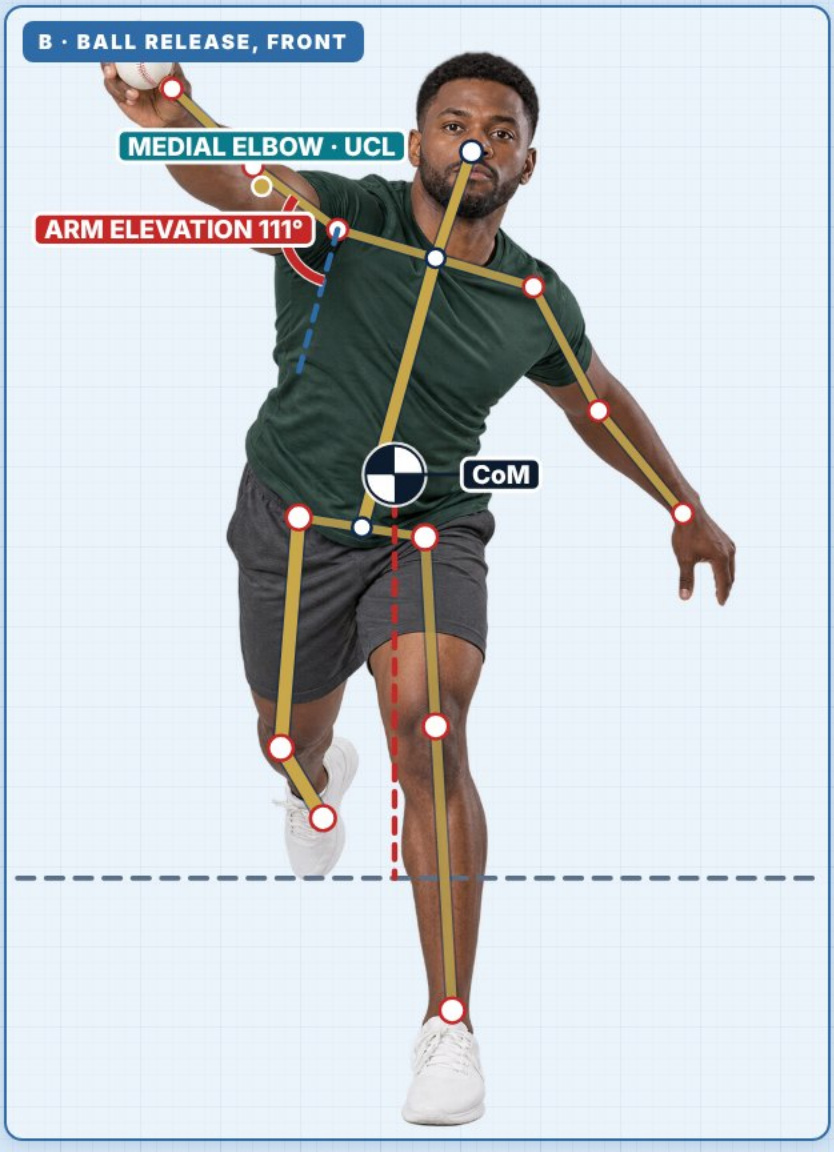
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EYE-OPENER

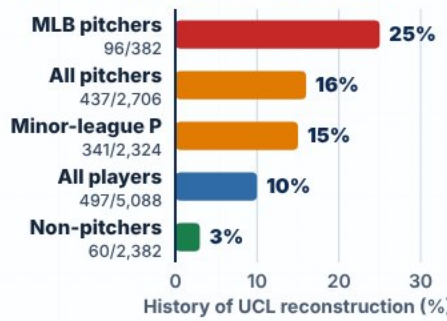
20.5 months, on average, from UCL reconstruction back to major-league pitching.

± 9.72 months; 179 MLB pitchers. Erickson et al. (2014).

Release: the arm whips through

- At release the arm is elevated ≈**111°** and the elbow is nearly straight; the medial elbow has just come through its peak valgus load.
- Repeating that cycle pitch after pitch is why workload, not one throw, is the usual story in UCL injury.

Pitchers carry the UCL burden



Survey of 5,088 professional baseball players. Conte et al. (2015).

2-D estimates from pose landmarks on an illustrated figure; CoM (if shown) from de Leva (1996); cm for a 1.70 m adult (Winter, 2009). Arm elevation from pose landmarks in the front view. Educational, not diagnostic.

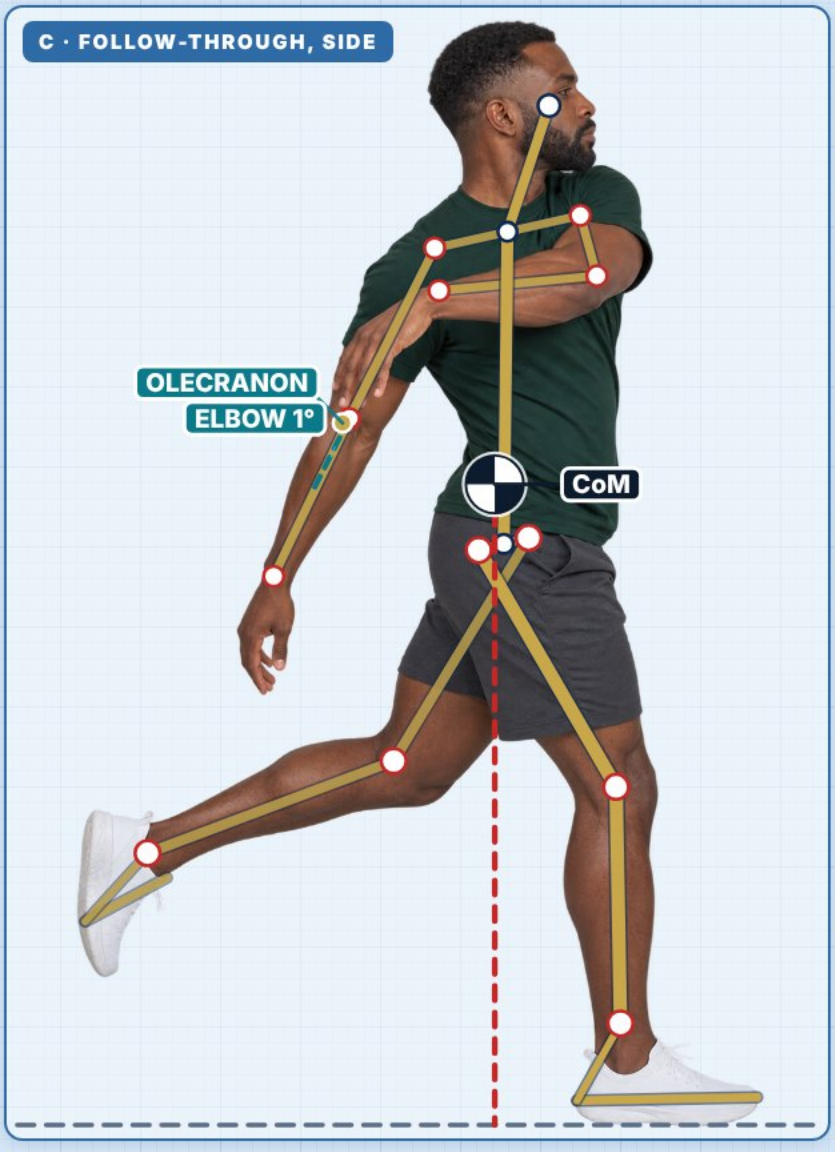
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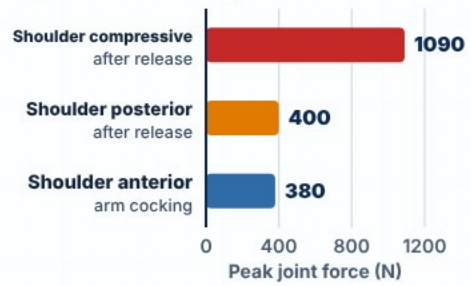
3.9 y mean major-league career after UCL reconstruction.

± 2.84 years; 179 MLB pitchers. Erickson et al. (2014).

Follow-through: braking the arm

- After release the elbow is almost fully straight (≈**1°** of flexion) as the arm crosses the body; the shoulder must decelerate it, while the olecranon meets its fossa.
- A long follow-through spreads that braking over more time and more muscles, including trunk and hips.

Large forces to stop the arm



26 skilled adult pitchers. Fleisig et al. (1995).

Myth: "Have Tommy John early to throw harder." Return is high but not universal, takes about 20 months, and revisions occur (Erickson et al., 2014).

2-D estimates from pose landmarks on an illustrated figure; CoM (if shown) from de Leva (1996); cm for a 1.70 m adult (Winter, 2009). Elbow angle from pose landmarks in the side view. Educational, not diagnostic.

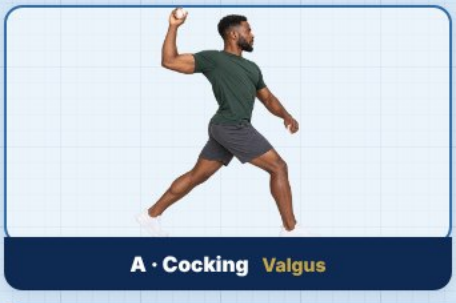
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A · Cocking Valgus

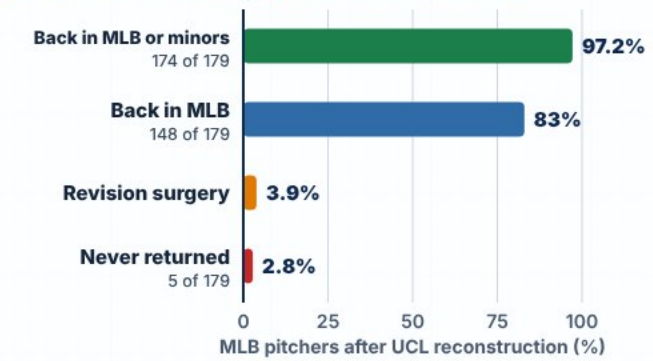


B · Release Whip



C · Follow Braking

Reconstruction: high, not certain, return



179 MLB pitchers. Erickson et al. (2014).

Decision pathway

1. **CONTROL**
   Track throwing workload and rest; medial pain is a signal to reduce volume, not to throw through.
2. **BUILD**
   Strengthen the whole chain (trunk, hips, shoulder, forearm flexor–pronators) and review mechanics (expert principle).
3. **DECIDE**
   For a complete tear in an athlete who wants to keep throwing, discuss reconstruction and the long return.

NOT RECOMMENDED

Throwing through medial elbow pain, or treating surgery as a performance upgrade.

SEEK ASSESSMENT IF

An acute medial "pop", sudden loss of velocity or control, tingling in the ring and little fingers, or medial pain in a young thrower: seek prompt assessment.

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Conte, S. A., Fleisig, G. S., Dines, J. S., Wilk, K. E., Aune, K. T., Patterson-Flynn, N., & ElAttrache, N. (2015). Prevalence of ulnar collateral ligament surgery in professional baseball players. *The American Journal of Sports Medicine, 43*(7), 1764–1769. https://doi.org/10.1177/0363546515580792

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Erickson, B. J., Gupta, A. K., Harris, J. D., Bush-Joseph, C., Bach, B. R., Abrams, G. D., San Juan, A. M., Cole, B. J., & Romeo, A. A. (2014). Rate of return to pitching and performance after Tommy John surgery in Major League Baseball pitchers. *The American Journal of Sports Medicine, 42*(3), 536–543. https://doi.org/10.1177/0363546513510890

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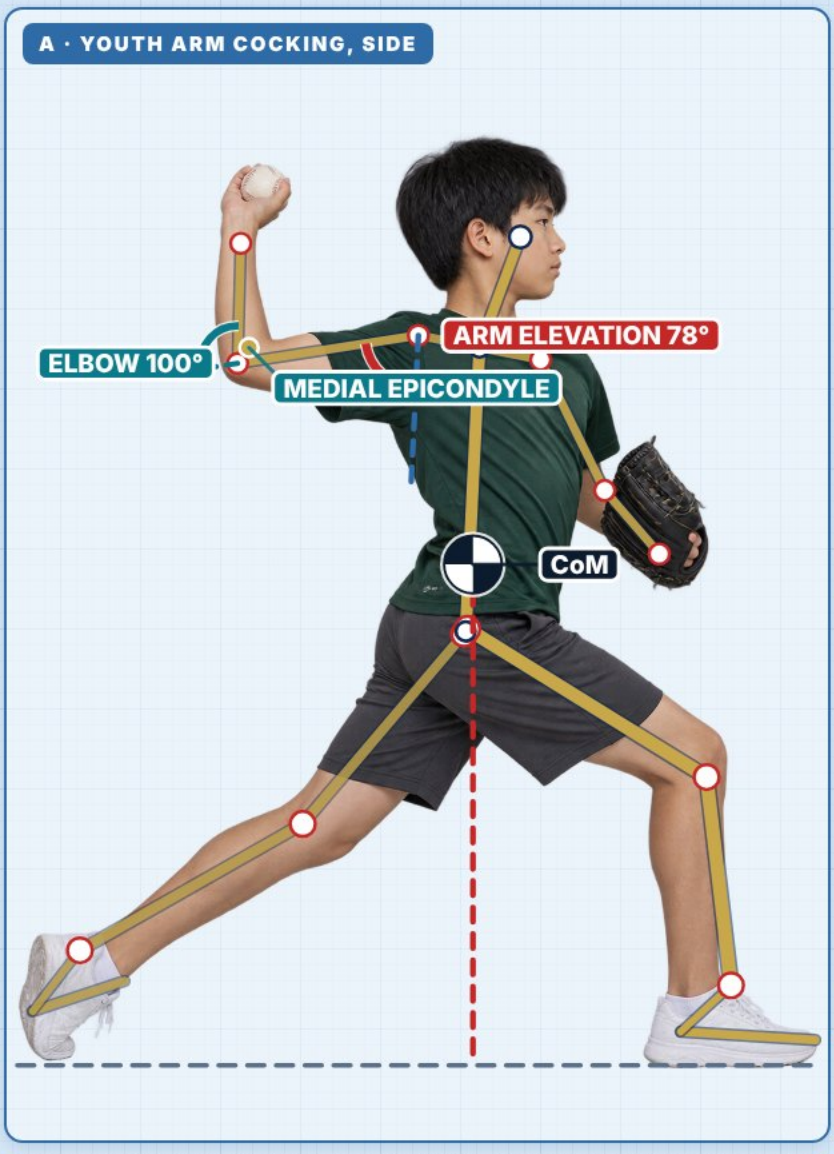
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LITTLE LEAGUE ELBOW: WHY YOUNG THROWERS NEED PITCH COUNTS

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EYE-OPENER

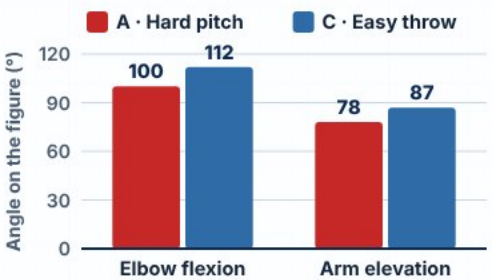
5.0% of youth pitchers aged 9–14 had a serious throwing injury within 10 years.

481 pitchers, prospective cohort. Fleisig et al. (2011).

A growth plate takes the pull

- In cocking, elbow ≈**100°** and arm ≈**78°** elevated, the ball lagging behind pushes the elbow into valgus, pulling on the inner elbow.
- In a growing thrower that traction falls on the medial epicondyle apophysis (growth plate), the classic site of little league elbow.

Similar positions, different effort



Measured on Frames A and C (2-D, camera plane); elbow 0° = straight, arm elevation from the trunk line.

2-D estimates from pose landmarks on an illustrated youth figure; CoM from adult segment parameters (de Leva, 1996), approximate for a child. Angles only; no lengths or moments are estimated. Educational, not diagnostic.

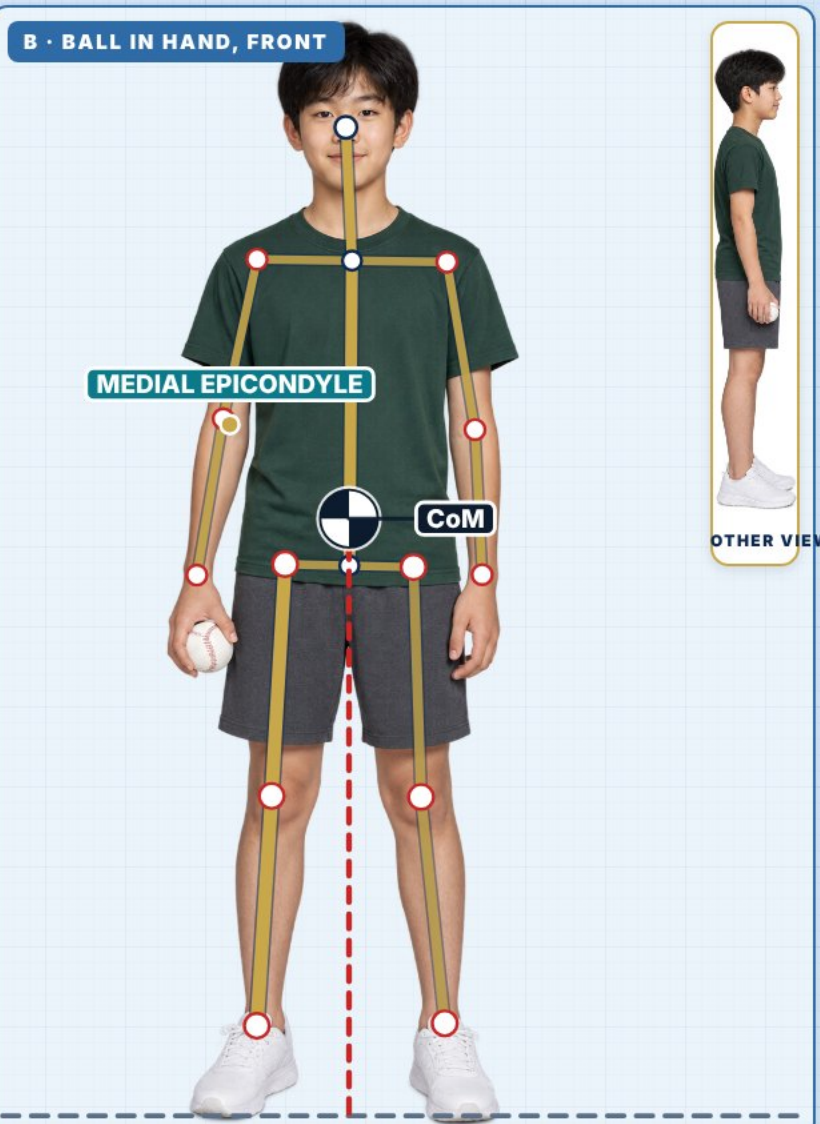
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2-D pose landmarks on an illustrated youth figure; anatomy marker placed for teaching. No angles, lengths or moments are reported for this frame. Educational, not diagnostic.

EYE-OPENER

61% of minor-league pitchers with UCL reconstruction had it in high school or college.

Conte et al. (2015).

Growing bones, different weak link

- In an adult the ligament is the usual casualty; before the growth plates close, the medial epicondyle apophysis is often the weaker structure.
- Repeated valgus traction can irritate or injure it, so volume matters more than any single throw.

Pitch type and pain in youth pitchers



Ages 9–14, n = 476. Lyman et al. (2002); change-up value from an MLB.com (2014) summary (secondary source).

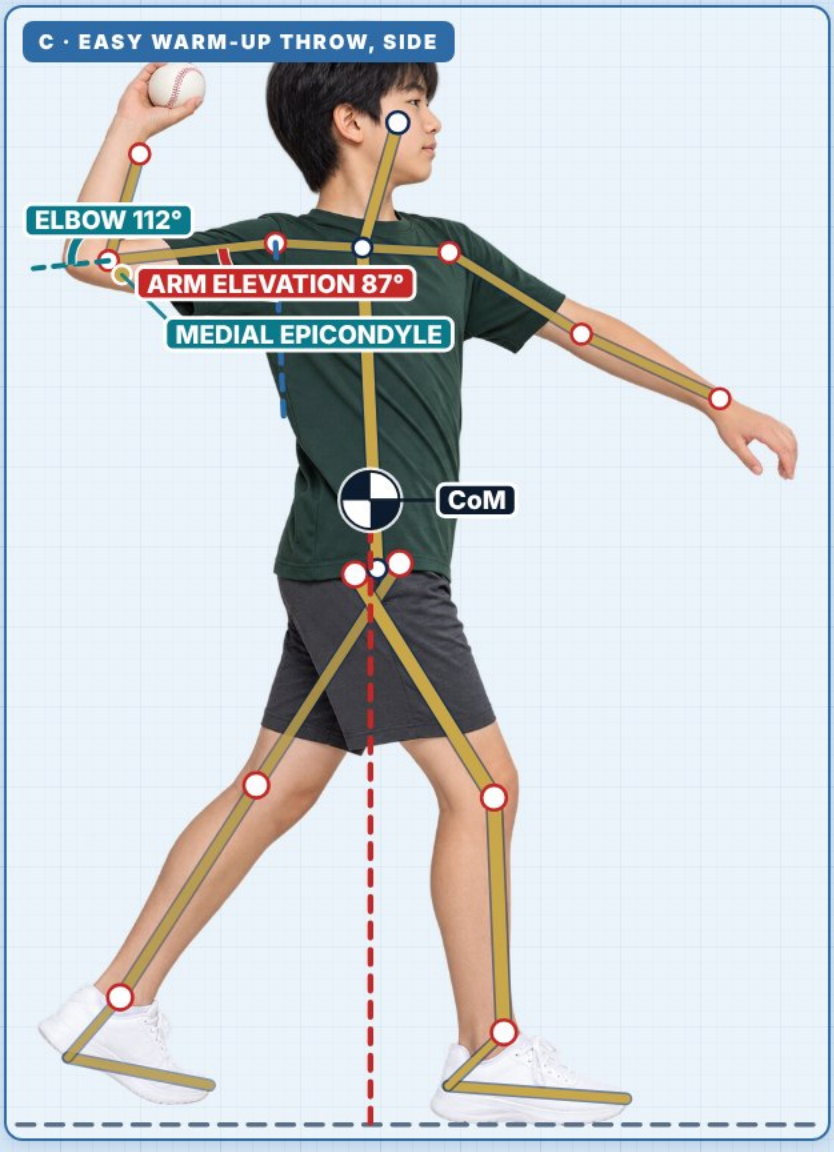
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INTEGRATING PERFORMANCE & REHABILITATION HEALTHCARE PATHWAYS.

LITTLE LEAGUE ELBOW: WHY YOUNG THROWERS NEED PITCH COUNTS

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EYE-OPENER

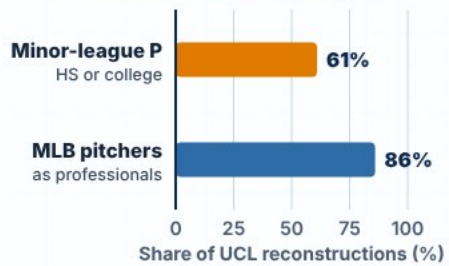
75 pitches per game and 600 per season: the limits the authors suggested for ages 9–14.

Lyman et al. (2002), as reported by MLB.com (2014).

Teach mechanics while loads are low

- An easy, short throw (elbow ≈**112°**, arm ≈**87°**) rehearses the pattern at a fraction of full effort.
- From youth to professional level, positions were similar but all eight joint-load measures rose (Fleisig et al., 1999).

Where adult UCL surgery begins



Timing of reconstruction among professional pitchers. Conte et al. (2015).

Myth: "Curveballs wreck young elbows." The 10-year cohort could not show that curveballs before 13 raised risk; volume did (Fleisig et al., 2011).

2-D estimates from pose landmarks on an illustrated youth figure; CoM from adult segment parameters (de Leva, 1996), approximate for a child. Angles only; no lengths or moments are estimated. Educational, not diagnostic.

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A · Pitch Valgus

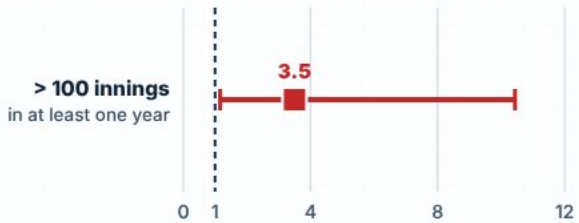


B · Growth Apophysis



C · Easy Mechanics

Volume, not curveballs, tracked with injury



Relative risk of serious injury, 95% CI (1 = no difference)

481 pitchers aged 9–14 followed for 10 years; curveballs before 13: no increase in risk shown. Fleisig et al. (2011).

Decision pathway

1. **COUNT**
   Keep pitch counts and innings limits, e.g. the suggested 75 per game and 600 per season (secondary report).
2. **REST**
   Build in rest days and avoid year-round pitching or more than 100 innings in a year.
3. **TEACH**
   Use easy, short throws to teach sound mechanics early, while joint loads are lower.

NOT RECOMMENDED

Throwing through elbow pain, or pitching year-round without rest.

SEEK ASSESSMENT IF

Inner-elbow pain during or after throwing, loss of elbow straightening, swelling or locking in a child: stop throwing and seek assessment.

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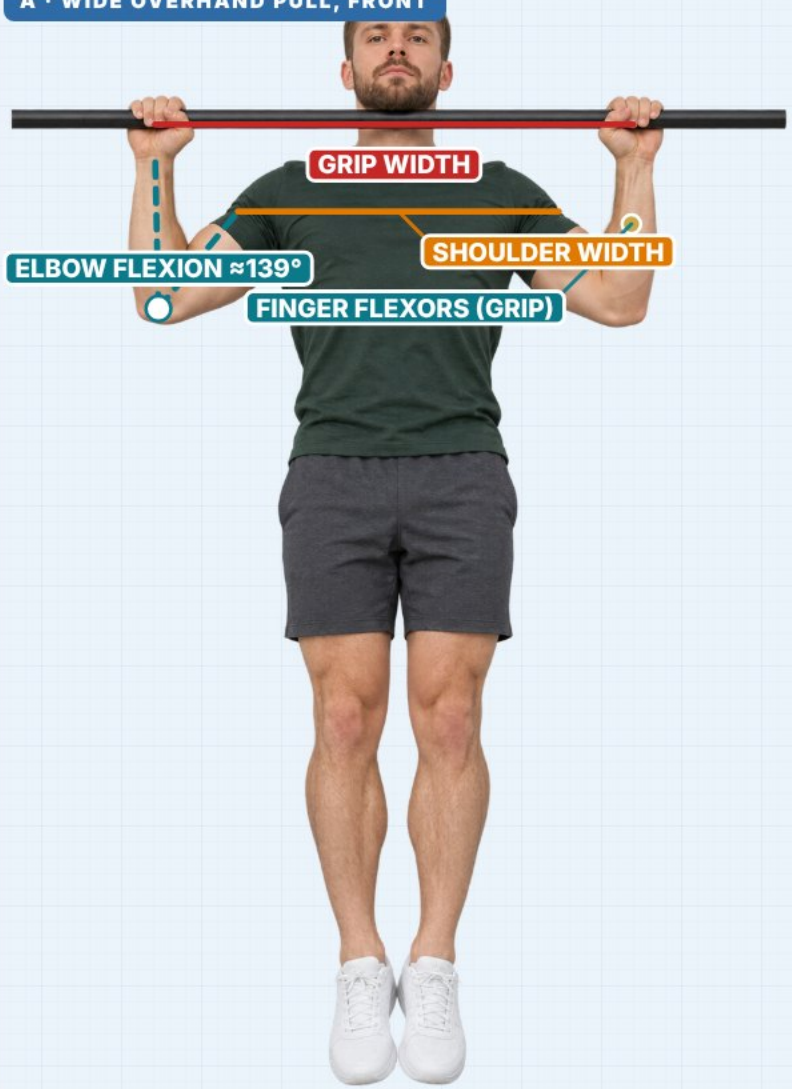
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ELBOW PAIN IN PULL-UPS AND CHIN-UPS: GRIP WIDTH AND LOAD PATH

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A · WIDE OVERHAND PULL, FRONT



EYE-OPENER

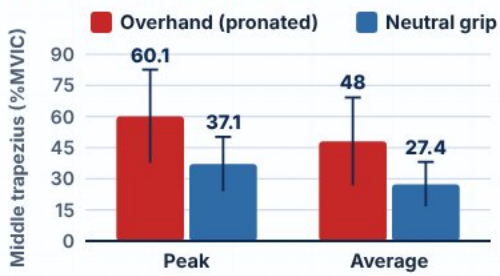
1.29 effect size: grip orientation alone sharply changed back-muscle activity in the same pull-up.

Average EMG, overhand vs neutral; 19 trained men. Dickie et al. (2016).

Grip changes the load path

- Wide overhand top position: grip **≈1.5×** shoulder width, forearms near vertical, elbow flexion **≈139°** in the front view.
- Changing the grip altered recruitment of brachioradialis, biceps and pectoralis major as well as the back, so elbow tissues share the load differently.

Overhand grip shifts muscle demand



Mean ± SD, % of maximal voluntary isometric contraction; 19 strength-trained men. Dickie et al. (2016).

2-D estimates from pose landmarks on an illustrated figure; CoM (if shown) from de Leva (1996); cm for a 1.70 m adult (Winter, 2009). Elbow angle and grip/shoulder widths from manually placed joint centres; widths are a ratio, not cm. Educational, not diagnostic.

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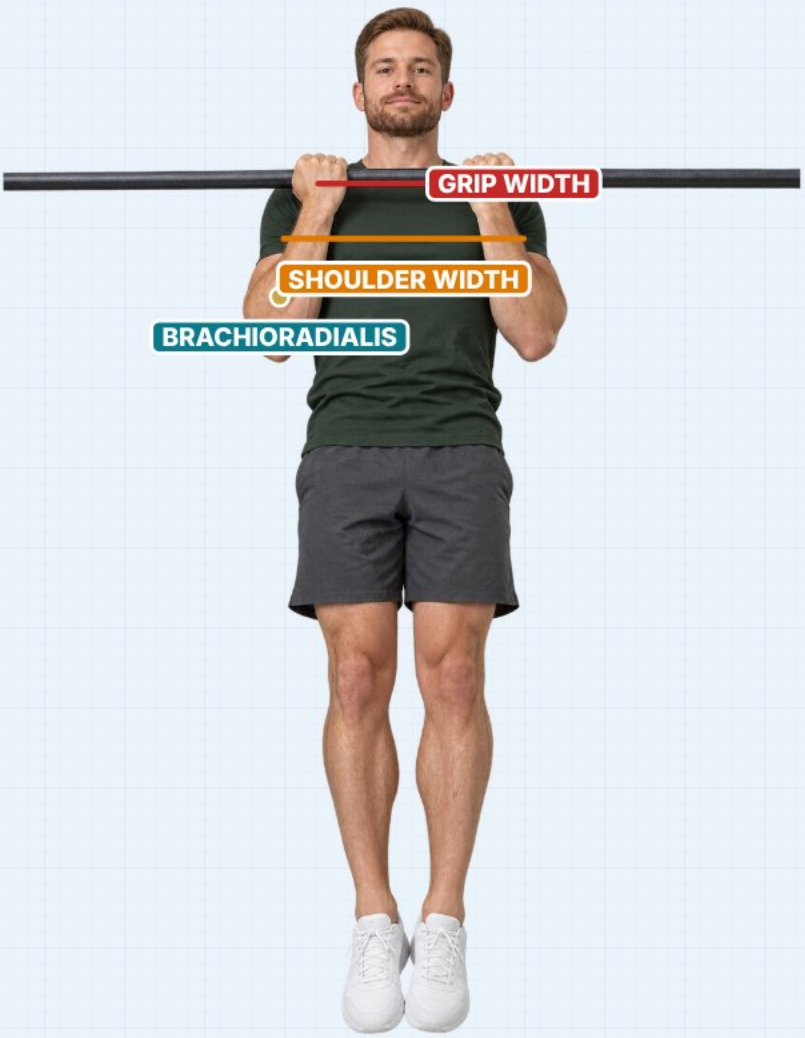
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B · NARROW UNDERHAND, FRONT



EYE-OPENER

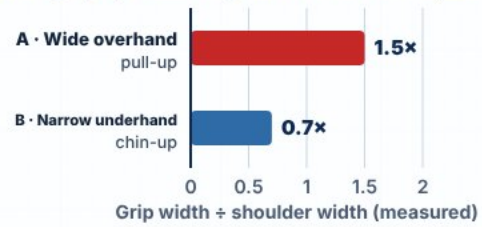
95% of distal biceps ruptures in a US national sample were in men (mean age 46).

National estimate. Kelly et al. (2015).

Palms up recruits the biceps twice

- Narrow underhand grip ≈**0.7×** shoulder width: the elbows finish fully bent in front of the trunk, with the forearms turned palm-up.
- The biceps both bends the elbow and holds supination, so its distal tendon at the front of the elbow carries load in chin-ups.

Two grips, two very different set-ups



Measured on Frames A and B: hand centres ÷ shoulder-joint centres, front view.

Myth: "A wide grip protects the elbow." Grip changes which muscles work; no study in this evidence base shows lower elbow load with a wide grip.

2-D estimates from pose landmarks on an illustrated figure; CoM (if shown) from de Leva (1996); cm for a 1.70 m adult (Winter, 2009). Grip and shoulder widths from manually placed hand and shoulder-joint centres (2-D ratio). Educational, not diagnostic.

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EYE-OPENER

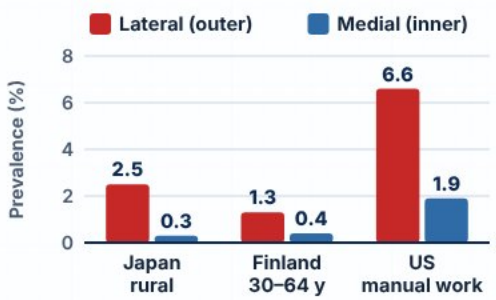
5.6× higher odds of tennis elbow when arm work is both forceful and repetitive.

Adjusted OR, 95% CI 1.9–16.5. Shiri et al. (2006).

The hang: grip holds the body

- Dead hang with the elbow ≈**4°** from straight and the arm elevated ≈**178°**: body weight hangs from the hands through the finger flexors.
- Those flexors arise at the medial epicondyle, and gripping also recruits the wrist extensors, so high pulling volume loads both sides.

Both sides of the elbow are affected



Japan n = 1,777 (Otoshi et al., 2015); Finland n = 4,783 (Shiri et al., 2006); US pooled n = 1,824 (Thiese et al., 2016).

2-D estimates from pose landmarks on an illustrated figure; CoM (if shown) from de Leva (1996); cm for a 1.70 m adult (Winter, 2009). Elbow angle and arm elevation from pose landmarks in the side view. Educational, not diagnostic.

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A · Wide Overhand



B · Narrow Palms up



C · Hang Grip load

The biceps matters most for palm-up turning



Distal biceps rupture, pooled strength vs uninjured arm; 53 studies, 1,380 patients. Cuzzolin et al. (2021).

Decision pathway

1. **MODIFY**
   Note which grip and which side of the elbow hurts; swap to a less provocative grip and cut sets while pain settles.
2. **LOAD**
   Use assisted or partial-range pulls, then rebuild full range and volume step by step (expert principle).
3. **TRACK**
   Progress only when pain during and the morning after training stays stable.

NOT RECOMMENDED

Grinding out high-volume or kipping sets through sharp elbow pain, or assuming a wide grip protects the elbow.

SEEK ASSESSMENT IF

A "pop" at the front of the elbow with bruising or weak palm-up turning, tingling in the ring and little fingers, or deformity after a fall: seek prompt assessment.

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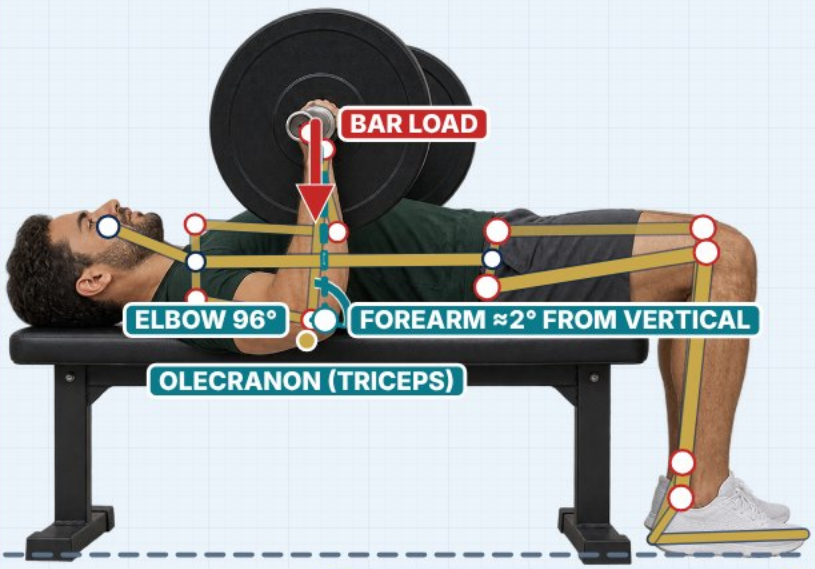
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ELBOW PAIN IN THE BENCH PRESS AND PUSH-UPS: FOREARM ANGLE AND JOINT LOAD

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A · BENCH PRESS, SIDE





OTHER VIEW

EYE-OPENER

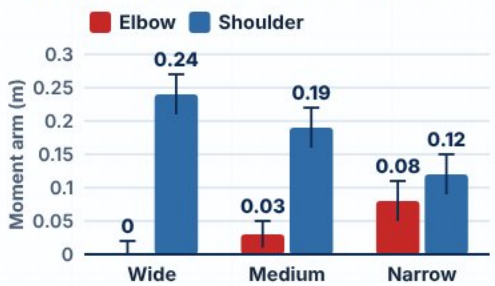
13–16% of vertical bar force was pushed outward with a wide bench grip.

Sticking region, 1-RM. Larsen et al. (2021).

Stack the forearm under the bar

- Bar low, elbow flexed ≈**96°**, forearm ≈**2°** from vertical: the bar load runs down the forearm through the elbow.
- Forearm vertical (wide or medium grip): elbow moment arm near zero. A narrow grip shifts demand onto the elbow and triceps.

Narrow grip shifts load to the elbow



Start of the press, mean ± SD; 14 trained men, 1-RM. Larsen et al. (2021).

Myth: "A narrow grip spares the elbows." It raised the elbow moment arm to 0.08 m.

2-D estimates from pose landmarks on an illustrated figure; CoM (if shown) from de Leva (1996); cm for a 1.70 m adult (Winter, 2009). Elbow angle from pose landmarks; forearm angle from manually placed elbow and wrist centres. Educational, not diagnostic.

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B · HANDS NEAR SHOULDERS, FRONT





EYE-OPENER

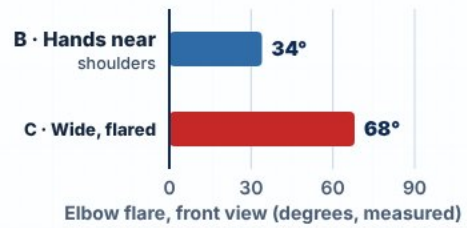
45% of body weight runs along the forearm at the elbow in a standard push-up.

Peak axial force, averaged. Donkers et al. (1993).

Hand position sets the elbow load

- Bottom position with hands ≈**1.2×** shoulder width and elbow flare ≈**34°** from vertical in the front view.
- A push-up loads the elbow in flexion, forearm rotation and valgus, and hand position changes these joint loads.

Measured: how far the elbows flare



Measured on Frames B and C: upper arm (shoulder to elbow centre) vs the vertical, front view.

Angles from landmarks placed on an illustrated figure (2-D, camera-plane); approximate. Flare angle and hand/shoulder widths from manually placed joint centres; widths are a 2-D ratio. Educational, not diagnostic.

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C · WIDE, FLARED, FRONT



EYE-OPENER

+42% more valgus (inner-elbow) torque when a push-up became a one-handed simulated fall.

Donkers et al. (1993).

Wide and flared changes the lever

- Hands ≈**1.4×** shoulder width with elbow flare ≈**68°**: the upper arm sits far out to the side.
- Elbow loads for these exact hand positions are not measured in the evidence here; grade total load by body angle.

Grade the load by body angle



Push-up variations; hands or feet elevated. Wurm et al. (2010).

Myth: "Push-ups are light on the elbow." Hand force reaches 0.64–0.74 × body weight.

Angles from landmarks placed on an illustrated figure (2-D, camera-plane); approximate. Flare angle and hand/shoulder widths from manually placed joint centres; widths are a 2-D ratio. Educational, not diagnostic.

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A · Bench Forearm vertical



B · Push-up Near shoulders



C · Push-up Wide, flared

Grip width changes where the bar is pushed



Range across the sticking region, 1-RM bench press; 14 trained men. Larsen et al. (2021).

Decision pathway

1. **MODIFY**
   Use a medium grip that keeps the forearm close to vertical under the bar while the elbow is irritable.
2. **LOAD**
   Regress push-ups by raising the hands, then lower the incline and rebuild volume step by step.
3. **TRACK**
   Note which side of the elbow hurts and the next-day response; progress only when it is stable.

NOT RECOMMENDED

Switching to a narrow grip to "spare" the elbows, or pressing through sharp pain with deep, high-volume sets.

SEEK ASSESSMENT IF

A "pop" at the back of the elbow, inability to straighten it against gravity, inner-elbow pain with little-finger tingling, or deformity after a fall: seek prompt assessment.

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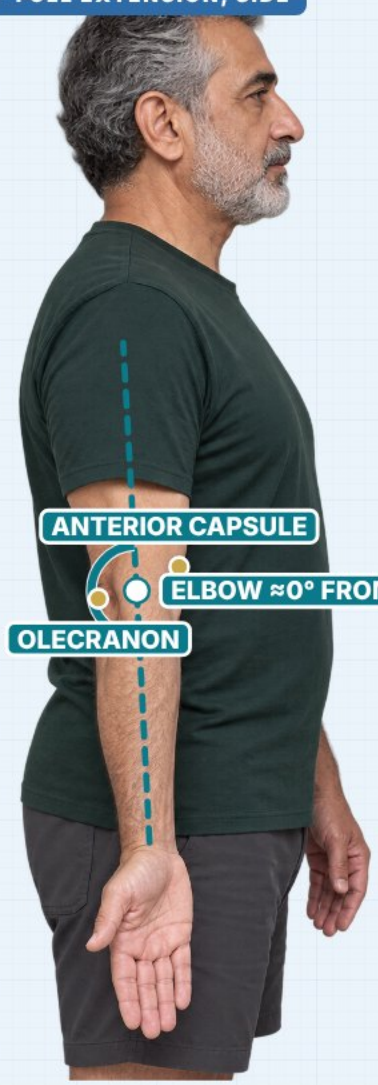
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ELBOW STIFFNESS AFTER INJURY: WHY LOSING FULL EXTENSION MATTERS

AN MMSX AUTHORITY | APPLIED BIOMECHANICS LAB EDUCATIONAL ANALYSIS

A · FULL EXTENSION, SIDE





OTHER VIEW

EYE-OPENER

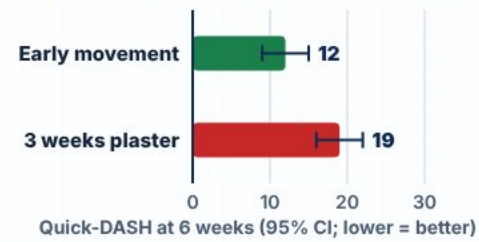
8 days sooner back to work when a simple dislocation was moved early instead of casted.

10 vs 18 days. Iordens et al. (2017).

The last few degrees

- This figure reaches full extension (≈**0°** from straight). After injury, the anterior capsule and flexors often stiffen, so the elbow stops short of this.
- An extension deficit shortens reach and keeps the elbow bent under load when lifting, carrying or pushing.

Early movement, better early function



Quick-DASH at 6 weeks (95% CI; lower = better)

Simple elbow dislocation, randomised trial (n = 100). Iordens et al. (2017).

Myth: "Keep it in plaster longer so it heals properly." Early movement gave a larger arc and no recurrent dislocations.

Angles from landmarks placed on an illustrated figure (2-D, camera-plane); approximate. Elbow angle from manually placed shoulder, elbow and wrist centres. Educational, not diagnostic.

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ELBOW STIFFNESS AFTER INJURY: WHY LOSING FULL EXTENSION MATTERS

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B · SUPPORTED STRETCH, SIDE



EYE-OPENER

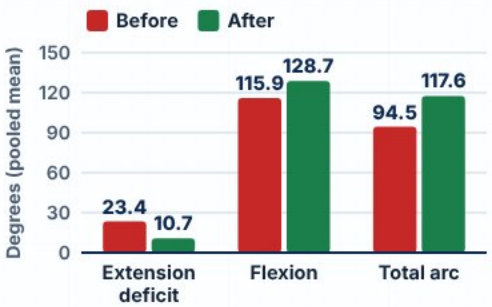
100° of elbow bend, from 30° to 130°, covers most activities of daily living.

Morrey et al. (1981).

Low load, long duration

- Forearm supported palm-up with a small weight, elbow flexed ≈**71°** in this figure; the stretch is held gently at the end of the range available that day.
- Stiff tissue responds to sustained, tolerable positioning better than to brief, forceful stretching.

Stiff arthritic elbows: range before and after surgery



Arthroscopic debridement, 213 elbows, 9 studies (systematic review). Sochacki et al. (2017).

Angles from landmarks placed on an illustrated figure (2-D, camera-plane); approximate. Elbow angle from manually placed upper-arm, elbow and wrist points. Educational, not diagnostic.

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INTEGRATING PERFORMANCE & REHABILITATION HEALTHCARE PATHWAYS.

ELBOW STIFFNESS AFTER INJURY: WHY LOSING FULL EXTENSION MATTERS

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C · CUP TO MOUTH, FRONT



Angles from landmarks placed on an illustrated figure (2-D, camera-plane); approximate. No angle is quoted in this front view (the arm is foreshortened). Educational, not diagnostic.

EYE-OPENER

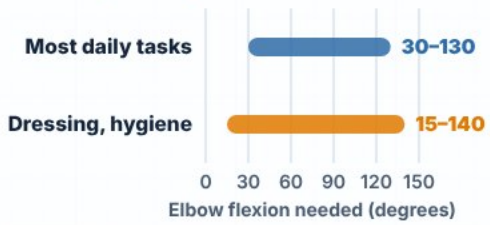
50° each of pronation and supination covers most forearm tasks.

Functional forearm rotation. Morrey et al. (1981).

Reaching the mouth needs deep flexion

- Bringing a cup to the mouth takes the elbow to the top of its functional arc, with the biceps and brachialis working at short length.
- So stiffness costs function at both ends: lost extension limits reach, lost flexion limits eating, washing and dressing.

The range daily life asks for



Functional elbow motion in healthy adults. Morrey et al. (1981).

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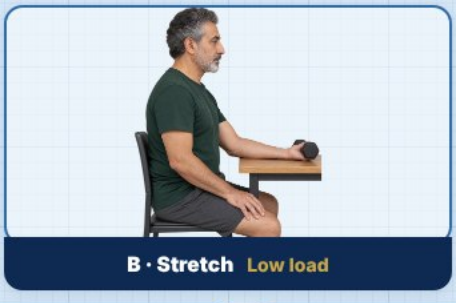
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A · Extend End range

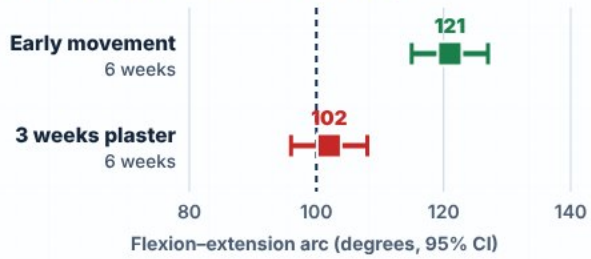


B · Stretch Low load



C · Cup Deep flexion

Early movement restored more range



Simple elbow dislocation; dashed line = 100° functional arc (Morrey et al., 1981). Iordens et al. (2017).

Decision pathway

1. **MOVE EARLY**
   Once the clinician confirms the elbow is stable, start protected active motion rather than long immobilisation.
2. **POSITION**
   Use low-load, long-duration positioning to regain extension; build towards the 30°–130° functional arc.
3. **TRACK**
   Measure extension deficit and flexion weekly; link targets to tasks such as reaching the mouth.

NOT RECOMMENDED

Forcing painful end-range stretches, or keeping a stable elbow immobilised longer than advised.

SEEK ASSESSMENT IF

Worsening stiffness with a hard block, new swelling, numbness or a fixed bent posture after injury: seek prompt review.

REFERENCES (APA 7)

de Leva, P. (1996). Adjustments to Zatsiorsky-Seluyanov's segment inertia parameters. *Journal of Biomechanics, 29*(9), 1223–1230. https://doi.org/10.1016/0021-9290(95)00178-6

Iordens, G., Van Lieshout, E. M. M., Schep, N. W. L., de Haan, J., Tuinebreijer, W., Eygendaal, D., van Beeck, E., Patka, P., Verhofstad, M., & den Hartog, D. (2017). Early mobilisation versus plaster immobilisation of simple elbow dislocations: Results of the FuncSiE multicentre randomised clinical trial. *British Journal of Sports Medicine, 51*(6), 531–538. https://doi.org/10.1136/bjsports-2015-094704

Morrey, B. F., Askew, L. J., & Chao, E. Y. (1981). A biomechanical study of normal functional elbow motion. *Journal of Bone and Joint Surgery (American Volume), 63*(6), 872–877. https://doi.org/10.2106/00004623-198163060-00002

Sochacki, K. R., Jack, R. A., Hirase, T., McCulloch, P. C., Lintner, D. M., Liberman, S. R., & Harris, J. D. (2017). Arthroscopic debridement for primary degenerative osteoarthritis of the elbow leads to significant improvement in range of motion and clinical outcomes: A systematic review. *Arthroscopy, 33*(12), 2255–2262. https://doi.org/10.1016/j.arthro.2017.08.247

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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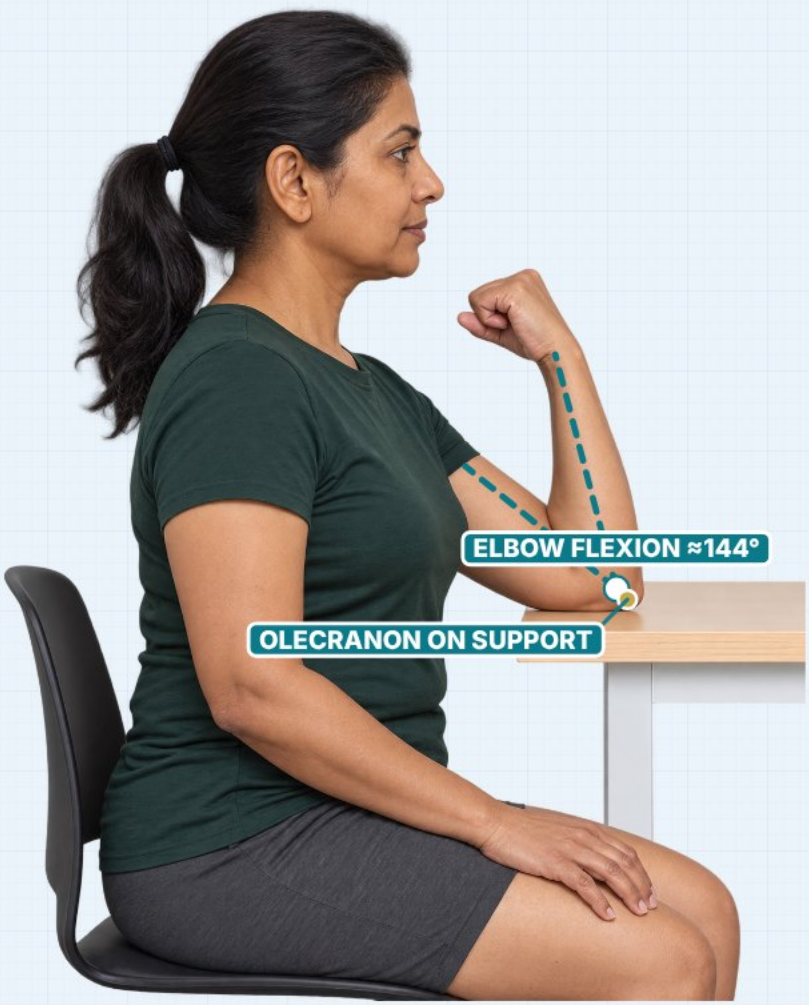
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ELBOW DISLOCATION AND FRACTURE REHAB: RESTORING MOTION SAFELY

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A · ACTIVE ELBOW BEND, SIDE



EYE-OPENER

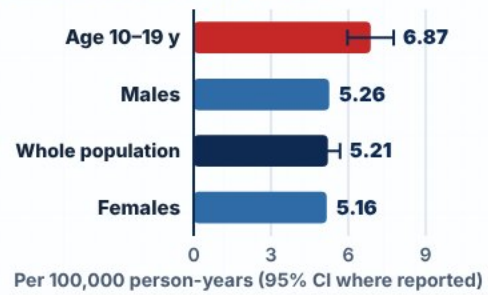
43.5% of US elbow dislocations happen in people aged 10–19.

Stoneback et al. (2012).

Move early, inside a stable arc

- Elbow resting on the table and actively bent to ≈**144°** of flexion: her own muscles control the motion while the support steadies the joint.
- After a simple dislocation, early active motion within the stable range is the evidence-based start; fracture rehab follows the fixation and surgeon's protocol.

Who dislocates the elbow



US national estimate. Stoneback et al. (2012).

Angles from landmarks placed on an illustrated figure (2-D, camera-plane); approximate. Elbow angle from manually placed upper-arm, elbow and wrist points. Educational, not diagnostic.

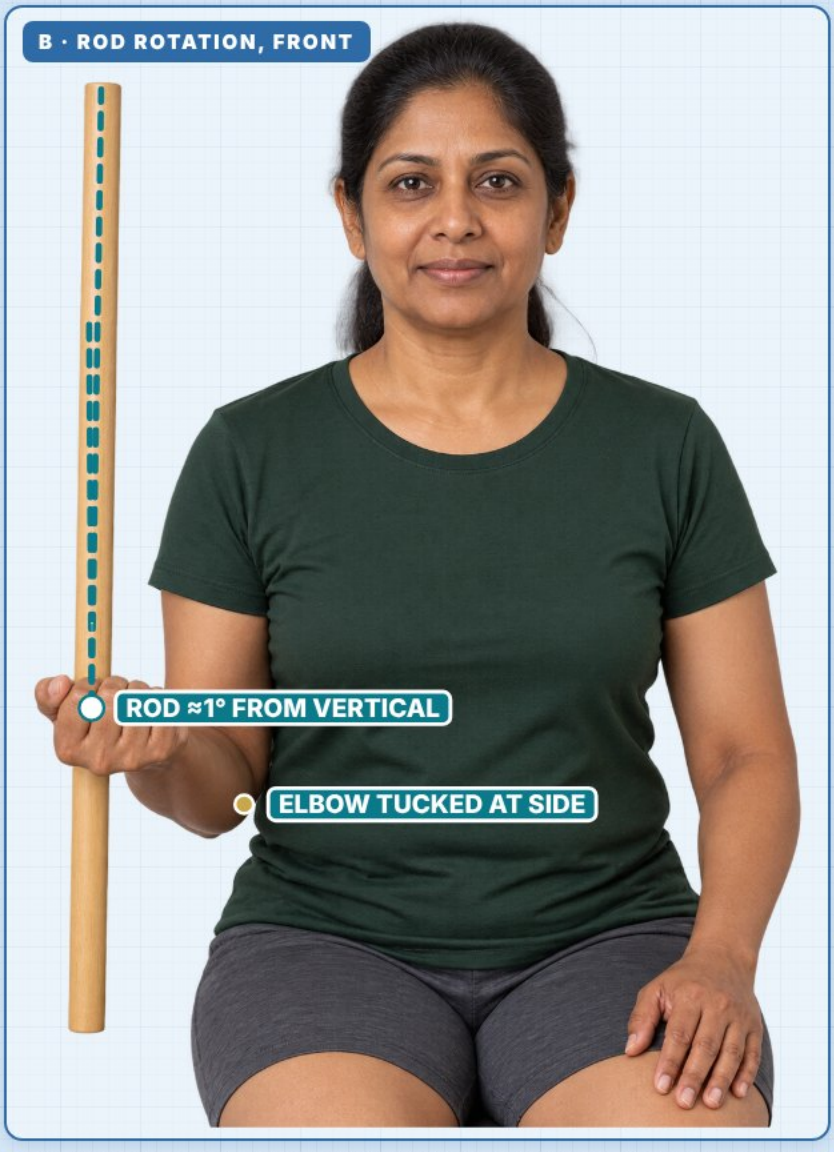
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EYE-OPENER

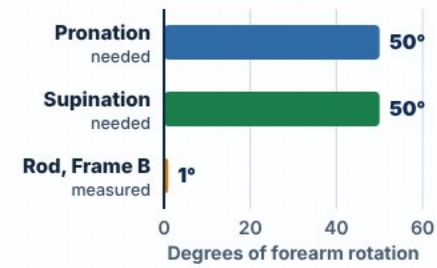
44.5% of dislocations in people aged 10 and over were sustained in sport.

Stoneback et al. (2012).

The rod shows forearm rotation

- Elbow tucked at the side so the shoulder cannot cheat; the rod is ≈**1°** from vertical, the neutral start before turning the palm up.
- Turning the palm up (supination) and down (pronation) is retrained alongside bending and straightening.

Rotation targets for daily tasks



Needed: Morrey et al. (1981). Measured: rod tilt from vertical on Frame B.

Angles from landmarks placed on an illustrated figure (2-D, camera-plane); approximate. Rod angle from manually placed points on the rod and a vertical reference. Educational, not diagnostic.

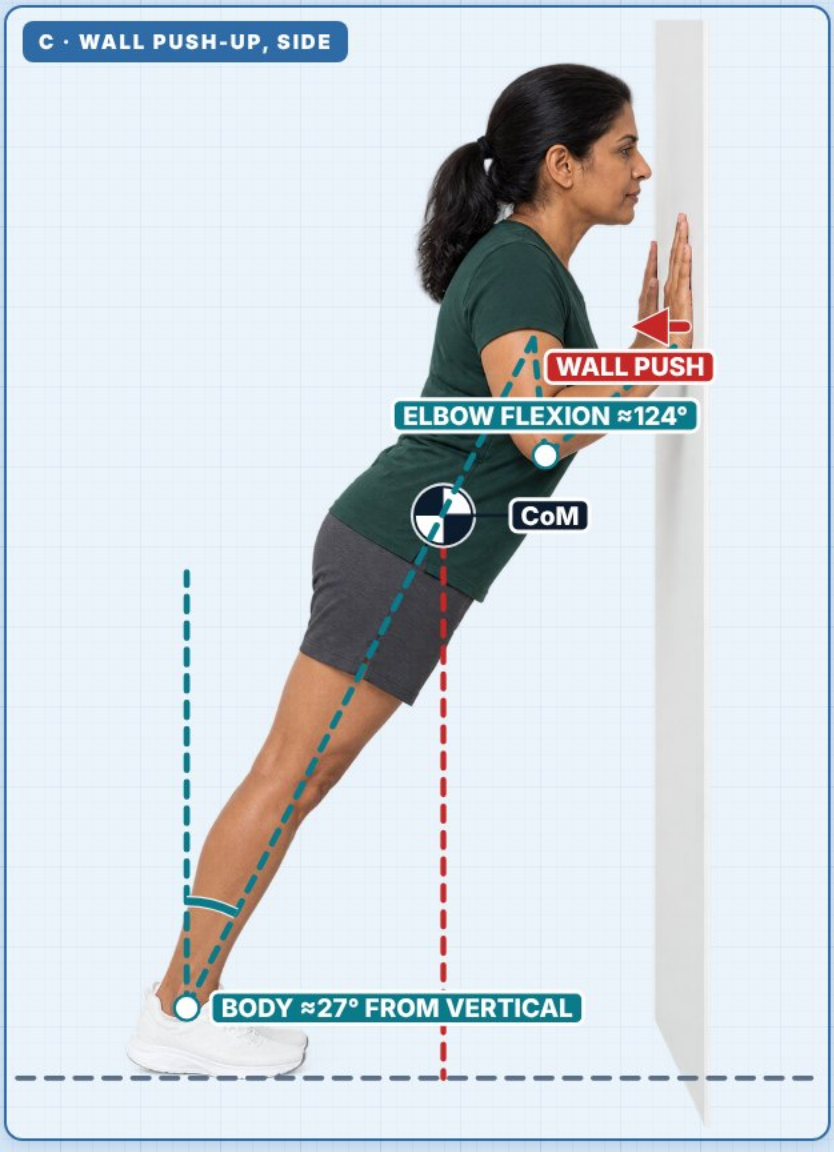
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EYE-OPENER

4.0 Quick-DASH score (0–100, lower = better) one year after early movement.

Simple dislocation, early group. Iordens et al. (2017).

Weight-bearing, graded by angle

- Wall push-up: body ≈**27°** from vertical, elbow flexed ≈**124°**. Standing this upright puts only part of body weight through the hands.
- The wall push-up itself was not measured; the ladder shows that more upright means less hand load.

More upright, less load



Push-up variations; hands or knees supported. Wurm et al. (2010).

Myth: "No weight through the arm until fully healed." Once stability is confirmed, load is graded upward from about 0.4 × body weight.

2-D estimates from pose landmarks on an illustrated figure; CoM (if shown) from de Leva (1996); cm for a 1.70 m adult (Winter, 2009). Body and elbow angles from manually placed ankle, shoulder, elbow and wrist points. Educational, not diagnostic.

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A · Bend Active arc



B · Rotate Palm up



C · Wall Graded load

Early movement: back to work sooner



FuncSiE randomised trial, n = 100. Iordens et al. (2017).

Decision pathway

1. **MOVE**
   With stability confirmed, start early active bending and straightening inside the stable arc.
2. **ROTATE**
   Add palm-up and palm-down turns with the elbow at the side, aiming towards 50° each way.
3. **LOAD**
   Begin weight-bearing at the wall and progress the incline only as the clinician advises.

NOT RECOMMENDED

Forcing range with heavy stretching, or loading a fracture before the surgeon confirms fixation is stable.

SEEK ASSESSMENT IF

Visible deformity, inability to move the elbow, a numb, pale or cold hand, rising pain under a cast, or repeated giving way: seek urgent assessment.

REFERENCES (APA 7)

de Leva, P. (1996). Adjustments to Zatsiorsky-Seluyanov's segment inertia parameters. *Journal of Biomechanics, 29*(9), 1223–1230. https://doi.org/10.1016/0021-9290(95)00178-6

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ELBOW OSTEOARTHRITIS: PAIN, LOCKING AND LOSS OF RANGE

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Angles from landmarks placed on an illustrated figure (2-D, camera-plane); approximate. Elbow angle from manually placed shoulder, elbow and wrist points. Educational, not diagnostic.

EYE-OPENER

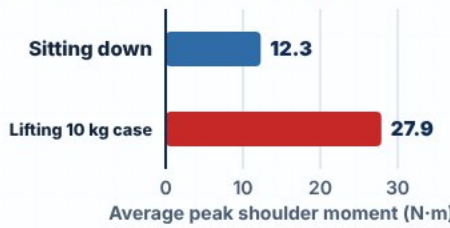
187/209 people having surgery for elbow osteoarthritis were men; mean age 45.7.

Systematic review, 9 studies. Sochacki et al. (2017).

Load near the end of range

- Lifting a full kettle with the elbow flexed ≈**100°**: the load hangs ahead of the joint, so the elbow flexors work hard to hold it.
- Elbow osteoarthritis typically causes pain at end range, where bony osteophytes block full extension and flexion.

Everyday lifting loads the arm



6 healthy adults, mean age 55; elbow values not reported. Anglin & Wyss (2000).

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B · CUP TO MOUTH, FRONT



EYE-OPENER

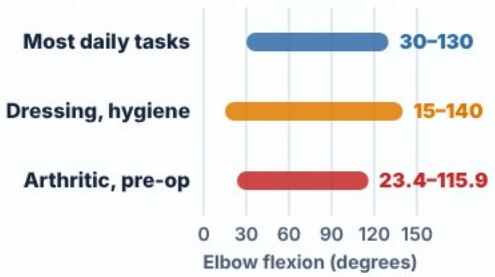
23.4° average loss of full extension in arthritic elbows before arthroscopic surgery.

Pooled, 213 elbows. Sochacki et al. (2017).

Why the cup becomes hard

- Bringing a cup to the mouth needs deep flexion near the top of the functional arc, where an arthritic elbow often runs out of range.
- Locking or catching can come from loose bodies within the joint; the movement stops abruptly rather than easing to an end.

Needed range vs an arthritic elbow



Needed: Morrey et al. (1981). Pre-operative OA mean range: Sochacki et al. (2017).

Angles from landmarks placed on an illustrated figure (2-D, camera-plane); approximate. No angle is quoted in this front view (the arm is foreshortened). Educational, not diagnostic.

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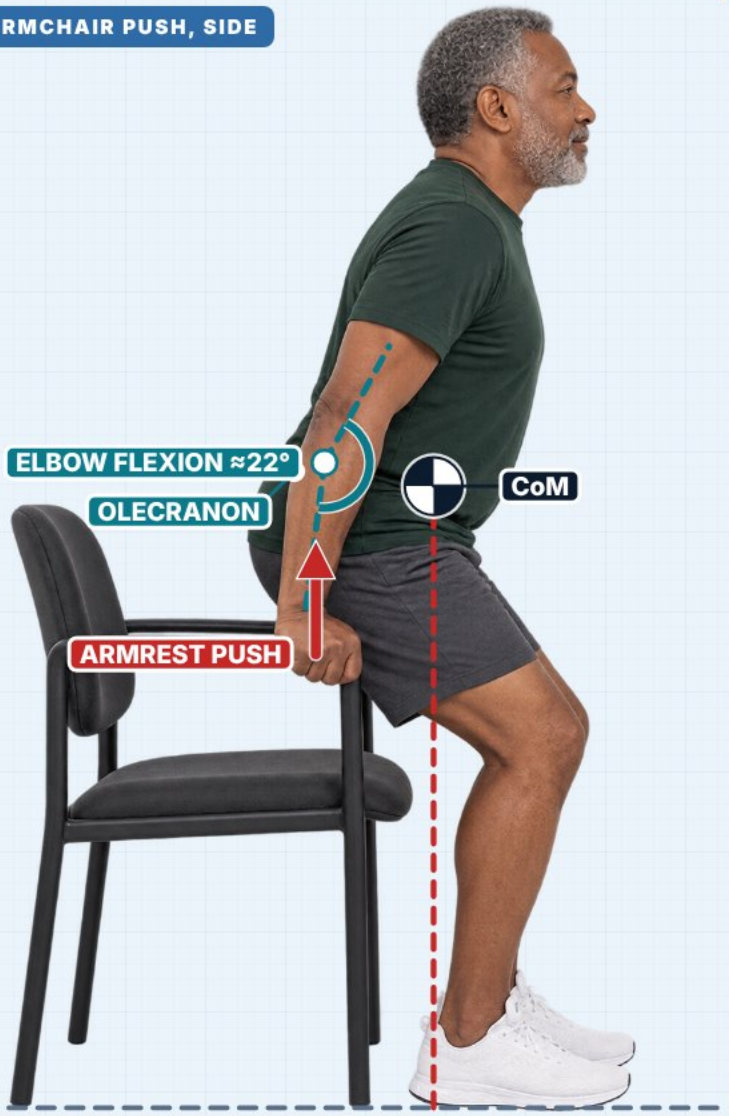
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C · ARMCHAIR PUSH, SIDE



EYE-OPENER

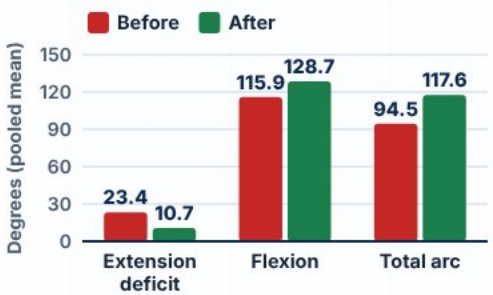
16–19% of body weight goes through the hands when rising from a chair.

Peak hand load, adults over 50. Anglin & Wyss (2000).

Pushing up straightens the elbow

- Pushing on the armrests, the elbow extends to ≈**22°** of flexion under body-weight load, near the end of extension range.
- A stiff arthritic elbow may stop short of this, making chair rises a useful functional test.

Arthroscopic debridement restores range



213 elbows, 9 studies; all changes p < 0.0001. Sochacki et al. (2017).

Myth: "Arthritis means resting the arm." Graded use within tolerance is the aim.

2-D estimates from pose landmarks on an illustrated figure; CoM (if shown) from de Leva (1996); cm for a 1.70 m adult (Winter, 2009). Elbow angle from manually placed upper-arm, elbow and wrist points. Educational, not diagnostic.

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A · Kettle End-range load



B · Cup Deep flexion



C · Rise Extension

Surgery helps persistent mechanical cases



Arthroscopic debridement; complications 2.8%, reoperation 4.2%; level IV evidence. Sochacki et al. (2017).

Decision pathway

1. **MODIFY**
   Avoid repeated forceful end-range extension; lift close to the body and within the pain-free arc.
2. **LOAD**
   Keep range moving daily and strengthen with paced, tolerable loading of the elbow and grip.
3. **TRACK**
   Record extension, flexion and locking episodes; a persistent block may warrant a surgical opinion.

NOT RECOMMENDED

Stopping use of the arm altogether, or forcing through locking and painful end range.

SEEK ASSESSMENT IF

Locking that will not release, a hot swollen joint, rapid loss of function, or tingling in the ring and little fingers: seek prompt assessment.

REFERENCES (APA 7)

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CUBITAL TUNNEL SYNDROME: TINGLING IN THE RING AND LITTLE FINGERS

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EYE-OPENER

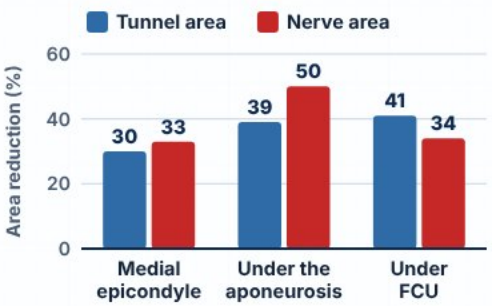
45% higher pressure inside the ulnar nerve than around it at 130° elbow flexion.

Cadaver study, $p < 0.001$. Gelberman et al. (1998).

A deep bend squeezes the tunnel

- Holding a phone to the ear keeps the elbow flexed ≈**143°**; behind the medial epicondyle the cubital tunnel narrows and the ulnar nerve is compressed and stretched.
- The nerve supplies sensation to the little finger and the little-finger half of the ring finger, so that is where tingling appears.

Flexion shrinks tunnel and nerve



Change from full extension to 135° flexion, MRI, 20 cadaver arms; means, no SD reported. Gelberman et al. (1998).

2-D estimates from pose landmarks on an illustrated figure (head-to-hip framing); lengths scaled to a 1.70 m adult (Winter, 2009). Elbow angle from manually placed shoulder, elbow and wrist landmarks. The cubital tunnel lies on the inner side, out of view. Educational, not diagnostic.

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Angles from landmarks placed on an illustrated figure (2-D, camera-plane); approximate. Ring-finger split line drawn on the figure for teaching. Educational, not diagnostic.

EYE-OPENER

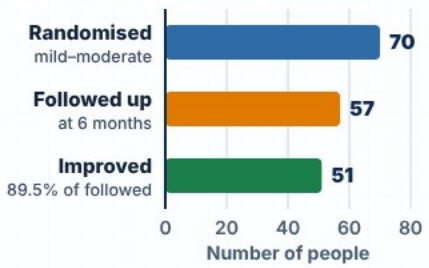
24.7 new cases of ulnar neuropathy at the elbow per 100,000 people each year.

Population study cited in Caliandro et al. (2016).

Read the map on the hand

- Tingling in the little finger and the little-finger half of the ring finger fits the ulnar nerve; a split down the ring finger is a useful clue.
- Thumb, index and middle-finger symptoms point instead to the median nerve, often at the wrist.

Most improve without surgery



Night splint, nerve gliding or information only; the information-only group did no worse. Svernlöv et al. (2009).

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C · ELBOW ON DESK, SIDE



EYE-OPENER

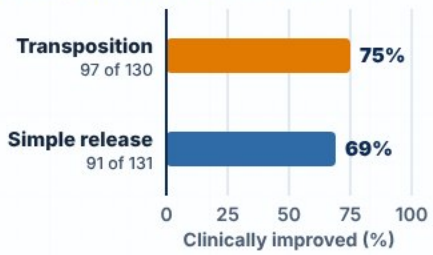
30% did well after a steroid injection, against 28% after a placebo injection.

One trial, 55 people. Caliandro et al. (2016).

Bend plus pressure

- Leaning on the desk with the elbow flexed ≈**145°** adds direct pressure to a tunnel already narrowed by flexion.
- Advice on avoiding long, deep elbow bending and leaning is a sensible first step; no treatment has been shown clearly best.

Moving the nerve adds little



3 trials, 261 people; RR 0.93 (95% CI 0.80–1.08), moderate-quality evidence. Caliandro et al. (2016).

Myth: "Surgery that moves the nerve beats simply freeing it." Results were similar, with more wound infections after transposition.

2-D estimates from pose landmarks on an illustrated figure; CoM (if shown) from de Leva (1996); cm for a 1.70 m adult (Winter, 2009). Elbow angle from manually placed shoulder, elbow and wrist landmarks; skeleton omitted for clarity. Educational, not diagnostic.

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INTEGRATING PERFORMANCE & REHABILITATION HEALTHCARE PATHWAYS.

CUBITAL TUNNEL SYNDROME: TINGLING IN THE RING AND LITTLE FINGERS

AN MMSX AUTHORITY | APPLIED BIOMECHANICS LAB EDUCATIONAL ANALYSIS



A · Phone Deep bend

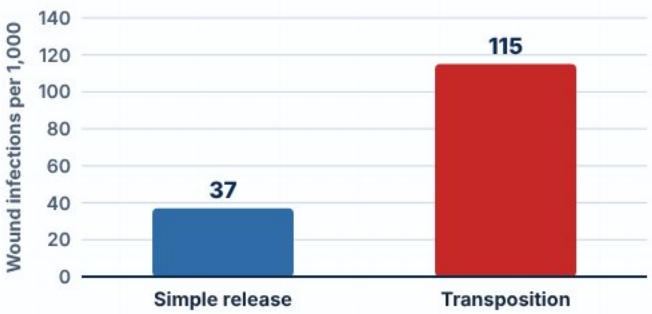


B · Hand Ulnar map



C · Lean Bend + press

If surgery is needed, simpler is safer



Assumed risk per 1,000; RR 0.32 (95% CI 0.12–0.85) favouring simple decompression. Caliandro et al. (2016).

Decision pathway

1. **MODIFY**
   Use a headset or speaker, stop leaning on the elbow and break up long periods of deep elbow bending.
2. **ADVISE**
   Explain the nerve's path and which positions provoke it; simple information did as well as splints or gliding.
3. **ESCALATE**
   Persisting symptoms or weakness: nerve-conduction testing; if operating, simple decompression is preferred.

NOT RECOMMENDED

Routine nerve transposition as first-choice surgery, or a steroid injection expected to cure; neither beat its comparator.

SEEK ASSESSMENT IF

Weakness or wasting of the small hand muscles, clumsiness, constant numbness or worsening symptoms.

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

DOI 10.5281/zenodo.23735910

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

INTEGRATING PERFORMANCE & REHABILITATION HEALTHCARE PATHWAYS.

SLEEPING WITH A BENT ELBOW: HOW THE ULNAR NERVE IS COMPRESSED

AN MMSX AUTHORITY | APPLIED BIOMECHANICS LAB EDUCATIONAL ANALYSIS

A · ARM UNDER HEAD, SIDE





OTHER VIEW

EYE-OPENER

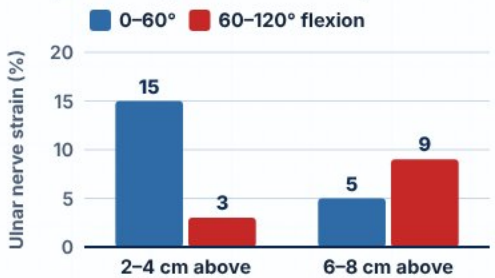
≥15% stretch of the ulnar nerve at the elbow during elbow bending.

10 cadaver arms. Wright et al. (2001).

Hours in a deep bend

- With the arm folded under the head the elbow sits at ≈**120°** flexion, a position that may be held for hours during sleep.
- The ulnar nerve runs behind the medial epicondyle, so bending both narrows its tunnel and stretches it along its length.

Deep bending shifts strain up the arm



Strain by segment above the medial epicondyle; 4 cadaver arms, shoulder 60° abducted ($p < 0.01$ and $p < 0.05$). Nagashima et al. (2021).

Angles from landmarks placed on an illustrated figure (2-D, camera-plane); approximate. Elbow angle from manually placed shoulder, elbow and wrist landmarks; skeleton omitted (lying pose). Educational, not diagnostic.

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B · HANDS ON CHEST, SIDE





OTHER VIEW

EYE-OPENER

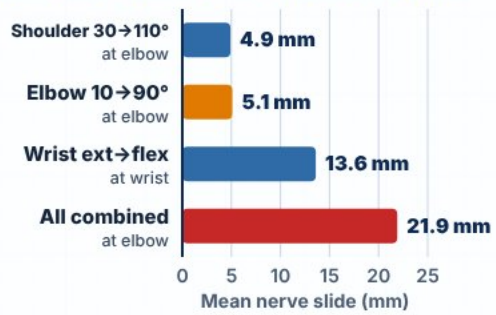
10.5 mm the nerve slides just above the elbow as the elbow bends fully.

2 cm above the medial epicondyle, cadaver arms. Nagashima et al. (2021).

Lying on the back still bends it

- Hands folded on the chest put both elbows at ≈**123°** flexion, with the back of the elbow resting on the mattress.
- A healthy nerve slides to accommodate each joint; when it cannot glide freely, tension rises and symptoms appear on waking.

The nerve must slide with every joint



Mean ulnar nerve excursion, 10 arms from 5 cadavers; no SD reported. Wright et al. (2001).

Angles from landmarks placed on an illustrated figure (2-D, camera-plane); approximate. Elbow angle from manually placed shoulder, elbow and wrist landmarks; skeleton omitted (lying pose). Educational, not diagnostic.

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C · ARMS STRAIGHT, SIDE



EYE-OPENER

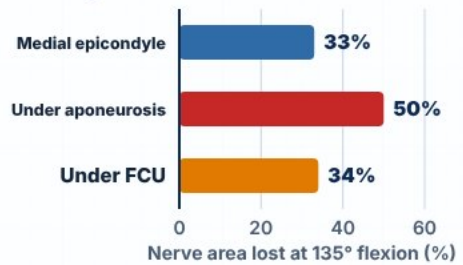
18% more nerve strain above the elbow at full bend than with the arm straight.

2–4 cm above the medial epicondyle. Nagashima et al. (2021).

Straighter arms, roomier tunnel

- Arms by the side keep the elbow near straight (≈**14°** flexion here), where the cubital tunnel and the nerve are largest.
- Night splints or a loosely wrapped towel aim to hold this position, but added benefit over advice alone is uncertain.

Bending flattens the nerve itself



Change in ulnar nerve cross-sectional area, extension to 135° flexion, MRI, 20 cadaver arms. Gelberman et al. (1998).

Myth: "Tingling on waking always comes from the wrist." Ring- and little-finger tingling often points to the elbow.

Angles from landmarks placed on an illustrated figure (2-D, camera-plane); approximate. Elbow angle from manually placed shoulder, elbow and wrist landmarks; skeleton omitted (lying pose). Educational, not diagnostic.

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A · Side-lying Deep bend

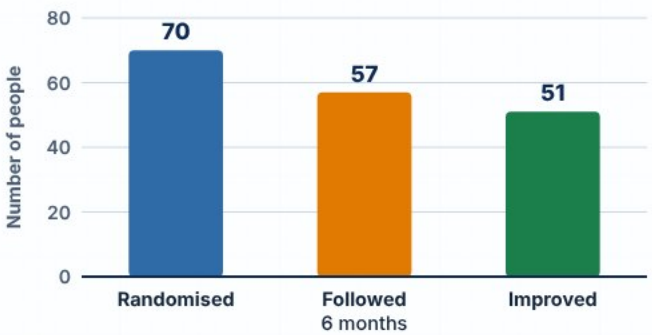


B · On back Bent + pressed



C · Straight Nerve slack

Simple advice did as well as splints



Mild–moderate symptoms: night splint, nerve gliding or information only; 89.5% improved, information did no worse. Svernlöv et al. (2009).

Decision pathway

1. **POSITION**
   Sleep with elbows straighter; avoid tucking the hand under the head or pillow.
2. **ADVISE**
   Explain the nerve's path and give written advice on positions to avoid (Dutch guideline, 2011).
3. **TRIAL**
   A night splint or towel wrap may be tried for comfort; review symptoms after a few weeks.

NOT RECOMMENDED

Promising that a night splint is necessary or better than advice; the evidence for added benefit is very low certainty.

SEEK ASSESSMENT IF

Constant numbness, hand-muscle weakness or wasting, or symptoms that progress despite position changes.

REFERENCES (APA 7)

de Leva, P. (1996). Adjustments to Zatsiorsky-Seluyanov's segment inertia parameters. *Journal of Biomechanics, 29*(9), 1223–1230. https://doi.org/10.1016/0021-9290(95)00178-6

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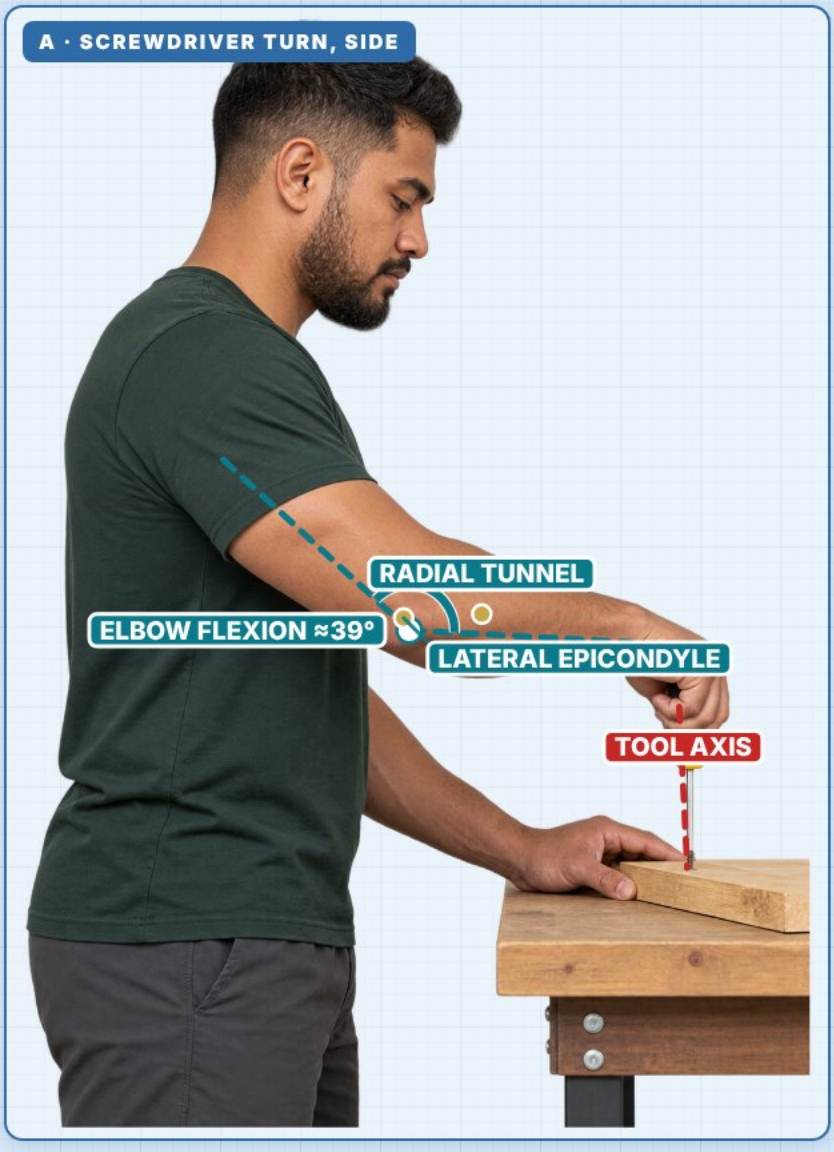
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INTEGRATING PERFORMANCE & REHABILITATION HEALTHCARE PATHWAYS.

RADIAL TUNNEL SYNDROME: WHEN "TENNIS ELBOW" IS REALLY A NERVE

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EYE-OPENER

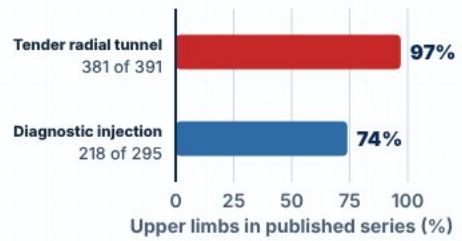
16% had already been injected for presumed tennis elbow before radial tunnel surgery.

46 of 295 limbs, 13 studies. Hones et al. (2024).

Same region, different tissue

- Turning a screwdriver with the elbow **≈39°** from straight repeatedly rotates the forearm, using the supinator through which the posterior interosseous nerve passes.
- Pain sits in the muscle mass below the lateral epicondyle rather than on it, which is easily mistaken for tennis elbow.

How surgeons made the diagnosis



Systematic review of 13 clinical series, 391 upper limbs. Hones et al. (2024).

2-D estimates from pose landmarks on an illustrated figure (head-to-hip framing); lengths scaled to a 1.70 m adult (Winter, 2009). Elbow angle from manually placed shoulder, elbow and wrist landmarks; forearm rotation not measurable in 2-D. Educational, not diagnostic.

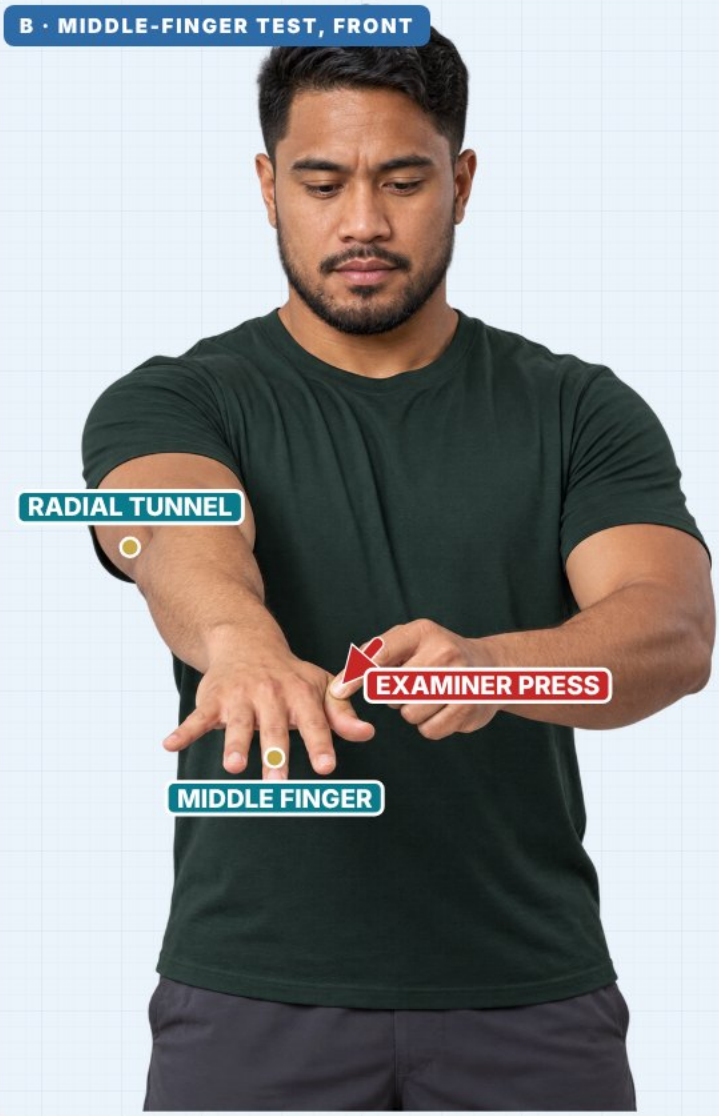
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EYE-OPENER

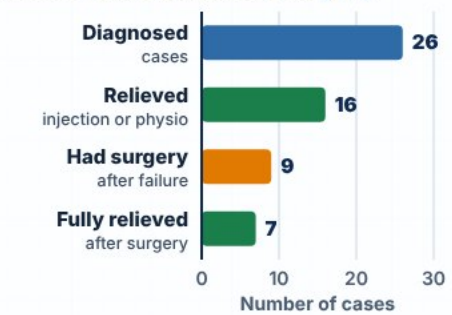
8.9% of operated limbs had abnormal nerve tests beforehand; most cases test normal.

29 of 327 limbs. Hones et al. (2024).

Testing the nerve's territory

- Resisting middle-finger extension with the elbow straight loads the extensors supplied by the posterior interosseous nerve; pain here is one diagnostic sign.
- One series required two of three signs: a tender radial tunnel, painful resisted supination or middle-finger extension, and relief with local anaesthetic.

Most settled without surgery



26 cases in 25 patients over 2.5 years; conservative care was mostly steroid injection. Sarhadi et al. (1998).

2-D estimates from pose landmarks on an illustrated figure (head-to-hip framing); lengths scaled to a 1.70 m adult (Winter, 2009). Elbow angle not quoted (arm points towards the camera). Press arrow drawn for teaching. Educational, not diagnostic.

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C · PRESSING FOREARM, FRONT



EYE-OPENER

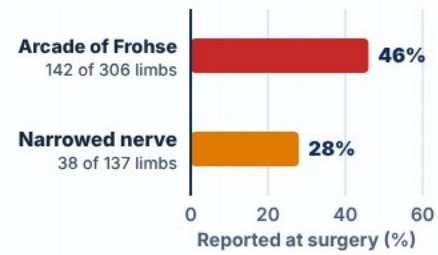
14/14 surgical studies were level IV evidence, the lowest tier of clinical research.

Systematic review. de Moraes et al. (2017).

Press below, not on, the bone

- Tenderness over the radial tunnel, a few finger-widths below the lateral epicondyle, was present in almost every published case.
- Point tenderness on the epicondyle itself, with pain on gripping, fits tennis elbow better; the two can be confused.

Where the nerve is caught at surgery



Most common compression site and most common operative finding. Hones et al. (2024).

Myth: "Normal nerve tests rule out a nerve problem." In published surgical series, only 8.9% of limbs had abnormal tests.

2-D estimates from pose landmarks on an illustrated figure (head-to-hip framing); lengths scaled to a 1.70 m adult (Winter, 2009). Anatomy callouts placed on the figure for teaching. Educational, not diagnostic.

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A · Rotate Supinator

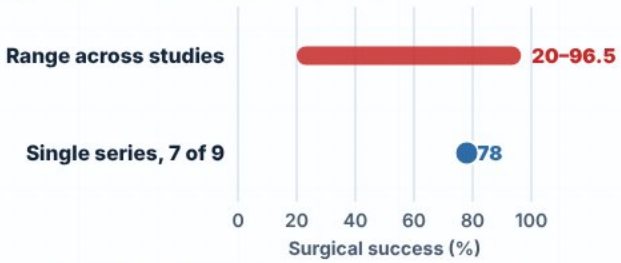


B · Test Middle finger



C · Locate Below the bone

Surgery: success varies widely



14 studies, all level IV (de Moraes et al., 2017); complete relief in 7 of 9 operated cases (Sarhadi et al., 1998).

Decision pathway

1. **DIFFERENTIATE**
   Find where it is tender: on the epicondyle, or in the muscle below it; test resisted middle-finger extension.
2. **MODIFY**
   Reduce repeated forearm rotation and hard gripping with the elbow straight while symptoms settle.
3. **REVIEW**
   If pain persists, a clinician may use a diagnostic injection; surgery is reserved for persistent cases.

NOT RECOMMENDED

Labelling all outer-forearm pain as tennis elbow, or repeating injections at the epicondyle when tenderness lies lower.

SEEK ASSESSMENT IF

Weakness lifting the fingers or thumb (finger drop), worsening numbness, or a hot swollen forearm: seek prompt assessment.

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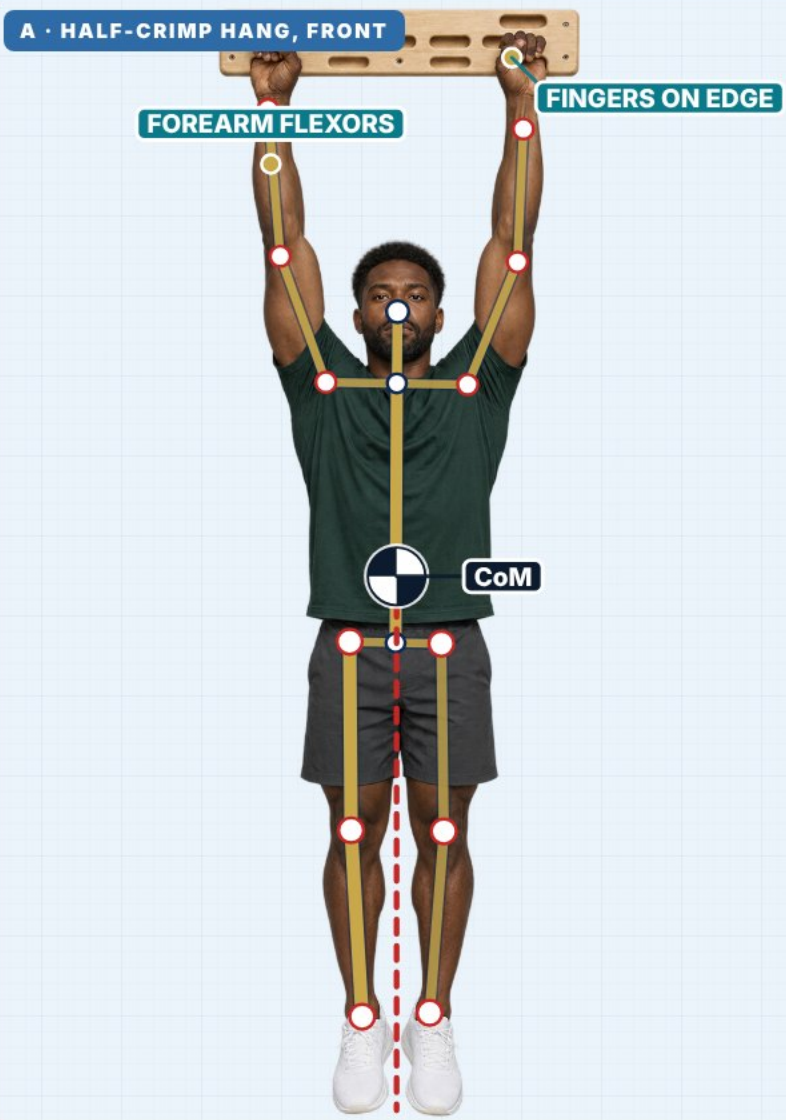
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FOREARM PAIN IN CLIMBERS: FINGER FLEXOR OVERLOAD AND PULLEY STRAIN

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2-D estimates from pose landmarks on an illustrated figure; CoM (if shown) from de Leva (1996); cm for a 1.70 m adult (Winter, 2009). Skeleton and CoM from pose landmarks; feet off the floor, so no ground contact is drawn. Grip type taken from the image brief. Educational, not diagnostic.

EYE-OPENER

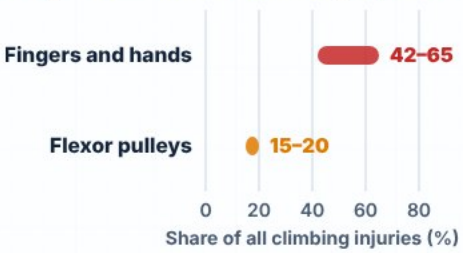
36× higher A2 pulley force in a crimp grip than in an open-hand grip.

Biomechanical model, expert climbers. Vigouroux et al. (2006).

Body weight hangs on the fingertips

- In a dead hang the whole body weight passes through the fingertips on the edge, then up the finger flexor tendons to the forearm muscles.
- The annular pulleys hold those tendons against the bones; how the fingers are bent decides how hard the tendons pull on them.

Fingers dominate climbing injuries



Ranges from earlier epidemiology, cited in the background of a systematic review. Larsson et al. (2022).

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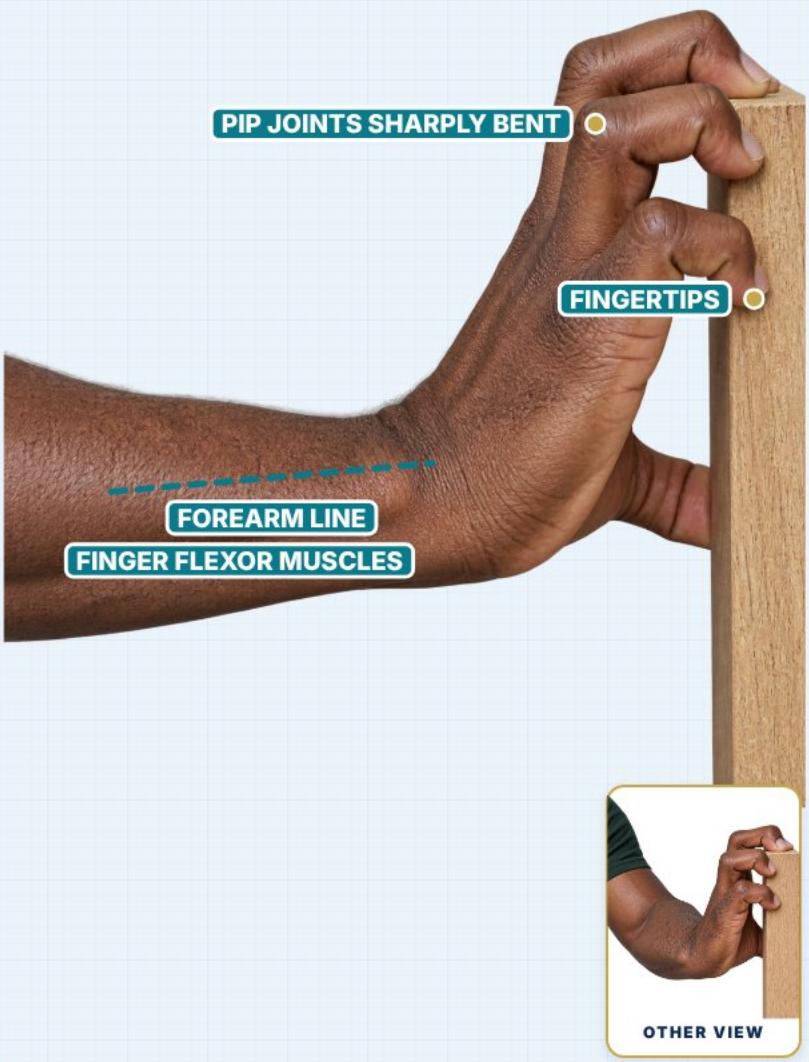
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B · CRIMP GRIP, SIDE



EYE-OPENER

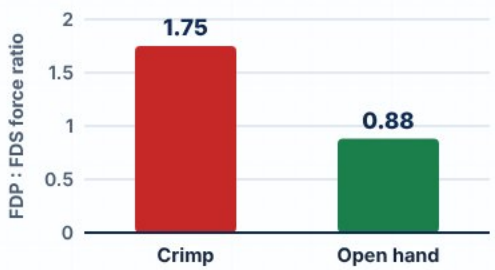
4× higher A4 pulley force in a crimp than with an open hand.

Biomechanical model. Vigouroux et al. (2006).

Sharp bends make the tendons bowstring

- With the PIP joints bent sharply, the deep flexor tendon turns a tight corner, so it presses outwards on the pulleys that hold it.
- The crimp also shifts the work to the deep flexor (FDP), which inserts at the fingertip.

The crimp loads the deep flexor



Deep (FDP) to superficial (FDS) flexor tendon-force ratio; 1 = equal share. Vigouroux et al. (2006).

Angles from landmarks placed on an illustrated figure (2-D, camera-plane); approximate. Joint and forearm callouts placed on the figure for teaching; joint angles not quoted. Educational, not diagnostic.

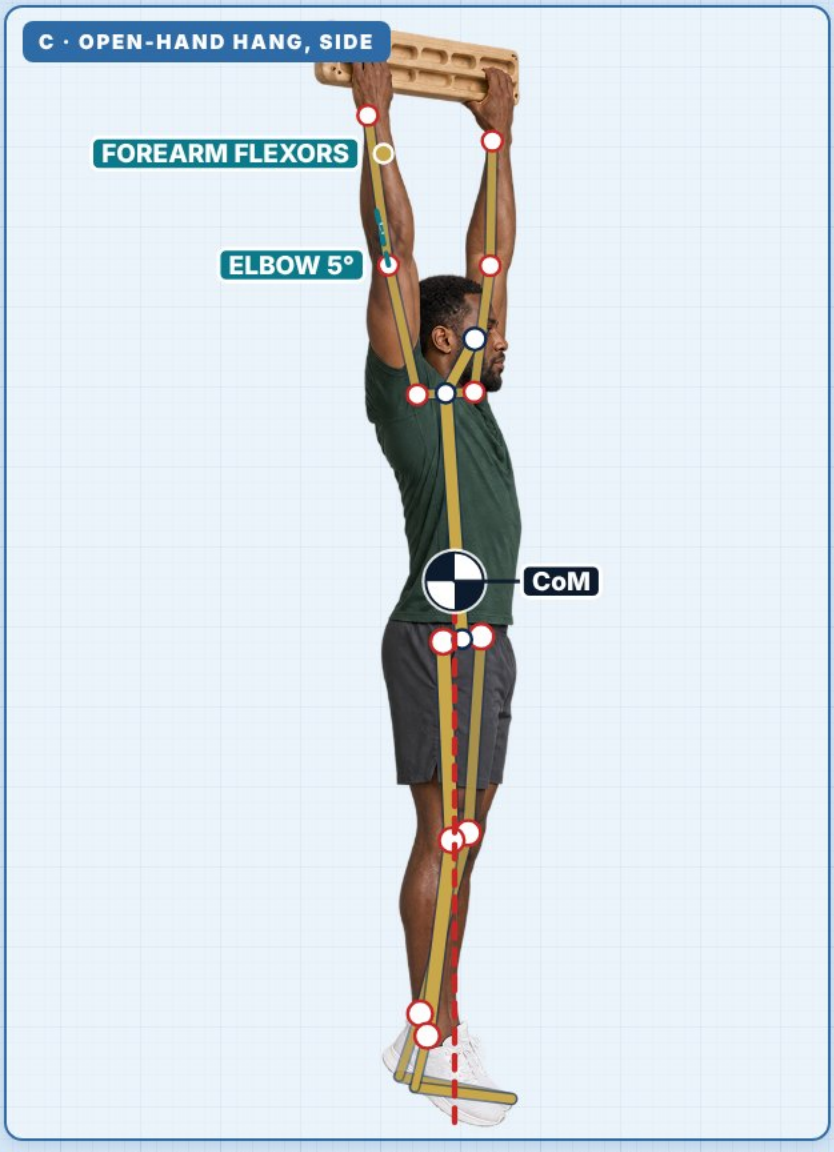
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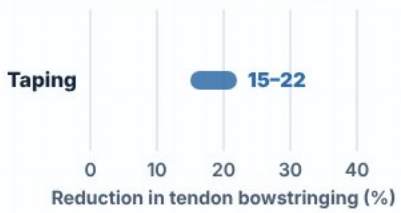
2 of 5 median clinical-relevance score of studies testing tape on climbers' pulleys.

8 studies and 1 case report, 206 climbers. Larsson et al. (2022).

Open hand spreads the load

- Hanging with an open hand and elbows near straight (≈**5°** flexion), the fingers are only slightly bent, so tendons pull more along the bone.
- Pulley force is far lower and the two flexors share the work more evenly than in the crimp.

Tape: a modest mechanical effect



Range across studies; low-to-moderate certainty (GRADE). Larsson et al. (2022).

Myth: "Crimping just works the forearm harder." The finger pulleys, not the forearm muscles, take the steepest rise in load.

2-D estimates from pose landmarks on an illustrated figure; CoM (if shown) from de Leva (1996); cm for a 1.70 m adult (Winter, 2009). Skeleton, CoM and elbow angle from pose landmarks; feet off the floor, so no ground contact is drawn. Educational, not diagnostic.

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A · Half crimp Full weight

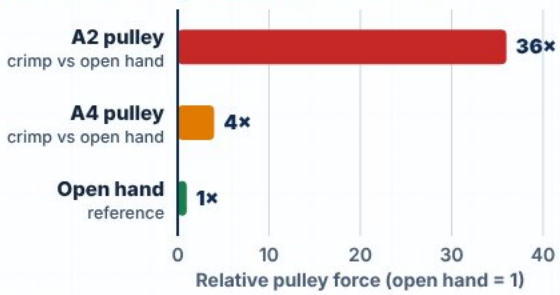


B · Crimp Bowstring



C · Open hand Shared load

Grip choice changes pulley load most



Model estimates in expert climbers; open-hand (slope) grip = 1. Vigouroux et al. (2006).

Decision pathway

1. **REDUCE**
   Cut crimp-grip and fingerboard volume while the fingers or forearm are sore.
2. **REORDER**
   Reintroduce open-hand loading first, then build crimp loading gradually as symptoms allow.
3. **MONITOR**
   Track pain at the finger base the next day; tape may modestly limit bowstringing.

NOT RECOMMENDED

Relying on tape to protect a pulley from rupture; evidence is low to moderate certainty and the effect small.

SEEK ASSESSMENT IF

A felt or heard "pop" at a finger base, visible tendon bowstringing, swelling or inability to grip: seek imaging and specialist assessment.

REFERENCES (APA 7)

de Leva, P. (1996). Adjustments to Zatsiorsky-Seluyanov's segment inertia parameters. *Journal of Biomechanics, 29*(9), 1223–1230. https://doi.org/10.1016/0021-9290(95)00178-6

Larsson, R., Nordeman, L., & Blomdahl, C. (2022). To tape or not to tape: Annular ligament (pulley) injuries in rock climbers: A systematic review. *BMC Sports Science, Medicine and Rehabilitation, 14*, 148. https://doi.org/10.1186/s13102-022-00539-6

Vigouroux, L., Quaine, F., Labarre-Vila, A., & Moutet, F. (2006). Estimation of finger muscle tendon tensions and pulley forces during specific sport-climbing grip techniques. *Journal of Biomechanics, 39*(14), 2583–2592. https://doi.org/10.1016/j.jbiomech.2005.08.027

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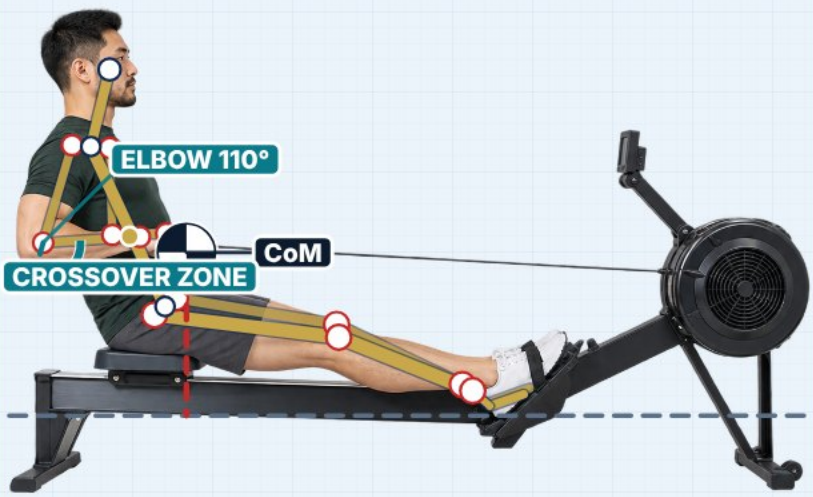
BIOMECHANICS IS A FORCE-GOVERNED DECISION SYSTEM – NOT A POSTURE MODEL.

INTEGRATING PERFORMANCE & REHABILITATION HEALTHCARE PATHWAYS.

INTERSECTION SYNDROME: FOREARM PAIN IN ROWERS AND PADDLERS

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A · ROWING FINISH, SIDE





2-D estimates from pose landmarks on an illustrated figure; CoM (if shown) from de Leva (1996); cm for a 1.70 m adult (Winter, 2009). Skeleton, CoM and elbow angle from pose landmarks; crossover zone placed on the figure for teaching. Educational, not diagnostic.

EYE-OPENER

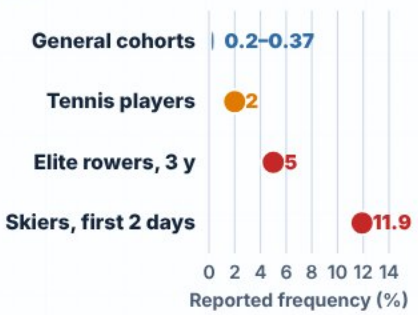
~5% of an elite rowing squad developed intersection syndrome over three years.

Case series. Hoy et al. (2019).

Where two tendon groups cross

- At the finish the elbow is flexed ≈**110°** and the wrist extensors hold the handle level, stroke after stroke.
- On the back of the thumb-side forearm the thumb muscles (APL, EPB) cross over the wrist extensors (ECRL, ECRB); repeated gliding here can inflame the crossing.

Rare overall, common in repetitive sport



Incidence or prevalence as reported; general, tennis and ski figures are older studies quoted in an evidence synthesis (Balakatounis et al., 2017); rowers from Hoy et al. (2019).

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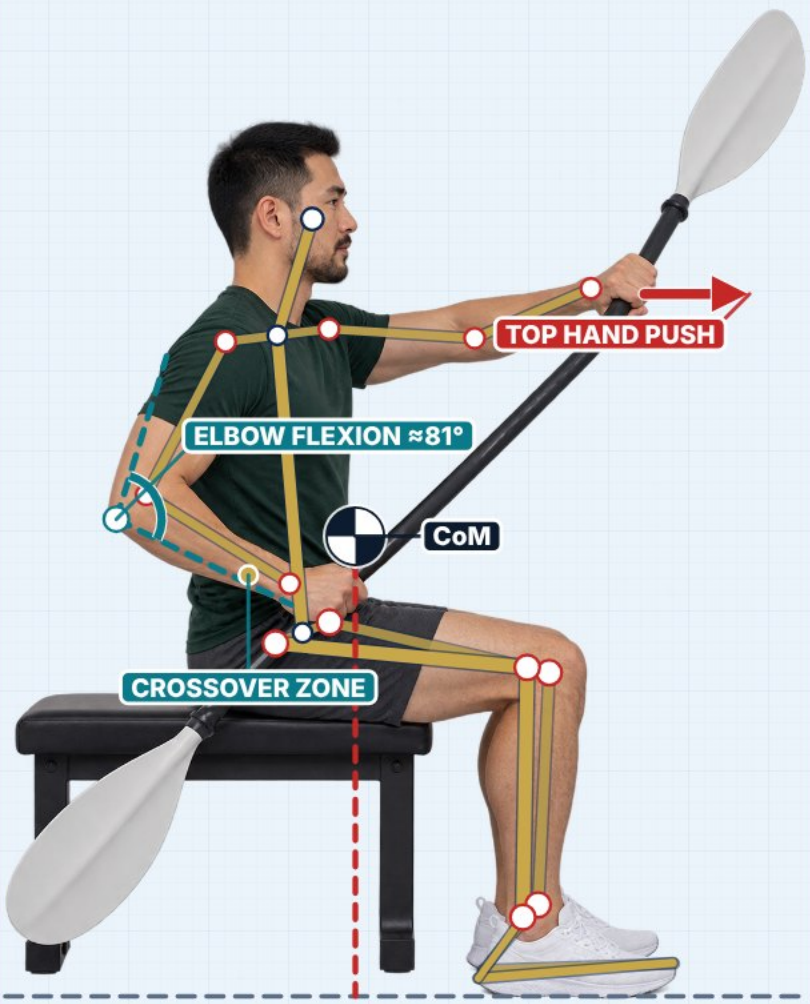
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B · PADDLE STROKE, SIDE



EYE-OPENER

20–40% of training time was lost by affected elite rowers.

Retrospective case series. Hoy et al. (2019).

Paddling repeats the same glide

- The bottom hand pulls with the elbow flexed ≈**81°** while the top hand pushes; both wrists cock and grip on every stroke.
- Swelling, tenderness and sometimes a creaking feel appear a hand's breadth above the wrist on the thumb side.

Early release in international rowers



6 international rowers; 5 returned in an accelerated programme within weeks. Case series only. Hoy et al. (2019).

2-D estimates from pose landmarks on an illustrated figure; CoM (if shown) from de Leva (1996); cm for a 1.70 m adult (Winter, 2009). Skeleton and CoM from pose landmarks; elbow angle from manually placed landmarks; push arrow drawn for teaching. Educational, not diagnostic.

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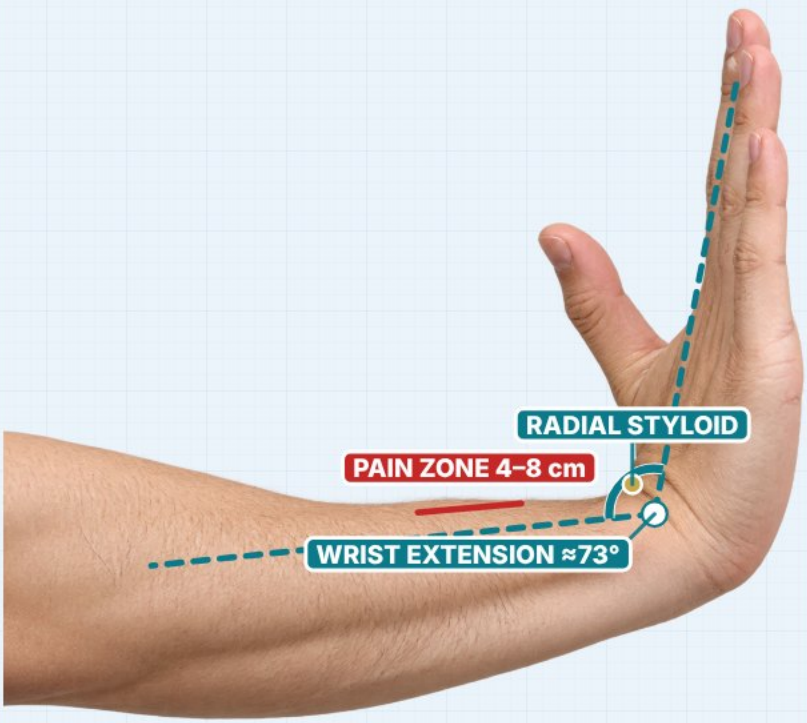
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C · WRIST BACK, THUMB SIDE



EYE-OPENER

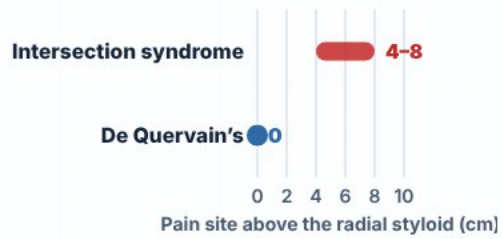
60% reported to heal with conservative care alone, without injection or surgery.

Evidence synthesis of older studies. Balakatounis et al. (2017).

Location tells them apart

- Bending the wrist back (≈**73°** here) with the thumb raised slides both tendon groups across each other at the crossover zone.
- Pain 4–8 cm above the radial styloid suggests intersection syndrome; pain at the styloid itself suggests De Quervain's tenosynovitis.

A forearm ruler for diagnosis



Typical pain site; De Quervain's sits at the styloid (0 cm). Balakatounis et al. (2017).

Myth: "Rower's forearm pain is always a muscle strain." A distinct tendon-crossing condition can cost 20–40% of training time.

Angles from landmarks placed on an illustrated figure (2-D, camera-plane); approximate. Wrist angle from manually placed forearm and hand landmarks; pain zone scaled from hand length. Educational, not diagnostic.

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A · Row Wrist hold

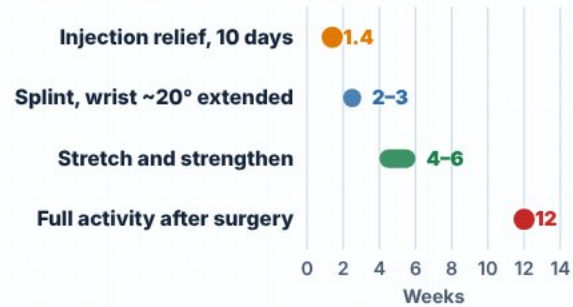


B · Paddle Grip + cock



C · Locate 4–8 cm

A graded path back to the water



Durations from an evidence synthesis quoting older, low-level studies; surgery return is ≥ 12 weeks. Balakatounis et al. (2017).

Decision pathway

1. **UNLOAD**
   Reduce rowing or paddling volume; splint the wrist in about 20° extension for 2–3 weeks.
2. **LOAD**
   Then progress stretching and strengthening over 4–6 weeks, rebuilding stroke volume gradually.
3. **ESCALATE**
   If symptoms persist after 2–3 weeks, discuss an injection; surgery is for refractory cases.

NOT RECOMMENDED

Treating it as De Quervain's or a muscle strain; the pain site differs and so does management.

SEEK ASSESSMENT IF

Marked swelling, redness and heat with fever, or symptoms not settling after 2–3 weeks of rest and splinting.

REFERENCES (APA 7)

Balakatounis, K., Angoules, A. G., Angoules, N. A., & Panagiotopoulou, K. (2017). Synthesis of evidence for the treatment of intersection syndrome. *World Journal of Orthopedics, 8*(8), 619–623. https://doi.org/10.5312/wjo.v8.i8.619

de Leva, P. (1996). Adjustments to Zatsiorsky-Seluyanov's segment inertia parameters. *Journal of Biomechanics, 29*(9), 1223–1230. https://doi.org/10.1016/0021-9290(95)00178-6

Hoy, G., Trease, L., & Braybon, W. (2019). Intersection syndrome: An acute surgical disease in elite rowers. *BMJ Open Sport & Exercise Medicine, 5*(1), e000535. https://doi.org/10.1136/bmjsem-2019-000535

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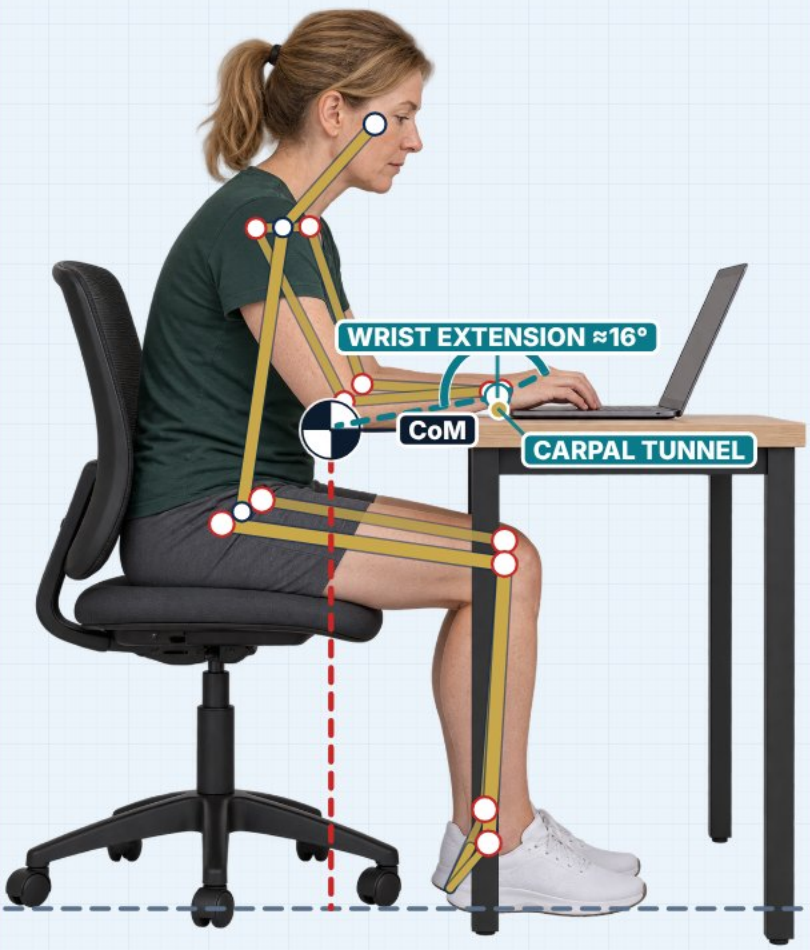
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FOREARM PAIN FROM TYPING AND MOUSE USE: POSTURE, LOAD AND BREAKS

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A · LAPTOP TYPING, SIDE



EYE-OPENER

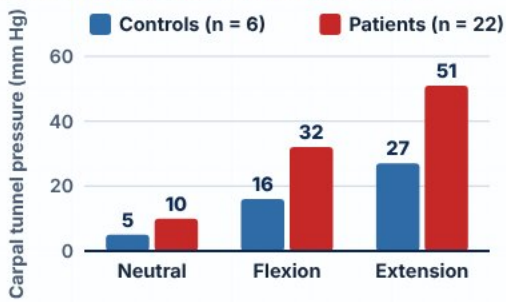
20–60% of office workers have musculoskeletal disorders, depending on the study.

Earlier studies cited in Hoe et al. (2018).

Low screen, hunched reach

- With a low laptop she leans forward, shoulders rounded, and the wrist sits ≈**16°** extended over the keys for long periods.
- Pressure in the carpal tunnel is lowest near a straight wrist and rises as the wrist bends either way.

Bent wrists raise tunnel pressure



Mean values from an earlier study (Szabo & Chidgey, 1989) as compiled in Weiss et al. (1995).

2-D estimates from pose landmarks on an illustrated figure; CoM (if shown) from de Leva (1996); cm for a 1.70 m adult (Winter, 2009). Skeleton and CoM from pose landmarks; wrist angle from manually placed forearm and hand landmarks. Educational, not diagnostic.

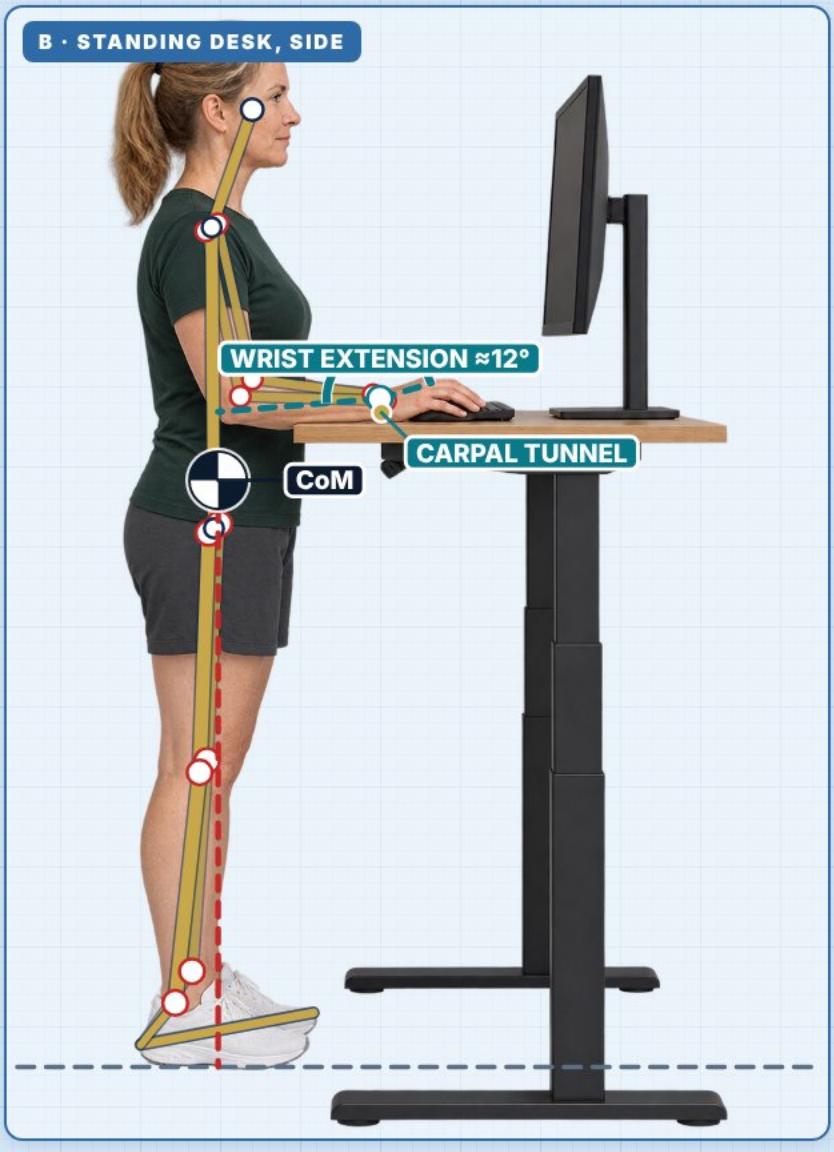
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2-D estimates from pose landmarks on an illustrated figure; CoM (if shown) from de Leva (1996); cm for a 1.70 m adult (Winter, 2009). Skeleton and CoM from pose landmarks; wrist angle from manually placed forearm and hand landmarks. Image shows a standing desk. Educational, not diagnostic.

EYE-OPENER

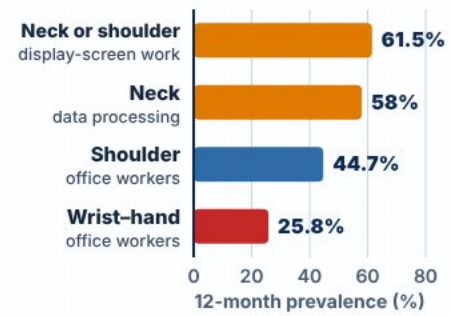
8 mm Hg lowest tunnel pressure in healthy wrists, found at about 2° of extension.

8 ± 4 mm Hg, n = 20. Weiss et al. (1995).

Raise the screen, rest the forearm

- At a raised desk and screen she stands upright, forearms resting on the desk edge, wrist ≈**12°** extended: close to the low-pressure zone.
- Changing between sitting and standing adds posture variety; no single set-up suits every hour of the day.

Upper-body symptoms are common at desks



Figures from individual studies cited in the background of a Cochrane review. Hoe et al. (2018).

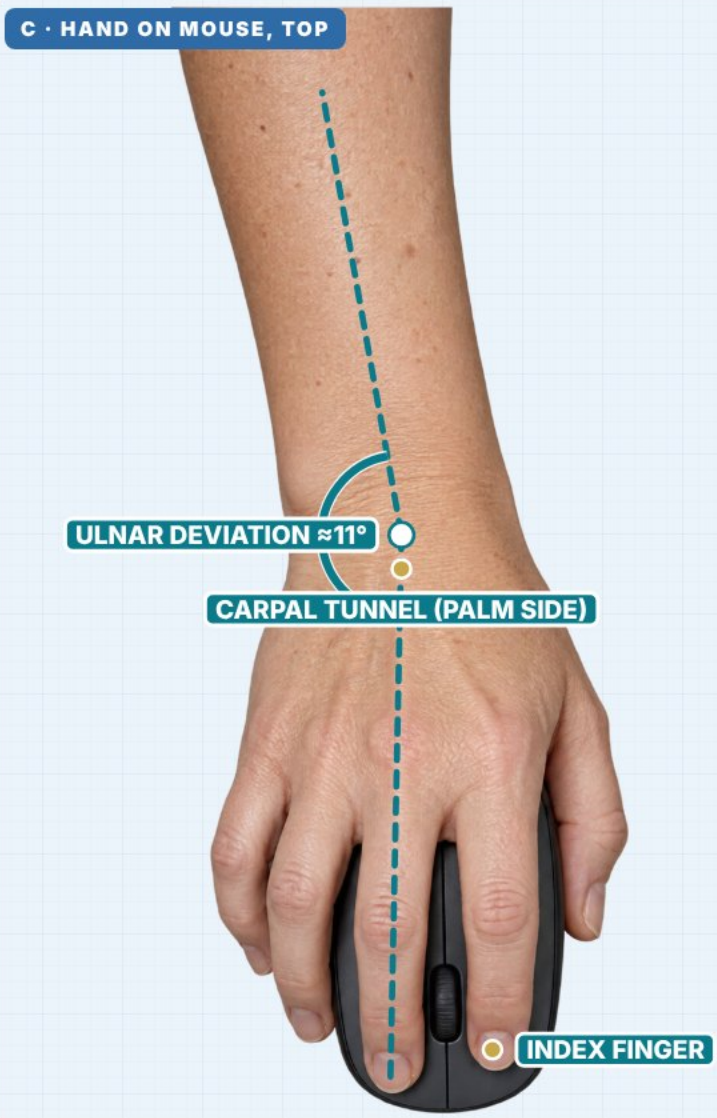
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EYE-OPENER

RR 0.91 for arm disorders with an alternative mouse alone: no clear benefit.

95% CI 0.48–1.72. Hoe et al. (2018).

Small moves, steady pressure

- On the mouse the hand is turned ≈**11°** towards the little finger (ulnar deviation) while the fingers hold and click.
- Dragging raised pressure about 12 mm Hg above static postures; versus pointing, p = 0.06.

Mouse work keeps tunnel pressure up



Mean carpal tunnel pressure, 14 healthy adults, three mouse designs. Keir et al. (1999).

Myth: "An ergonomic mouse prevents arm pain." The mouse alone showed no clear benefit; breaks and posture variety matter too.

Angles from landmarks placed on an illustrated figure (2-D, camera-plane); approximate. Deviation angle from manually placed forearm and middle-finger axes. Educational, not diagnostic.

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A · Laptop Hunched

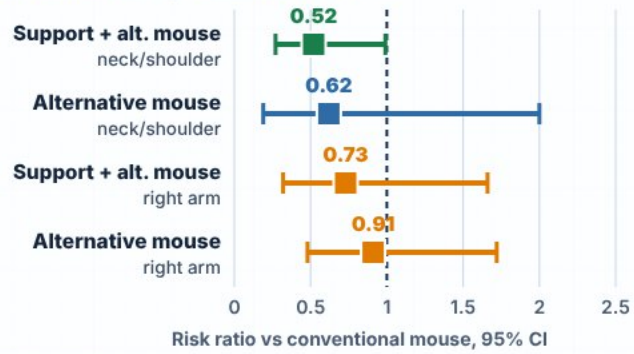


B · Raised Supported



C · Mouse Deviation

Only one change clearly helped



15 RCTs, 2,165 workers; low-quality evidence, one study at low risk of bias. Hoe et al. (2018).

Decision pathway

1. **SET UP**
   Raise the screen, support the forearms and keep wrists near straight while typing and mousing.
2. **BREAK**
   Add short supplementary breaks; they reduced neck discomfort in two trials.
3. **VARY**
   Alternate tasks and postures; consider arm support with an alternative mouse for neck and shoulder symptoms.

NOT RECOMMENDED

Relying on a single gadget (mouse, keyboard or support) to prevent forearm or hand disorders.

SEEK ASSESSMENT IF

Persistent numbness, night pain, weakness or dropping objects, or symptoms that do not ease with rest and workstation changes.

REFERENCES (APA 7)

de Leva, P. (1996). Adjustments to Zatsiorsky-Seluyanov's segment inertia parameters. *Journal of Biomechanics, 29*(9), 1223–1230. https://doi.org/10.1016/0021-9290(95)00178-6

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Keir, P. J., Bach, J., & Rempel, D. (1999). Effects of computer mouse design and task on carpal tunnel pressure. *Ergonomics, 42*(10), 1350–1360. https://doi.org/10.1080/001401399184992

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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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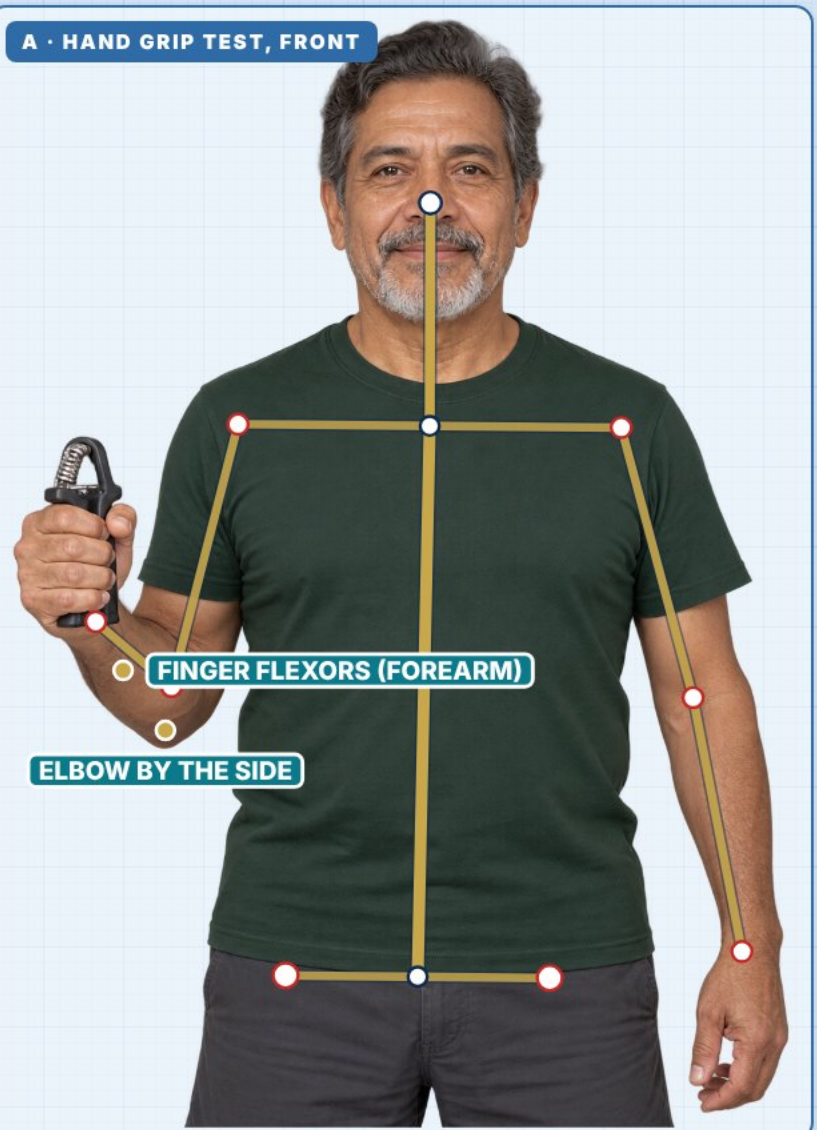
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GRIP STRENGTH: WHY IT PREDICTS HEALTH, NOT JUST HAND FUNCTION

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EYE-OPENER

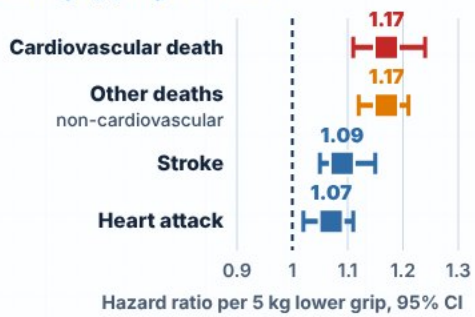
16% higher hazard of death from any cause for each 5 kg lower grip strength.

HR 1.16, 95% CI 1.13–1.20. Leong et al. (2015).

A simple squeeze, a whole-body signal

- Grip is a maximal squeeze of the finger flexors in the forearm, measured with a dynamometer, usually with the elbow bent by the side.
- It tracks overall muscle strength, so low grip is associated with poorer health; an association, not proof that grip itself is the cause.

Lower grip, higher risk



139,691 adults aged 35–70, 17 countries; median follow-up 4.0 years. Leong et al. (2015).

2-D estimates from pose landmarks on an illustrated figure (head-to-hip framing); lengths scaled to a 1.70 m adult (Winter, 2009). Skeleton from pose landmarks; elbow angle not quoted (forearm angled towards the camera). The device shown is a spring hand gripper. Educational, not diagnostic.

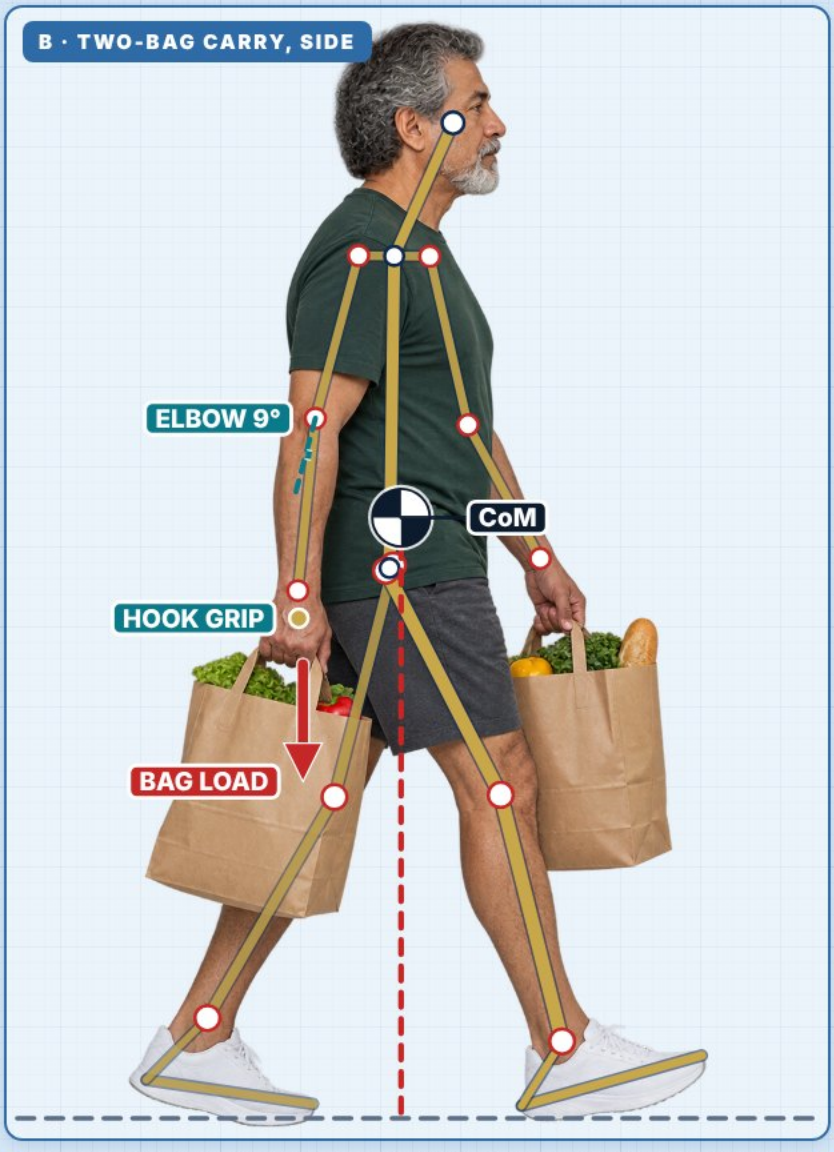
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2-D estimates from pose landmarks on an illustrated figure; CoM (if shown) from de Leva (1996); cm for a 1.70 m adult (Winter, 2009). Skeleton, CoM and elbow angle from pose landmarks; load arrow drawn for teaching. No grip value is measured from the image. Educational, not diagnostic.

EYE-OPENER

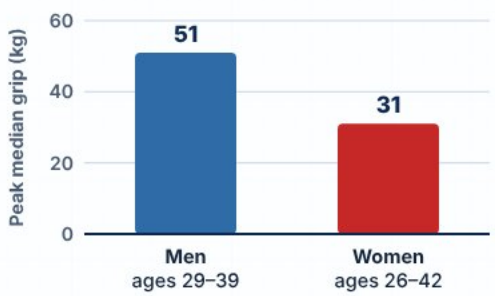
139,691 adults in 17 countries linked lower grip with later death and heart disease.

PURE study. Leong et al. (2015).

Everyday grip under load

- Carrying two bags, the arms hang with the elbows ≈**9°** from straight while the fingers hook the handles and hold the load.
- Grip strength peaks in early adulthood and then declines, so tasks like this get relatively harder with age.

Strongest in early adulthood



49,964 people, 12 British general-population studies. Dodds et al. (2014).

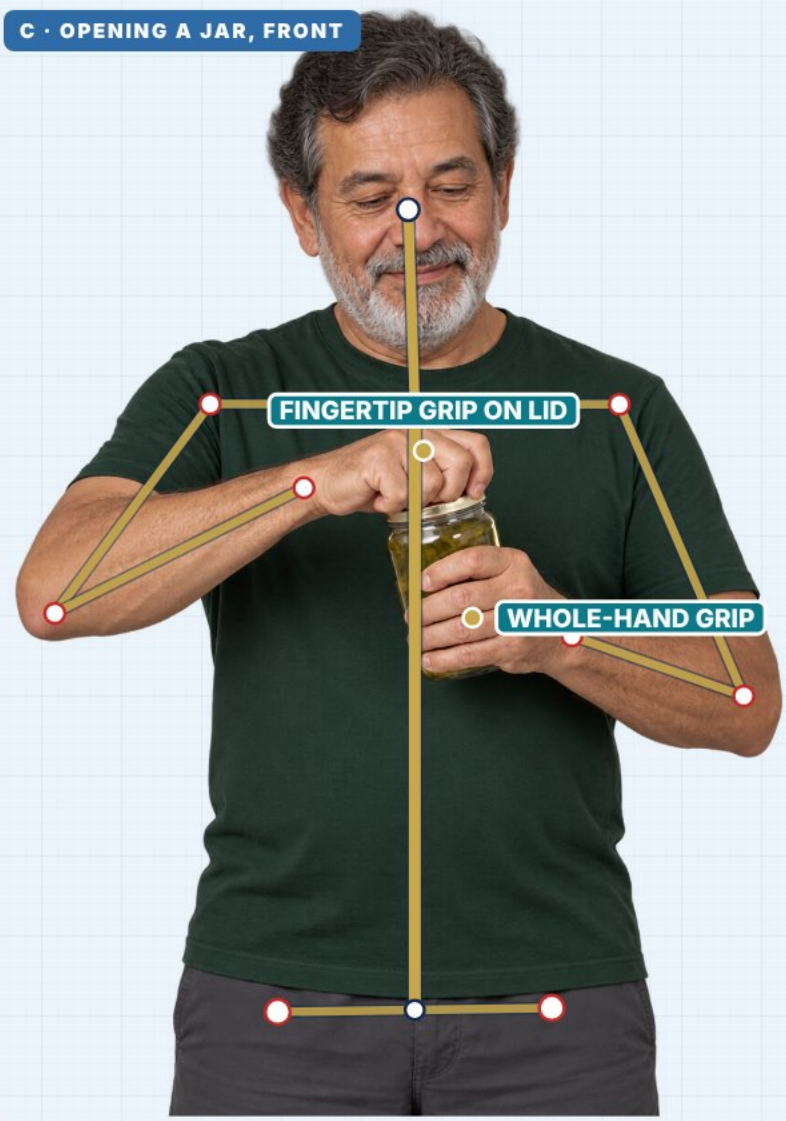
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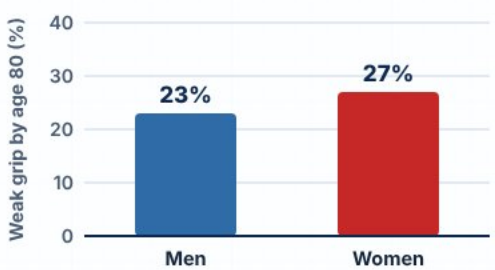
<27 kg grip in men flags probable sarcopenia; under 16 kg in women.

EWGSOP2 cut-offs, as applied by Van Ancum et al. (2020).

Two grips at once

- Opening a jar pairs a fingertip grip twisting the lid with a whole-hand grip steadying the jar, a common task people notice getting harder.
- A single grip test cannot tell which task will fail, but it is a quick screen for low overall strength.

Weak grip is common by 80



Weak = 2.5 SD or more below the sex-specific peak mean; British population data. Dodds et al. (2014).

Myth: "Grip only matters for the hands." Each 5 kg lower grip was linked with a 16% higher hazard of death.

2-D estimates from pose landmarks on an illustrated figure (head-to-hip framing); lengths scaled to a 1.70 m adult (Winter, 2009). Skeleton from pose landmarks; grip callouts placed on the figure for teaching. No grip value is measured from the image. Educational, not diagnostic.

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A · Test Dynamometer

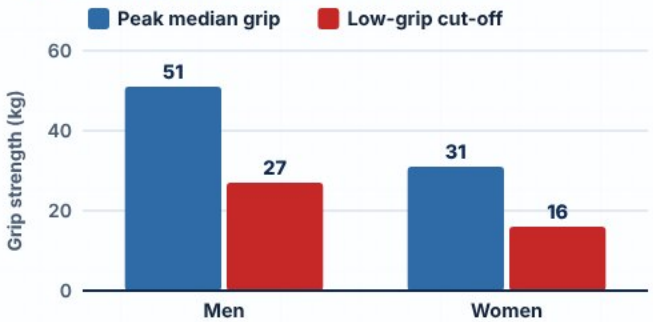


B · Carry Hook grip



C · Jar Twist + hold

The warning line is about half the peak



Peak medians: Dodds et al. (2014); EWGSOP2 cut-offs (Cruz-Jentoft et al., 2019) as stated by Van Ancum et al. (2020).

Decision pathway

1. **MEASURE**
   Use a standard dynamometer protocol, elbow bent by the side, and record the best effort.
2. **INTERPRET**
   Below 27 kg (men) or 16 kg (women): assess for sarcopenia, including muscle quantity and physical performance.
3. **BUILD**
   Treat grip as a marker: build overall strength and activity, then retest with the same protocol.

NOT RECOMMENDED

Presenting grip as a cause of death, or training grip alone to "fix" the risk it signals.

SEEK ASSESSMENT IF

A sudden one-sided fall in grip, or grip loss with numbness or muscle wasting: seek assessment for a nerve or local problem.

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DOI 10.5281/zenodo.23735910

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INTEGRATING PERFORMANCE & REHABILITATION HEALTHCARE PATHWAYS.

CARPAL TUNNEL SYNDROME: NIGHT TINGLING AND WRIST POSITION

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A · WRISTS TUCKED, SIDE





Angles from landmarks placed on an illustrated figure (2-D, camera-plane); approximate. Wrists are hidden under the chin, so no wrist angle is quoted; skeleton omitted (lying pose). Educational, not diagnostic.

EYE-OPENER

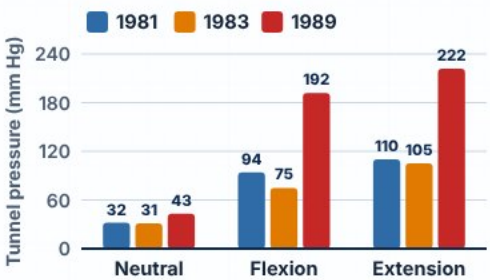
1 in 5 adults with median-finger tingling would be expected to have carpal tunnel syndrome.

Southern Sweden, n = 2,466. Atroshi et al. (1999).

Curled wrists, hours at a time

- Sleeping with the hands tucked under the chin keeps the wrists flexed for hours, narrowing the space around the median nerve.
- In every patient series pressure was lowest at neutral and rose steeply with flexion or extension, a plausible basis for waking with tingling.

Bending multiplies tunnel pressure



Patients with CTS; means from Gelberman 1981 (n = 15), Werner 1983 (n = 16) and Okutsu 1989 (n = 62) wrists, as compiled in Weiss et al. (1995).

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B · NEUTRAL SPLINT, SIDE





OTHER VIEW

EYE-OPENER

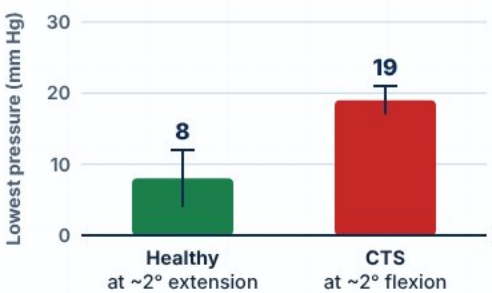
NNT 2 a night splint helped one extra person for every two treated (one trial).

RR 3.86, 80 people, low certainty. Karjalainen et al. (2023).

Hold the wrist where pressure is lowest

- The splint keeps the wrist ≈**1°** from straight, inside the near-neutral zone where tunnel pressure is lowest.
- In carpal tunnel syndrome even the lowest pressure was more than twice that of healthy wrists, so position matters more.

Lowest pressure sits near neutral



Mean ± SD; healthy n = 20, CTS n = 4 (p < 0.003). Weiss et al. (1995).

Angles from landmarks placed on an illustrated figure (2-D, camera-plane); approximate. Wrist angle from manually placed forearm and hand axes; the palm faces away from the camera. Educational, not diagnostic.

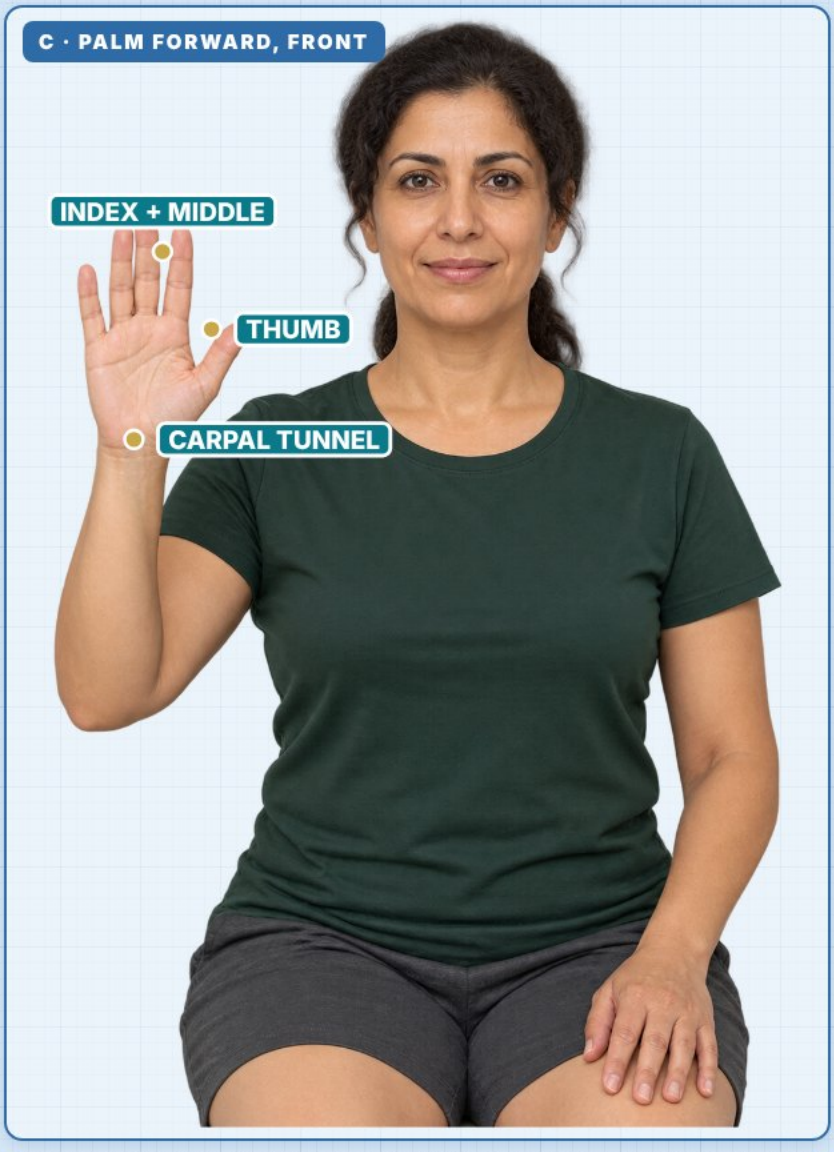
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EYE-OPENER

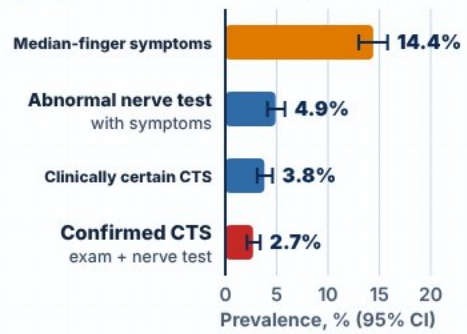
18.4% of people without symptoms had abnormal median-nerve tests.

23 of 125 controls. Atroshi et al. (1999).

Map the fingers, not just the test

- The median nerve supplies the thumb, index, middle and part of the ring finger; night tingling there is typical.
- Because abnormal tests are common without symptoms, results must match the clinical picture.

Symptoms are common; CTS is less so



2,466 adults aged 25–74, southern Sweden. Atroshi et al. (1999).

Myth: "A splint that bends the wrist back is best." Lowest pressure lies close to neutral.

2-D estimates from pose landmarks on an illustrated figure (head-to-hip framing); lengths scaled to a 1.70 m adult (Winter, 2009). Finger and wrist callouts placed on the figure for teaching. Educational, not diagnostic.

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A · Curled Flexed

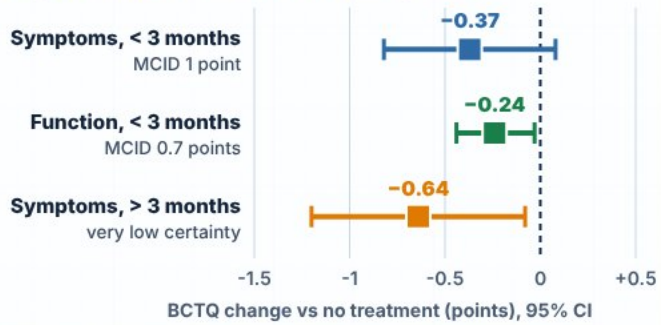


B · Splint Neutral



C · Map Median

Night splints: small, uncertain gains



Negative = better; effects mostly below the minimal important change. 29 trials, 1,937 adults. Karjalainen et al. (2023).

Decision pathway

1. **POSITION**
   Wear a night splint that holds the wrist near straight, not bent back.
2. **REDUCE**
   Break up long periods of strong wrist bending by day, and avoid sleeping with curled wrists.
3. **REVIEW**
   Expect modest change; if symptoms persist, review further options with a clinician.

NOT RECOMMENDED

Cock-up splints that hold the wrist well extended, or promising large symptom change from splinting alone.

SEEK ASSESSMENT IF

Constant numbness, weakness or wasting at the base of the thumb, or rapidly worsening symptoms: seek prompt assessment and nerve testing.

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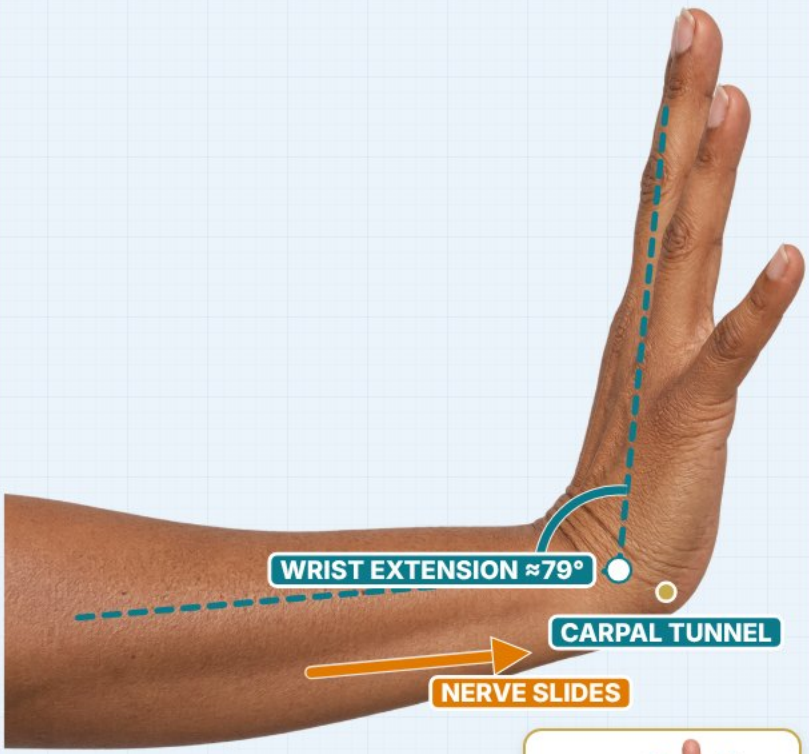
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A · NERVE GLIDE, SIDE





EYE-OPENER

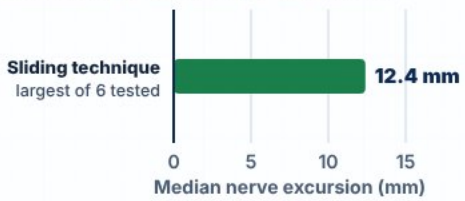
2.7% of adults aged 25–74 have carpal tunnel syndrome confirmed by examination and nerve tests.

95% CI 2.1–3.4%. Atroshi et al. (1999).

A glide, not a stretch

- Wrist extension ≈**79°** with the fingers and thumb straight moves the median nerve through the carpal tunnel at the front of the wrist.
- A "slider" pairs this with an opposite movement elsewhere, so the nerve travels further while its strain stays low: movement without tension.

Sliders move the nerve the most



Cadaver study, 6 specimens, 6 techniques; 30% more than any other technique, with minimal peak strain. Coppieters & Alshami (2007).

Angles from landmarks placed on an illustrated figure (2-D, camera-plane); approximate. Wrist angle from manually placed forearm and hand axes; nerve path drawn for teaching. Educational, not diagnostic.

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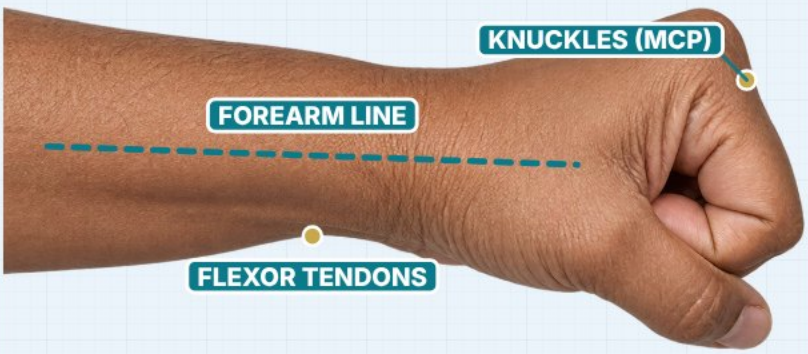
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B · FIST GLIDE, SIDE





OTHER VIEW

EYE-OPENER

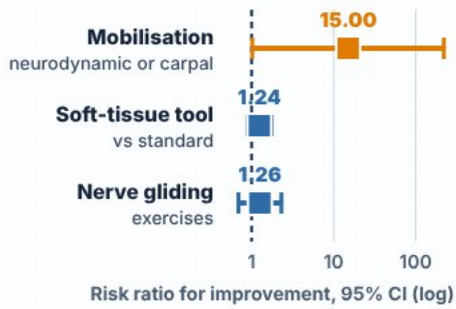
4/16 exercise and mobilisation studies reported the review's main outcome: overall improvement.

741 participants in all. Page et al. (2012).

Tendon gliding: low risk, low proof

- Moving from straight fingers to a full fist makes the nine flexor tendons slide past one another and the median nerve inside the carpal tunnel.
- Gliding exercises are safe to offer alongside other care, but the trial evidence is very low quality and does not show a clear benefit.

Wide intervals: no firm answer



Single small trials (14, 22 and 26 people); evidence quality very low to low. Page et al. (2012).

Angles from landmarks placed on an illustrated figure (2-D, camera-plane); approximate. Forearm line marked on the figure for teaching. Figure shows a full fist. Educational, not diagnostic.

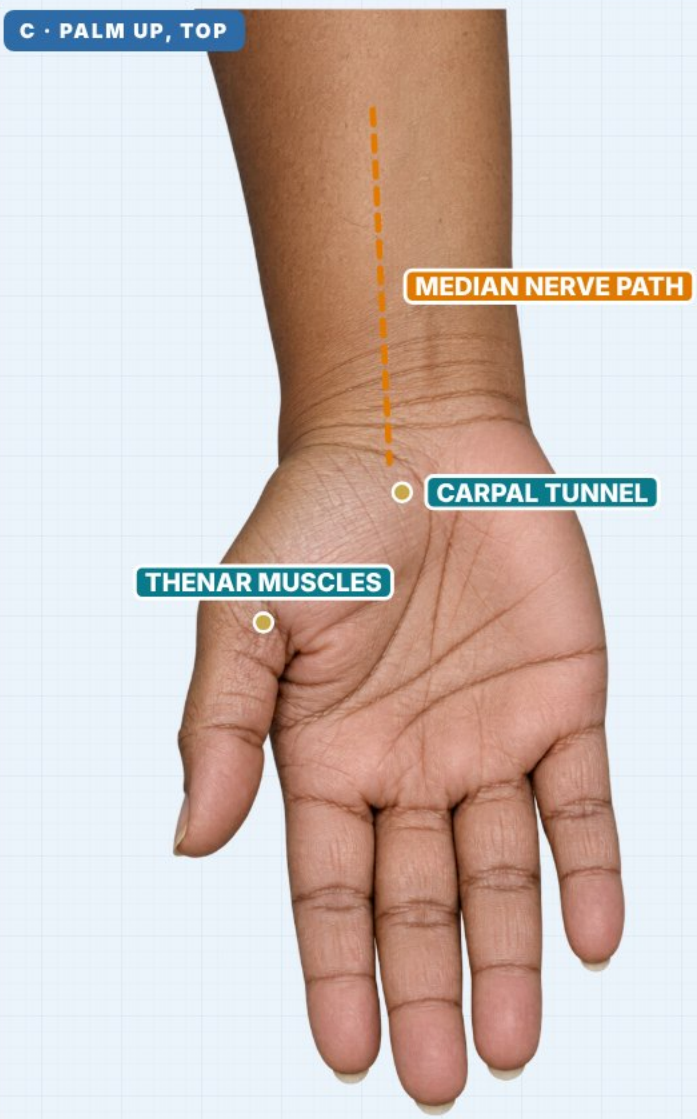
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EYE-OPENER

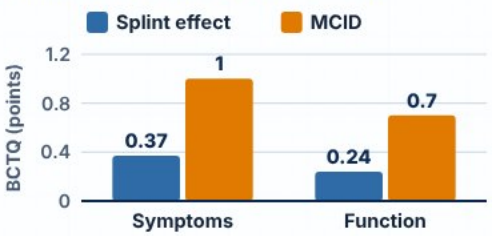
41% of people randomised to a splint had also had surgery within 18 months.

32 of 79. Gerritsen et al. (2002).

Where the nerve is squeezed

- The median nerve passes under the transverse carpal ligament with nine tendons, then supplies the thumb-side fingers and the thenar muscles.
- Thenar wasting or constant numbness signals sustained compression: test the nerve and seek a surgical opinion.

Splints help a little, short term



Splint vs no active treatment, < 3 months; MCID = minimal clinically important difference; 29 trials, 1,937 adults. Karjalainen et al. (2023).

Myth: "Surgery is inevitable." Many people improve without it, although release is more effective on average in the trial.

Angles from landmarks placed on an illustrated figure (2-D, camera-plane); approximate. Nerve path and anatomy positions marked on the figure for teaching. Educational, not diagnostic.

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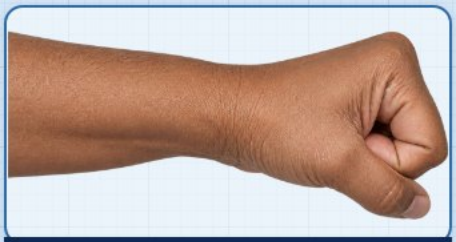
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A · Nerve Slider glide

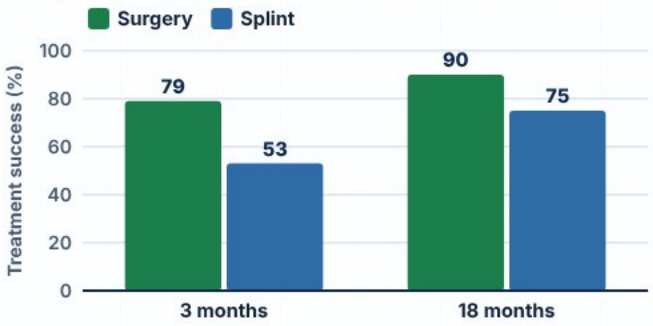


B · Tendons Fist glide



C · Check Thenar bulk

Surgery succeeded more often at every point



176 patients, 13 Dutch hospitals; differences 26% (95% CI 12–40) and 15% (3–27). Gerritsen et al. (2002), Dutch-language report.

Decision pathway

1. **MODIFY**
   Wear a neutral night splint and cut sustained end-range wrist positions; expect a small, short-term benefit.
2. **LOAD**
   Add gentle nerve sliders and tendon glides as low-risk extras, not as a proven cure.
3. **TRACK**
   If symptoms persist or progress, ask for nerve testing and a surgical opinion: release succeeded more often.

NOT RECOMMENDED

Presenting nerve gliding as a cure, or delaying referral in severe or progressive cases while trying more splints.

SEEK ASSESSMENT IF

Thenar muscle wasting, constant numbness, worsening weakness or dropping objects: seek prompt nerve testing and a surgical opinion.

REFERENCES (APA 7)

Atroshi, I., Gummesson, C., Johnsson, R., Ornstein, E., Ranstam, J., & Rosén, I. (1999). Prevalence of carpal tunnel syndrome in a general population. *JAMA, 282*(2), 153–158. https://doi.org/10.1001/jama.282.2.153

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DE QUERVAIN'S TENOSYNOVITIS: THUMB-SIDE WRIST PAIN IN NEW PARENTS

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A · LIFT UNDER ARMS, FRONT



EYE-OPENER

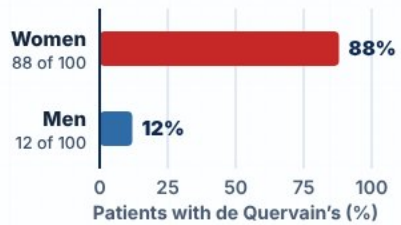
1.3% of working-age women had de Quervain's on examination, against 0.5% of men.

Population survey, 1,960 examined. Walker-Bone et al. (2004).

Thumbs wide, wrist loaded

- Lifting under the arms with the thumbs spread holds the thumb abducted and extended while the wrist carries the baby's weight.
- Abductor pollicis longus and extensor pollicis brevis must then pull hard through the narrow first dorsal compartment over the radial styloid.

Most patients in clinic are women



100 consecutive patients, prospective clinic series. Goubau et al. (2014). No postpartum-specific figure is available here.

2-D estimates from pose landmarks on an illustrated figure (head-to-hip framing); lengths scaled to a 1.70 m adult (Winter, 2009). Load direction and anatomy marked on the figure for teaching. Educational, not diagnostic.

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EYE-OPENER

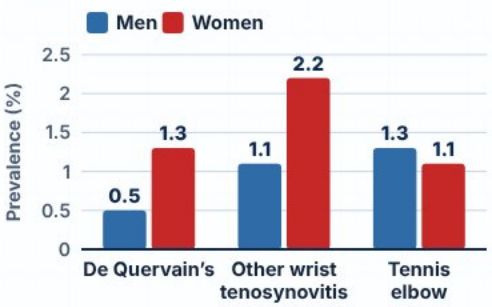
95% of positive WHAT tests (wrist flexed, thumb pushed out) were true de Quervain's.

Positive predictive value 0.95; 100 patients. Goubau et al. (2014).

Sustained, not heavy

- In the cradle hold the elbow is flexed ≈**131°** and the thumb stays abducted to support the head, often for long feeds and settles.
- The load is modest but held for long periods and repeated many times a day: a dose problem for the first dorsal compartment.

Hand and wrist tendons: women more often



Working-age adults; 9,696 surveyed, 1,960 examined. Walker-Bone et al. (2004).

2-D estimates from pose landmarks on an illustrated figure (head-to-hip framing); lengths scaled to a 1.70 m adult (Winter, 2009). Elbow angle from manually placed shoulder, elbow and wrist landmarks. Educational, not diagnostic.

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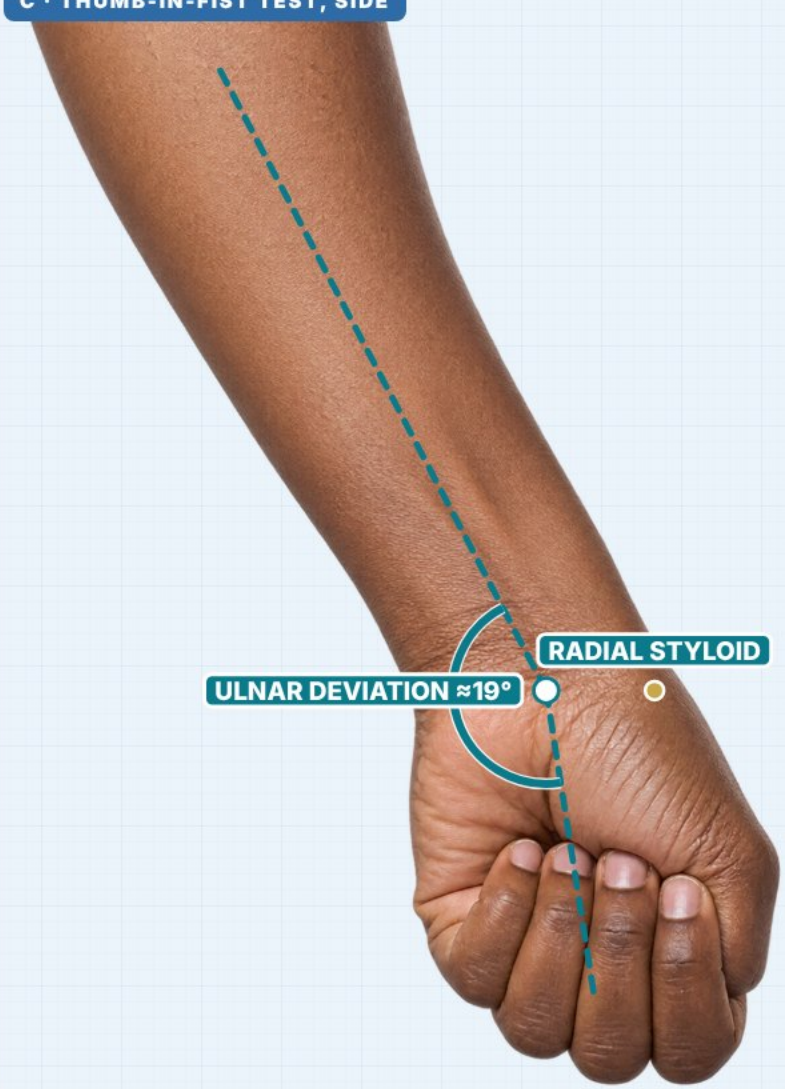
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C · THUMB-IN-FIST TEST, SIDE



Angles from landmarks placed on an illustrated figure (2-D, camera-plane); approximate. Wrist angle from manually placed forearm and hand axes, viewed from the palm side. Educational, not diagnostic.

EYE-OPENER

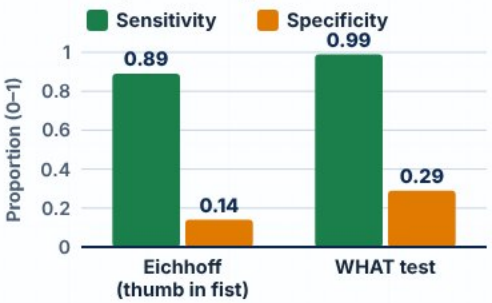
0% cure rate with rest or anti-inflammatory tablets alone in pooled clinic studies.

7 descriptive studies, 459 wrists. Richie & Briner (2003).

The classic test over-calls

- Thumb tucked in a fist with ulnar deviation ≈**19°** stretches the two tendons over the radial styloid, so pain there is expected.
- It is sensitive but hurts in many normal wrists; the WHAT test was more specific.

Sensitive, but not specific



Prospective series, 100 patients (88 women). Goubau et al. (2014).

Key point: a positive thumb-in-fist test alone does not make the diagnosis; combine it with the history and local tenderness.

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DE QUERVAIN'S TENOSYNOVITIS: THUMB-SIDE WRIST PAIN IN NEW PARENTS

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A · Lift Thumbs wide

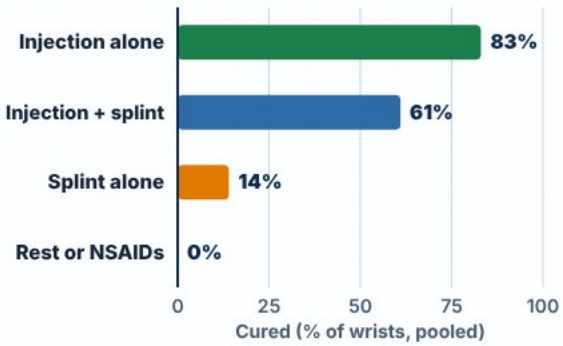


B · Cradle Held load



C · Test Low specificity

Passive rest alone rarely settles it



7 descriptive, non-comparative studies, 459 wrists; no CIs; not randomised comparisons. Richie & Briner (2003).

Decision pathway

1. **MODIFY**
   Scoop the baby with palms under the body and the thumbs alongside the fingers, not spread wide.
2. **LOAD**
   Use a thumb splint for flare-ups; discuss a steroid injection, which had the highest pooled cure rate.
3. **TRACK**
   Check pain on lifting and resisted thumb abduction weekly; refer for surgical release if it persists.

NOT RECOMMENDED

Relying on rest or anti-inflammatory tablets alone, or diagnosing from a positive thumb-in-fist test by itself.

SEEK ASSESSMENT IF

Marked swelling, redness and warmth with fever, or thumb-side wrist pain after a fall onto the hand: seek prompt assessment.

REFERENCES (APA 7)

de Leva, P. (1996). Adjustments to Zatsiorsky-Seluyanov's segment inertia parameters. *Journal of Biomechanics, 29*(9), 1223–1230. https://doi.org/10.1016/0021-9290(95)00178-6

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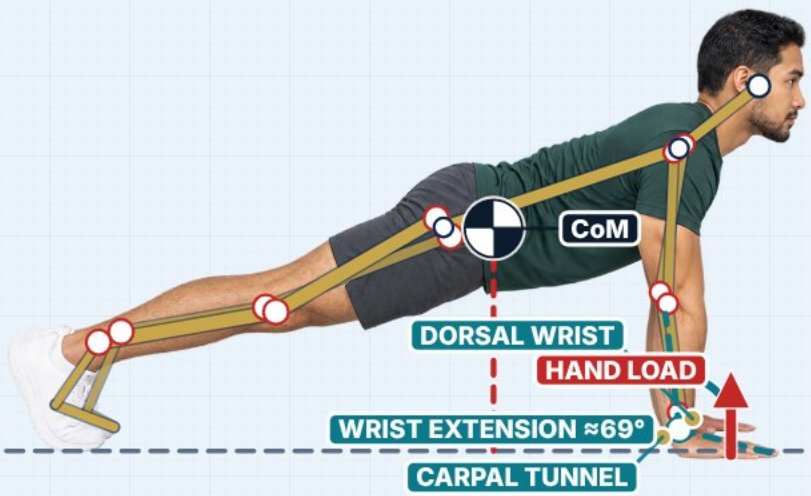
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INTEGRATING PERFORMANCE & REHABILITATION HEALTHCARE PATHWAYS.

WRIST PAIN IN PUSH-UPS AND PLANKS: EXTENSION LOAD AND HAND POSITION

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A · FLAT-HAND PLANK, SIDE





OTHER VIEW

EYE-OPENER

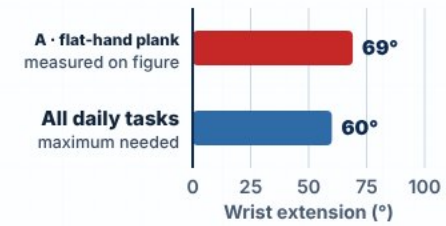
0.64× body mass reaches the hands at the top of a regular push-up, not full body weight.

Peak force, 23 fit young adults. Wurm et al. (2010).

End-range extension under load

- Flat hands put the wrist at ≈**69°** extension while body weight presses through the heel of the hand.
- At this end range the back of the wrist is compressed and carpal tunnel pressure rises, so dorsal ache or finger tingling can follow.

More extension than daily life needs



Daily-task range: 40 healthy adults (Ryu et al., 1991). Plank value measured on Frame A (2-D).

2-D estimates from pose landmarks on an illustrated figure; CoM (if shown) from de Leva (1996); cm for a 1.70 m adult (Winter, 2009). Wrist angle from manually placed forearm and hand axes. Educational, not diagnostic.

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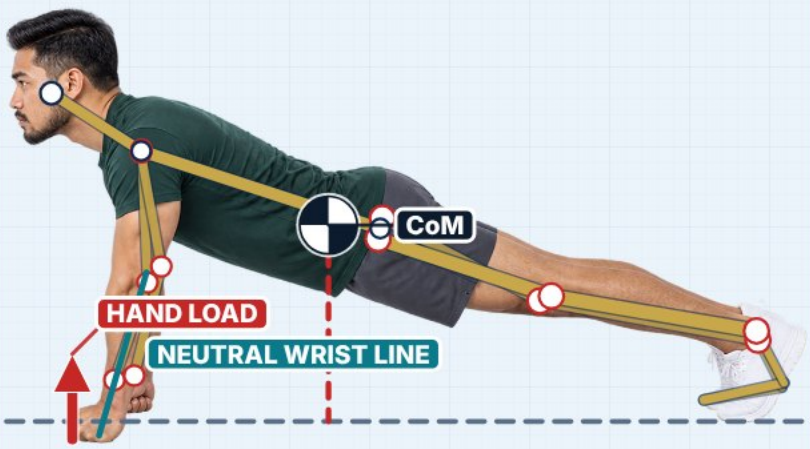
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B · PLANK ON FISTS, SIDE





OTHER VIEW

EYE-OPENER

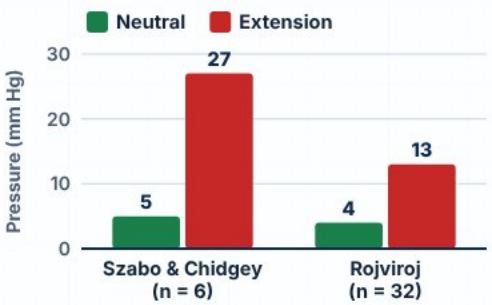
158 mm Hg carpal tunnel pressure in extension in one control group, against 14 in neutral.

Okutsu et al., as tabulated by Weiss et al. (1995).

Fists keep the wrist straight

- On fists or handles the hand stays in line with the forearm, so load passes straight through the wrist rather than at end range.
- In push-ups on a neutral wrist the force path was more uniform and vertical; in hyperextension it moved dorsally and towards the ulnar side.

Extension raises tunnel pressure



Healthy controls; secondary compilation of earlier studies (Table II). Weiss et al. (1995). Force path: Polovinets et al. (2018), 14 volunteers.

2-D estimates from pose landmarks on an illustrated figure; CoM (if shown) from de Leva (1996); cm for a 1.70 m adult (Winter, 2009). Neutral wrist line and load direction drawn on the figure for teaching. Educational, not diagnostic.

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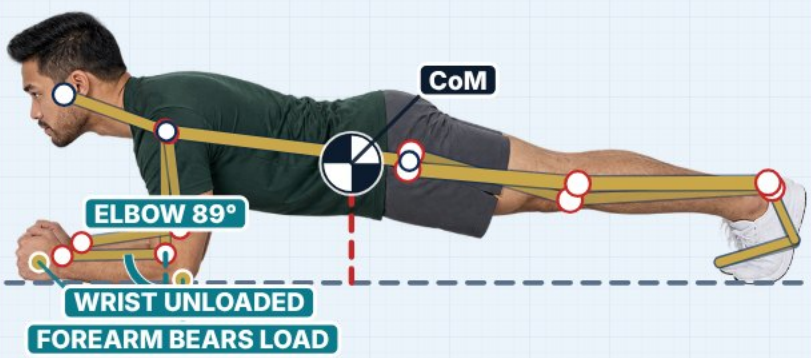
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C · FOREARM PLANK, SIDE



EYE-OPENER

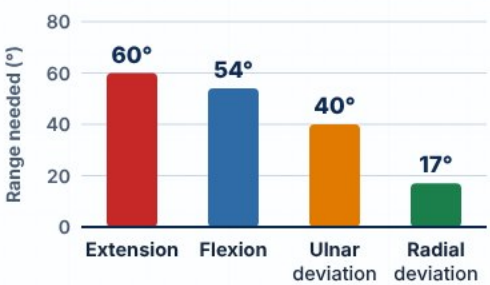
36% less peak hand load with the hands raised 61 cm than in a regular push-up.

0.41 vs 0.64 × body mass. Wurm et al. (2010).

Take the wrist out of it

- On the forearms, with the elbows bent ≈**89°**, the wrists are not loaded at all; the forearms and shoulders carry the plank.
- It keeps trunk training going while wrist extension tolerance is rebuilt separately and gradually.

What daily life asks of the wrist



Range needed to complete all tested daily tasks; 40 healthy adults. Ryu et al. (1991).

Myth: "Push-ups load the hands with your whole body weight." A regular push-up loads them with about 0.64 × body mass.

2-D estimates from pose landmarks on an illustrated figure; CoM (if shown) from de Leva (1996); cm for a 1.70 m adult (Winter, 2009). Elbow angle from pose landmarks in the side view. Educational, not diagnostic.

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A · Flat hand End range

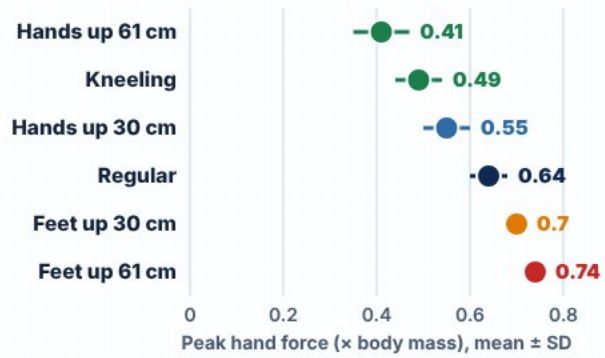


B · Fists Neutral wrist



C · Forearms Wrist off

Regress the share of body weight



Push-up variations, 23 recreationally fit young adults; feet-elevated higher, kneeling and hands-elevated lower ($p \leq 0.05$). Wurm et al. (2010).

Decision pathway

1. **MODIFY**
   Swap flat hands for fists, handles or a forearm plank while the wrist is sore.
2. **LOAD**
   Lower the hand share first (incline, kneeling), then add flat-hand time in short, pain-free holds.
3. **TRACK**
   Progress extension and volume only when wrist pain stays settled the next day.

NOT RECOMMENDED

Pushing through sharp pain at the back of the wrist at end-range extension.

SEEK ASSESSMENT IF

Wrist pain after a fall, swelling, clicking with weaker grip, or numbness that persists after loading: seek prompt assessment.

REFERENCES (APA 7)

de Leva, P. (1996). Adjustments to Zatsiorsky-Seluyanov's segment inertia parameters. *Journal of Biomechanics, 29*(9), 1223–1230. https://doi.org/10.1016/0021-9290(95)00178-6

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Ryu, J., Cooney, W. P., Askew, L. J., An, K. N., & Chao, E. Y. S. (1991). Functional ranges of motion of the wrist joint. *The Journal of Hand Surgery, 16*(3), 409–419. https://doi.org/10.1016/0363-5023(91)90006-W

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WRIST PAIN IN YOGA AND HANDSTANDS: BUILDING WEIGHT-BEARING TOLERANCE

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A · DOWNWARD DOG, SIDE





OTHER VIEW

EYE-OPENER

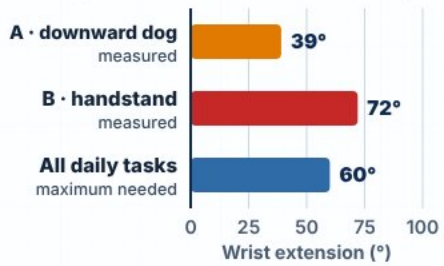
≈10% of recreational yoga participants developed new pain from yoga over a year.

Campo et al. (2018), as reported in a university news release; 354 people.

Hips high, hands loaded

- Downward dog places the wrist at ≈**39°** extension with a share of body weight through the heel of the hand.
- Held for long breaths and repeated through a class, the dose is in the time at end range as much as in the force.

Poses go beyond daily wrist range



Daily-task range: 40 healthy adults (Ryu et al., 1991). Pose values measured on Frames A and B (2-D).

2-D estimates from pose landmarks on an illustrated figure; CoM (if shown) from de Leva (1996); cm for a 1.70 m adult (Winter, 2009). Wrist angle from manually placed forearm and hand axes. Educational, not diagnostic.

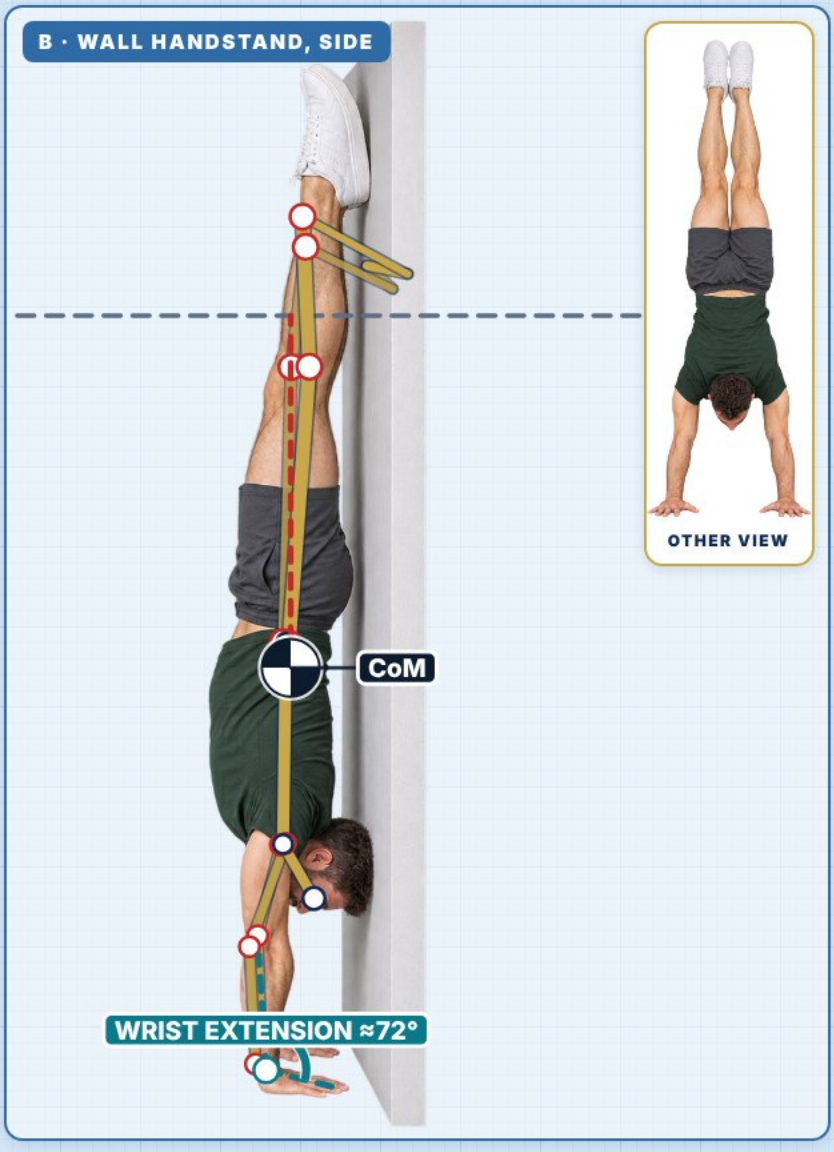
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EYE-OPENER

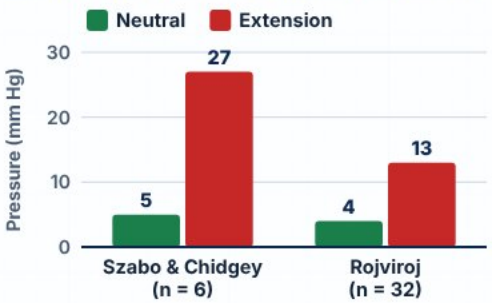
0.74× body mass reaches the hands once the feet are raised 61 cm in a push-up.

Peak force, 23 fit young adults. Wurm et al. (2010).

Inverted: all of you on two wrists

- In a handstand the full body weight passes down straight arms into wrists extended ≈**72°**.
- Raising the feet already moves more weight onto the hands, so incline and pike work are the steps between downward dog and inversion.

Extension squeezes the carpal tunnel



Healthy controls; secondary compilation (Table II). Weiss et al. (1995). Relevant if poses bring on finger tingling.

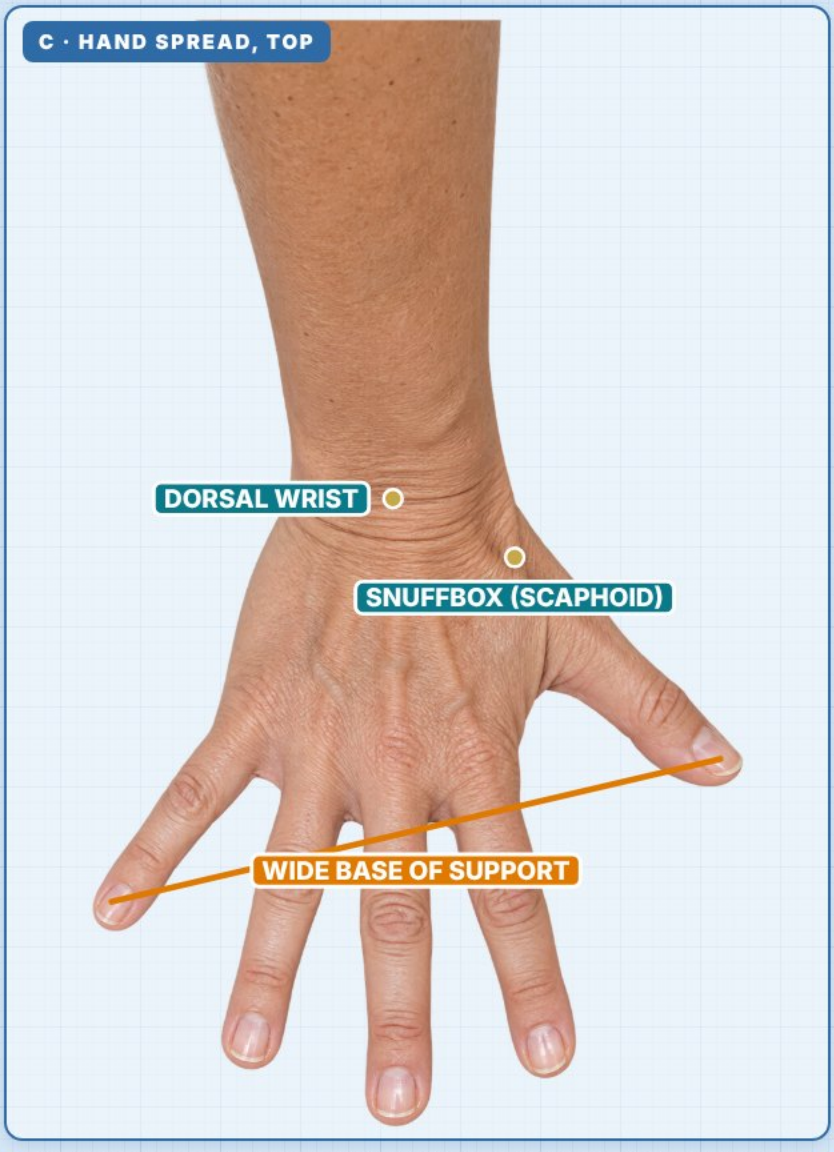
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Angles from landmarks placed on an illustrated figure (2-D, camera-plane); approximate. Base of support and anatomy positions marked on the figure for teaching. Educational, not diagnostic.

EYE-OPENER

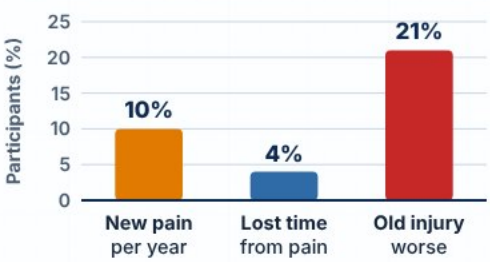
40° of wrist extension is enough for most everyday tasks; handstands need far more.

40 healthy adults. Ryu et al. (1991).

Spread the hand, share the load

- Fingers spread and pressing down widen the base of support, so less load is left on the heel of the hand and the back of the wrist.
- Snuffbox pain after a fall is different: check for a scaphoid fracture.

Yoga is not injury-free



354 recreational participants, 1-year follow-up; mostly upper-limb pain. Campo et al. (2018), as reported in a university news release.

Myth: "Yoga is too gentle to hurt the wrist." Most new yoga-related pain in that cohort was in the upper limbs.

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A · Down dog Share of weight

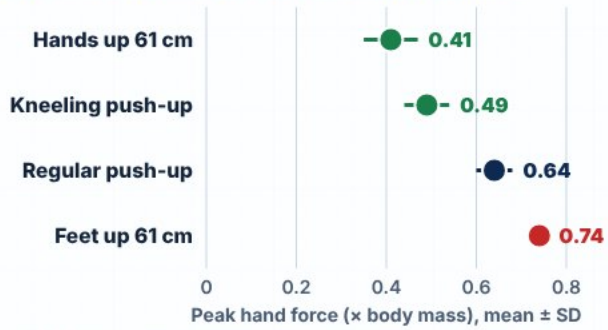


B · Handstand Full weight



C · Hand Wide base

A ladder of hand load towards inversion



Push-up variations, 23 recreationally fit young adults. Wurm et al. (2010).

Decision pathway

1. **MODIFY**
   Use a wedge, fists or parallettes to reduce extension, and shorten holds while the wrist is sore.
2. **LOAD**
   Climb the ladder: incline, kneeling, regular, feet raised, then pike and wall handstand.
3. **TRACK**
   Add hold time or a rung only when wrist pain stays settled the next day.

NOT RECOMMENDED

Long holds in painful end-range extension, or jumping from kneeling progressions straight to inversions.

SEEK ASSESSMENT IF

Wrist pain after a fall onto the hand, persistent swelling, clicking with weakness, or night numbness: seek prompt assessment.

REFERENCES (APA 7)

Campo, M., Shiyko, M. P., Kean, M. B., Roberts, L., & Pappas, E. (2018). Musculoskeletal pain associated with recreational yoga participation: A prospective cohort study with 1-year follow-up. *Journal of Bodywork and Movement Therapies, 22*(2). https://doi.org/10.1016/j.jbmt.2017.05.022

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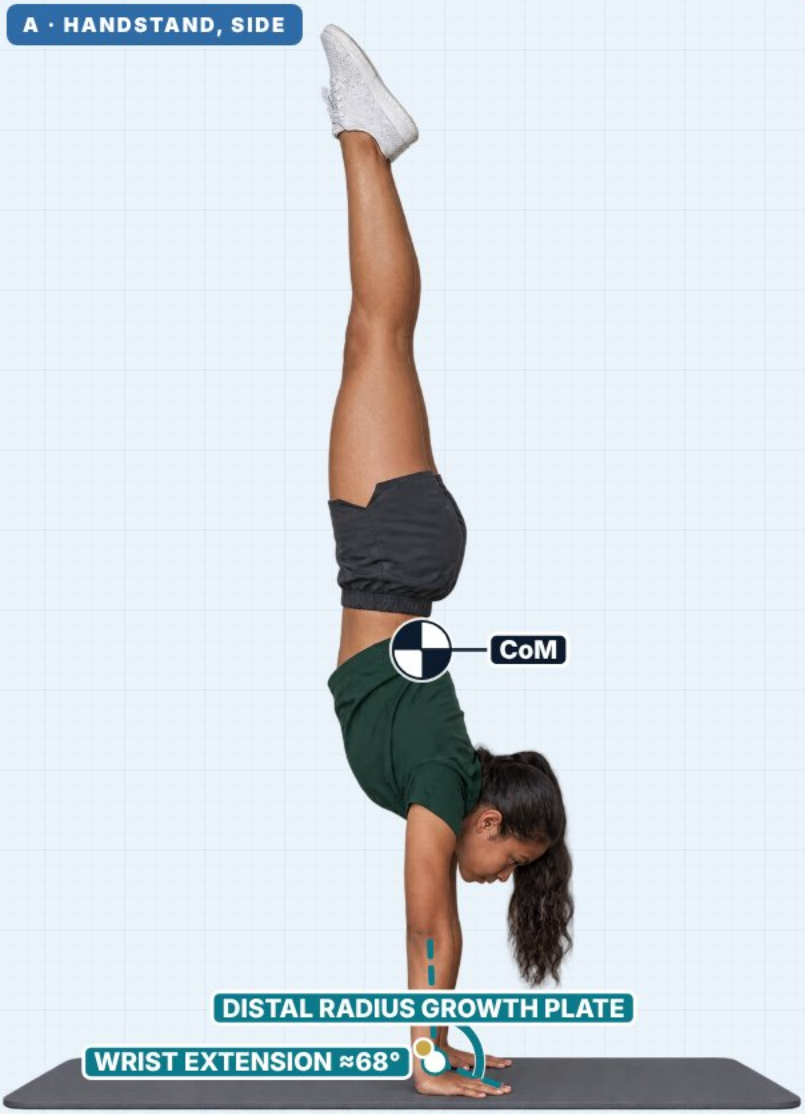
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GYMNAST'S WRIST: GROWTH-PLATE STRESS IN YOUNG ATHLETES

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A · HANDSTAND, SIDE



2-D estimates from pose landmarks on an illustrated figure; CoM (if shown) from de Leva (1996); cm for a 1.70 m adult (Winter, 2009). Wrist angle from manually placed forearm and hand axes; growth-plate site marked for teaching. Educational, not diagnostic.

EYE-OPENER

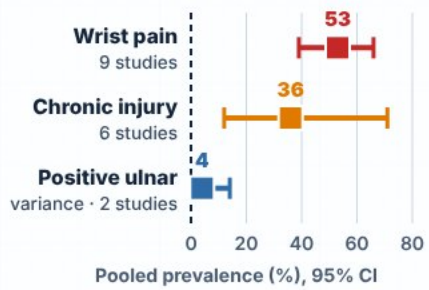
34% of adolescent gymnasts in one study had had an acute wrist injury.

Single study in a meta-analysis. DiLeo et al. (2026).

Arms become legs

- In a handstand the whole body weight passes through wrists extended ≈**68°**, compressing the distal radius.
- Before growth stops, the weakest link there is the growth plate (physis), not the bone or ligaments, so repeated loading can stress it.

Wrist pain is the norm, not the exception



Adolescent artistic gymnasts; meta-analysis of 25 studies. DiLeo et al. (2026).

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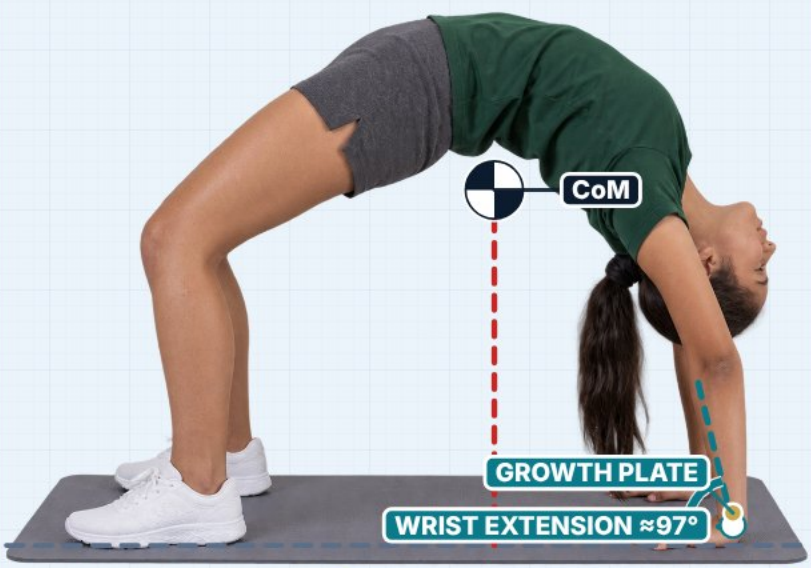
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GYMNAST'S WRIST: GROWTH-PLATE STRESS IN YOUNG ATHLETES

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B · BACK BRIDGE, SIDE





OTHER VIEW

EYE-OPENER

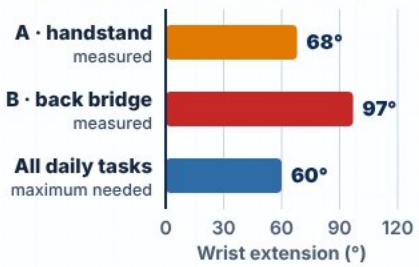
16% of preteen gymnasts developed positive ulnar variance over 18 months.

One cohort, mean age 10. DiLeo et al. (2026).

Bridges push the wrist further

- In the back bridge the hands point back towards the feet and the wrist is extended ≈**97°** under load.
- Positive ulnar variance, where the ulna ends up longer than the radius, is associated with this repeated stress and shifts load across the wrist.

Far beyond everyday wrist range



Daily-task range: 40 healthy adults (Ryu et al., 1991). Skill values measured on Frames A and B (2-D).

2-D estimates from pose landmarks on an illustrated figure; CoM (if shown) from de Leva (1996); cm for a 1.70 m adult (Winter, 2009). Wrist angle from manually placed forearm and hand axes. Educational, not diagnostic.

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C · CARTWHEEL, FRONT



EYE-OPENER

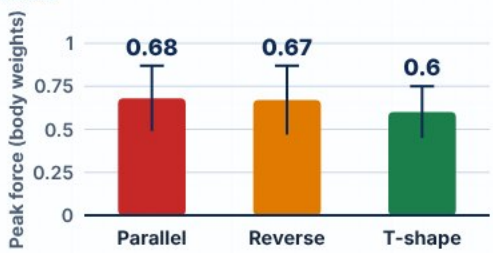
0.90× body weight through one hand in a round-off with parallel hands.

Second-contact hand, 10 young female gymnasts. Brtva et al. (2020).

One hand at a time

- Each hand briefly carries a large share of body weight, with the wrist extended and often twisted.
- Hand placement is a coachable variable: the T-shape position gave the lowest peak load in every skill tested.

Cartwheel: hand position changes load



Peak vertical force on the second-contact hand, mean ± SD; 10 young female gymnasts. Brtva et al. (2020).

Myth: "Sore wrists are just part of gymnastics." Common is not harmless: persistent pain in a growing wrist needs checking.

Angles from landmarks placed on an illustrated figure (2-D, camera-plane); approximate. Load arrows drawn on the figure for teaching; no angles quoted for this inverted front view. Educational, not diagnostic.

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DOI 10.5281/zenodo.23735910

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

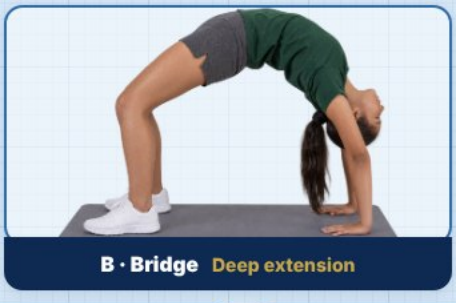
INTEGRATING PERFORMANCE & REHABILITATION HEALTHCARE PATHWAYS.

GYMNAST'S WRIST: GROWTH-PLATE STRESS IN YOUNG ATHLETES

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A · Handstand Full weight

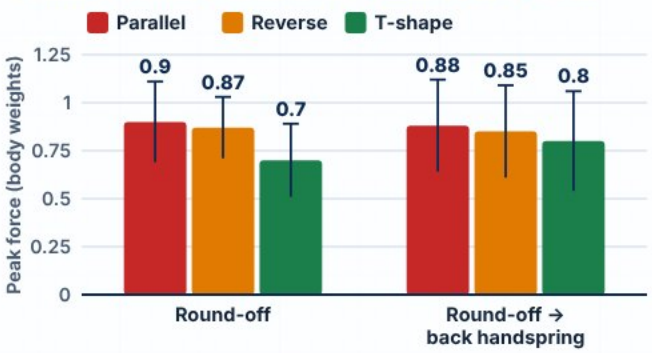


B · Bridge Deep extension



C · Cartwheel One hand

T-shape hands lowered the peak in every skill



Second-contact hand, mean ± SD; 10 young female gymnasts. Brtva et al. (2020).

Decision pathway

1. **MODIFY**
   Cut wrist weight-bearing volume when pain persists; no safe weekly-hours limit has been established.
2. **LOAD**
   Coach the T-shape hand position and return to skills gradually, guided by pain.
3. **TRACK**
   Log weekly hours and intensity, which are associated with wrist pain; refer if pain lasts.

NOT RECOMMENDED

Training through persistent wrist pain in a growing athlete, or dismissing it as normal for the sport.

SEEK ASSESSMENT IF

Pain lasting more than a few sessions, pain at rest or at night, swelling over the distal radius, or lost wrist motion: seek assessment and imaging.

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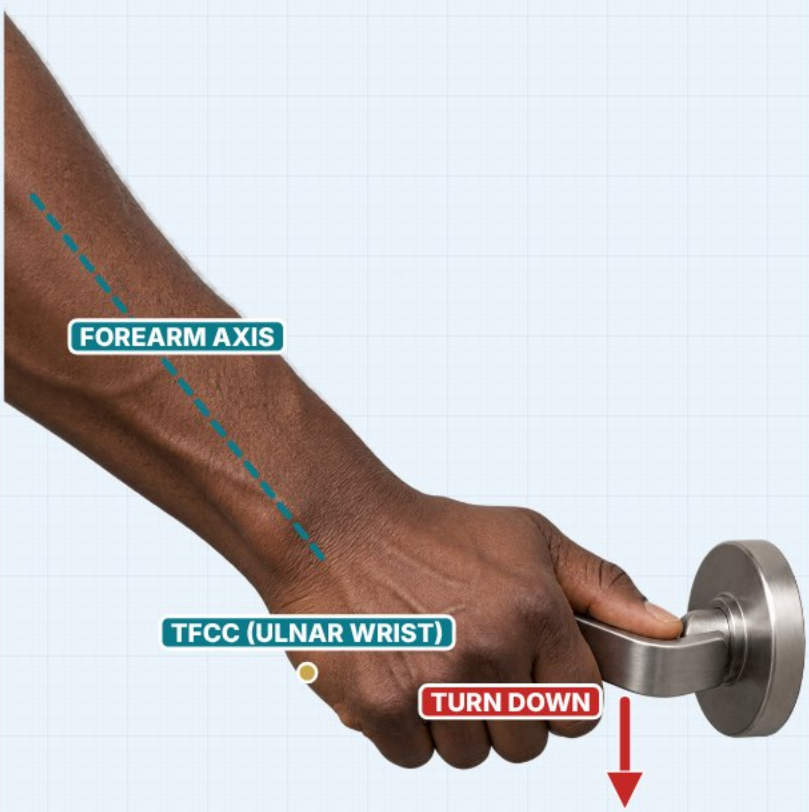
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INTEGRATING PERFORMANCE & REHABILITATION HEALTHCARE PATHWAYS.

TFCC INJURY: LITTLE-FINGER-SIDE WRIST PAIN WITH TWISTING

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A · TURN DOOR HANDLE, SIDE



EYE-OPENER

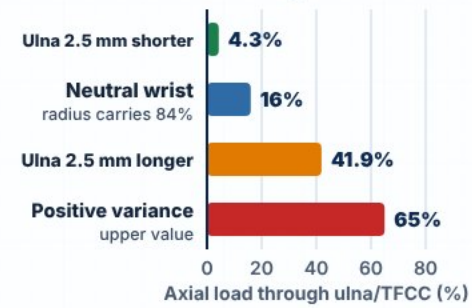
40° of ulnar deviation, towards the little finger, was needed across everyday tasks.

40 healthy adults. Ryu et al. (1991).

Twist plus grip loads the ulnar side

- Turning a lever handle combines a firm grip with forearm rotation, pulling the hand towards the little-finger side.
- The TFCC, a cartilage disc and ligaments between the ulna and the carpus, steadies the forearm joint and carries part of the wrist load.

A few millimetres change the load



Cadaver studies (af Ekenstam 1984; Werner 1986; Friedman 1991) as summarised in a literature review. Barbaric et al. (2015).

Angles from landmarks placed on an illustrated figure (2-D, camera-plane); approximate. Forearm axis and turning direction drawn on the figure for teaching. Educational, not diagnostic.

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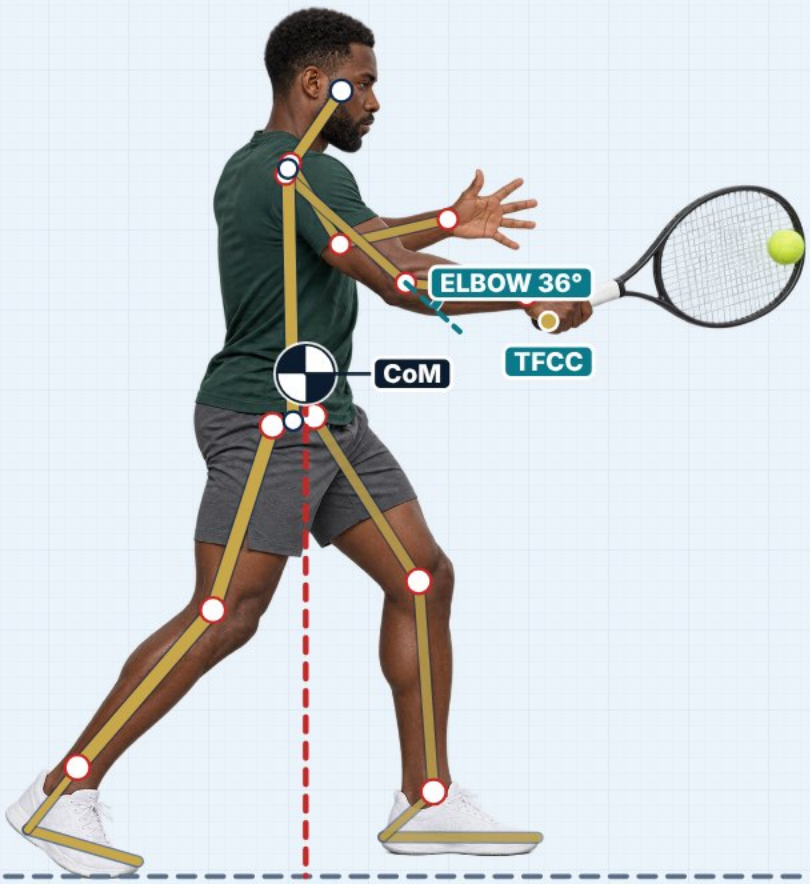
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TFCC INJURY: LITTLE-FINGER-SIDE WRIST PAIN WITH TWISTING

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B · TENNIS FOREHAND, SIDE



EYE-OPENER

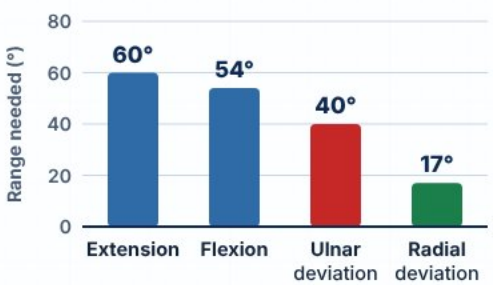
3/3 pain-free volunteers aged 60 or over had an abnormal TFCC on MRI.

Iordache et al. (2012).

Forehand: impact on a tilted wrist

- At contact the elbow is flexed ≈**36°** and the wrist is cocked, often towards the little finger, as the racquet meets the ball.
- Impact and topspin rotation are passed through the ulnar side of the wrist, so repetition can provoke TFCC pain.

Ulnar tilt: the largest sideways demand



Range needed to complete all tested daily tasks; 40 healthy adults. Ryu et al. (1991).

2-D estimates from pose landmarks on an illustrated figure; CoM (if shown) from de Leva (1996); cm for a 1.70 m adult (Winter, 2009). Elbow angle from pose landmarks in the side view. Educational, not diagnostic.

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TFCC INJURY: LITTLE-FINGER-SIDE WRIST PAIN WITH TWISTING

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C · HOLDING ULNAR WRIST, FRONT



EYE-OPENER

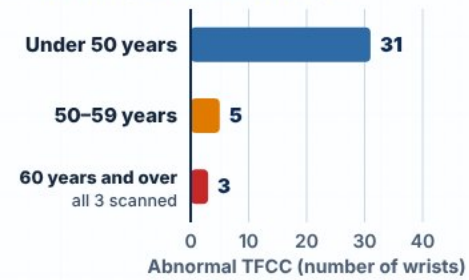
23/103 people with no wrist pain had a complete TFCC tear on MRI.

Asymptomatic volunteers. Iordache et al. (2012).

Where it hurts

- TFCC pain sits on the little-finger side, between the end of the ulna and the carpal bones, and is provoked by gripping with rotation.
- Clunking or the ulna standing proud suggests forearm-joint instability and needs specialist assessment.

Scan changes rise with age



103 asymptomatic volunteers, 1.9-T MRI, 3 readers; abnormality correlated with age. Iordache et al. (2012).

Myth: "A TFCC tear on MRI explains my pain." Many tears are incidental; the scan must match the examination.

2-D estimates from pose landmarks on an illustrated figure (head-to-hip framing); lengths scaled to a 1.70 m adult (Winter, 2009). Anatomy positions marked on the figure for teaching; no angles quoted. Figure holds the left wrist. Educational, not diagnostic.

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TFCC INJURY: LITTLE-FINGER-SIDE WRIST PAIN WITH TWISTING

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A · Handle Grip + twist

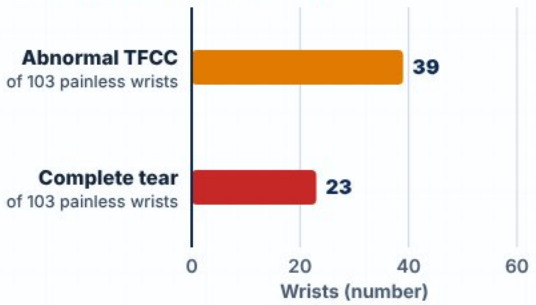


B · Forehand Ulnar tilt



C · Locate Ulnar wrist

Painless wrists often look "torn"



Asymptomatic volunteers, 1.9-T MRI. Iordache et al. (2012). No verified outcome data for TFCC treatments are available here.

Decision pathway

1. **MODIFY**
   Reduce gripping with rotation and little-finger tilt; brace or splint while pain settles.
2. **LOAD**
   Rebuild grip and forearm rotation strength in graded steps within comfort.
3. **TRACK**
   If pain, clicking or weakness persist, seek specialist assessment; judge the scan against the examination.

NOT RECOMMENDED

Treating an incidental MRI tear as the certain cause of pain, or forcing painful twisting under load.

SEEK ASSESSMENT IF

Clunking or the ulna standing proud, pain after a fall or high-energy twist, marked swelling or lost rotation: seek prompt assessment.

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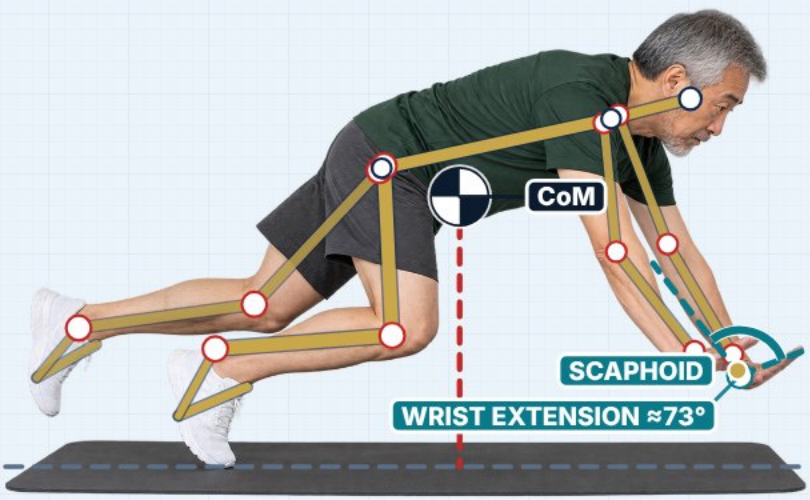
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INTEGRATING PERFORMANCE & REHABILITATION HEALTHCARE PATHWAYS.

WRIST SPRAIN OR SCAPHOID FRACTURE? WHY A "SPRAIN" AFTER A FALL NEEDS CHECKING

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A · FALL ON HANDS, SIDE





OTHER VIEW

EYE-OPENER

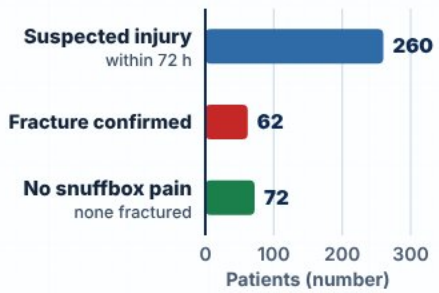
1 in 5 suspected scaphoid injuries with a normal first X-ray are true fractures.

Median prevalence 20%. Mallee et al. (2015).

The classic fall

- Landing on outstretched hands drives body weight into wrists extended ≈**73°** on this figure, loading the scaphoid as it bridges the two rows of carpal bones.
- Impact forces for falls are not quantified here; the point is the mechanism, which is why pain after such a fall is treated with suspicion.

Who really had a fracture



260 consecutive patients; snuffbox pain tested on ulnar deviation within 72 h. Duckworth et al. (2012).

2-D estimates from pose landmarks on an illustrated figure; CoM (if shown) from de Leva (1996); cm for a 1.70 m adult (Winter, 2009). Wrist angle from manually placed forearm and hand axes. Educational, not diagnostic.

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B · THUMB UP, SIDE





EYE-OPENER

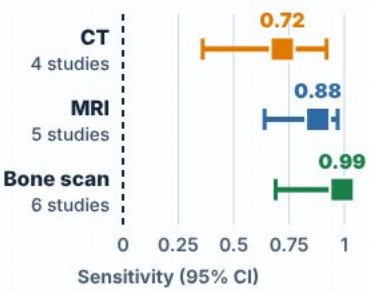
91% fracture risk when all four clinical predictors were positive.

Male sex, sports injury, snuffbox pain on ulnar deviation, tubercle tenderness at 2 weeks. Duckworth et al. (2012).

Press the snuffbox

- With the thumb stretched up and back, the tendons outline the anatomical snuffbox; the scaphoid lies at its floor.
- Snuffbox pain when the wrist tilts towards the little finger, within 72 hours, was a strong independent predictor of fracture.

After a normal X-ray: which scan finds it?



Suspected scaphoid fracture with negative first radiographs. Mallee et al. (2015).

Angles from landmarks placed on an illustrated figure (2-D, camera-plane); approximate. Forearm axis and anatomy positions marked on the figure for teaching. Educational, not diagnostic.

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WRIST SPRAIN OR SCAPHOID FRACTURE? WHY A "SPRAIN" AFTER A FALL NEEDS CHECKING

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C · GUARDING WRIST, FRONT



EYE-OPENER

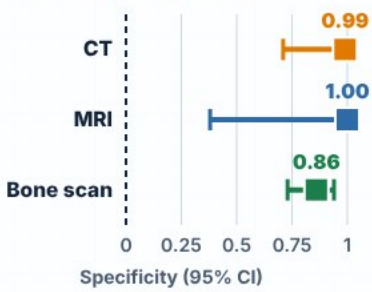
62 of 260 consecutive suspected scaphoid injuries proved to be fractures; most were not.

Duckworth et al. (2012).

Guarding is a clue

- Holding the wrist still, pain on the thumb side and painful gripping after a fall are reasons to immobilise and re-assess, not to "run it off".
- An untreated scaphoid fracture can fail to heal, so the safer error is a short splint until the diagnosis is clear.

Specific scans rarely over-call



Same studies as sensitivity; MRI 5 studies, 221 suspected fractures. Mallee et al. (2015).

Myth: "A normal X-ray means it's not broken." About 1 in 5 such wrists is fractured.

2-D estimates from pose landmarks on an illustrated figure (head-to-hip framing); lengths scaled to a 1.70 m adult (Winter, 2009). Anatomy position marked on the figure for teaching; no angles quoted. Educational, not diagnostic.

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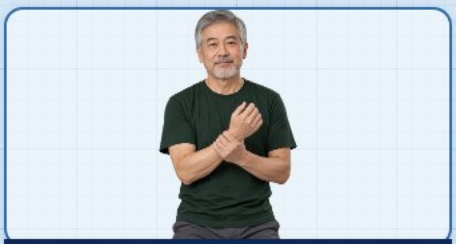
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A · Fall Mechanism

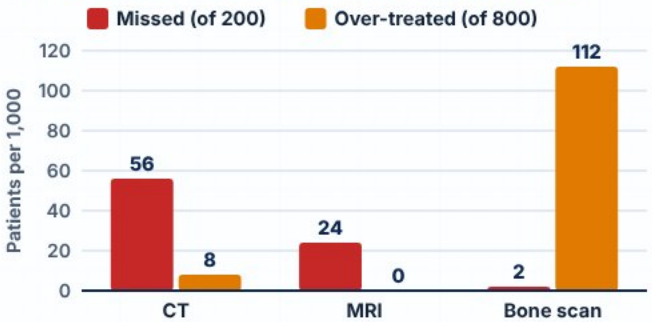


B · Snuffbox Key sign



C · Guarding Re-assess

Per 1,000 suspected fractures, normal X-rays



Assumed prevalence 20% (200 fractures). Mallee et al. (2015), summary of findings.

Decision pathway

1. **PROTECT**
   After a fall with thumb-side pain, splint the wrist and arrange review even if the X-ray is normal.
2. **CHECK**
   Re-examine the snuffbox and scaphoid tubercle; positive predictors call for further imaging.
3. **IMAGE**
   MRI combines high specificity with good sensitivity; bone scans miss little but over-treat.

NOT RECOMMENDED

Calling a painful wrist after a fall a "sprain" because the first X-ray is normal.

SEEK ASSESSMENT IF

Fall onto an outstretched hand with snuffbox pain, pain on ulnar deviation, thumb-side swelling or painful grip: seek prompt assessment.

REFERENCES (APA 7)

de Leva, P. (1996). Adjustments to Zatsiorsky-Seluyanov's segment inertia parameters. *Journal of Biomechanics, 29*(9), 1223–1230. https://doi.org/10.1016/0021-9290(95)00178-6

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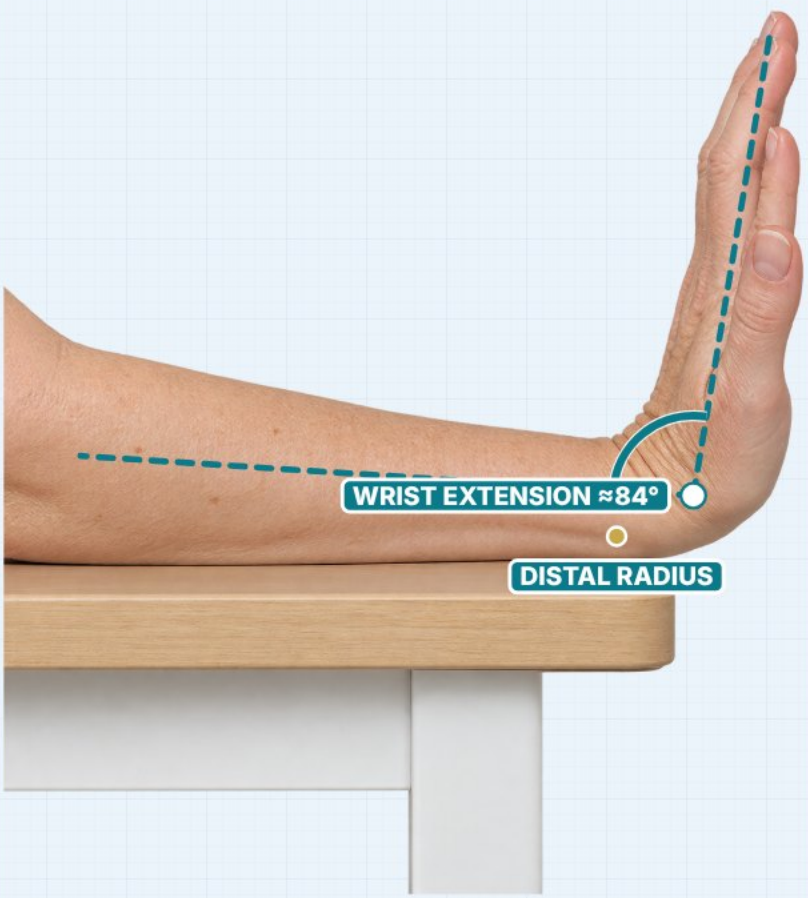
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DISTAL RADIUS FRACTURE: REHAB AFTER A BROKEN WRIST

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A · SUPPORTED WRIST LIFT, SIDE



EYE-OPENER

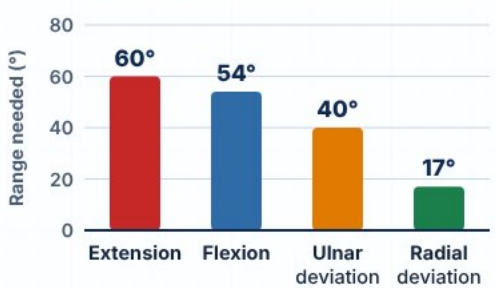
40° of flexion and 40° of extension covered most everyday tasks in healthy adults.

About 70% of maximal range. Ryu et al. (1991).

Range first, on a supported forearm

- With the forearm resting on the table the wrist moves alone; this figure lifts to **≈84°** extension, more than daily tasks require.
- After cast removal or fixation, active wrist range is rebuilt step by step towards these functional targets.

The range daily life needs



Range needed to complete all tested daily tasks; 40 healthy adults. Ryu et al. (1991).

Angles from landmarks placed on an illustrated figure (2-D, camera-plane); approximate. Wrist angle from manually placed forearm and hand axes. Educational, not diagnostic.

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DISTAL RADIUS FRACTURE: REHAB AFTER A BROKEN WRIST

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2-D estimates from pose landmarks on an illustrated figure (head-to-hip framing); lengths scaled to a 1.70 m adult (Winter, 2009). Lever line and rotation direction drawn for teaching; no angles quoted (forearm foreshortened). Educational, not diagnostic.

EYE-OPENER

1,269 adults, mainly older women, took part in 26 rehabilitation trials after this fracture.

Handoll & Elliott (2015).

Turning the palm down and up

- Holding a hammer upright and letting it tip lengthens the lever, so slow forearm rotation can be loaded gently through the forearm joints.
- Rotation targets were not part of the range study used here, so progress is judged against daily tasks and the other arm.

Most trials began after the cast



26 trials of rehabilitation after distal radius fracture. Handoll & Elliott (2015).

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C · SOFT-BALL SQUEEZE, FRONT



EYE-OPENER

4/23 rehabilitation comparisons had been tested by more than one trial.

Handoll & Elliott (2015).

Grip comes back slowly

- Squeezing a soft ball loads the finger flexors at low force, an early step before heavier grip work.
- Grip on the injured side was still clearly weaker at 6 months; by 2 years the gap was small.

Grip lags behind for months



Mean deficit, injured vs uninjured hand (Jamar); 154 patients; 12-month value not reported. Bobos et al. (2018).

Myth: "Once the cast is off, the wrist is healed." Grip was still 7.47 kg weaker at 6 months on average.

2-D estimates from pose landmarks on an illustrated figure (head-to-hip framing); lengths scaled to a 1.70 m adult (Winter, 2009). Anatomy marked for teaching; no angles quoted. Educational, not diagnostic.

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DISTAL RADIUS FRACTURE: REHAB AFTER A BROKEN WRIST

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A · Range Wrist lift

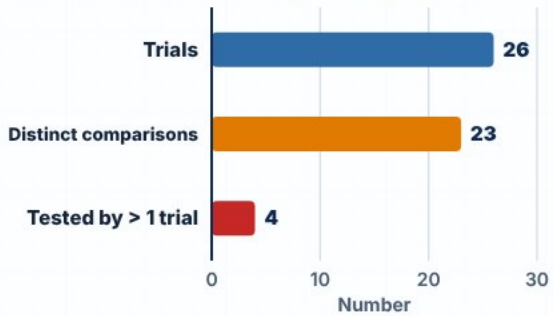


B · Rotate Hammer lever



C · Grip Soft ball

The evidence rests on single small trials



Cochrane review, 1,269 participants. Handoll & Elliott (2015).

Decision pathway

1. **EARLY**
   Keep fingers, elbow and shoulder moving while the wrist is immobilised.
2. **RANGE**
   After the cast or fixation, rebuild active wrist and forearm range towards daily-task targets.
3. **STRENGTH**
   Progress grip from soft-ball squeezes to heavier work; expect it to lag for at least 6 months.

NOT RECOMMENDED

Expecting full grip by 3 months, or relying on passive modalities such as ice or whirlpool (very low-quality evidence).

SEEK ASSESSMENT IF

Increasing finger swelling, severe pain, colour or temperature change, numbness, a cast that feels too tight, or lost thumb extension: seek urgent review.

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DOI 10.5281/zenodo.23735910

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

INTEGRATING PERFORMANCE & REHABILITATION HEALTHCARE PATHWAYS.

WRIST GANGLION CYST: THE LUMP ON THE BACK OF THE WRIST

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EYE-OPENER

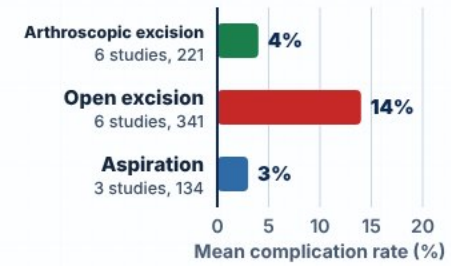
76% less recurrence with surgical excision than aspiration in randomised trials.

Meta-analysis; 58% in cohort studies. Head et al. (2015).

A sac of joint fluid

- A ganglion is a benign, mucin-filled cyst from a joint capsule or tendon sheath, most often on the back of the wrist between the extensor tendons.
- It may be painless or ache at end range, and can change size; a good share resolve without any treatment.

Open surgery carries more complications



Systematic review, 35 studies, 2,239 ganglions (studies, ganglions per row). Head et al. (2015).

Angles from landmarks placed on an illustrated figure (2-D, camera-plane); approximate. Anatomy positions marked on the figure for teaching; no lump is shown on this figure. Educational, not diagnostic.

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B · KNEELING PUSH-UP, SIDE





OTHER VIEW

EYE-OPENER

8/103 people had a complication after surgical excision in a 6-year follow-up.

Dias et al. (2007).

Extension squeezes the back of the wrist

- In a kneeling push-up the wrist is extended ≈**69°** under load, compressing the dorsal capsule where most ganglia arise.
- If that aches, raise the hands to cut the load, or use fists or handles to keep the wrist straight.

Raise the hands to lower the load



Push-up variations, 23 recreationally fit young adults. Wurm et al. (2010).

2-D estimates from pose landmarks on an illustrated figure; CoM (if shown) from de Leva (1996); cm for a 1.70 m adult (Winter, 2009). Wrist angle from manually placed forearm and hand axes. Educational, not diagnostic.

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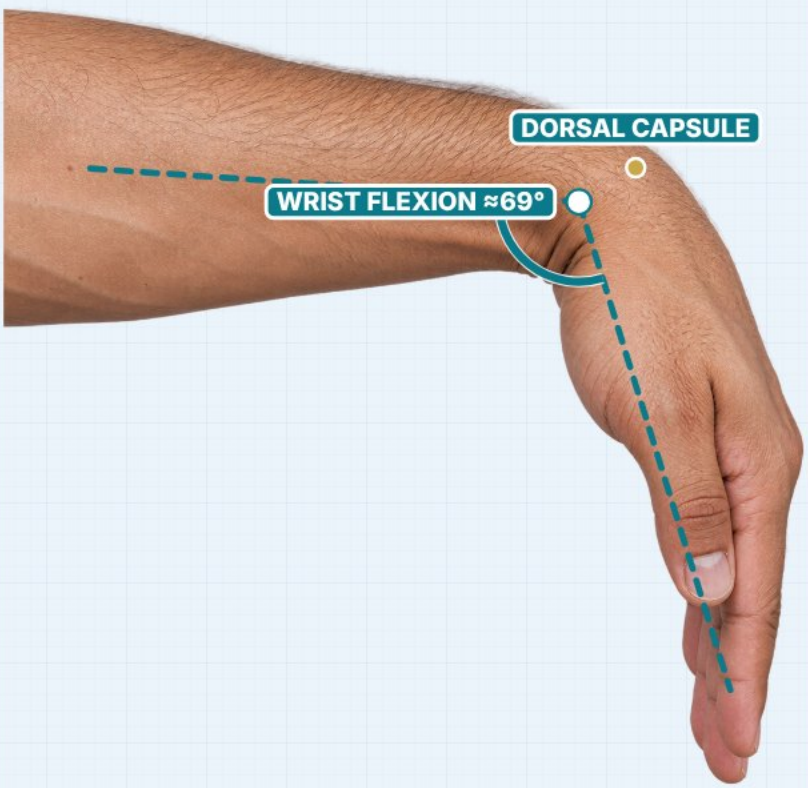
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C · WRIST FLEXED, SIDE



EYE-OPENER

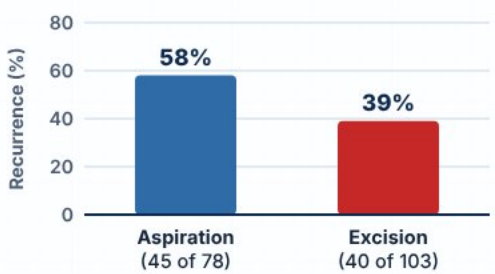
6% mean recurrence after arthroscopic excision, the lowest of the treatments reviewed.

11 studies, 512 ganglions. Head et al. (2015).

Flexion makes it stand out

- Wrist flexion ≈**69°** stretches the dorsal capsule, so a dorsal ganglion becomes more prominent and may ache at end range.
- Recurrent or persistent ganglia were linked with more pain, stiffness and unsightliness at about 6 years.

Recurrence about 6 years later



Mean 70-month follow-up; 236 of 283 patients responded. Dias et al. (2007).

Myth: "Surgery guarantees the lump will not come back." Ganglia recurred after open excision too.

Angles from landmarks placed on an illustrated figure (2-D, camera-plane); approximate. Wrist angle from manually placed forearm and hand axes. Educational, not diagnostic.

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A · Locate Dorsal wrist

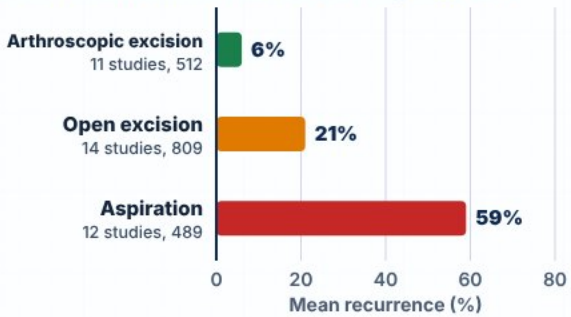


B · Load Extension



C · Flex Prominent

Lower recurrence comes at a surgical cost



Systematic review (studies, ganglions per row); aspiration was not significantly better than reassurance. Head et al. (2015).

Decision pathway

1. **REASSURE**
   Painless ganglia can be watched: many resolve, and aspiration was no better than reassurance.
2. **MODIFY**
   If loading aches, reduce end-range extension with fists, handles or an incline.
3. **DECIDE**
   For persistent symptoms, weigh aspiration (simple, often recurs) against excision (fewer recurrences, more complications).

NOT RECOMMENDED

Striking the cyst with a heavy object ("bible therapy"): no evidence of benefit and a risk of injury.

SEEK ASSESSMENT IF

A hard, fast-growing or fixed lump, pain at rest, an unusual site, or numbness or weakness: seek assessment and imaging.

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de Leva, P. (1996). Adjustments to Zatsiorsky-Seluyanov's segment inertia parameters. *Journal of Biomechanics, 29*(9), 1223–1230. https://doi.org/10.1016/0021-9290(95)00178-6

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

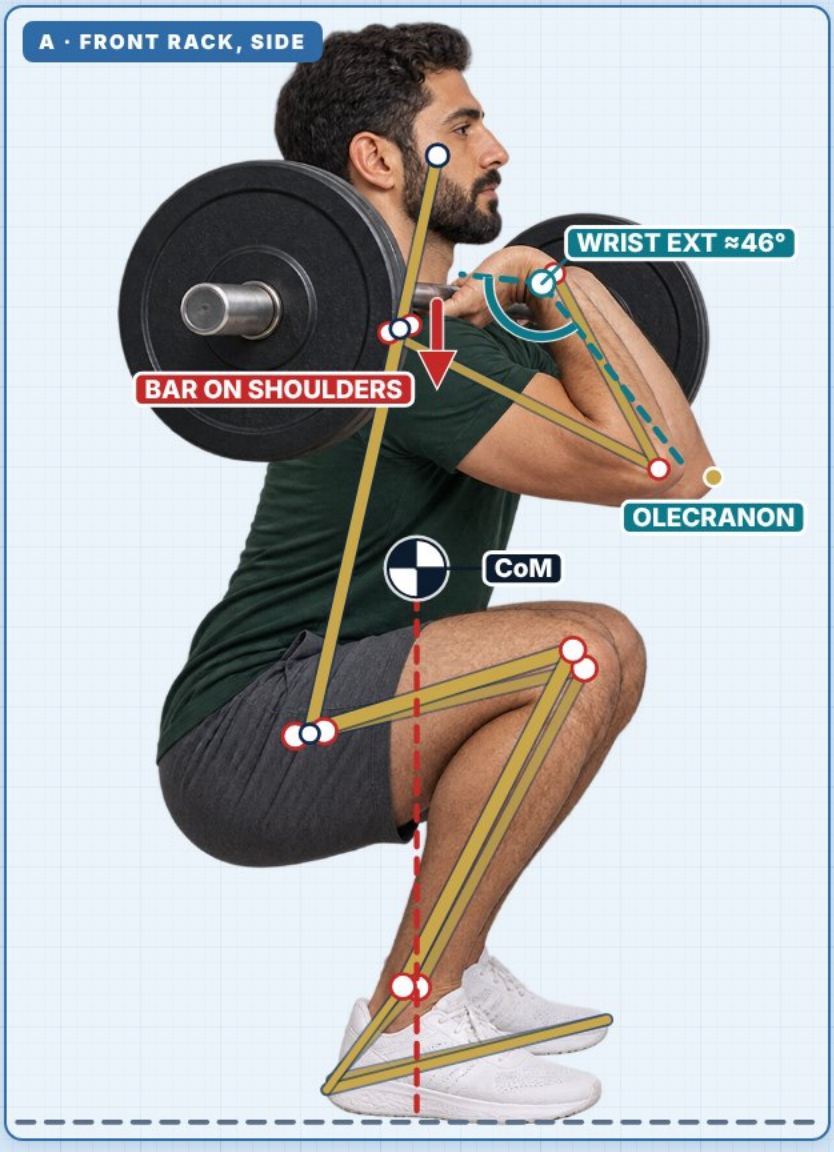
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INTEGRATING PERFORMANCE & REHABILITATION HEALTHCARE PATHWAYS.

WRIST POSITION IN FRONT SQUATS, CLEANS AND DEADLIFTS

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EYE-OPENER

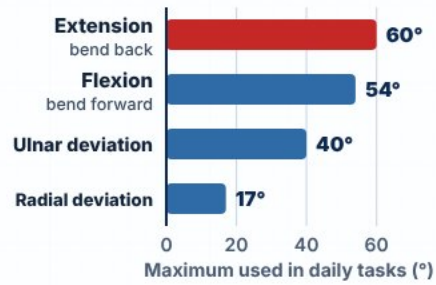
68% of weightlifters injured during competition periods in the highest estimate reviewed.

Period prevalence range 10.7%–68%. Tung et al. (2024).

The bar sits on the shoulders

- In this rack the wrist is extended ≈**46°** with only fingertip contact: the front deltoids carry the bar, the hand just keeps it in place.
- Gripping the bar in a full palm forces the wrist toward end-range extension under load, so tolerance is built, not assumed.

Daily tasks used at most 60° of extension



Everyday wrist ROM, not barbell data: 40 healthy adults across daily tasks. Ryu et al. (1991).

2-D estimates from pose landmarks on an illustrated figure; CoM (if shown) from de Leva (1996); cm for a 1.70 m adult (Winter, 2009). Wrist angle from manually placed forearm and hand landmarks. Educational, not diagnostic.

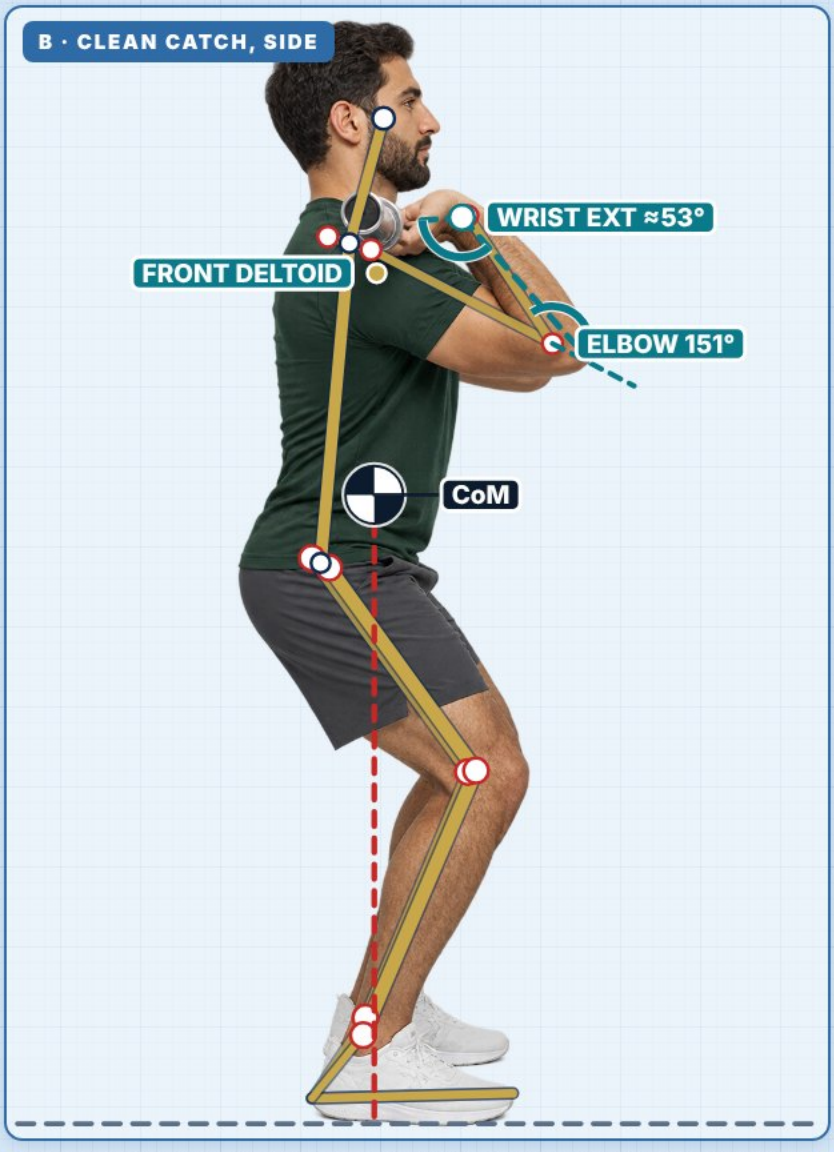
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EYE-OPENER

40° of wrist extension was enough for most daily activities in healthy adults.

70% of maximal functional motion. Ryu et al. (1991).

The catch arrives fast

- In the catch the elbow is flexed ≈**151°** and the wrist ≈**53°** extended as the bar lands on the shoulders.
- If the elbows stay low, the falling bar drives the hand back and the wrist absorbs the impact at end range.

Hands and fingers make the list

Weightlifting	Powerlifting
1 Knee	1 Lower back / pelvis
2 Lower back	2 Shoulder
3 Shoulder	3 Elbow / upper arm
4 Hands / fingers	

Most common injury sites, in order as reported (no percentages pooled). Tung et al. (2024).

2-D estimates from pose landmarks on an illustrated figure; CoM (if shown) from de Leva (1996); cm for a 1.70 m adult (Winter, 2009). Elbow from pose landmarks; wrist angle from manually placed forearm and hand landmarks. Educational, not diagnostic.

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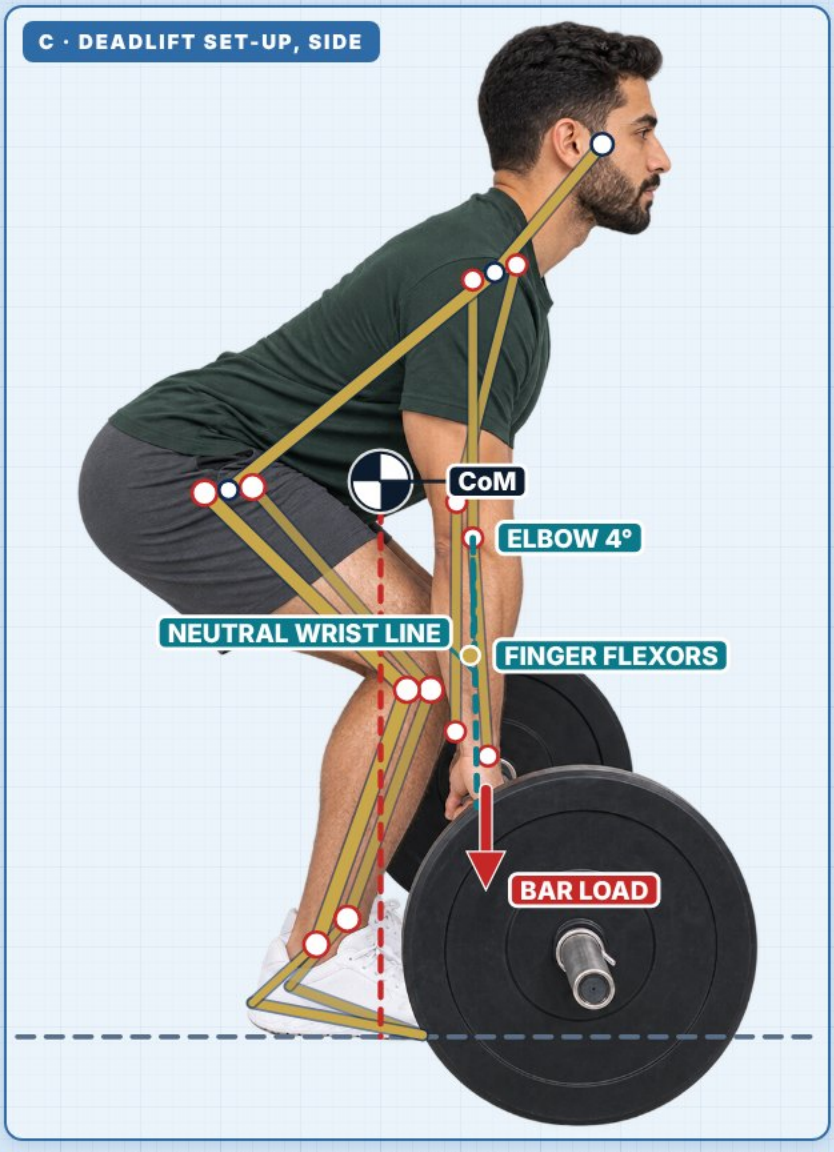
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2-D estimates from pose landmarks on an illustrated figure; CoM (if shown) from de Leva (1996); cm for a 1.70 m adult (Winter, 2009). Elbow from pose landmarks; neutral wrist line drawn on the figure for teaching. Educational, not diagnostic.

EYE-OPENER

10.7% of weightlifters injured in competition periods even in the lowest estimate reviewed.

Updated review of 17 reports. Tung et al. (2024).

A deadlift loads the grip, not the bend

- Arms hang straight (elbow ≈**4°**) and the wrist stays neutral: the bar pulls straight down through the finger flexors.
- When grip fails first, train grip or use straps; do not let the wrist curl or hyperextend to hold the bar.

Lifting injuries per training hour are low



Ranges across studies in a review of 9 studies. Aasa et al. (2017).

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A · Rack Fingertips

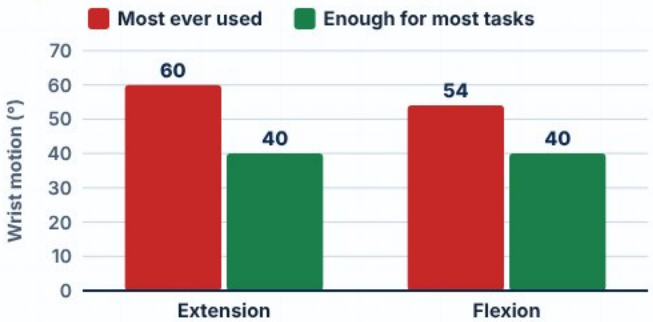


B · Catch Elbows up



C · Pull Neutral

Daily life uses far less than end range



Functional wrist motion in 40 healthy adults; most activities possible within 70% of the maximum. Ryu et al. (1991).

Decision pathway

1. **MODIFY**
   Rack on the shoulders with fingertip contact, high elbows and a wider grip; use straps for front squats if needed.
2. **LOAD**
   Build wrist-extension tolerance gradually with light holds and range work; train grip for heavy pulls.
3. **TRACK**
   Note pain during and the day after racking; progress load only when it stays settled.

NOT RECOMMENDED

Forcing a full-palm rack through pain, or bending the wrist to rescue a failing deadlift grip.

SEEK ASSESSMENT IF

Wrist pain after a fall on the hand or a dropped bar, snuffbox tenderness, swelling or loss of grip: seek prompt assessment.

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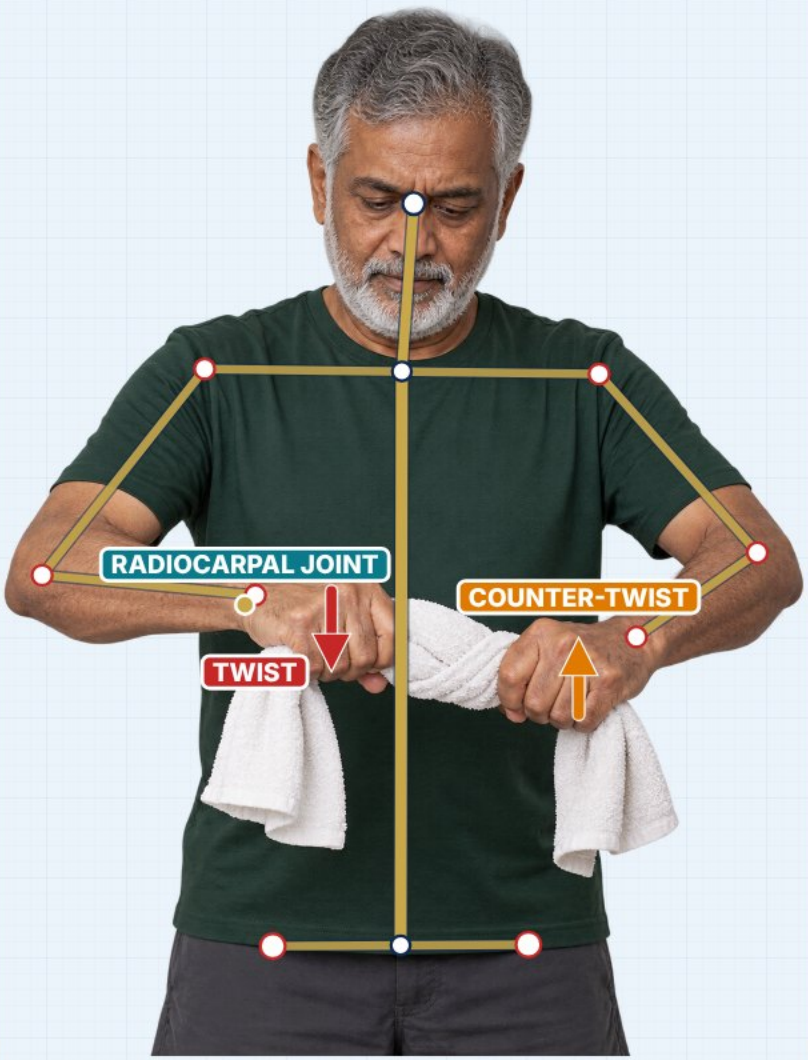
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WRIST OSTEOARTHRITIS: STIFFNESS, GRIP LOSS AND LOAD MANAGEMENT

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A · WRINGING A TOWEL, FRONT



EYE-OPENER

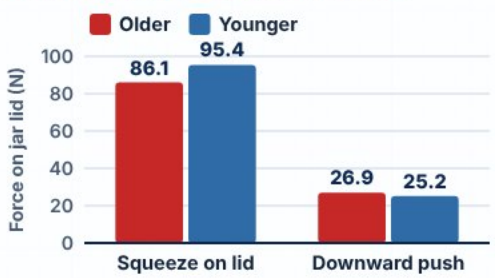
<50% of wrist arthritis on X-ray fitted the classic scapholunate collapse (SLAC) pattern.

1,007 wrist radiographs screened. Miller et al. (2017).

Twist plus squeeze

- Wringing combines a firm grip with opposite forearm rotation in each hand, so the radiocarpal joint is compressed while it is twisted.
- An arthritic wrist tolerates this poorly: pain and stiffness, not the X-ray, should set how hard and how often.

Older hands push the lid as hard



Instrumented jar, older vs younger adults; group means. Carse et al. (2011).

2-D estimates from pose landmarks on an illustrated figure (head-to-hip framing); lengths scaled to a 1.70 m adult (Winter, 2009). Twist arrows drawn on the figure for teaching; no angle measured. Educational, not diagnostic.

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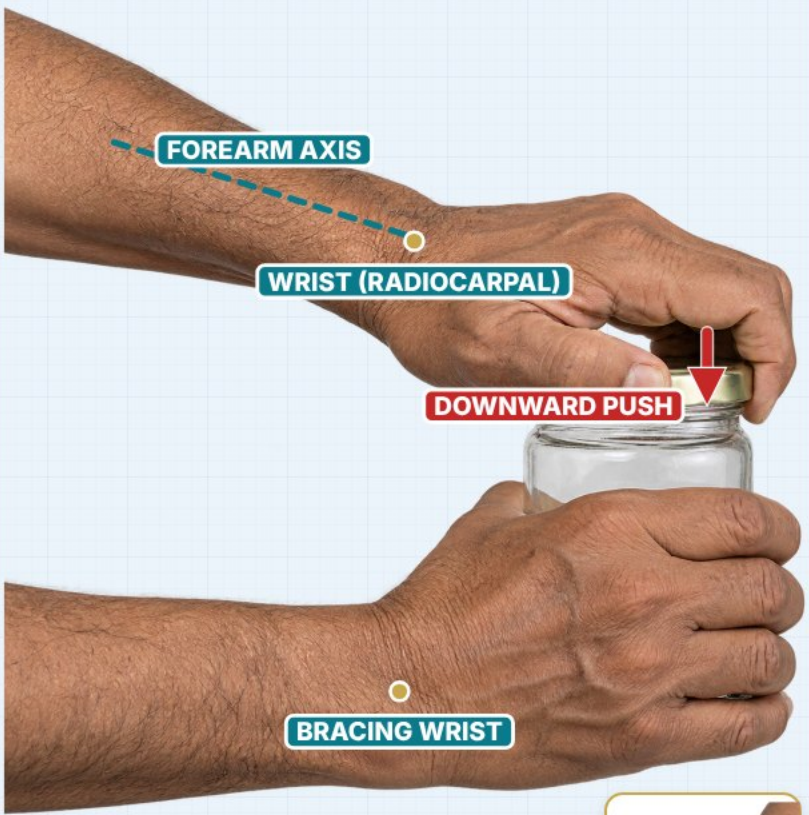
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B · OPENING A JAR, SIDE





EYE-OPENER

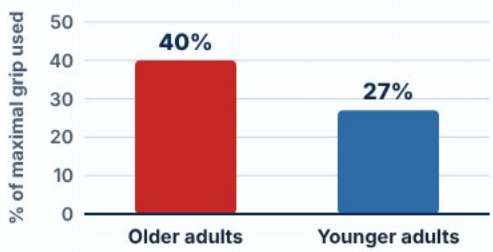
1.9× faster jar opening in younger adults (1.59 vs 0.84 rad/s).

Opening rate, instrumented jar. Carse et al. (2011).

Working near the ceiling

- One hand pushes and squeezes the lid while the other wrist braces the jar; both wrists are loaded at once.
- Older hands opened the jar using a larger share of their maximal grip, leaving less reserve for a painful joint.

Less spare grip in older hands



Proportion of maximal grip strength used to open the jar. Carse et al. (2011).

Practical: a jar opener, a wider lid grip or a rubber pad lowers the share of maximal grip needed.

Angles from landmarks placed on an illustrated figure (2-D, camera-plane); approximate. Load arrow and forearm axis drawn on the figure for teaching. Educational, not diagnostic.

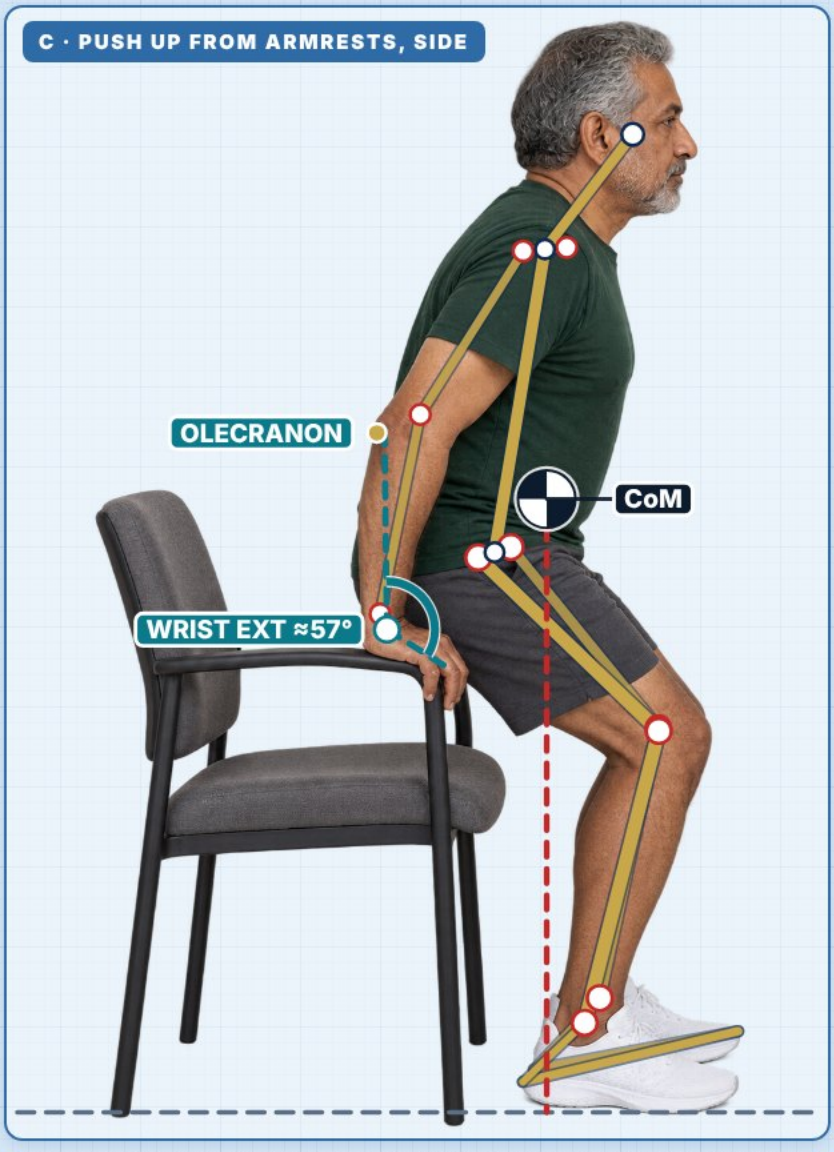
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2-D estimates from pose landmarks on an illustrated figure; CoM (if shown) from de Leva (1996); cm for a 1.70 m adult (Winter, 2009). Wrist angle from manually placed forearm and hand landmarks. Educational, not diagnostic.

EYE-OPENER

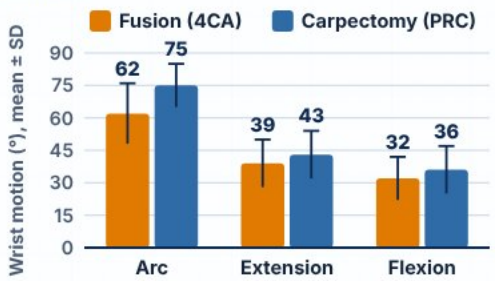
1.05× higher odds of radiographic wrist arthritis with each extra year of age.

Odds ratio per year; women had lower odds than men (OR 0.306). Miller et al. (2017).

Pushing up asks for end range

- Rising with palms on the armrests needs **≈57°** of wrist extension under body weight; healthy adults used up to 60° in daily tasks (Ryu et al., 1991).
- Fist-on-armrest or a higher seat keeps the wrist nearer neutral.

Even after salvage surgery, motion is limited



7 studies, 242 wrists, post-traumatic arthritis. Saltzman et al. (2015).

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A · Wring Twist load

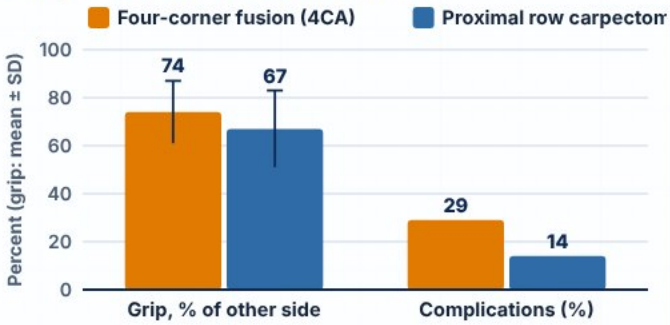


B · Jar Grip reserve



C · Rise End range

Surgery is a trade-off, not a reset



Salvage surgery for post-traumatic wrist arthritis, 240 patients. Saltzman et al. (2015).

Decision pathway

1. **MODIFY**
   Use jar openers, thick handles and fist-on-armrest rising; spread heavy twisting tasks through the day.
2. **LOAD**
   Keep daily wrist motion and build grip and forearm strength within a tolerable pain response.
3. **TRACK**
   Log grip strength and pain the next day; splint short-term only during flare-ups.

NOT RECOMMENDED

Resting the wrist completely for long periods; it loses motion and grip that daily tasks need.

SEEK ASSESSMENT IF

A hot swollen wrist with fever, new deformity after a fall, worsening numbness, or swelling of several joints with long morning stiffness.

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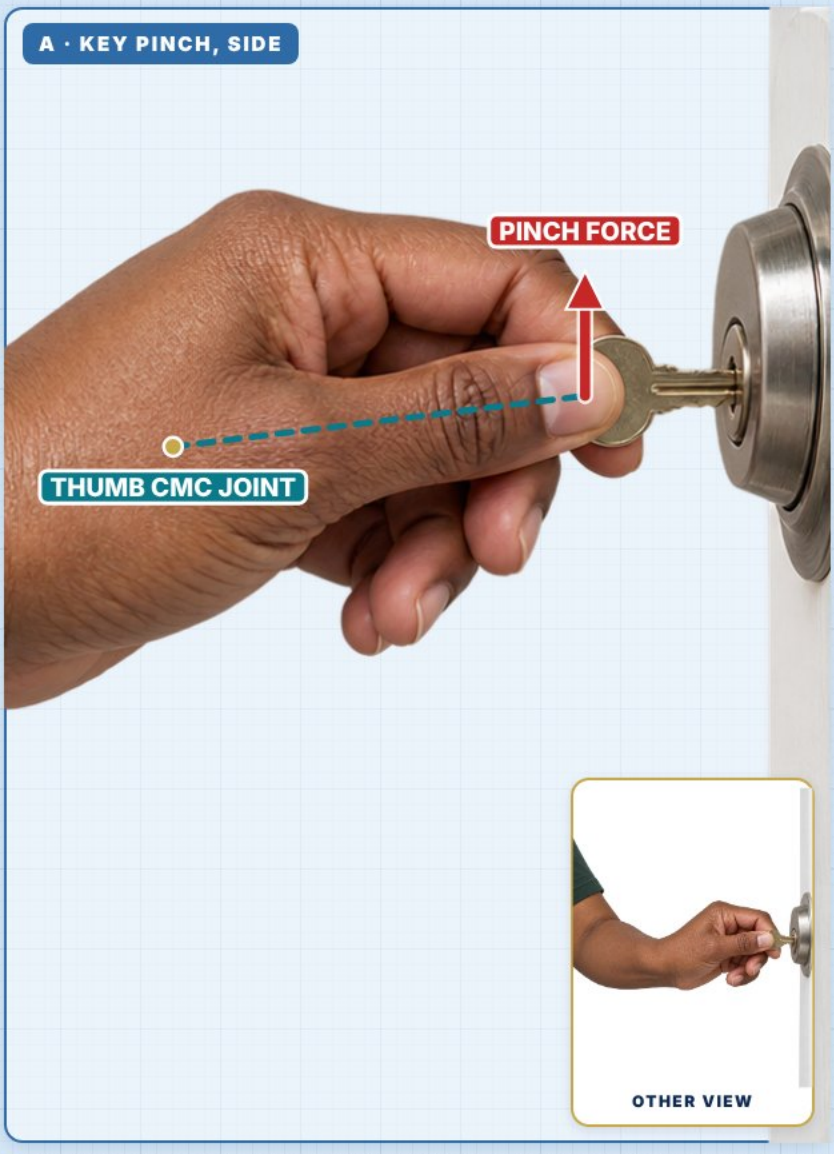
BIOMECHANICS IS A FORCE-GOVERNED DECISION SYSTEM – NOT A POSTURE MODEL.

INTEGRATING PERFORMANCE & REHABILITATION HEALTHCARE PATHWAYS.

THUMB BASE ARTHRITIS: PAIN WITH PINCHING, OPENING JARS AND KEYS

AN MMSX AUTHORITY | APPLIED BIOMECHANICS LAB EDUCATIONAL ANALYSIS

A · KEY PINCH, SIDE



EYE-OPENER

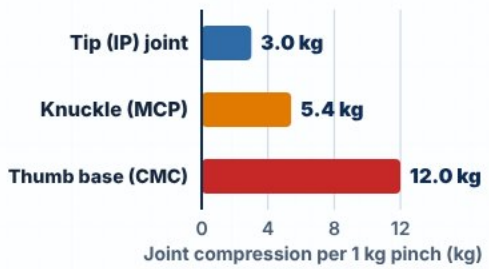
3 of 2,321 adults with thumb-base X-rays had ever had thumb-base surgery.

Radiographs taken for wrist fracture, age 31+. Becker et al. (2013).

A small pinch, a big joint load

- A key pinch presses the thumb pad against the side of the index finger; the thumb muscles that make that force also compress the joint at the thumb base.
- The thumb base sits at the root of the lever, so it carries the most compression.

Load builds toward the thumb base



Static biomechanical model of the thumb, simple pinch with 1 kg applied force. Cooney & Chao (1977).

Angles from landmarks placed on an illustrated figure (2-D, camera-plane); approximate. Dashed thumb axis and pinch direction drawn on the figure for teaching. Educational, not diagnostic.

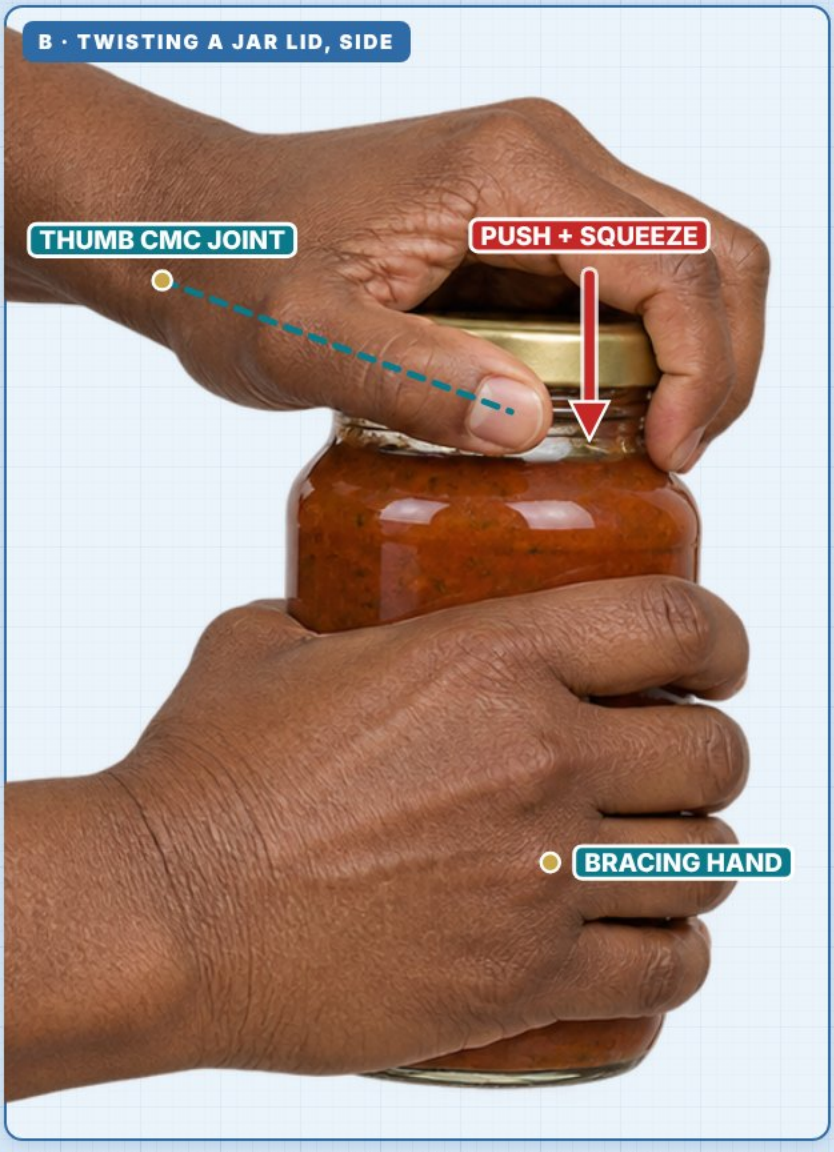
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EYE-OPENER

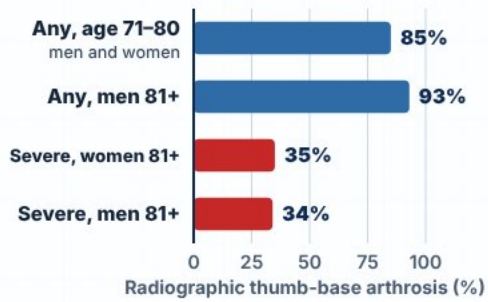
≥3 mo of regular thumb-orthosis use before trials showed benefit.

EULAR 2018 hand OA recommendations. Kloppenburg et al. (2019).

Twisting needs pinch and grip together

- Turning a lid combines a downward push, a squeeze and a twist; the thumb wraps the lid and its base resists the turning load.
- A jar opener or a rubber pad cuts the force the thumb must make.

Common on X-ray, rarely operated on



2,321 patients aged 31+ with radiographs. Becker et al. (2013).

Angles from landmarks placed on an illustrated figure (2-D, camera-plane); approximate. Dashed thumb axis and lid load drawn on the figure for teaching. Educational, not diagnostic.

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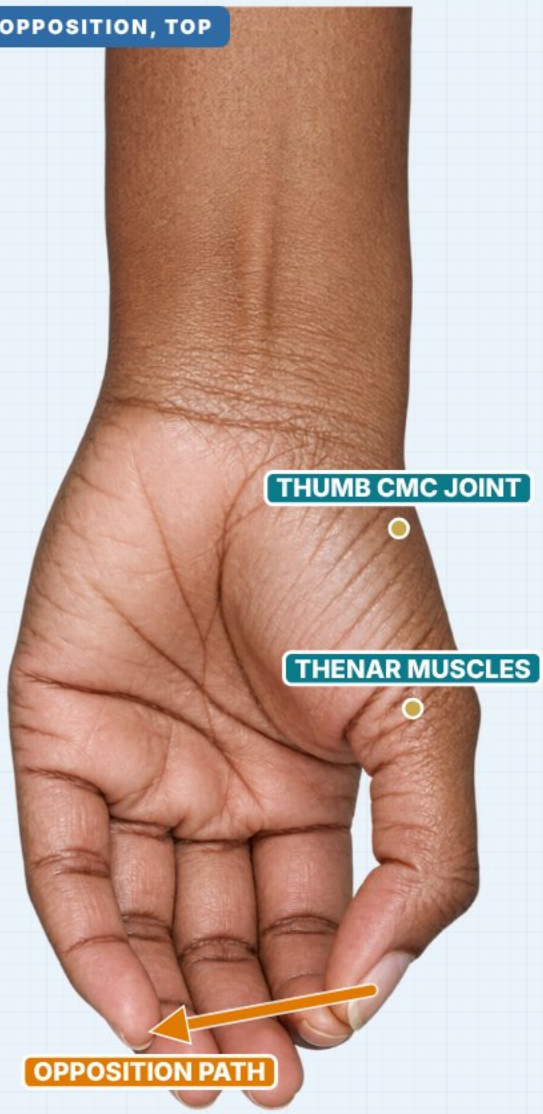
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C · THUMB OPPOSITION, TOP



EYE-OPENER

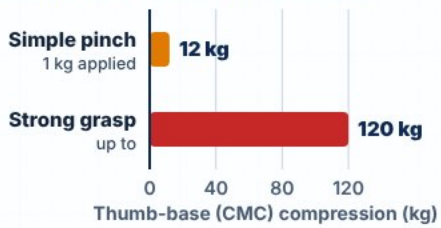
100% of women aged 91+ had radiographic thumb-base arthrosis; half of them severe.

Becker et al. (2013).

Opposition shows the joint working

- Bringing the thumb across the palm rotates the first metacarpal on the trapezium, the joint where thumb-base arthritis develops.
- Pain at the base of the thumb during this sweep, rather than at the wrist crease, points to the CMC joint.

A strong grasp multiplies the load



Static biomechanical model of the thumb. Cooney & Chao (1977).

Myth: "A bad X-ray means surgery." Education, orthoses and exercise are graded first-line (EULAR Grade A).

Angles from landmarks placed on an illustrated figure (2-D, camera-plane); approximate. Opposition path drawn on the figure for teaching. Educational, not diagnostic.

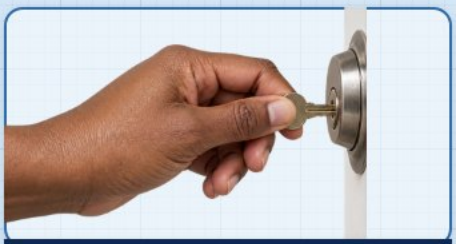
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A · Key 12× load

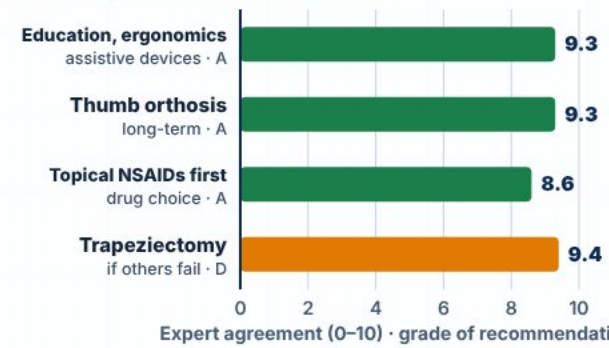


B · Jar Twist



C · Oppose CMC joint

Non-surgical care comes first



EULAR 2018 update; surgery when other treatments have not relieved pain. Kloppenburg et al. (2019).

Decision pathway

1. **MODIFY**
   Use key turners, jar openers and thick-handled tools; pace pinch-heavy tasks through the day.
2. **LOAD**
   Exercise for function and strength within comfort; wear a thumb orthosis regularly for at least 3 months.
3. **TRACK**
   Record pinch pain and task ease monthly; discuss surgery only if non-surgical care fails.

NOT RECOMMENDED

Routine steroid injection into the thumb base: the guideline does not generally recommend it.

SEEK ASSESSMENT IF

A suddenly hot, red, swollen joint, numbness in the thumb or index, rapidly worsening deformity, or swelling of several knuckles with long morning stiffness.

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

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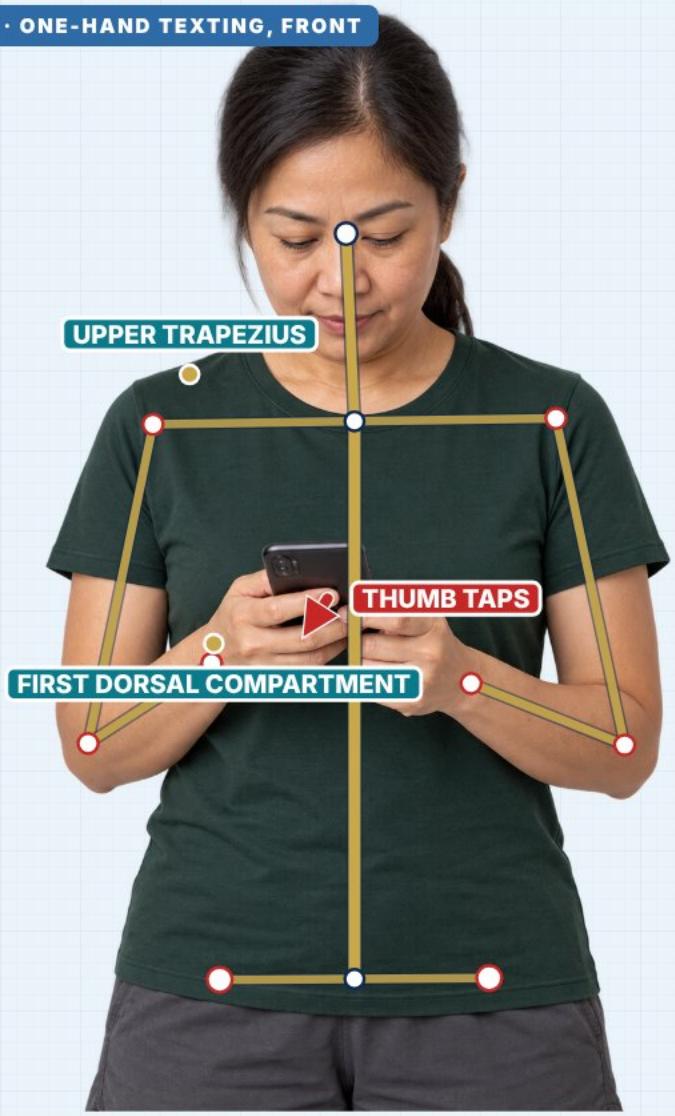
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TEXTING THUMB: SMARTPHONE LOAD ON THE THUMB TENDONS

AN MMSX AUTHORITY | APPLIED BIOMECHANICS LAB EDUCATIONAL ANALYSIS

A · ONE-HAND TEXTING, FRONT



EYE-OPENER

≈2× thumb and neck-shoulder muscle activity when one hand held the phone and typed.

One- vs two-handed typing, %MVIC. Lee et al. (2015).

One hand does two jobs

- The same hand must grip the phone and swing the thumb across the screen, so thumb extensors and abductors work with little rest.
- Their tendons run in the first dorsal compartment at the thumb side of the wrist, the site of de Quervain-type pain.

Texting predicted new hand symptoms



Swedish young adults 20–24, n = 7,092, followed 1 and 5 years; CIs not in abstract; associations, not proof of cause. Gustafsson et al. (2017).

2-D estimates from pose landmarks on an illustrated figure (head-to-hip framing); lengths scaled to a 1.70 m adult (Winter, 2009). Skeleton from pose landmarks; thumb-tap arrow drawn for teaching. The left hand also touches the phone in this image. Educational, not diagnostic.

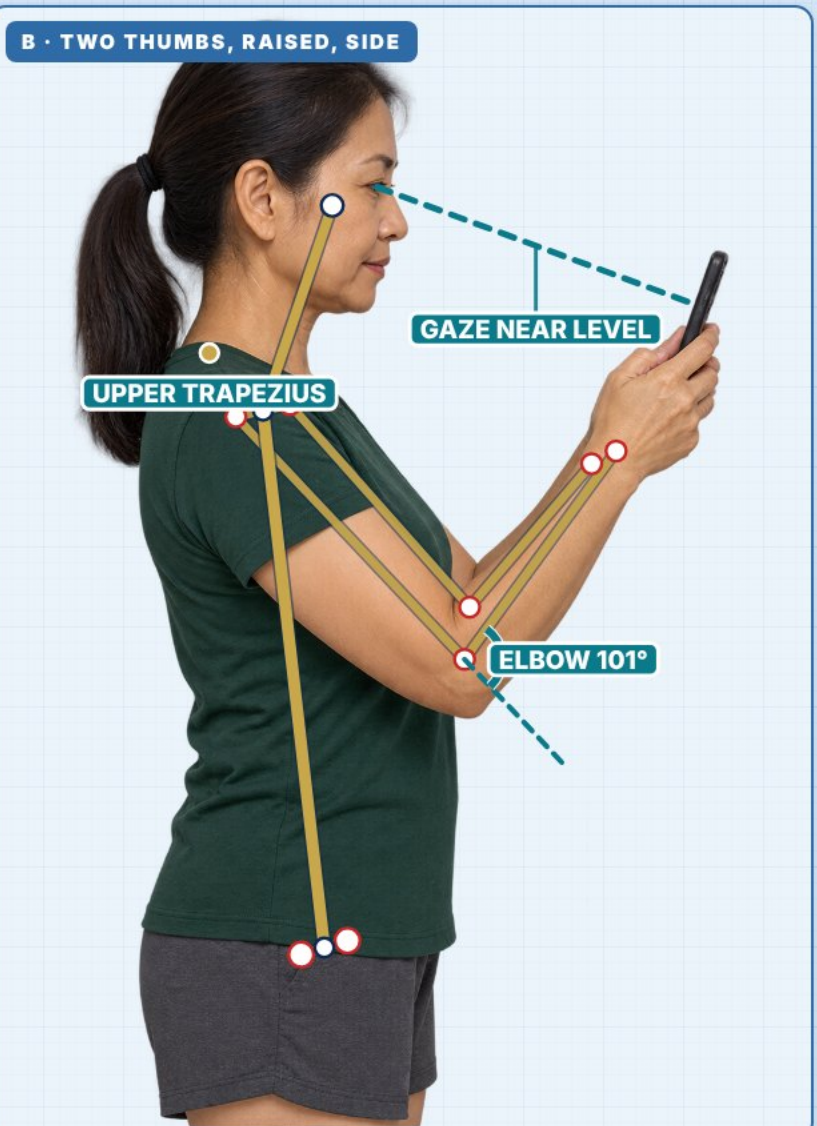
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EYE-OPENER

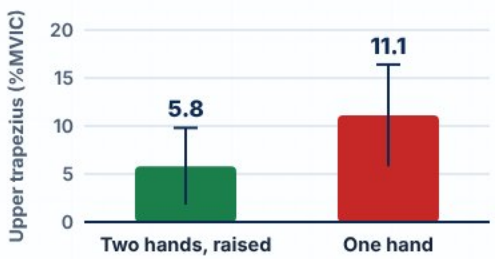
3 min of typing was all it took to show the one-hand penalty in muscle activity.

Asymptomatic women aged 20–22, n = 10 per condition. Lee et al. (2015).

Share the work, lift the phone

- Two thumbs split the tapping, the phone is held nearer eye level and the elbows bend ≈**101°** to support it.
- The head stays nearer upright, so the neck and shoulder muscles hold less load.

Neck-shoulder activity roughly halves



Mean ± SD, 3 min typing. Lee et al. (2015).

2-D estimates from pose landmarks on an illustrated figure (head-to-hip framing); lengths scaled to a 1.70 m adult (Winter, 2009). Elbow angle from pose landmarks; gaze line drawn on the figure for teaching. Educational, not diagnostic.

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TEXTING THUMB: SMARTPHONE LOAD ON THE THUMB TENDONS

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C · THUMB REACH, TOP



EYE-OPENER

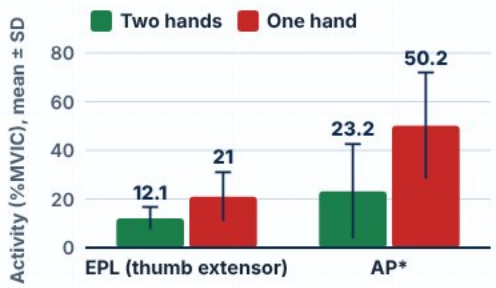
2.0× odds of new hand or finger symptoms a year later in symptom-free young texters.

Odds ratio. Gustafsson et al. (2017).

The long reach is the costly one

- Stretching the thumb to the far side of the screen pulls it into extension and abduction while the hand also grips.
- Repeated reaches load the thumb tendons at the wrist; shorter reaches and two-thumb typing spread the work.

Thumb muscles work far harder one-handed



*Thumb muscle labelled "AP" (as labelled in source). Differences p < 0.05. Lee et al. (2015).

Angles from landmarks placed on an illustrated figure (2-D, camera-plane); approximate. Thumb axis and reach direction drawn on the figure for teaching. Educational, not diagnostic.

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A · One hand Double load

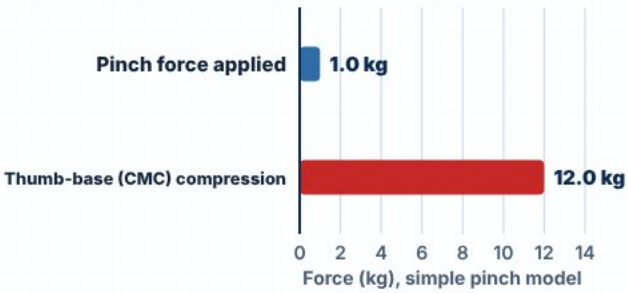


B · Two thumbs Shared



C · Reach Tendons

Every thumb force is multiplied at its base



Static model of a 1 kg pinch, not tapping; shown for the joint principle only. Cooney & Chao (1977).

Decision pathway

1. **MODIFY**
   Type with two thumbs, raise the phone, use voice input or a stand, and alternate hands.
2. **LOAD**
   Break long sessions into short bouts; keep thumb reaches short with a smaller keyboard zone.
3. **TRACK**
   Note thumb-side wrist pain after phone use; if swelling appears, manage as de Quervain's.

NOT RECOMMENDED

Pushing through thumb-side wrist pain with long one-handed sessions.

SEEK ASSESSMENT IF

Numbness or tingling in the thumb, index or middle finger, swelling or creaking over the thumb-side wrist that does not settle, or a thumb that locks.

REFERENCES (APA 7)

Cooney, W. P., & Chao, E. Y. S. (1977). Biomechanical analysis of static forces in the thumb during hand function. *The Journal of Bone and Joint Surgery (American Volume), 59*(1), 27–36. https://doi.org/10.2106/00004623-197759010-00004

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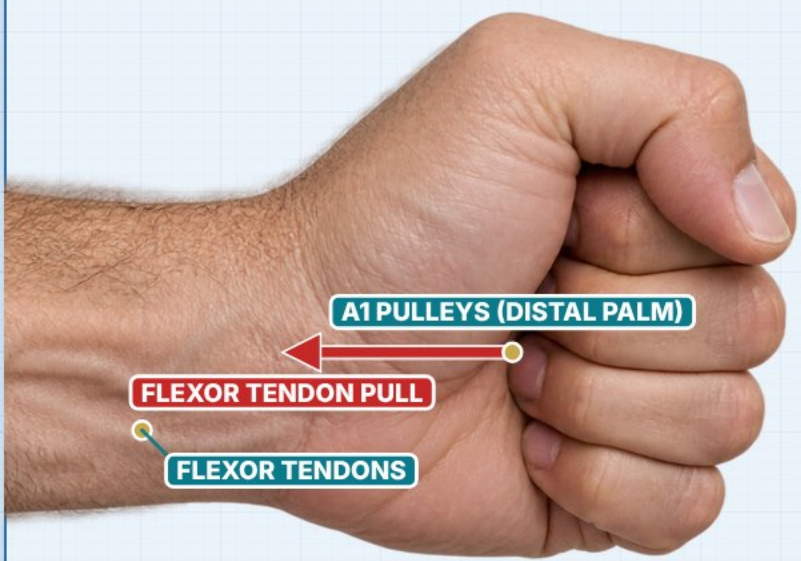
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TRIGGER FINGER: CATCHING AND LOCKING WHEN THE FINGER BENDS

AN MMSX AUTHORITY | APPLIED BIOMECHANICS LAB EDUCATIONAL ANALYSIS

A · FULL FIST, SIDE





EYE-OPENER

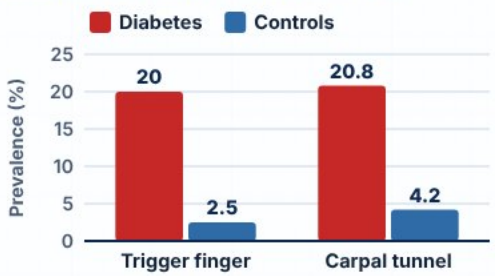
57% cured by a single steroid injection in a randomised trial of 150 fingers.

Types II–IV, follow-up ≥ 6 months. Sato et al. (2012).

A tendon through a tight ring

- Making a fist pulls the finger flexor tendons through a series of pulleys; the first, the A1 pulley, sits under the distal palm at each knuckle.
- If the tendon thickens or the pulley narrows, the tendon jams at A1 and pain is felt in the palm, not the finger.

Far more common with diabetes



120 adults with diabetes vs 120 controls; from reported counts (24, 3, 25, 5 of 120). Chammas et al. (1995).

Angles from landmarks placed on an illustrated figure (2-D, camera-plane); approximate. Tendon-pull direction drawn on the figure for teaching. Educational, not diagnostic.

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B · RING FINGER BENT, SIDE





EYE-OPENER

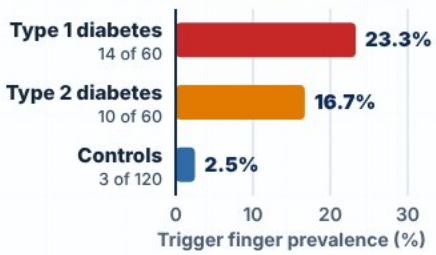
1 in 3 people with diabetes also had mild Dupuytren's disease in the same study.

38 of 120. Chammas et al. (1995).

Where the catch happens

- The ring finger bends easily, but on straightening the thickened tendon must squeeze back through the A1 pulley at the base of the finger.
- It sticks, then releases with a click, or locks bent; the joint itself is usually healthy.

Both types of diabetes raise the risk



Prospective comparative study; percentages from reported counts. Chammas et al. (1995).

Myth: "Clicking means the joint is damaged." The catch is at the tendon–pulley interface in the palm.

Angles from landmarks placed on an illustrated figure (2-D, camera-plane); approximate. Movement arrow drawn on the figure for teaching; the A1 pulley lies on the palm side. Educational, not diagnostic.

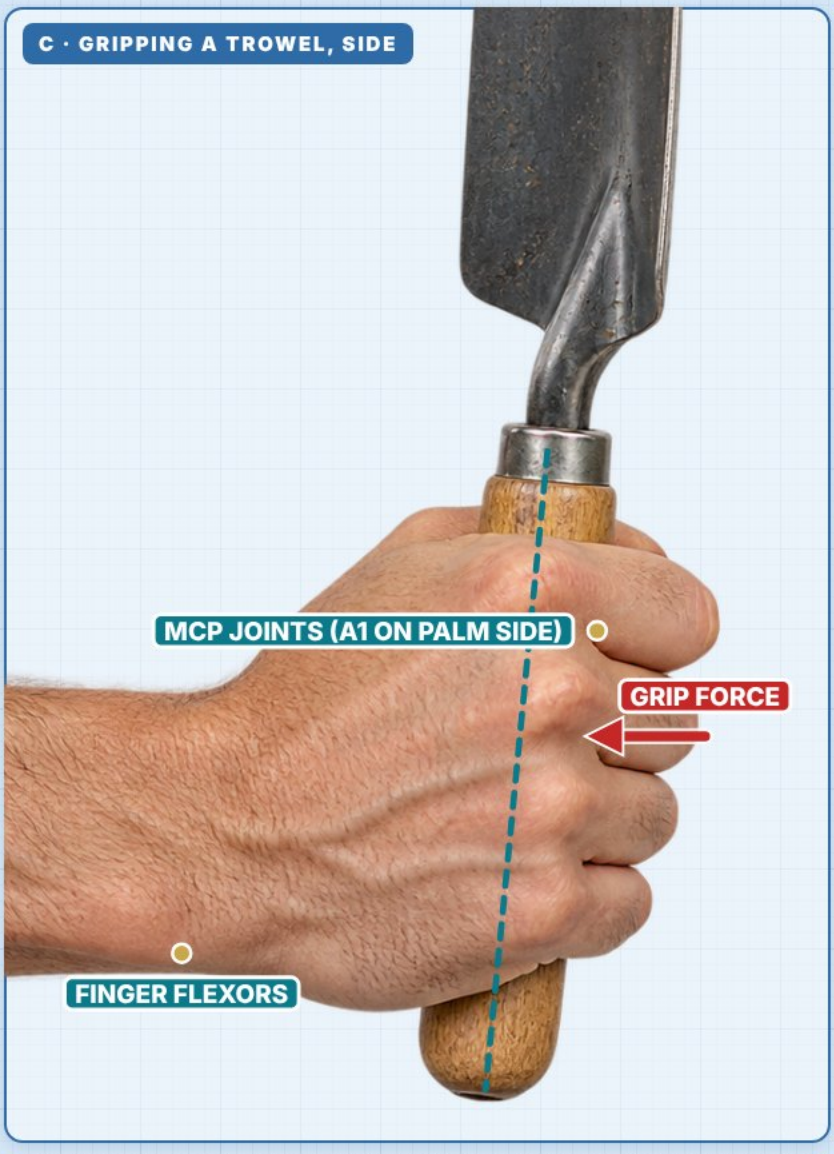
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EYE-OPENER

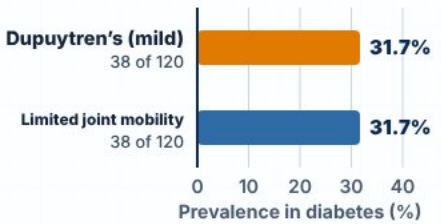
1 in 5 adults with diabetes had trigger finger, against 1 in 40 controls.

24 of 120 vs 3 of 120. Chammas et al. (1995).

Hard gripping presses on the pulley

- A tight grip on a narrow tool handle loads the flexor tendons hard and presses the handle into the palm right over the A1 pulleys.
- Padded, thicker handles and shorter spells of gripping reduce that local pressure.

Other hand changes in diabetes



120 adults with diabetes; control values not verified, so not shown. Chammas et al. (1995).

Angles from landmarks placed on an illustrated figure (2-D, camera-plane); approximate. Grip direction and dashed handle axis drawn on the figure for teaching. Educational, not diagnostic.

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A · Fist A1 pulley

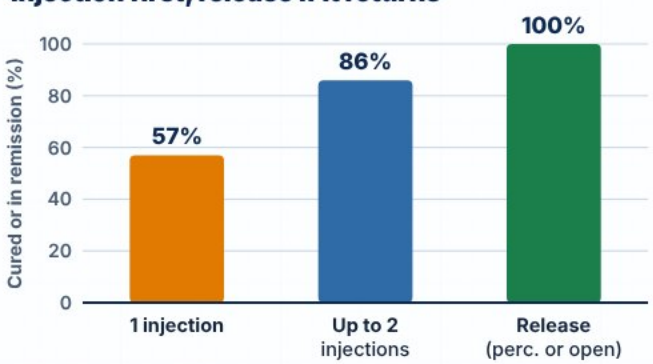


B · Catch Tendon jam



C · Grip Pressure

Injection first, release if it returns



RCT, 137 patients, 150 fingers (Sato et al., 2012); release 100% from a critically appraised summary of the trial. Injection carries more recurrence at 6 months than surgery (Amirfeyz et al., 2017).

Decision pathway

1. **MODIFY**
   Use padded, thicker handles and limit sustained hard gripping; splinting can settle a mild case.
2. **TREAT**
   Discuss a steroid injection first; up to two injections cured 86% in the trial.
3. **TRACK**
   If catching returns or persists, a percutaneous or open release is the next step.

NOT RECOMMENDED

Forcing a locked finger straight repeatedly, or ignoring triggering in several fingers with swollen joints.

SEEK ASSESSMENT IF

A finger locked bent that will not straighten, or a hot, swollen finger held bent with pain on stretching (possible tendon-sheath infection): seek urgent care.

REFERENCES (APA 7)

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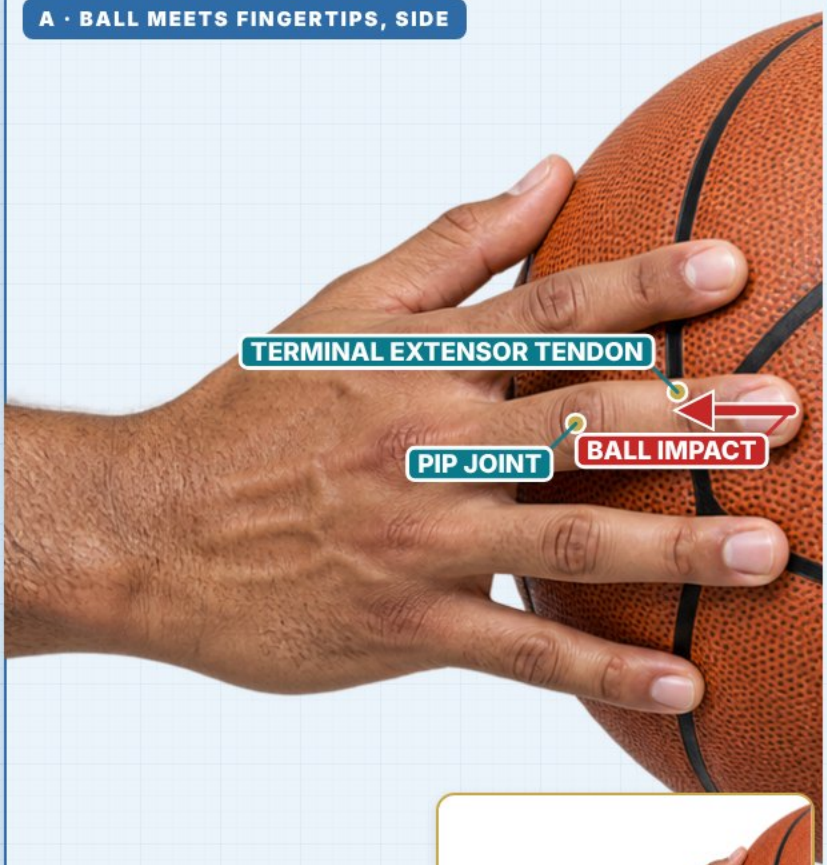
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MALLET FINGER: THE DROOPING FINGERTIP AND WHY SPLINT TIME MATTERS

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A · BALL MEETS FINGERTIPS, SIDE





EYE-OPENER

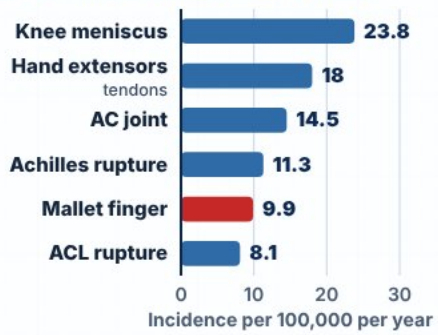
33.9% of all tendon and ligament injuries in a 5-year study were in the hand.

2,794 injuries, catchment of about 535,000. Clayton & Court-Brown (2008).

A sudden bend of a straight tip

- A ball striking the tip of a straight finger forces the end joint (DIP) into flexion while the extensor is tight.
- The thin terminal extensor tendon ruptures or pulls off a flake of bone, so the tip can no longer be actively straightened.

More common than ACL rupture



Five-year prospective population study. Clayton & Court-Brown (2008).

Angles from landmarks placed on an illustrated figure (2-D, camera-plane); approximate. Impact direction drawn on the figure for teaching. Educational, not diagnostic.

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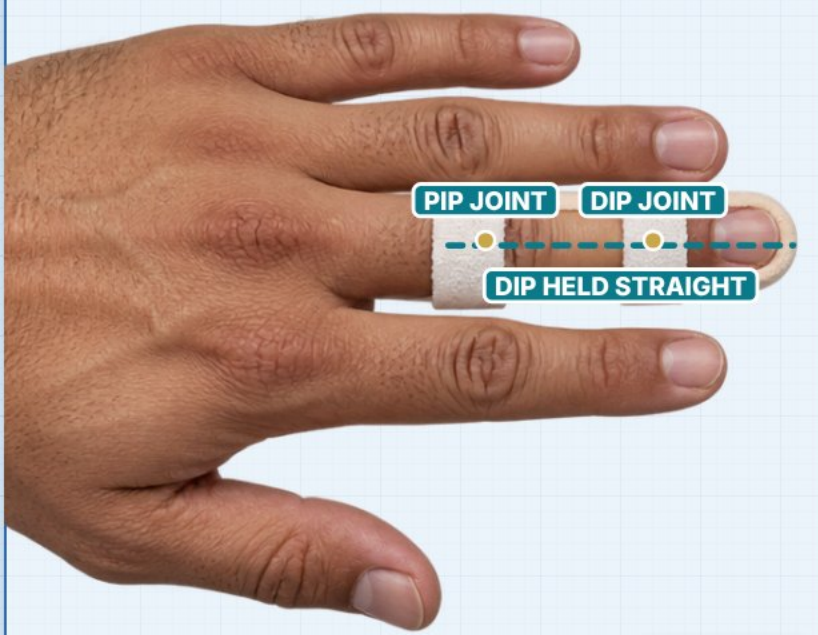
BIOMECHANICS IS A FORCE-GOVERNED DECISION SYSTEM – NOT A POSTURE MODEL.

INTEGRATING PERFORMANCE & REHABILITATION HEALTHCARE PATHWAYS.

MALLET FINGER: THE DROOPING FINGERTIP AND WHY SPLINT TIME MATTERS

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B · MALLET SPLINT, SIDE





Angles from landmarks placed on an illustrated figure (2-D, camera-plane); approximate. DIP line drawn on the figure for teaching. Image shows a left hand. Educational, not diagnostic.

EYE-OPENER

2 of 3 studies that measured it found large effect sizes for orthotic splinting.

Systematic review of 4 RCTs. Valdes et al. (2015).

The tip must never drop

- The splint holds the DIP joint straight so the tendon ends can heal in contact; every trial splinted continuously, day and night.
- Keep it straight at all times, including during skin care; this figure's splint also spans the PIP joint, which usually stays free.

Splint dose: 6 to 8 weeks, uninterrupted



All trials: 6 weeks acute, 8 weeks chronic; add weeks if an extensor lag persists. Valdes et al. (2015).

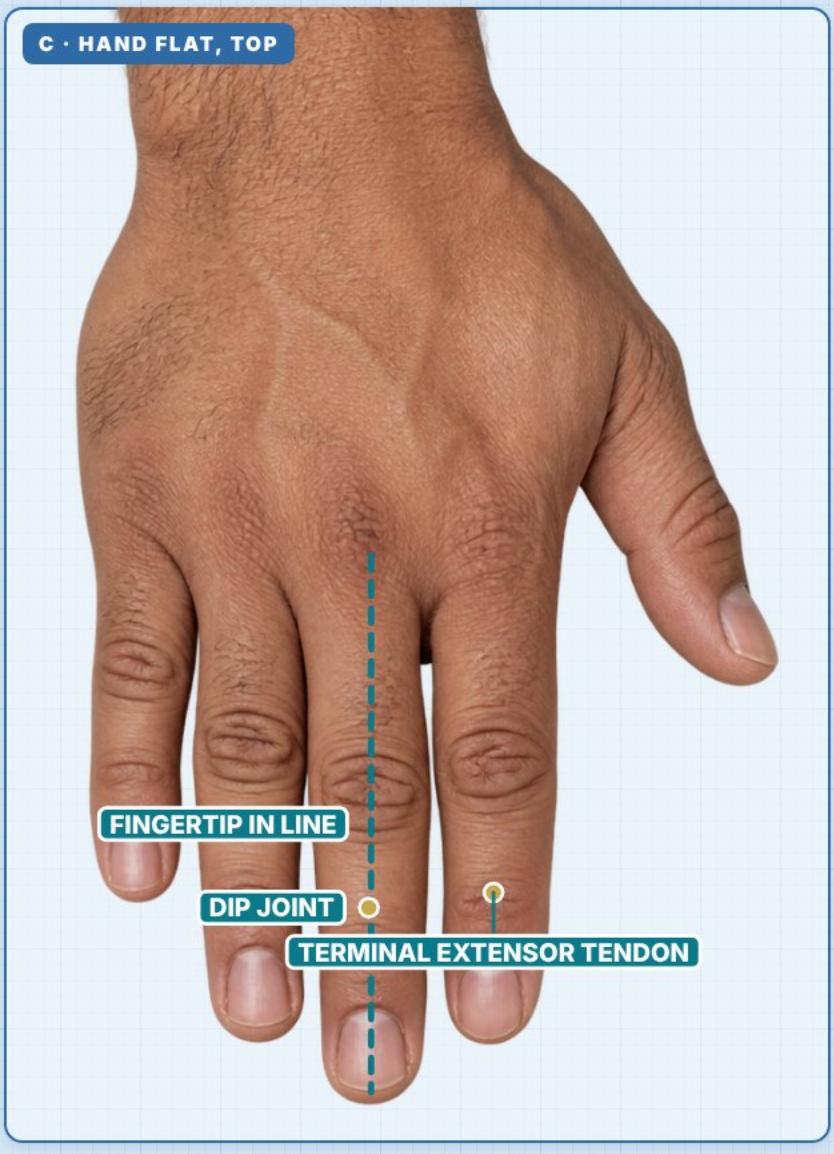
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Angles from landmarks placed on an illustrated figure (2-D, camera-plane); approximate. Finger line drawn on the figure for teaching. Educational, not diagnostic.

EYE-OPENER

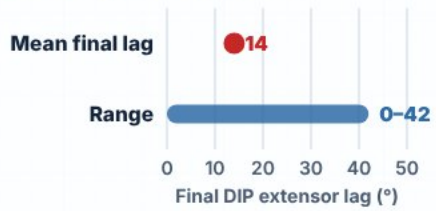
8.2/10 mean patient satisfaction after mallet splinting, despite some residual droop.

Gruber et al. (2014), via a third-party summary.

Checking the result

- With the hand flat, the fingertips should line up; a tip that will not lift fully at the DIP joint shows an extensor lag.
- Larger lag at enrolment and older age were linked to more lag at the end.

Some lag often remains



RCT after splinting; 20 analysed per group. Gruber et al. (2014), via a third-party summary.

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A · Impact Forced bend

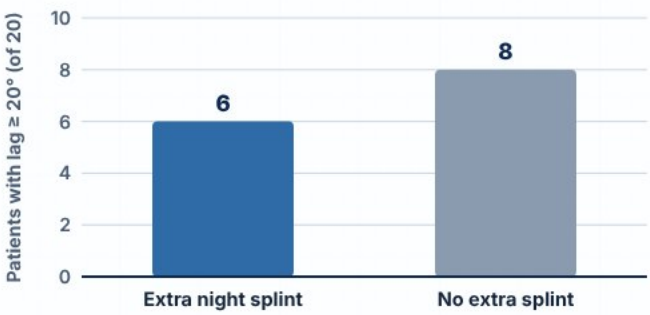


B · Splint 6–8 weeks



C · Check Lag

Extra night splinting added little



No significant difference ($p > 0.05$). Gruber et al. (2014), via a third-party summary.

Decision pathway

1. **PROTECT**
   Splint the DIP straight promptly after a drooping-tip injury and keep it on continuously.
2. **DOSE**
   Keep 6 weeks continuous for acute and 8 weeks for chronic injuries; extend if a lag persists.
3. **CHECK**
   Have the tip reviewed; a large bony fragment or a joint out of line needs a specialist decision.

NOT RECOMMENDED

Strapping a "jammed" tip and playing on; removing the splint and letting the tip bend during the healing weeks.

SEEK ASSESSMENT IF

A drooping fingertip after impact, a joint sitting out of line, an open wound over the joint or a nail-bed injury.

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

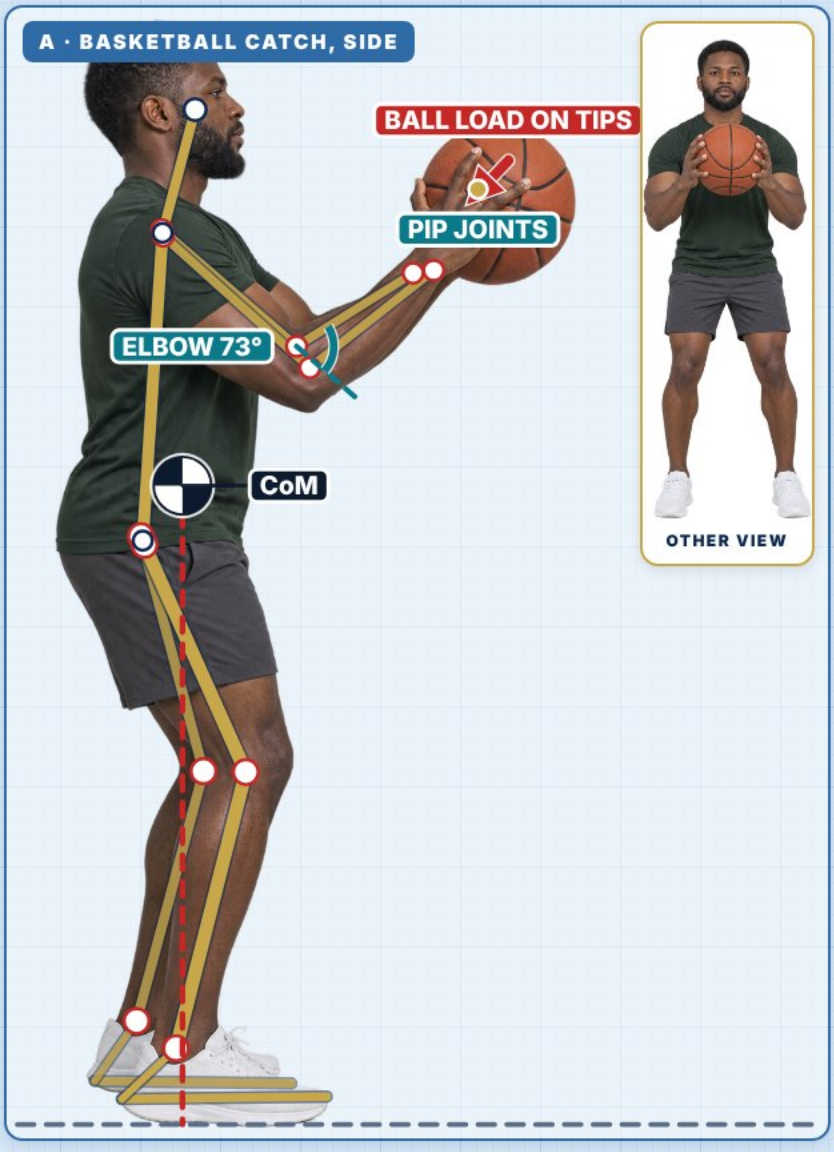
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FINGER SPRAINS AND JAMMED FINGERS IN BALL SPORTS

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2-D estimates from pose landmarks on an illustrated figure; CoM (if shown) from de Leva (1996); cm for a 1.70 m adult (Winter, 2009). Elbow from pose landmarks; ball-load arrow drawn on the figure for teaching. Educational, not diagnostic.

EYE-OPENER

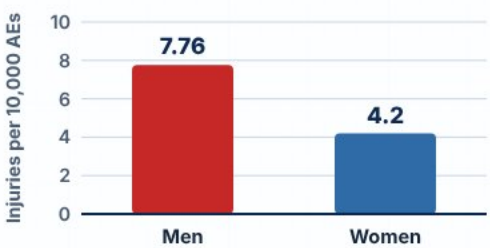
3.31× more likely in games than in practice for men's college basketball hand and wrist injuries.

Risk ratio, NCAA 2009/10–2013/14. Deckey et al. (2020).

The ball arrives at the fingertips

- Hands reach for the ball with the elbow flexed ≈**73°**; a mistimed catch drives the ball into the straight fingertips.
- That axial or sideways load lands on the PIP joint, spraining its collateral ligaments or volar plate.

Basketball hand and wrist injury rate



NCAA basketball; AE = athlete-exposure. Deckey et al. (2020).

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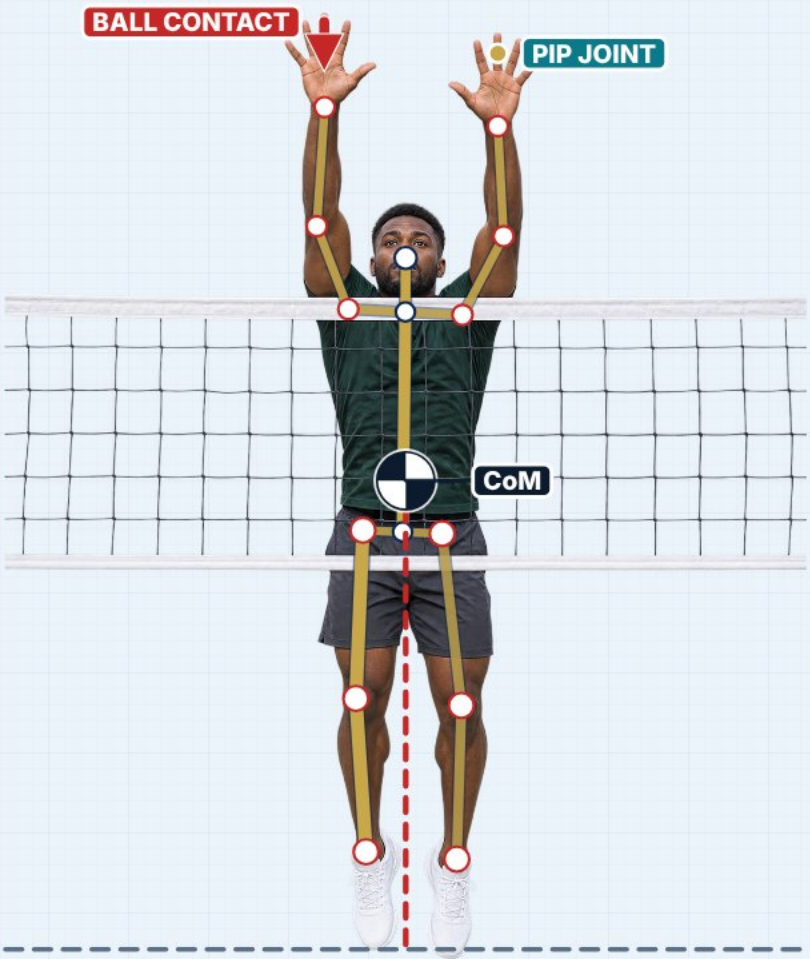
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B · VOLLEYBALL BLOCK, FRONT



EYE-OPENER

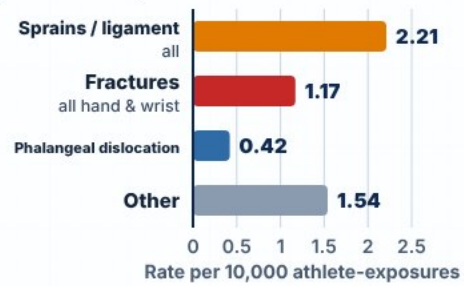
3.78% of college hand and wrist injuries needed surgery, across 11 sports.

103,098 injuries, NCAA 2004–2015. Holoyda et al. (2021).

Spread fingers meet a hard ball

- At the block, spread, straight fingers face a spiking ball; the impact bends a finger backward or sideways at the PIP joint.
- Most of these injuries are sprains, but fractures are about half as common, so not every jammed finger is minor.

Sprains lead, fractures follow



Hand and wrist injuries by diagnosis, 11 NCAA sports. Holoyda et al. (2021).

2-D estimates from pose landmarks on an illustrated figure; CoM (if shown) from de Leva (1996); cm for a 1.70 m adult (Winter, 2009). Skeleton and CoM from pose landmarks; contact arrow drawn on the figure for teaching. Educational, not diagnostic.

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EYE-OPENER

<24 h of restriction for most college basketball players after a hand or wrist injury.

Deckey et al. (2020).

The neighbour as a splint

- Taping the injured finger to its neighbour, with tape either side of the PIP joint, guards against sideways stress while still allowing it to bend.
- Buddy taping is common practice, not an evidence-graded treatment; deformity or a joint that will not straighten needs review.

Most return within a week



Time lost, all athletes; mean 7.14 days (95% CI 6.02–8.25). Holoyda et al. (2021).

Angles from landmarks placed on an illustrated figure (2-D, camera-plane); approximate. Load direction drawn on the figure for teaching. Educational, not diagnostic.

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A · Catch Axial load

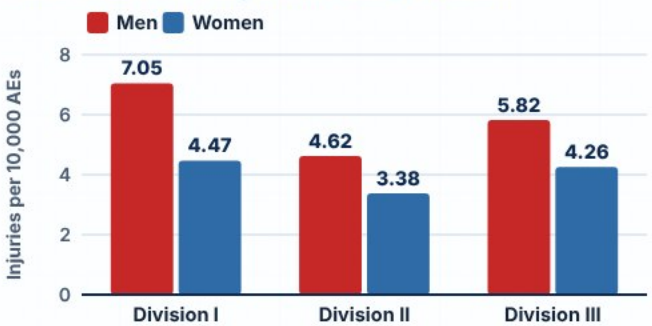


B · Block Spread tips



C · Tape Buddy

Men's rates are higher in every division



Hand and wrist injury rates, NCAA 2004–2015. Holoyda et al. (2021).

Decision pathway

1. **CHECK**
   Look for deformity, a tip or middle joint that will not straighten, and focal bone tenderness (X-ray if present).
2. **PROTECT**
   For a simple sprain, buddy tape to the neighbour finger and start gentle bending early.
3. **RETURN**
   Build grip and catching gradually as swelling and pain settle.

NOT RECOMMENDED

Pulling a jammed finger to "put it back"; it does not treat a sprain and may worsen a fracture-dislocation.

SEEK ASSESSMENT IF

Visible deformity, a fingertip or middle joint that will not straighten, numbness, a finger that rotates in a fist, a wound over the joint, or swelling not settling.

REFERENCES (APA 7)

de Leva, P. (1996). Adjustments to Zatsiorsky-Seluyanov's segment inertia parameters. *Journal of Biomechanics, 29*(9), 1223–1230. https://doi.org/10.1016/0021-9290(95)00178-6

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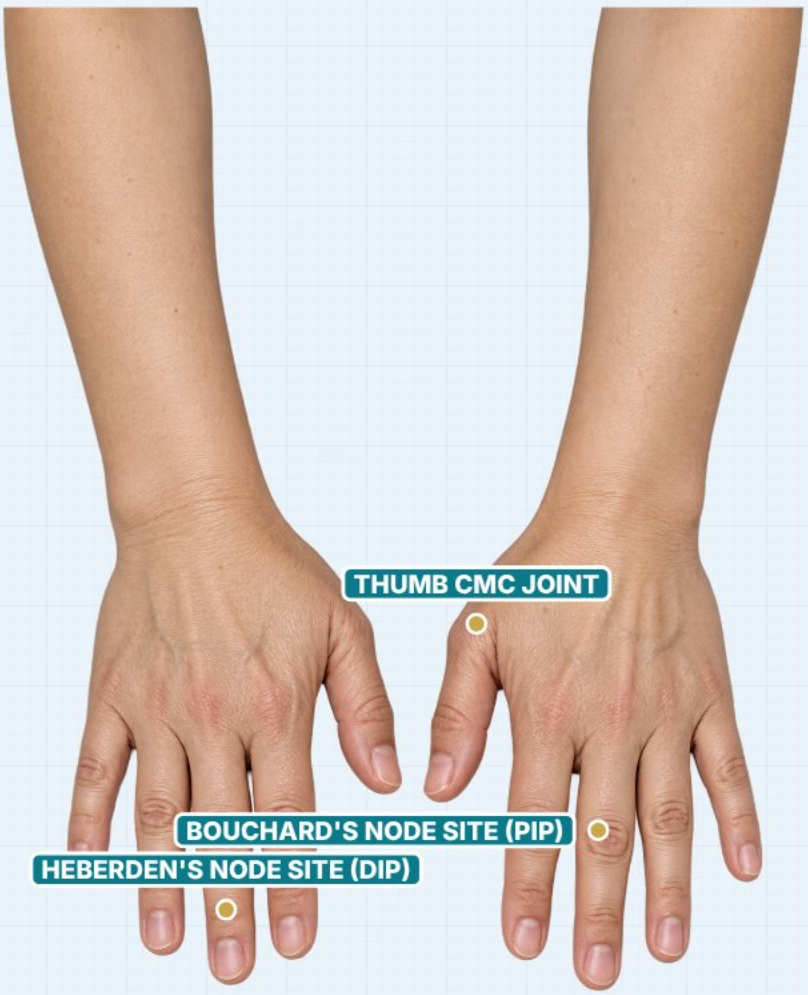
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HAND OSTEOARTHRITIS: HEBERDEN'S NODES, PAIN AND EXERCISE

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A · HANDS RESTING, TOP



EYE-OPENER

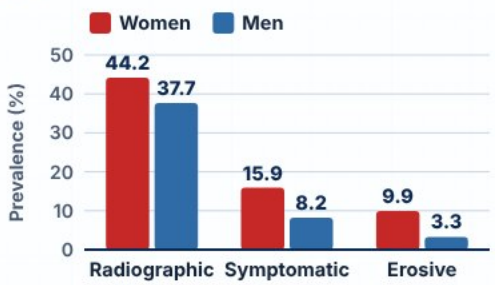
96% of women with hand OA showed X-ray progression over nine years.

Women 96.4%, men 91.4%. Framingham OA Study. Haugen et al. (2011).

Where the bumps appear

- Heberden's nodes are bony swellings at the end finger joints (DIP); Bouchard's nodes form at the middle joints (PIP); the thumb base is the third common site.
- Many hands with nodes on X-ray are not painful.

Nodes on X-ray are common, pain less so



Age-standardised; Framingham OA Study, ages 40–84 (mean 58.9). Haugen et al. (2011).

Angles from landmarks placed on an illustrated figure (2-D, camera-plane); approximate. Joint sites marked on the figure for teaching; no deformity measured. Educational, not diagnostic.

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Angles from landmarks placed on an illustrated figure (2-D, camera-plane); approximate. Pinch line drawn on the figure for teaching. Educational, not diagnostic.

EYE-OPENER

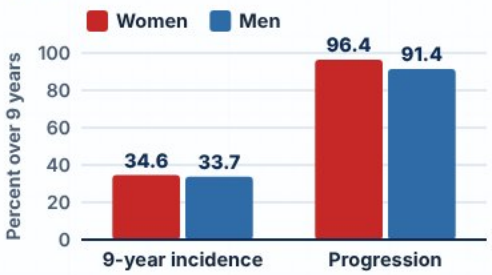
≥78% of participants stuck with hand-exercise programmes in the Cochrane trials.

Adherence 78%–94%. Østerås et al. (2017).

Fine pinch loads small joints

- Buttoning is a fingertip pinch: the force passes through the DIP and PIP joints, exactly where nodes form, so stiff or painful joints slow it down.
- Button hooks and larger buttons cut the pinch force needed.

New cases and progression over 9 years



Progression among people with OA at baseline. Haugen et al. (2011).

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EYE-OPENER

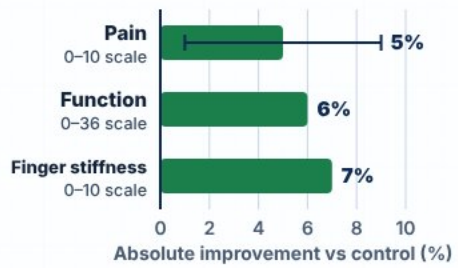
Grade A EULAR grade for exercise in every person with hand osteoarthritis.

Level of evidence 1a. Kloppenburg et al. (2019).

Squeeze to build tolerance

- Squeezing a soft ball works the finger flexors and thumb muscles against a gentle, adjustable resistance through all the small joints.
- Benefits in trials were small but consistent, with few, non-serious side effects.

Exercise helps pain, function and stiffness



7 RCTs, 534 participants; low-quality evidence; whisker = 95% CI (pain). Østerås et al. (2017).

Myth: "Using arthritic hands wears them out." Exercise is recommended for every patient (Grade A).

Angles from landmarks placed on an illustrated figure (2-D, camera-plane); approximate. Squeeze direction drawn on the figure for teaching. Educational, not diagnostic.

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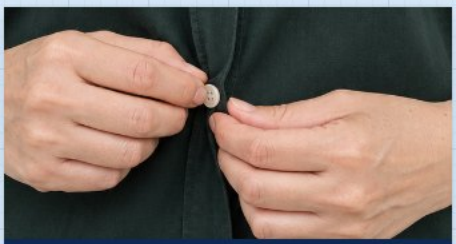
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A · Nodes DIP · PIP

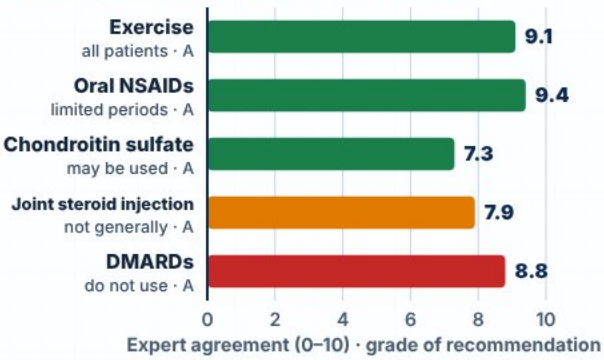


B · Button Fine pinch



C · Squeeze Exercise

What the guideline says to do, and not do



EULAR 2018 update; green = do, orange = not routinely, red = do not. Kloppenburg et al. (2019).

Decision pathway

1. **EDUCATE**
   Explain that nodes are common and often painless; teach pacing, joint-friendly grips and assistive devices.
2. **LOAD**
   Prescribe hand exercise for function, strength and pain, built up gradually.
3. **TRACK**
   Review pain, stiffness and task ease; topical NSAIDs before oral, oral only short-term.

NOT RECOMMENDED

Disease-modifying drugs (DMARDs) for hand OA, or routine steroid injections into finger joints.

SEEK ASSESSMENT IF

Symmetric knuckle and wrist swelling with morning stiffness over about an hour, a single hot red joint, rapid deformity or nerve symptoms.

REFERENCES (APA 7)

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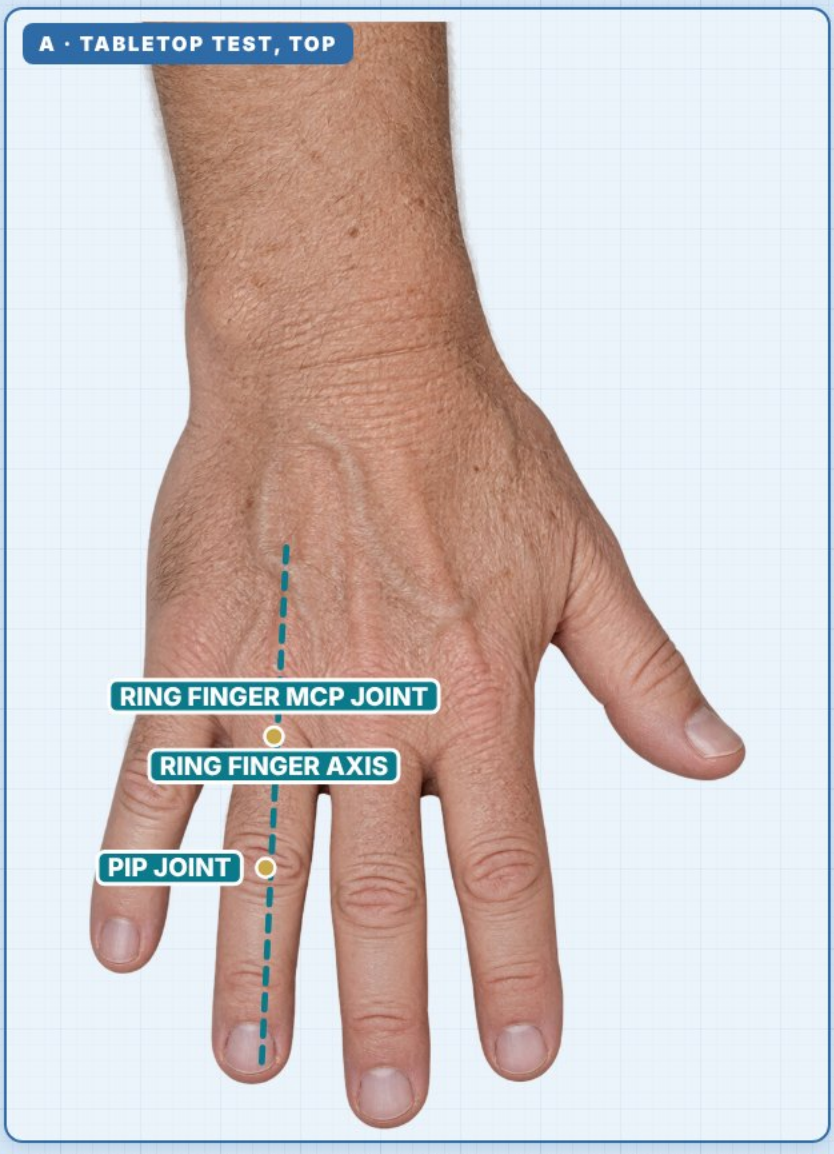
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DUPUYTREN'S CONTRACTURE: WHEN A FINGER SLOWLY PULLS INTO THE PALM

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Angles from landmarks placed on an illustrated figure (2-D, camera-plane); approximate. Finger axis and joint positions marked on the figure for teaching. Educational, not diagnostic.

EYE-OPENER

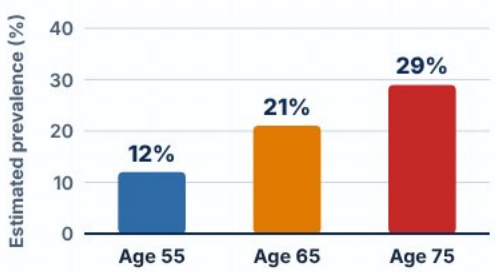
32% of 120 adults with diabetes had a mild form of Dupuytren's disease.

38 of 120 people. Chammas et al. (1995).

Fascia, not tendon

- Nodules and cords form in the palmar fascia; as a cord shortens it draws the MCP and PIP joints into fixed flexion. It is usually painless.
- The tabletop test asks whether the palm and fingers can lie flat; failure is commonly used in practice as a prompt for a hand-surgery opinion.

Prevalence climbs steeply with age



Mean modelled prevalence, western general populations (meta-analysis of 23 studies; age model from 10). Lanting et al. (2014).

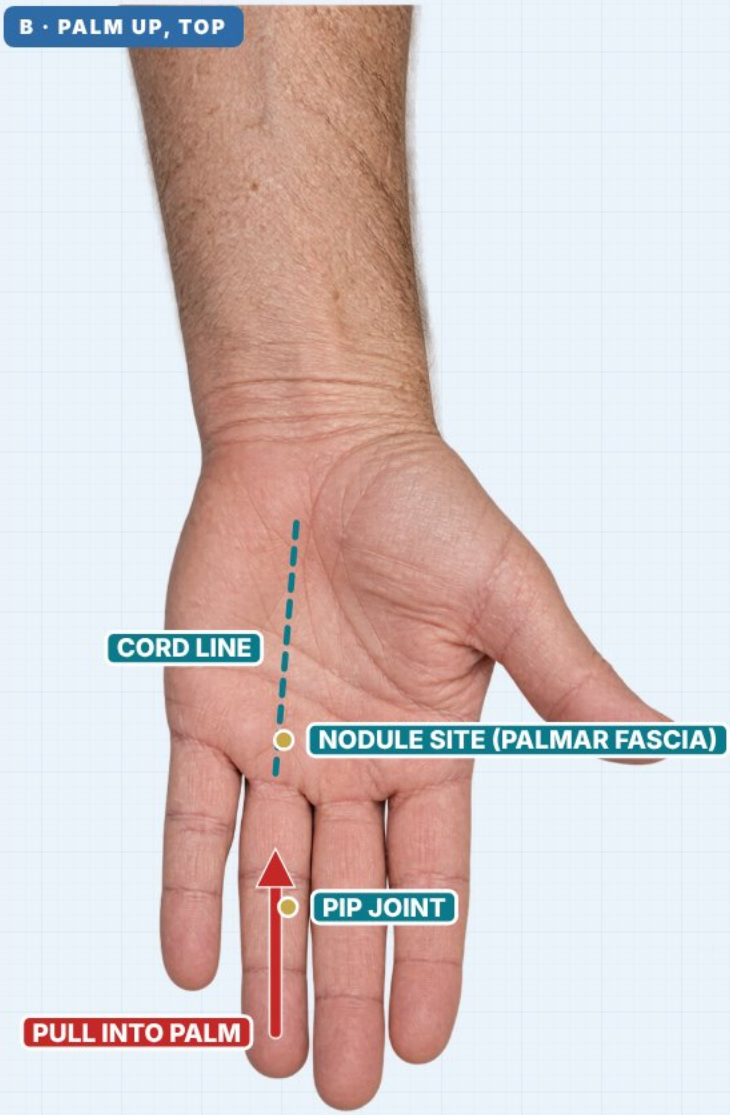
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Angles from landmarks placed on an illustrated figure (2-D, camera-plane); approximate. Cord line and pull direction drawn on the figure for teaching; no contracture is shown. Educational, not diagnostic.

EYE-OPENER

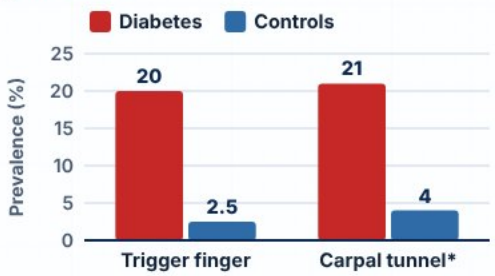
64% of cords treated with collagenase reached 0–5° of full extension, against 6.8% with placebo.

30 days after the last injection; 308 patients. Hurst et al. (2009).

Where to look in the palm

- Nodules typically sit in the palm in line with the ring and little fingers; a cord can be felt running from the palm towards the finger.
- As the cord contracts, extension is lost first, so the finger cannot be straightened even though it still bends normally.

Diabetes crowds the palm with problems



*Approximate values. Same diabetic sample, which also showed Dupuytren's disease in 32%. Chammas et al. (1995).

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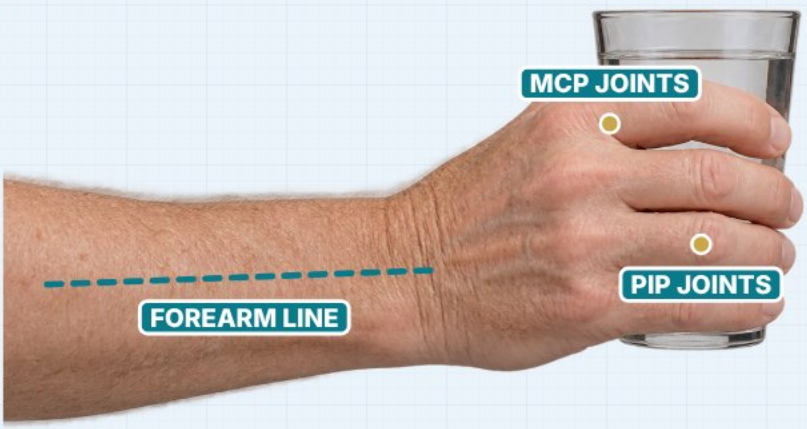
BIOMECHANICS IS A FORCE-GOVERNED DECISION SYSTEM – NOT A POSTURE MODEL.

INTEGRATING PERFORMANCE & REHABILITATION HEALTHCARE PATHWAYS.

DUPUYTREN'S CONTRACTURE: WHEN A FINGER SLOWLY PULLS INTO THE PALM

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C · GLASS GRIP, SIDE



EYE-OPENER

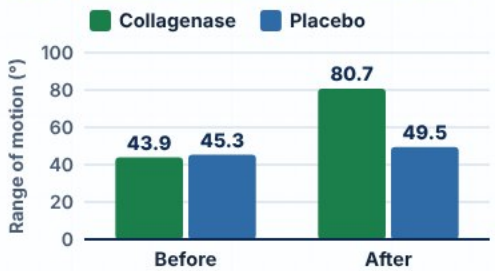
53% of needle-fasciotomy patients would choose the needle again, despite frequent recurrence.

Five-year randomised trial. van Rijssen et al. (2012).

Grip survives, opening fails

- Wrapping the fingers around a glass needs flexion, which the cord does not block; trouble starts when the hand must open or lie flat.
- So function is judged by extension deficit at each joint, not by grip strength alone.

Collagenase restored finger motion



Mean joint range of motion before and after treatment; CORD I trial, 308 patients. Hurst et al. (2009).

Myth: "Stretching fixes it." Trial corrections came from procedures; stretching alone was not shown to reverse a contracture.

Angles from landmarks placed on an illustrated figure (2-D, camera-plane); approximate. Forearm line and joint positions marked on the figure for teaching. Educational, not diagnostic.

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A · Flat Tabletop test

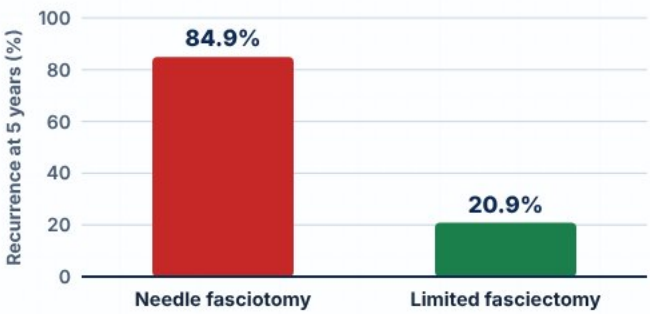


B · Palm Nodule site



C · Grip Extension lost

The quick fix returns more often



111 patients, 115 hands, extension deficit ≥ 30°; recurrence = deficit increase > 30°. van Rijssen et al. (2012).

Decision pathway

1. **CHECK**
   Tabletop test and joint extension deficits; refer for a hand-surgery opinion when the hand cannot lie flat.
2. **DISCUSS**
   Weigh needle fasciotomy (quick, recurs more), collagenase and limited fasciectomy (more durable).
3. **TRACK**
   Re-measure deficits over time; progression, especially at the PIP joint, brings review forward.

NOT RECOMMENDED

Forcing a bent finger straight, or relying on stretching or splinting alone to reverse a contracture.

SEEK ASSESSMENT IF

Chest or left-arm pain, a hot swollen joint with fever, deformity after a fall, worsening numbness or weakness, or a tight swollen forearm: seek prompt assessment.

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INTEGRATING PERFORMANCE & REHABILITATION HEALTHCARE PATHWAYS.

ARM PAIN THAT COMES FROM THE NECK: CERVICAL RADICULOPATHY

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A · HEAD TILTED BACK, SIDE





OTHER VIEW

EYE-OPENER

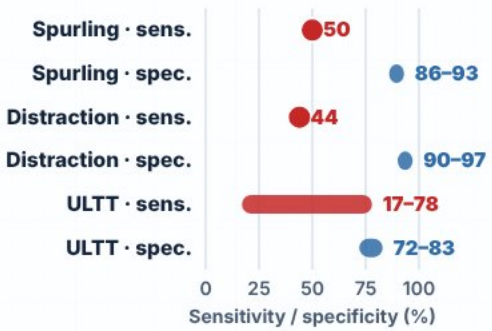
14.8% of people recalled any exertion or injury before their nerve-root pain began.

561 patients, Rochester, Minnesota, 1976–90. Radhakrishnan et al. (1994).

Closing the exit door

- Tilting the head back and turning towards the painful side narrows the intervertebral foramen, where the nerve root leaves the spine.
- This is the Spurling position: if it reproduces arm pain, the source may be the neck rather than the elbow or forearm.

Specific, but easily missed



Point or reported range; ULTT = median-nerve upper-limb tension test. JOSPT guideline summary, Blanpied et al. (2017).

2-D estimates from pose landmarks on an illustrated figure (head-to-hip framing); lengths scaled to a 1.70 m adult (Winter, 2009). Neck axis drawn on the figure for teaching; no angle is quoted. Educational, not diagnostic.

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2-D estimates from pose landmarks on an illustrated figure (head-to-hip framing); lengths scaled to a 1.70 m adult (Winter, 2009). Elbow angle from pose landmarks in the front view. Educational, not diagnostic.

EYE-OPENER

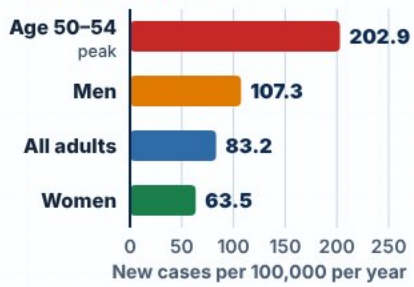
21.9% of cases were caused by a confirmed disc protrusion; most were not.

Population study, 561 patients. Radhakrishnan et al. (1994).

Hand on head, root unloaded

- Resting the hand on the head with the elbow bent ≈**82°** raises the shoulder girdle and shortens the nerve's path, slackening the root.
- Many people find this eases their arm pain, a clinical observation that points to the neck; no figure for it was verified.

Peaks in the early fifties



Annual incidence, Rochester, Minnesota, 1976–90; 561 patients. Radhakrishnan et al. (1994).

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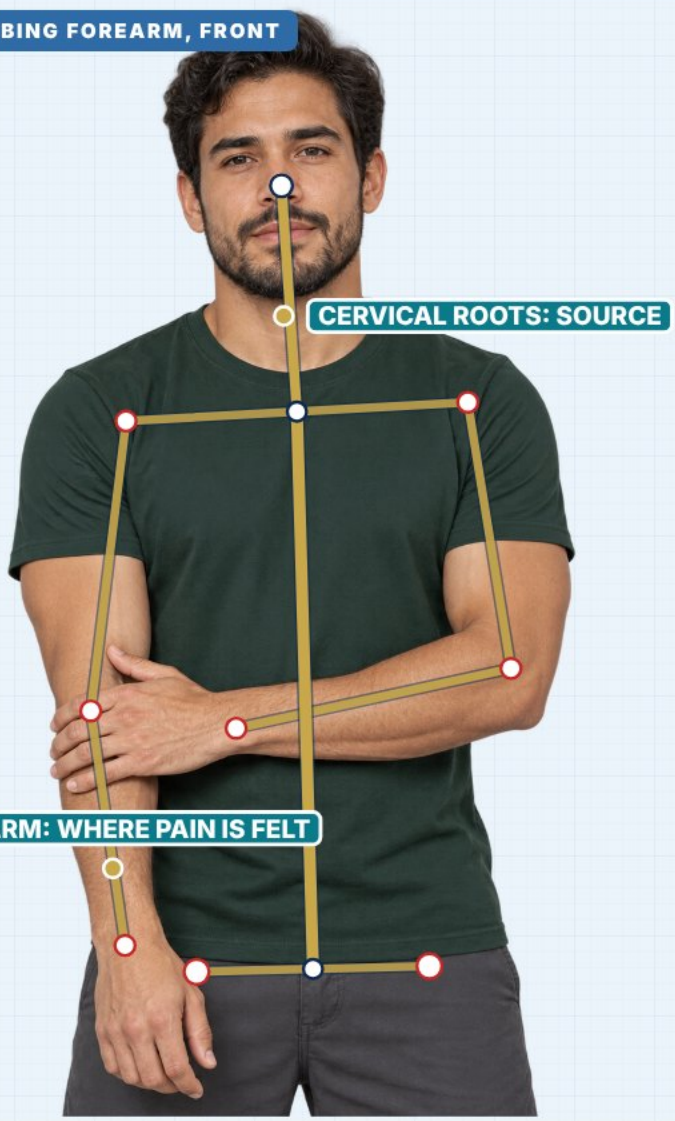
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C · RUBBING FOREARM, FRONT



EYE-OPENER

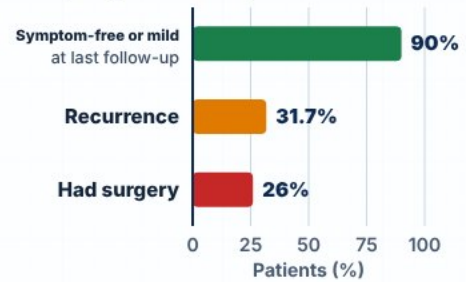
C7 was the commonest single nerve root affected, then C6, so pain often runs down the forearm.

Rochester population study. Radhakrishnan et al. (1994).

Felt in the forearm, born in the neck

- Root pain follows a dermatomal band, so forearm pain, tingling or weakness can come from a cervical root; arm pain often exceeds neck pain.
- Rubbing the forearm treats the symptom site, not the source; neck tests and a neurological check guide the decision.

Most people do well, but it can return



Population cohort, 561 patients, Rochester, Minnesota. Radhakrishnan et al. (1994).

Myth: "A trapped nerve needs surgery." 90% were symptom-free or only mildly affected at follow-up.

2-D estimates from pose landmarks on an illustrated figure (head-to-hip framing); lengths scaled to a 1.70 m adult (Winter, 2009). Skeleton from pose landmarks in the front view; anatomy labels for teaching. Educational, not diagnostic.

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A · Provoke Foramen closes



B · Relieve Root slack



C · Locate Referred pain

What the neck pain guideline grades

PHASE	INTERVENTION	GRADE
All	Screen for serious pathology first (infection, cancer, cardiac, fracture)	A
Chronic	Intermittent traction with stretching, strengthening and mobilisation	B
Chronic	Education to stay in work and exercise	B
Acute	Exercise, laser, short-term collar	C

Neck pain with radiating arm pain; A = strong, B = moderate, C = weak evidence. Blanpied et al. (2017).

Decision pathway

1. **SCREEN**
   Rule out serious pathology and myelopathy (clumsy hands, gait or bladder change) before any loading plan.
2. **TEST**
   Use Spurling, distraction and neurodynamic tests together with a neurological check; no single test decides.
3. **LOAD**
   Keep active; graded neck and arm exercise, with traction in a multimodal plan for persistent radiating pain.

NOT RECOMMENDED

Treating forearm pain locally without checking the neck, or forcing end-range neck positions that reproduce arm pain.

SEEK ASSESSMENT IF

Chest or left-arm pain, a hot swollen joint with fever, deformity after a fall, worsening numbness or weakness, or a tight swollen forearm: seek prompt assessment.

REFERENCES (APA 7)

Blanpied, P. R., Gross, A. R., Elliott, J. M., Devaney, L. L., Clewley, D., Walton, D. M., Sparks, C., & Robertson, E. K. (2017). Neck pain: Revision 2017. *Journal of Orthopaedic & Sports Physical Therapy, 47*(7), A1–A83. https://doi.org/10.2519/jospt.2017.0302

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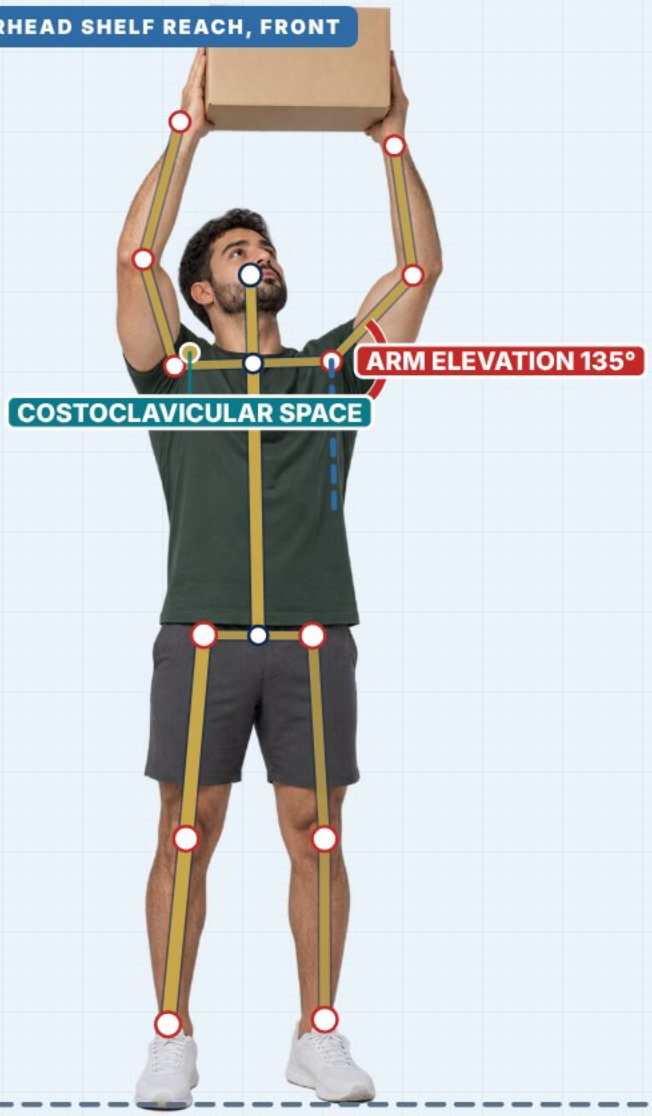
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THORACIC OUTLET SYNDROME: ARM HEAVINESS WITH OVERHEAD WORK

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A · OVERHEAD SHELF REACH, FRONT



EYE-OPENER

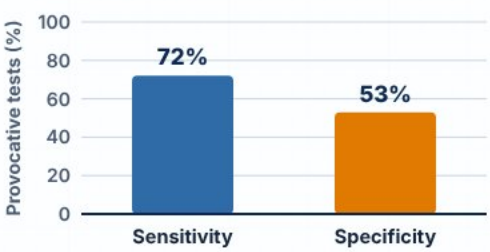
2–3 new cases of neurogenic TOS per 100,000 people a year: rare, and often over-diagnosed.

Estimated incidence, review. Dengler et al. (2022).

A crowded exit for the arm's supply

- Reaching high with the arm raised ≈**135°** narrows the gap between clavicle and first rib, where the brachial plexus and subclavian vessels pass.
- In neurogenic TOS, sustained overhead work brings arm heaviness, tingling and fatigue rather than sharp joint pain.

Tests flag many, confirm few



Pooled clinical provocative tests, as summarised in a review. Dengler et al. (2022).

2-D estimates from pose landmarks on an illustrated figure; CoM (if shown) from de Leva (1996); cm for a 1.70 m adult (Winter, 2009). Arm elevation from pose landmarks (trunk line to upper arm). Educational, not diagnostic.

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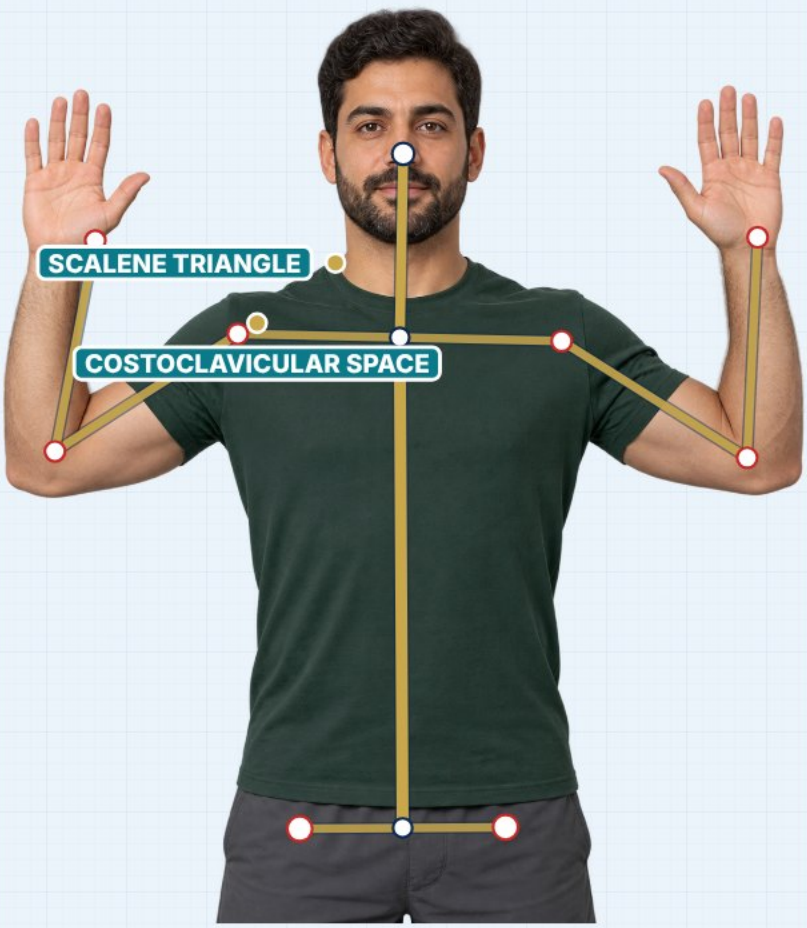
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B · HANDS-UP POSITION, FRONT



EYE-OPENER

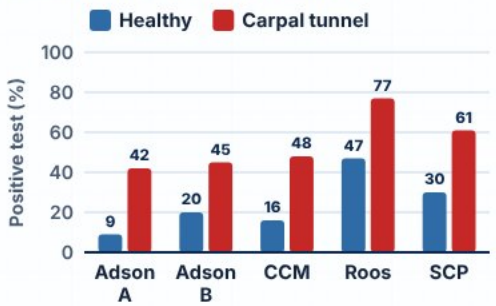
15 y Diagnostic delays of 1.3 up to 15 years have been reported for neurogenic TOS.

Review of published series. Dengler et al. (2022).

The hands-up test position

- Arms raised with elbows bent is the Roos (elevated arm stress) position: repeated hand opening and closing is meant to provoke heaviness or tingling.
- It closes the costoclavicular space, but healthy people and those with carpal tunnel syndrome often test positive too.

False positives are common



CCM = costoclavicular manoeuvre; SCP = supraclavicular pressure; Roos = elevated arm stress test. Nord et al. (2008).

2-D estimates from pose landmarks on an illustrated figure (head-to-hip framing); lengths scaled to a 1.70 m adult (Winter, 2009). Skeleton from pose landmarks; arms shown near shoulder height. Anatomy labels for teaching. Educational, not diagnostic.

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C · HEAVY SHOULDER BAG, SIDE



EYE-OPENER

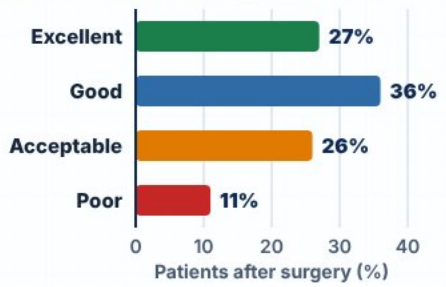
82–85% of classified surgical TOS cases are neurogenic, not venous or arterial.

Surgical series summarised in a review. Dengler et al. (2022).

Load that pulls the girdle down

- A heavy bag on one strap drags the shoulder girdle down and back, narrowing the space between clavicle and first rib over the plexus.
- Lighter, cross-body or two-strap carrying spreads the load, a simple first change in a conservative plan.

Outcomes in one surgical series



After failed conservative care; one series, as summarised in a review. Dengler et al. (2022).

Myth: "A positive Roos test confirms TOS." 47% of healthy people tested positive, and 56% had at least one positive manoeuvre.

2-D estimates from pose landmarks on an illustrated figure; CoM (if shown) from de Leva (1996); cm for a 1.70 m adult (Winter, 2009). Skeleton from pose landmarks; strap and bag load directions drawn for teaching. Educational, not diagnostic.

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A · Reach Space narrows

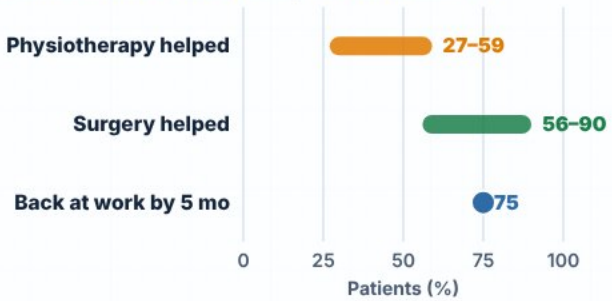


B · Test False positives



C · Carry Girdle dragged

Conservative first, surgery for the few



Ranges across studies; surgery after failed conservative care; return to work after surgery. Review. Dengler et al. (2022).

Decision pathway

1. **MODIFY**
   Cut sustained overhead work and heavy one-strap carrying; break up reaching with arm-down rests.
2. **LOAD**
   Physiotherapy for 8–12 weeks: scapular control, scalene and pectoral mobility, nerve gliding.
3. **REFER**
   Disabling symptoms after 8–12 weeks of conservative care: specialist review and investigations.

NOT RECOMMENDED

Diagnosing TOS from one positive provocative test, or rushing to surgery before a full conservative trial.

SEEK ASSESSMENT IF

Sudden arm swelling with blue discolouration, a cold pale painful hand, finger ulcers or hand-muscle wasting: same-day medical care.

REFERENCES (APA 7)

de Leva, P. (1996). Adjustments to Zatsiorsky-Seluyanov's segment inertia parameters. *Journal of Biomechanics, 29*(9), 1223–1230. https://doi.org/10.1016/0021-9290(95)00178-6

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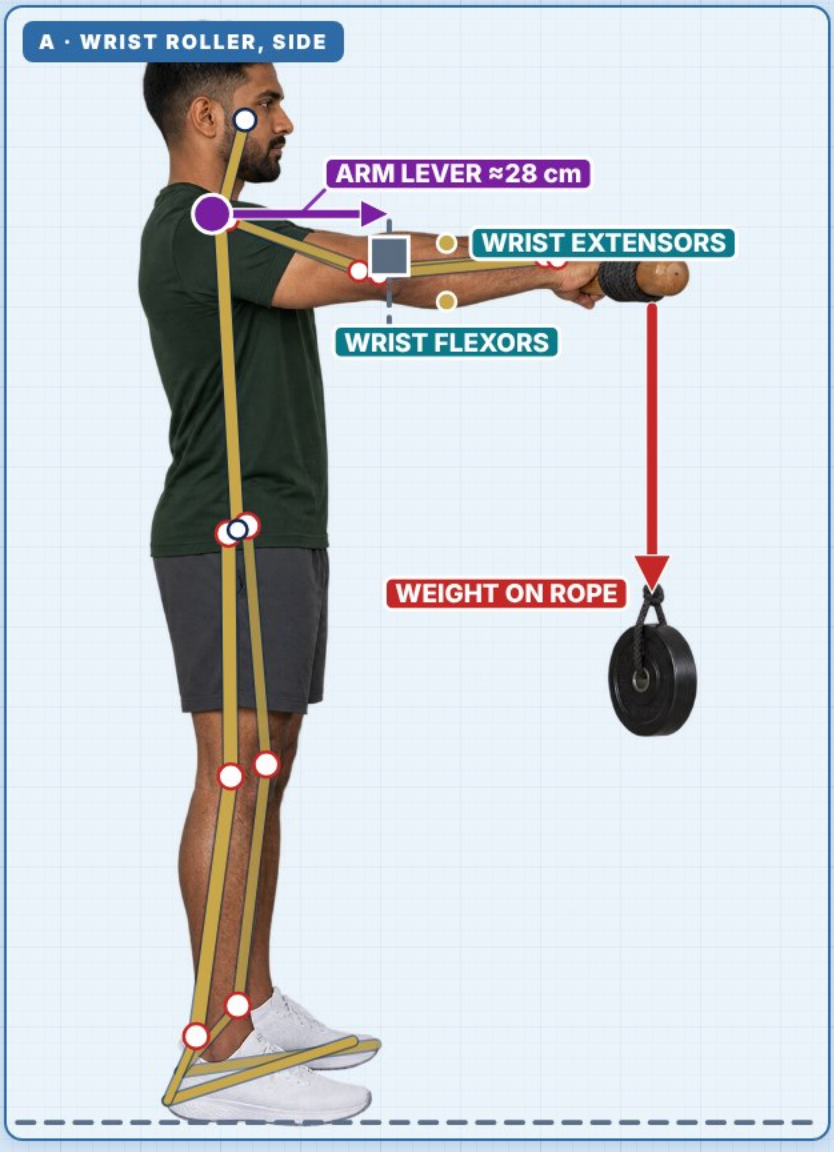
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ARM TENDON PAIN AND LOAD: THE STRESS-SHIELDING AND OVERLOAD BALANCE

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EYE-OPENER

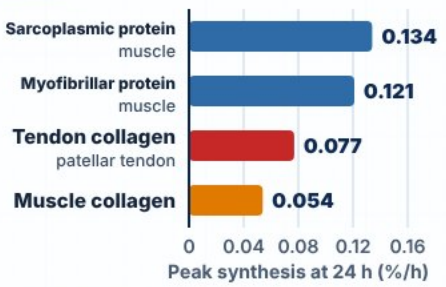
58% of tendon stiffness was lost after 90 days of bed rest, a leg tendon.

Gastrocnemius tendon, in vivo. Reeves et al. (2005).

Load is the tendon's signal

- Arms held forward: arm lever ≈**28 cm**, shoulder moment ≈**10 N·m** from arm weight alone, while rolling the rope loads the wrist tendons.
- One loading bout switches on collagen synthesis in tendon as well as muscle; the human data come from the leg (patellar tendon).

Tendon responds, more slowly than muscle



Healthy young men, 1 h one-legged kicking at 67% Wmax; leg data, used as a principle. Miller et al. (2005).

2-D estimates from pose landmarks on an illustrated figure; CoM (if shown) from de Leva (1996); cm for a 1.70 m adult (Winter, 2009). Arm lever: shoulder joint to arm CoM; moment = arm weight × lever, 70 kg adult, static. No rope load included. Educational, not diagnostic.

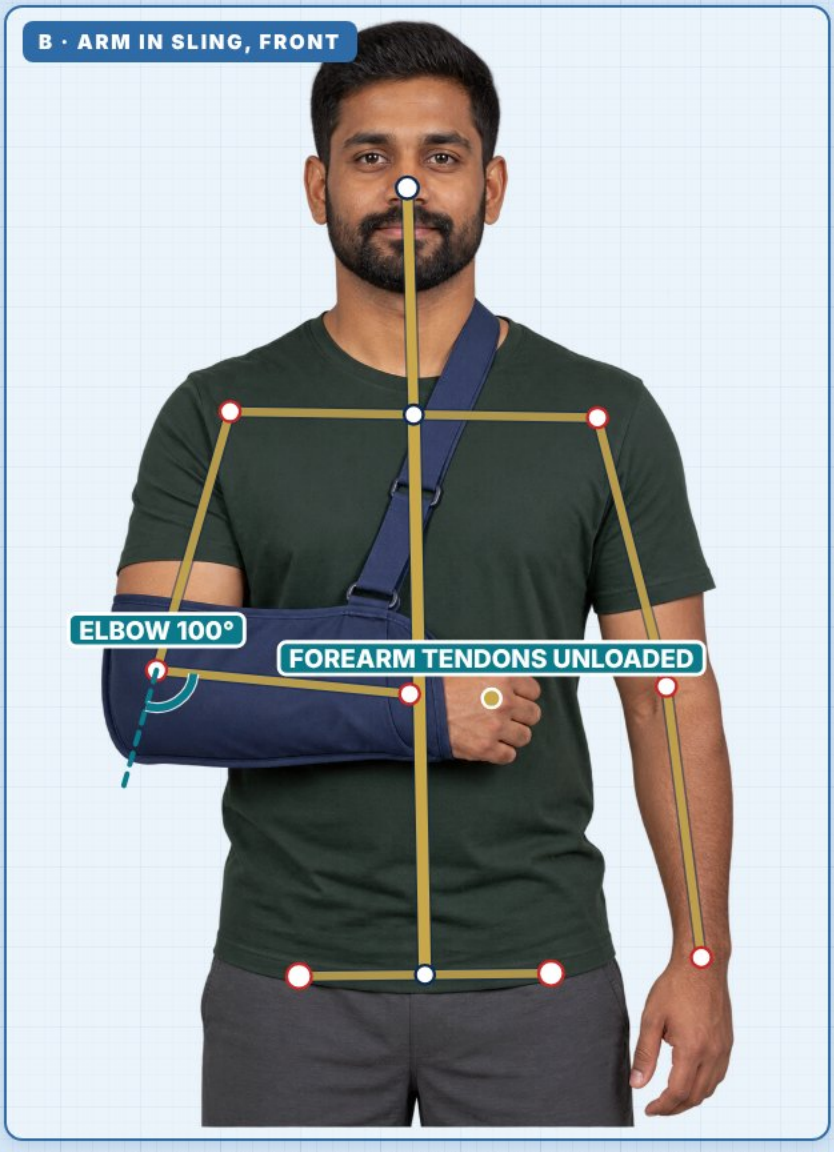
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2-D estimates from pose landmarks on an illustrated figure (head-to-hip framing); lengths scaled to a 1.70 m adult (Winter, 2009). Elbow angle from pose landmarks in the front view. Educational, not diagnostic.

EYE-OPENER

72 h Tendon collagen synthesis was still raised three days after one hour of exercise.

Patellar tendon biopsies. Miller et al. (2005).

Rest shields, then weakens

- In a sling the elbow rests at ≈**100°** and the forearm tendons carry almost no load: useful after acute injury or surgery, costly if prolonged.
- Human unloading data come from leg tendons: 90 days without load cut stiffness by more than half; exercise limited the loss.

Unloading costs stiffness; loading protects it



90-day bed rest, human gastrocnemius tendon (leg data; no arm dataset verified). Reeves et al. (2005).

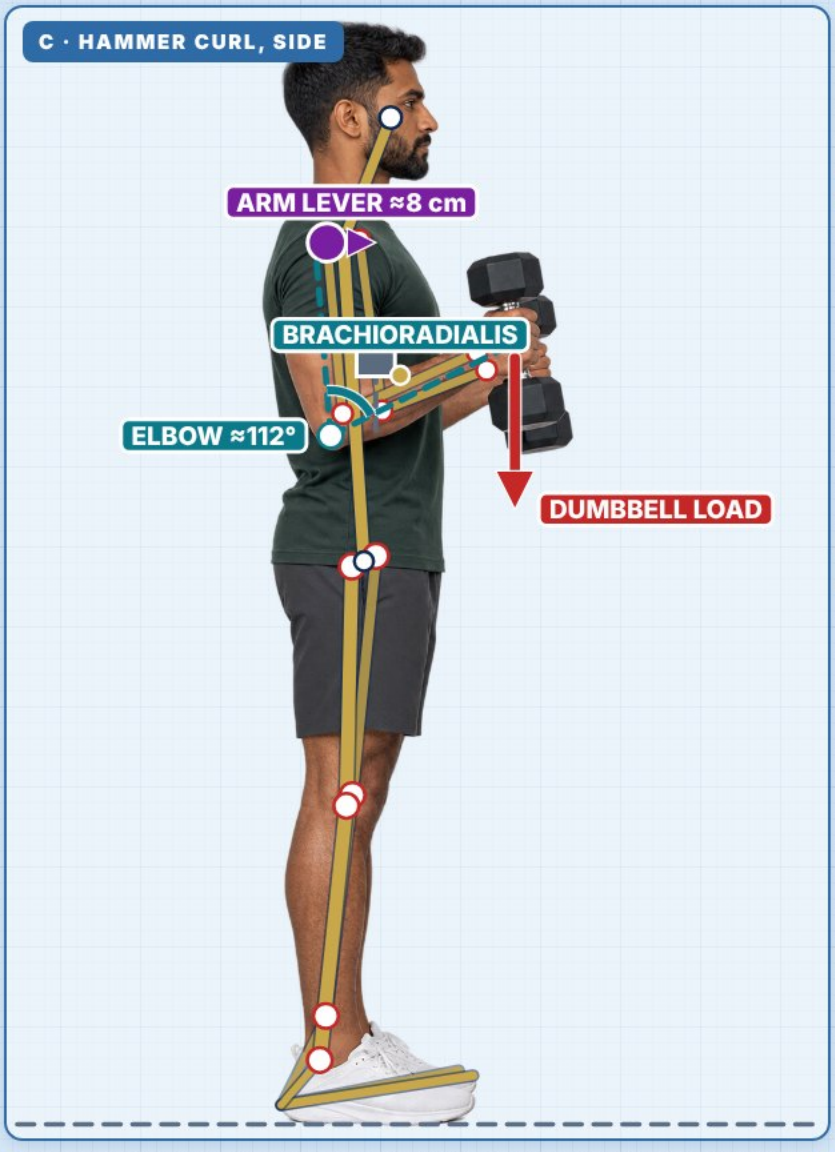
DOI 10.5281/zenodo.23735910

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

INTEGRATING PERFORMANCE & REHABILITATION HEALTHCARE PATHWAYS.

ARM TENDON PAIN AND LOAD: THE STRESS-SHIELDING AND OVERLOAD BALANCE

AN MMSX AUTHORITY | APPLIED BIOMECHANICS LAB EDUCATIONAL ANALYSIS



EYE-OPENER

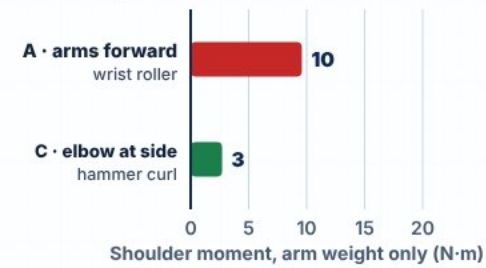
1h of one-legged kicking was enough to raise tendon collagen synthesis for days.

Healthy young men. Miller et al. (2005).

Dose the tissue you want to change

- Hammer curl with the elbow ≈**112°** and the upper arm by the side: the load sits on the elbow flexors and brachioradialis, not the shoulder.
- Choosing position is choosing dose: a short shoulder lever here, a long one with the arms held forward.

Same arm, different lever



Measured on Frames A and C; static moment from arm weight, 70 kg adult; hand load excluded.

Myth: "Rest until the tendon stops hurting." Unloading weakens tendon; graded loading during rest limited the loss.

2-D estimates from pose landmarks on an illustrated figure; CoM (if shown) from de Leva (1996); cm for a 1.70 m adult (Winter, 2009). Arm lever: shoulder joint to arm CoM; moment = arm weight × lever, 70 kg adult, static. Elbow angle from manual landmarks. Educational, not diagnostic.

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A · Load Long lever

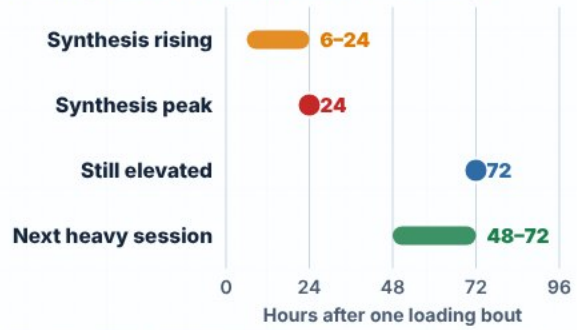


B · Shield Unloaded



C · Dose Short lever

Spacing heavy tendon work (teaching)



Timeline from leg-tendon synthesis data (Miller et al., 2005); 48–72 h spacing is a reasoned principle, not a trial result.

Decision pathway

1. **UNLOAD BRIEFLY**
   Use a sling or rest only as prescribed after acute injury or surgery, then reintroduce load.
2. **LOAD**
   Progress isometric, then slow heavy, then functional work such as wrist roller and hammer curl.
3. **MONITOR**
   Check pain the next day; if it escalates, reduce dose and allow 48–72 h before the next heavy session.

NOT RECOMMENDED

Prolonged complete rest or sling use for tendon pain, or jumping straight to heavy, fast loading.

SEEK ASSESSMENT IF

Chest or left-arm pain, a hot swollen joint with fever, deformity after a fall, worsening numbness or weakness, or a tight swollen forearm: seek prompt assessment.

REFERENCES (APA 7)

de Leva, P. (1996). Adjustments to Zatsiorsky-Seluyanov's segment inertia parameters. *Journal of Biomechanics, 29*(9), 1223–1230. https://doi.org/10.1016/0021-9290(95)00178-6

Miller, B. F., Olesen, J. L., Hansen, M., Døssing, S., Crameri, R. M., Welling, R. J., Langberg, H., Flyvbjerg, A., Kjaer, M., Babraj, J. A., Smith, K., & Rennie, M. J. (2005). Coordinated collagen and muscle protein synthesis in human patella tendon and quadriceps muscle after exercise. *The Journal of Physiology, 567*(3), 1021–1033. https://doi.org/10.1113/jphysiol.2005.093690

Reeves, N. D., Maganaris, C. N., Ferretti, G., & Narici, M. V. (2005). Influence of 90-day simulated microgravity on human tendon mechanical properties and the effect of resistive countermeasures. *Journal of Applied Physiology, 98*, 2278–2286. https://doi.org/10.1152/japplphysiol.01266.2004

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

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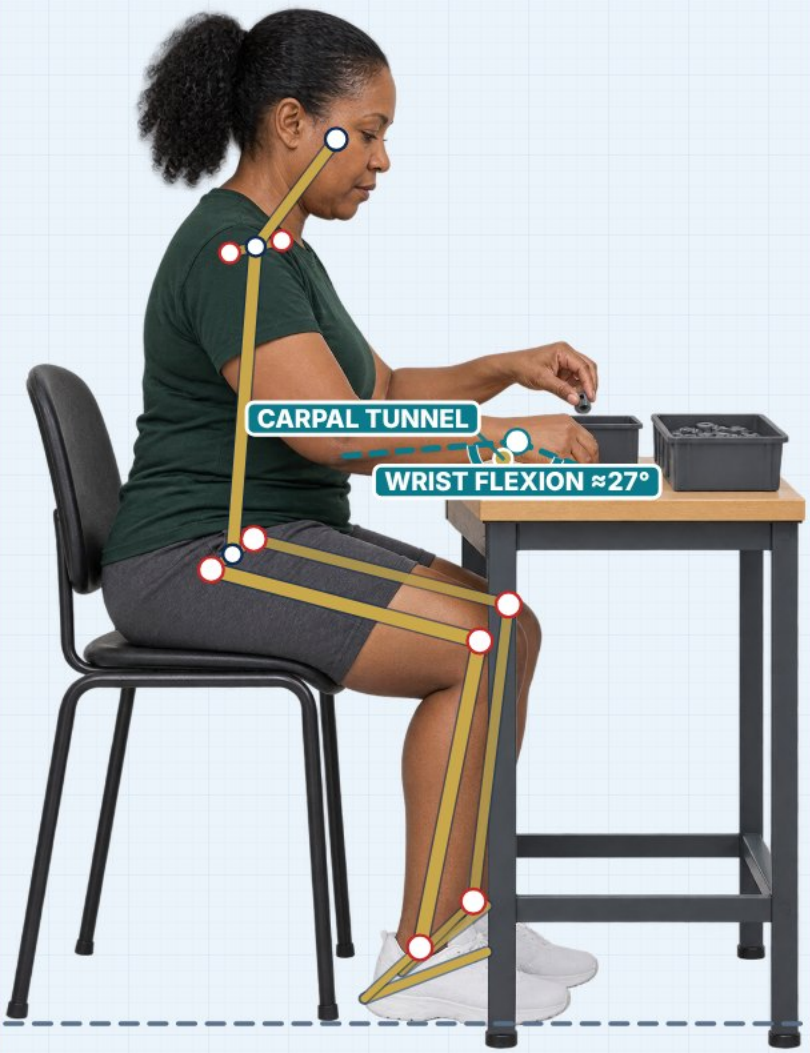
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INTEGRATING PERFORMANCE & REHABILITATION HEALTHCARE PATHWAYS.

REPETITIVE STRAIN INJURY AT WORK: A MECHANICAL APPROACH TO RSI

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A · BENCH ASSEMBLY, SIDE



2-D estimates from pose landmarks on an illustrated figure; CoM (if shown) from de Leva (1996); cm for a 1.70 m adult (Winter, 2009). Trunk and leg skeleton from pose landmarks. Wrist angle from manually placed forearm and hand landmarks. Educational, not diagnostic.

EYE-OPENER

20–60% of office workers have work-related upper-limb or neck disorders, depending on the study.

Prevalence range cited in a Cochrane review. Hoe et al. (2018).

RSI is a dose, not a diagnosis

- Pinching small parts with the wrist bent ≈**27°** into flexion, cycle after cycle, combines repetition with an awkward posture over the carpal tunnel.
- A mechanical approach asks which exposure dominates (force, repetition, posture or vibration) and changes that dose first.

Bent wrists carry higher odds



CTS = carpal tunnel syndrome. One study as reported in a New Zealand ACC evidence brief (secondary source). Stephenson & Barry (2014).

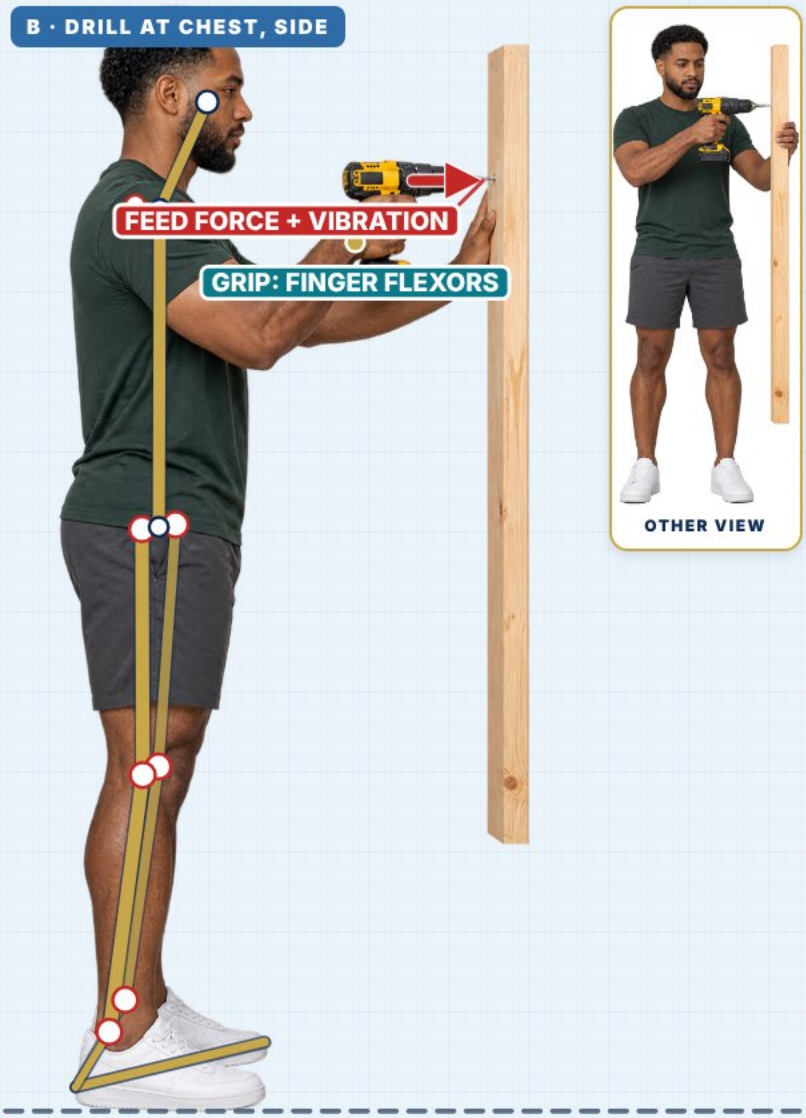
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EYE-OPENER

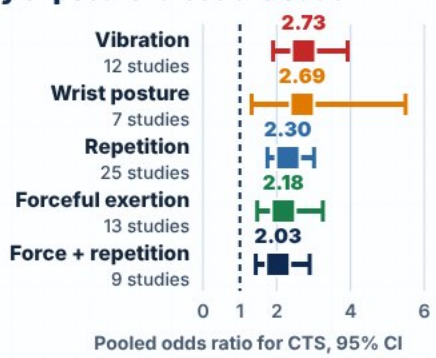
>4 kg average hand force was linked with carpal tunnel syndrome in a systematic review.

Also ≥ 50% of cycle time on the same movements. van Rijn et al. (2009).

Force plus vibration

- Pushing a drill into the board needs a hard grip and a steady feed force, while the tool transmits vibration into the hand and forearm.
- Daily vibration of 3.9 m/s² (8-h equivalent) was linked with carpal tunnel syndrome; lighter tools and time limits cut the dose.

Every exposure raises the odds



2012 meta-analysis as reported in a New Zealand ACC evidence brief (secondary source). Stephenson & Barry (2014).

2-D estimates from pose landmarks on an illustrated figure; CoM (if shown) from de Leva (1996); cm for a 1.70 m adult (Winter, 2009). Force direction drawn for teaching. Educational, not diagnostic.

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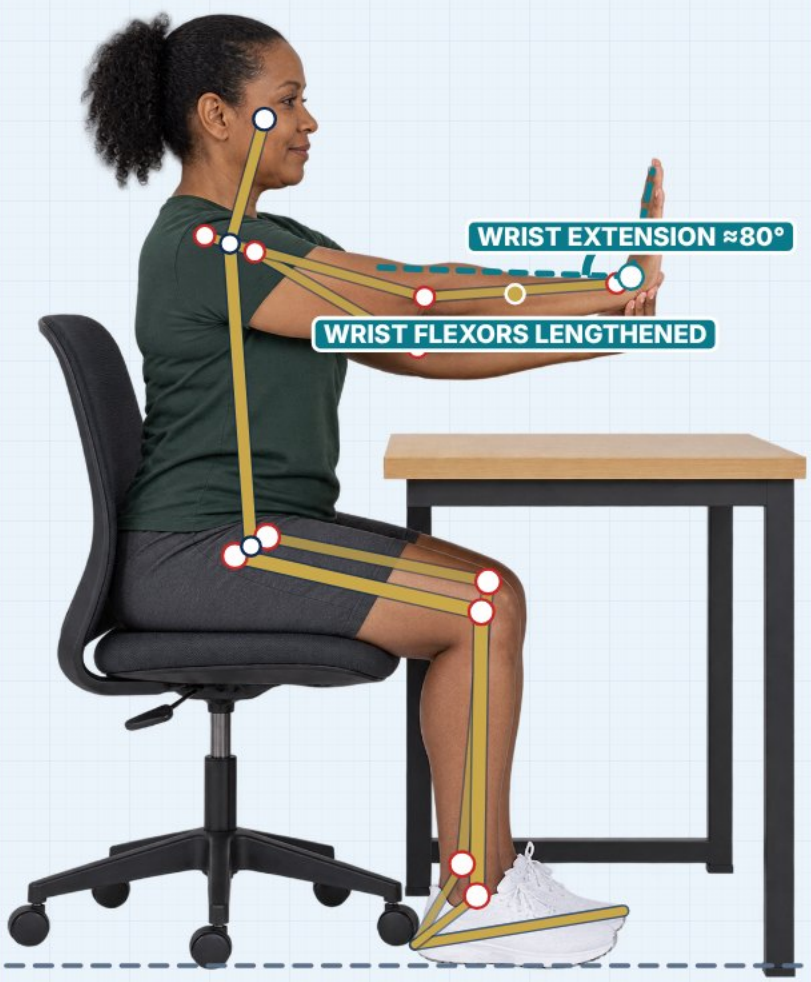
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C · WRIST STRETCH BREAK, SIDE



EYE-OPENER

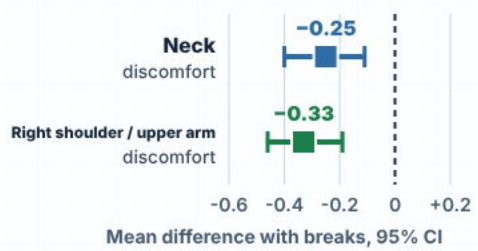
14/15 trials of office ergonomic interventions were at high risk of bias.

15 RCTs, 2,165 office workers. Hoe et al. (2018).

Breaks interrupt the dose

- A short break with the wrist eased back **≈80°** into extension reverses the sustained flexed, gripping posture of bench and keyboard work.
- Supplementary breaks gave small reductions in discomfort; ergonomic training alone did not reduce upper-limb pain.

Rest breaks: small but real



Data-entry workers; very low certainty evidence. Cochrane review, Hoe et al. (2018).

Myth: "Keyboards cause carpal tunnel syndrome." The ACC brief found insufficient evidence for computer work itself as a cause.

2-D estimates from pose landmarks on an illustrated figure; CoM (if shown) from de Leva (1996); cm for a 1.70 m adult (Winter, 2009). Wrist angle from manually placed forearm and hand landmarks. Educational, not diagnostic.

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A · Repeat Bent wrist

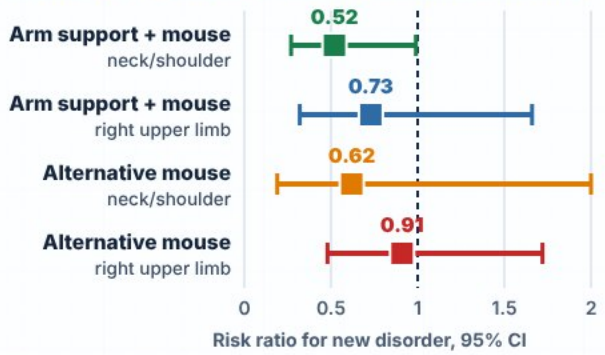


B · Vibrate Force + tool



C · Break Dose reset

Forearm support helped the neck and shoulder



Office workers; RR < 1 favours the intervention. Cochrane review, Hoe et al. (2018).

Decision pathway

1. **IDENTIFY**
   Find the dominant exposure: hand force, repetition, wrist posture or vibration.
2. **REDUCE**
   Lower grip force, rotate tasks, keep wrists near neutral, limit vibration time and support the forearms.
3. **BREAK**
   Add short breaks; do not rely on ergonomic training alone, which did not reduce upper-limb pain.

NOT RECOMMENDED

Treating "RSI" as one diagnosis, or relying on training alone without changing force, repetition, posture or vibration.

SEEK ASSESSMENT IF

Chest or left-arm pain, a hot swollen joint with fever, deformity after a fall, worsening numbness or weakness, or a tight swollen forearm: seek prompt assessment.

REFERENCES (APA 7)

de Leva, P. (1996). Adjustments to Zatsiorsky-Seluyanov's segment inertia parameters. *Journal of Biomechanics, 29*(9), 1223–1230. https://doi.org/10.1016/0021-9290(95)00178-6

Hoe, V. C. W., Urquhart, D. M., Kelsall, H. L., Zamri, E. N., & Sim, M. R. (2018). Ergonomic interventions for preventing work-related musculoskeletal disorders of the upper limb and neck among office workers. *Cochrane Database of Systematic Reviews, 2018*(10), CD008570. https://doi.org/10.1002/14651858.CD008570.pub3

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van Rijn, R. M., Huisstede, B. M. A., Koes, B. W., & Burdorf, A. (2009). Associations between work-related factors and the carpal tunnel syndrome: A systematic review. *Scandinavian Journal of Work, Environment & Health, 35*(1), 19–36. https://doi.org/10.5271/sjweh.1306

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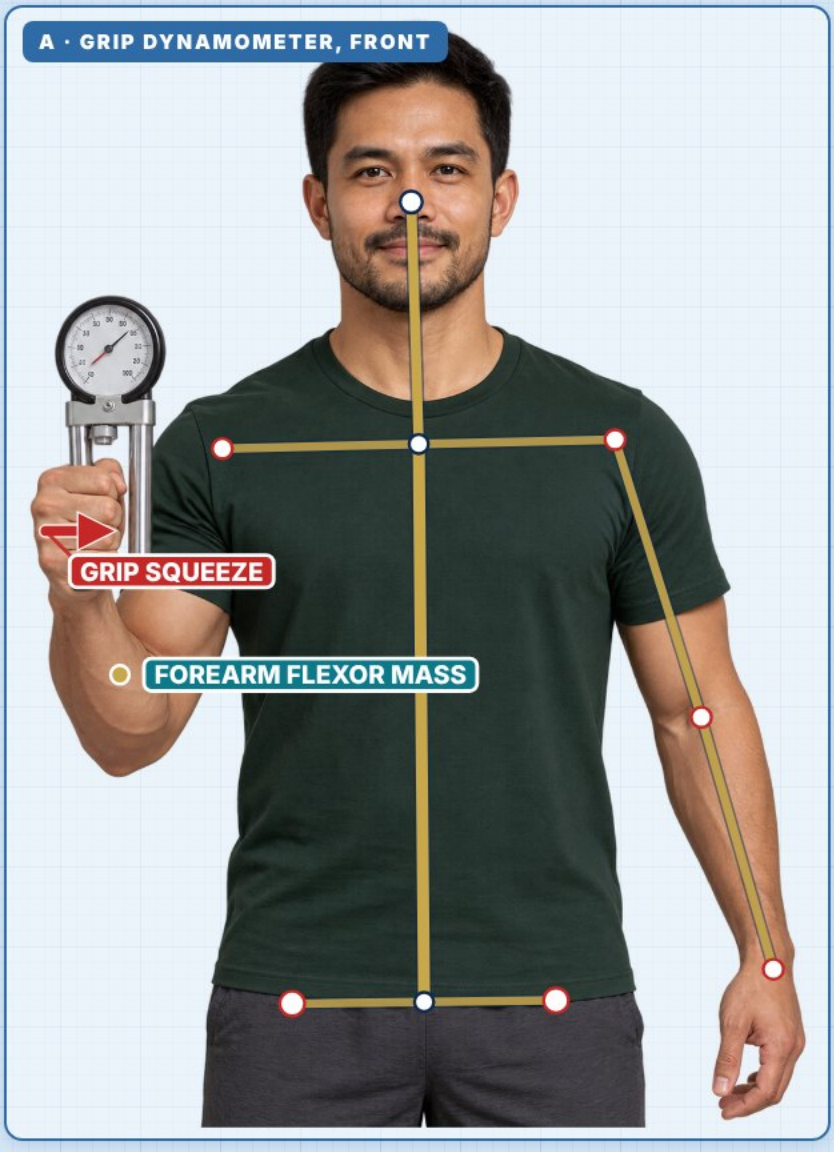
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RETURN TO SPORT AFTER ELBOW OR WRIST INJURY: STRENGTH AND GRIP BENCHMARKS

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2-D estimates from pose landmarks on an illustrated figure (head-to-hip framing); lengths scaled to a 1.70 m adult (Winter, 2009). Grip direction and forearm anatomy marked on the figure; the foreshortened grip arm is not measured. Educational, not diagnostic.

EYE-OPENER

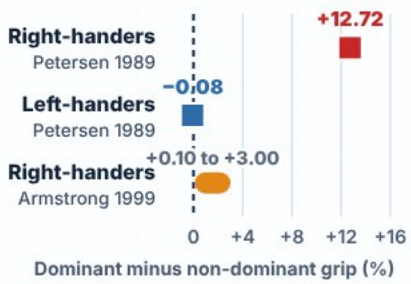
3 explicit return criteria were all that 15 studies after UCL reconstruction identified.

15 studies, 1,156 patients. Anderson et al. (2022).

Grip is a window on the forearm

- Squeezing a dynamometer recruits the finger and wrist flexors that arise near the medial elbow, so grip strength tracks forearm recovery after elbow or wrist injury.
- Compare with the other hand, but interpret the "10% rule" by hand dominance.

The 10% rule fits right-handers only



310 students and staff (Petersen et al., 1989); 0.1–3% range across three tests (Armstrong & Oldham, 1999).

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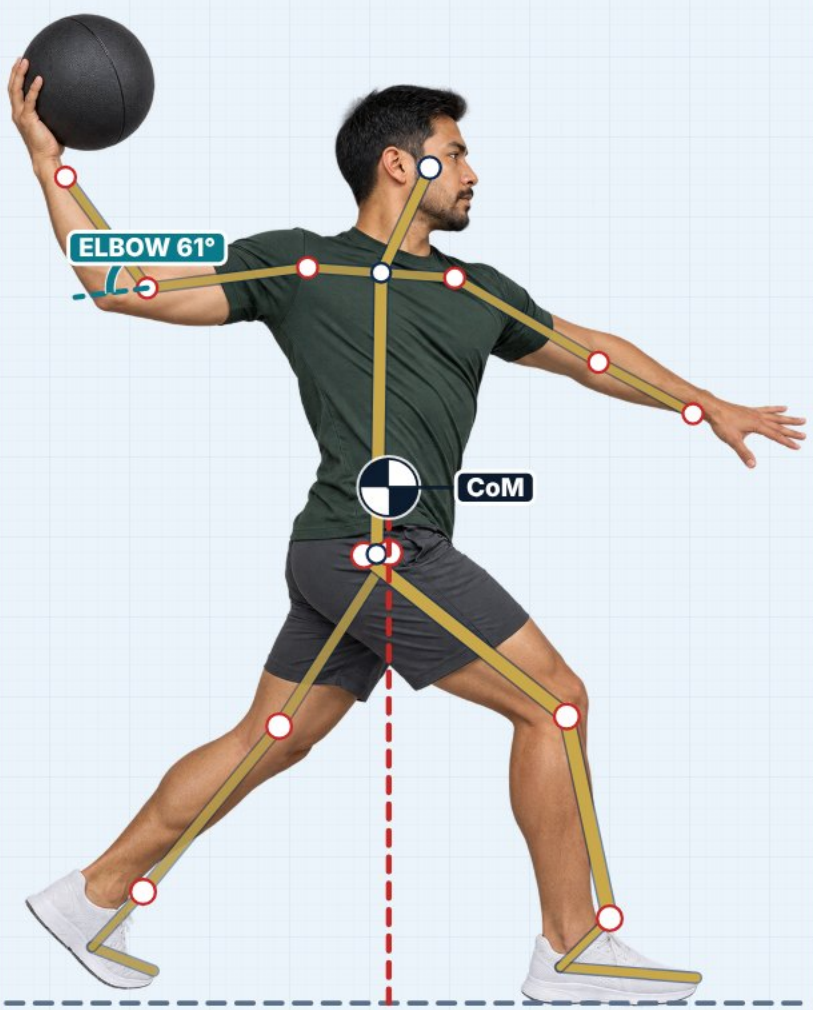
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B · MED-BALL THROW, SIDE



EYE-OPENER

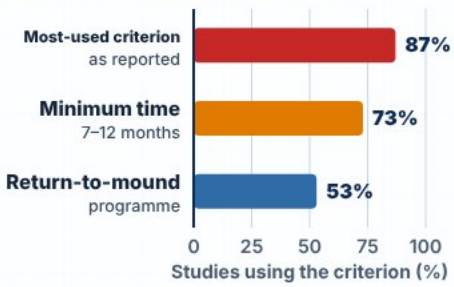
85.7% returned at their pre-injury level or higher after UCL reconstruction (SD 8.5%).

15 studies, 96.3% baseball players. Anderson et al. (2022).

Throwing is the real test

- Cocking the ball behind the head with the elbow ≈**61°** flexed loads the medial elbow in valgus; grip strength alone cannot show this tolerance.
- Graded plyometric throws then interval throwing build the load the elbow must accept before competition.

Time is used more than tests



Criteria reported after UCL reconstruction; the most-used criterion began at a mean 16.7 weeks (as reported). Anderson et al. (2022).

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

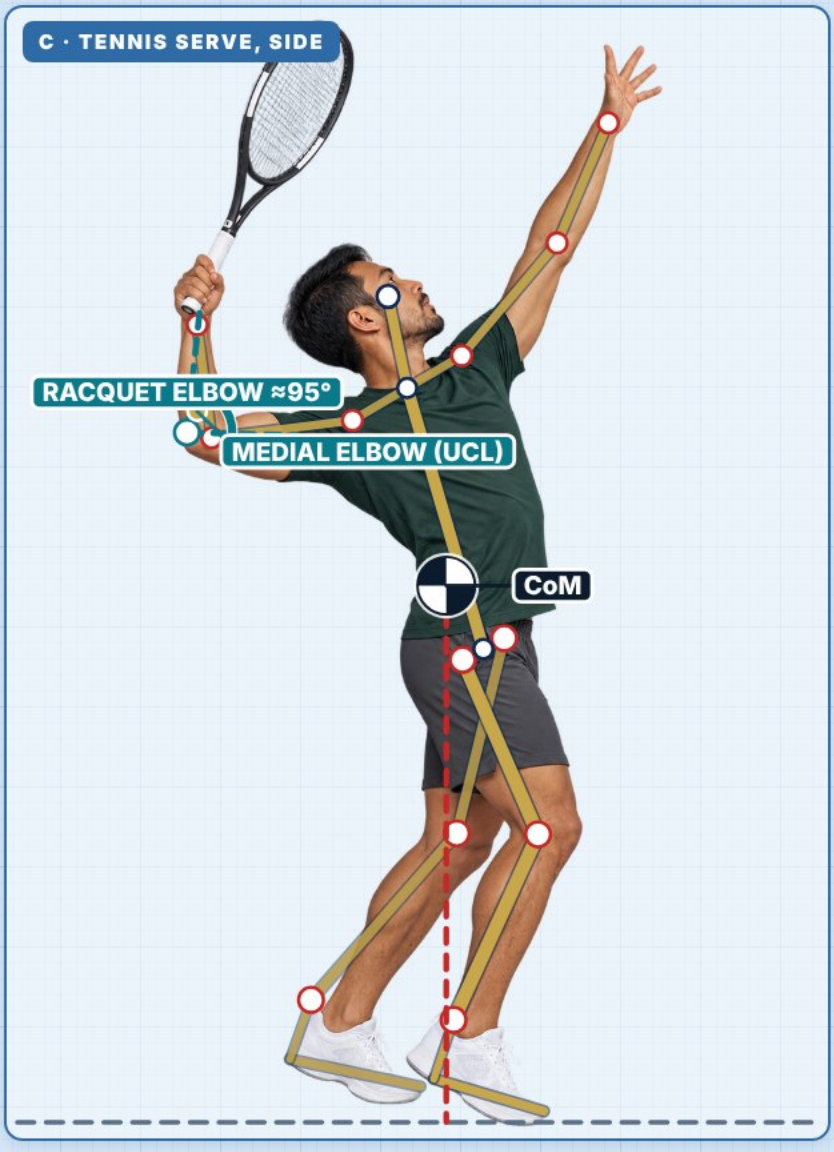
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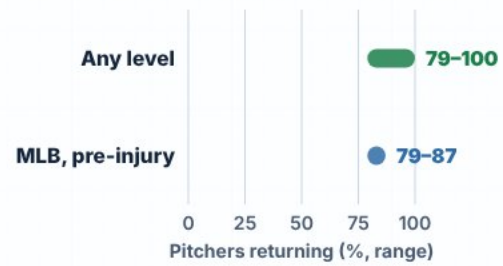
3 of 4 studies found fastball velocity fell after UCL reconstruction.

Systematic review, 1,520 pitchers. Coughlin et al. (2019).

Serving asks the same of the elbow

- In the serve's cocking phase the racquet elbow is flexed ≈**95°** with the arm back, the position that loads the medial elbow and UCL.
- Returning is common but slow: mean time to return to play was 19.8 ± 13.5 months.

Most pitchers return, not all to form



14 studies, 1,520 pitchers after UCL reconstruction. Coughlin et al. (2019).

Myth: "Equal grip means ready." Right-handers' dominant grip was 12.7% stronger, so equality may still be a deficit.

2-D estimates from pose landmarks on an illustrated figure; CoM (if shown) from de Leva (1996); cm for a 1.70 m adult (Winter, 2009). Racquet-arm elbow angle from manually placed shoulder, elbow and wrist landmarks. Educational, not diagnostic.

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A · Grip Dominance



B · Throw Valgus load



C · Serve Sport demand

The return-to-throwing timeline



Mean ± SD, or range (mound). Anderson et al. (2022); Coughlin et al. (2019).

Decision pathway

1. **RANGE**
   Restore full, pain-free elbow and wrist motion before loading the throw or swing.
2. **STRENGTH**
   Compare grip and forearm strength with the other side, reading the 10% rule by hand dominance.
3. **PROGRESS**
   Graded plyometric throws, then interval throwing or hitting, then sport volume before competition.

NOT RECOMMENDED

Clearing return on time alone, or on equal grip strength alone.

SEEK ASSESSMENT IF

Chest or left-arm pain, a hot swollen joint with fever, deformity after a fall, worsening numbness or weakness, or a tight swollen forearm: seek prompt assessment.

REFERENCES (APA 7)

Anderson, M. J. J., Crockatt, W. K., Mueller, J. D., Hellwinkel, J. E., Alexander, F. J., Trofa, D. P., & Ahmad, C. S. (2022). Return-to-competition criteria after ulnar collateral ligament reconstruction. *The American Journal of Sports Medicine, 50*(4), 1157–1165. https://doi.org/10.1177/03635465211016839

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Coughlin, R. P., Gohal, C., Horner, N. S., Shanmugaraj, A., Simunovic, N., Cadet, E. R., Bedi, A., & Ayeni, O. R. (2019). Return to play and in-game performance statistics among pitchers after ulnar collateral ligament reconstruction of the elbow: A systematic review. *The American Journal of Sports Medicine, 47*(8), 2003–2010. https://doi.org/10.1177/0363546518798768

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Petersen, P., Petrick, M., Connor, H., & Conklin, D. (1989). Grip strength and hand dominance: Challenging the 10% rule. *American Journal of Occupational Therapy, 43*(7), 444–447. https://doi.org/10.5014/ajot.43.7.444

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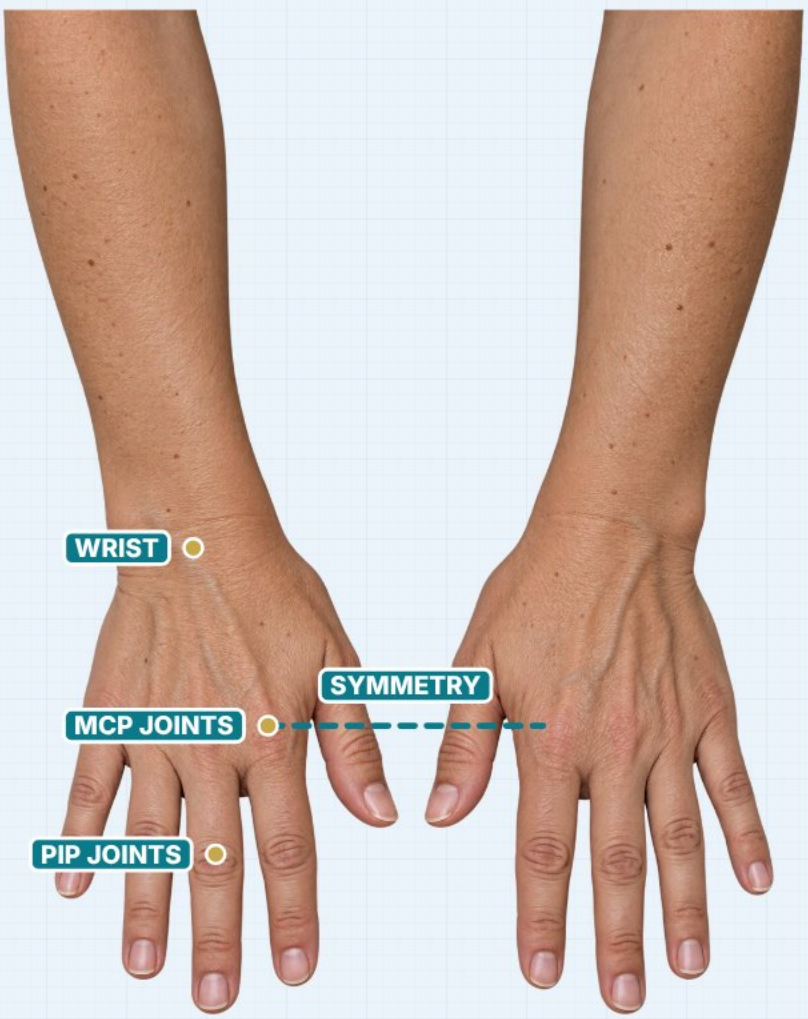
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RHEUMATOID ARTHRITIS SIGNS IN THE HAND: SWELLING, MORNING STIFFNESS AND SYMMETRY

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A · BOTH HANDS FLAT, TOP



EYE-OPENER

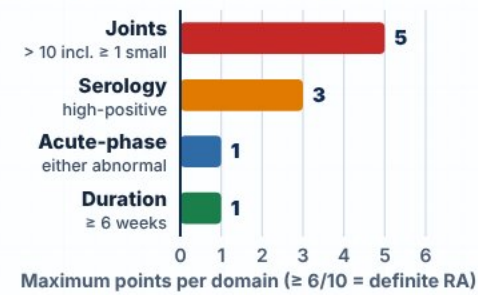
460 people in every 100,000 worldwide have rheumatoid arthritis (pooled prevalence 0.46%).

Meta-analysis of 67 studies. Almutairi et al. (2021).

Read the knuckles in pairs

- RA typically brings soft, boggy synovial swelling of the MCP and PIP joints and wrists, usually on both sides at once.
- Osteoarthritis nodes are hard and bony and favour the end (DIP) joints; symmetry and soft swelling point the other way.

Small joints score the most



2010 ACR/EULAR criteria, scoring read via a secondary page citing them. Aletaha et al. (2010).

Angles from landmarks placed on an illustrated figure (2-D, camera-plane); approximate. Joint positions and symmetry line marked on the figure for teaching. Educational, not diagnostic.

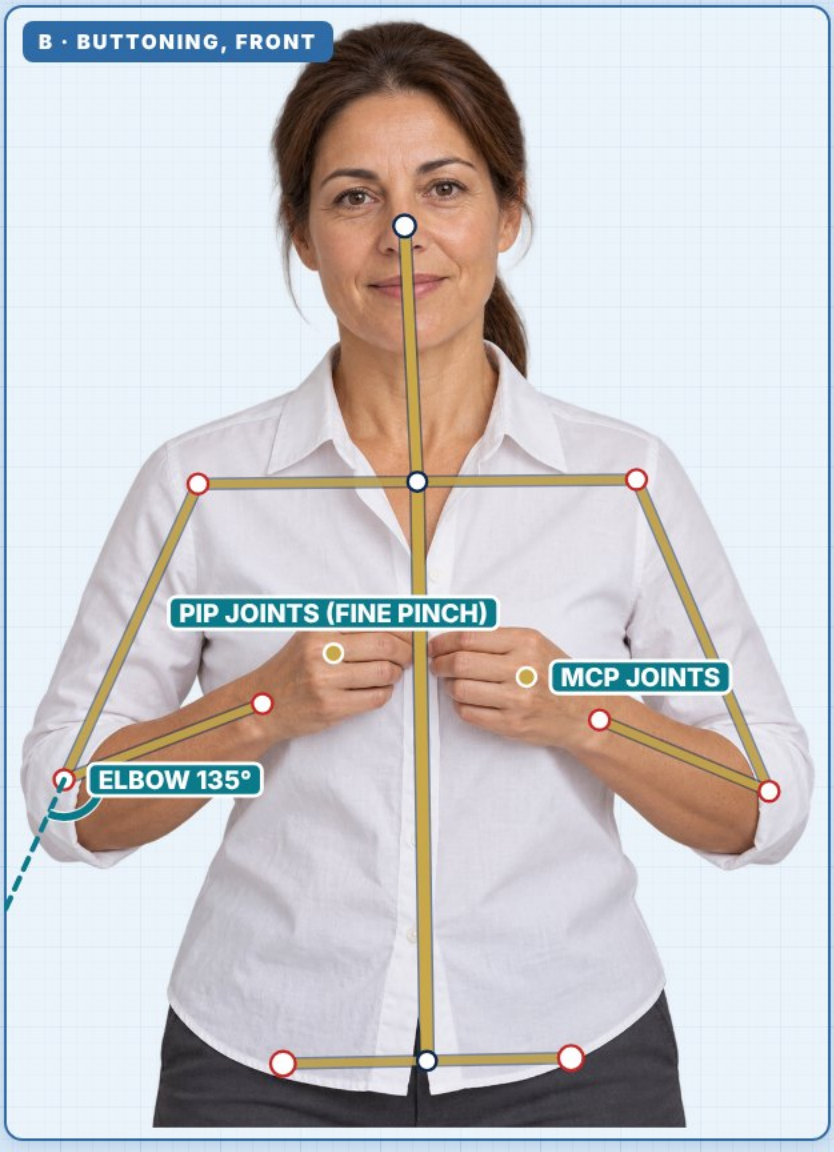
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2-D estimates from pose landmarks on an illustrated figure (head-to-hip framing); lengths scaled to a 1.70 m adult (Winter, 2009). Elbow angle from pose landmarks in the front view. Educational, not diagnostic.

EYE-OPENER

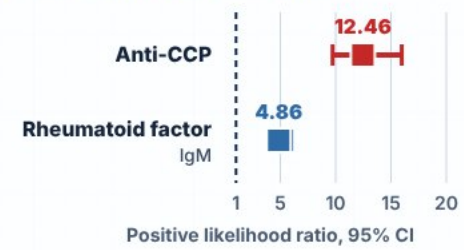
1 in 3 people with RA test negative for anti-CCP; rheumatoid factor misses a similar share.

Pooled sensitivity 67% and 69%. Nishimura et al. (2007).

Fine tasks reveal the joints

- Buttoning with the elbows flexed ≈**135°** needs precise pinch at the PIP and MCP joints; swollen, stiff joints make it slow and clumsy.
- Difficulty with buttons, jars or keys, on both hands, is a practical prompt to look for synovitis.

Anti-CCP shifts the odds more



Meta-analysis: 37 anti-CCP and 50 rheumatoid-factor studies. Nishimura et al. (2007).

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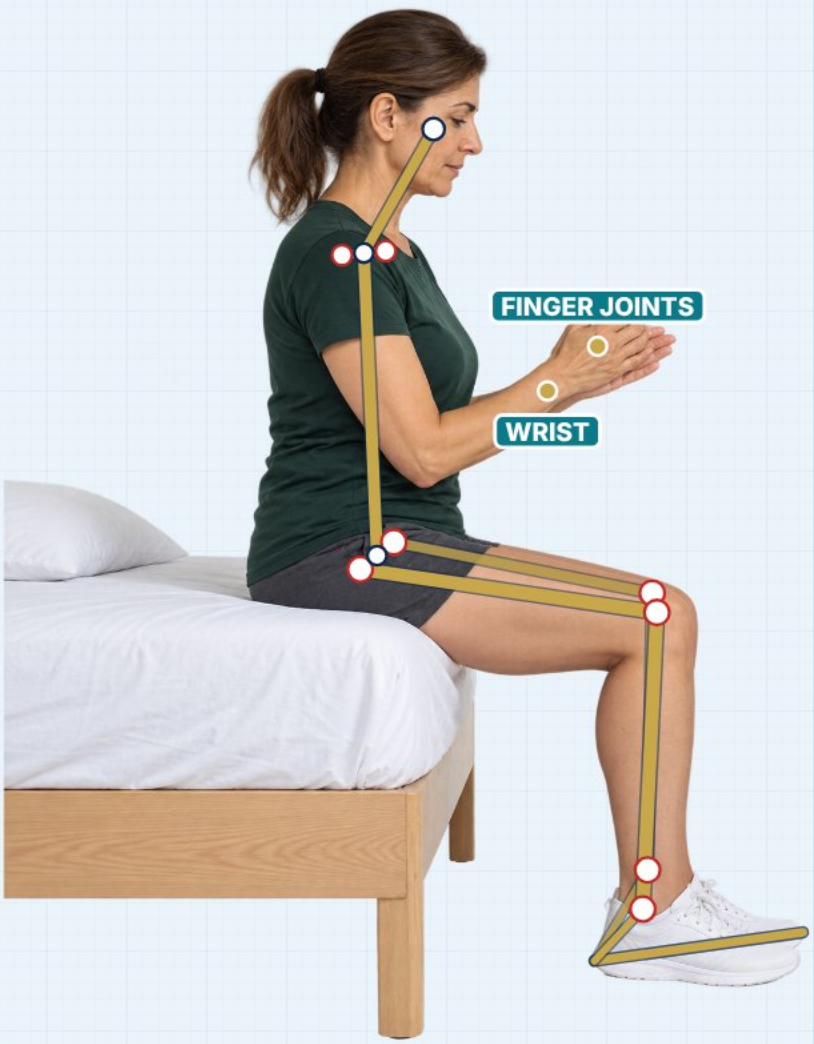
BIOMECHANICS IS A FORCE-GOVERNED DECISION SYSTEM – NOT A POSTURE MODEL.

INTEGRATING PERFORMANCE & REHABILITATION HEALTHCARE PATHWAYS.

RHEUMATOID ARTHRITIS SIGNS IN THE HAND: SWELLING, MORNING STIFFNESS AND SYMMETRY

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C · MORNING HAND RUB, SIDE



EYE-OPENER

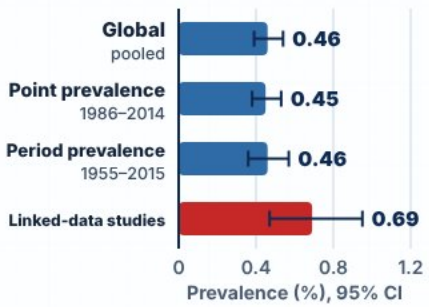
95% specificity of anti-CCP: a positive test is uncommon without RA.

95% CI 94–97. Nishimura et al. (2007).

Stiff on waking, easier with use

- Inflammatory stiffness is typically long-lasting in the morning and eases as the hands are rubbed and moved; mechanical stiffness settles within minutes.
- No verified threshold for its duration was found, so treat long morning stiffness as one clue among several.

About half a percent, by any count



Meta-analysis of 67 studies, 1980–2019. Almutairi et al. (2021).

Myth: "A normal rheumatoid factor rules out RA." Its pooled sensitivity was only 69%.

2-D estimates from pose landmarks on an illustrated figure; CoM (if shown) from de Leva (1996); cm for a 1.70 m adult (Winter, 2009). Trunk and leg skeleton from pose landmarks; hand anatomy labels for teaching. Educational, not diagnostic.

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A · Look Symmetry

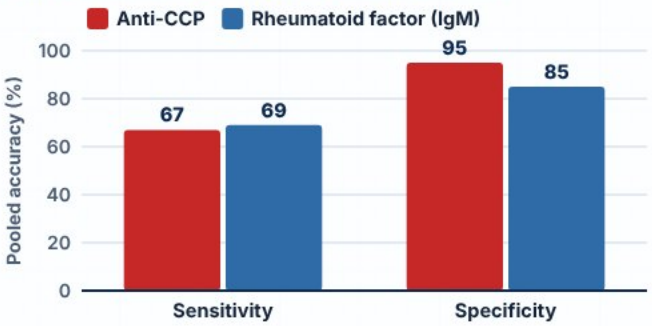


B · Function Fine pinch



C · Morning Stiffness

Blood tests support, they do not decide



Meta-analysis of diagnostic accuracy for rheumatoid arthritis. Nishimura et al. (2007).

Decision pathway

1. **SPOT**
   Soft, symmetrical swelling of MCP, PIP or wrist joints with long morning stiffness that eases with use.
2. **REFER**
   Suspected inflammatory arthritis goes early to rheumatology; drug treatment is specialist-led.
3. **SUPPORT**
   Hand therapy, joint protection and exercise as adjuncts, adjusted to joint swelling and pain.

NOT RECOMMENDED

Managing swollen finger joints with exercise alone, or ruling out RA on a normal rheumatoid factor.

SEEK ASSESSMENT IF

Chest or left-arm pain, a hot swollen joint with fever, deformity after a fall, worsening numbness or weakness, or a tight swollen forearm: seek prompt assessment.

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ARM, WRIST AND HAND RED FLAGS: WHEN PAIN NEEDS URGENT MEDICAL CARE

AN MMSX AUTHORITY | APPLIED BIOMECHANICS LAB EDUCATIONAL ANALYSIS

A · CHEST AND ARM PAIN, FRONT



EYE-OPENER

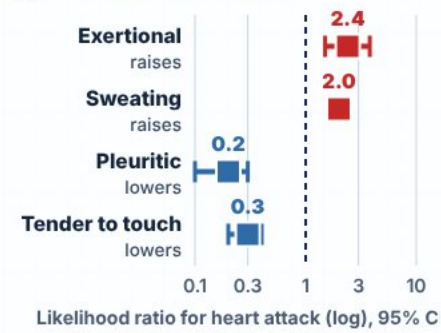
4.7 likelihood ratio for heart attack when pain spreads to the right arm; left arm: 2.3.

95% CI 1.9–12 and 1.7–3.1. Swap & Nagurney (2005).

Arm pain can come from the heart

- Chest discomfort spreading to one or both arms, jaw or shoulder, with sweating, nausea or breathlessness, is a medical emergency, not an arm problem.
- Do not test, stretch or treat the arm: call emergency services straight away.

No single feature rules it out



Chest pain history in suspected acute coronary syndrome; even "reassuring" features do not exclude it. Swap & Nagurney (2005).

2-D estimates from pose landmarks on an illustrated figure (head-to-hip framing); lengths scaled to a 1.70 m adult (Winter, 2009). No measurements on this frame; pain-spread arrow drawn for teaching. Educational, not diagnostic.

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B · AFTER A FALL, SIDE





EYE-OPENER

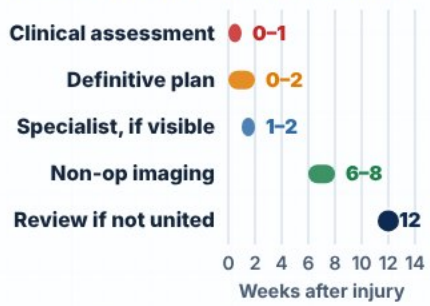
4 X-ray views at least are required when a scaphoid fracture is suspected; MRI is the recommended next scan.

Adults over 16. BSSH scaphoid standards (n.d.).

Thumb-side pain after a fall

- A fall on the outstretched hand drives load through the scaphoid; pain in the anatomical snuffbox needs a splint and imaging, not a sprain label.
- Deformity, an open wound or inability to move the wrist after a fall means the emergency department today.

The scaphoid pathway timeline



Upper time limits; surgery for waist fractures displaced > 2 mm ideally within 2 weeks. BSSH scaphoid standards (n.d.).

2-D estimates from pose landmarks on an illustrated figure; CoM (if shown) from de Leva (1996); cm for a 1.70 m adult (Winter, 2009). Trunk and leg skeleton from pose landmarks; wrist anatomy label for teaching. Educational, not diagnostic.

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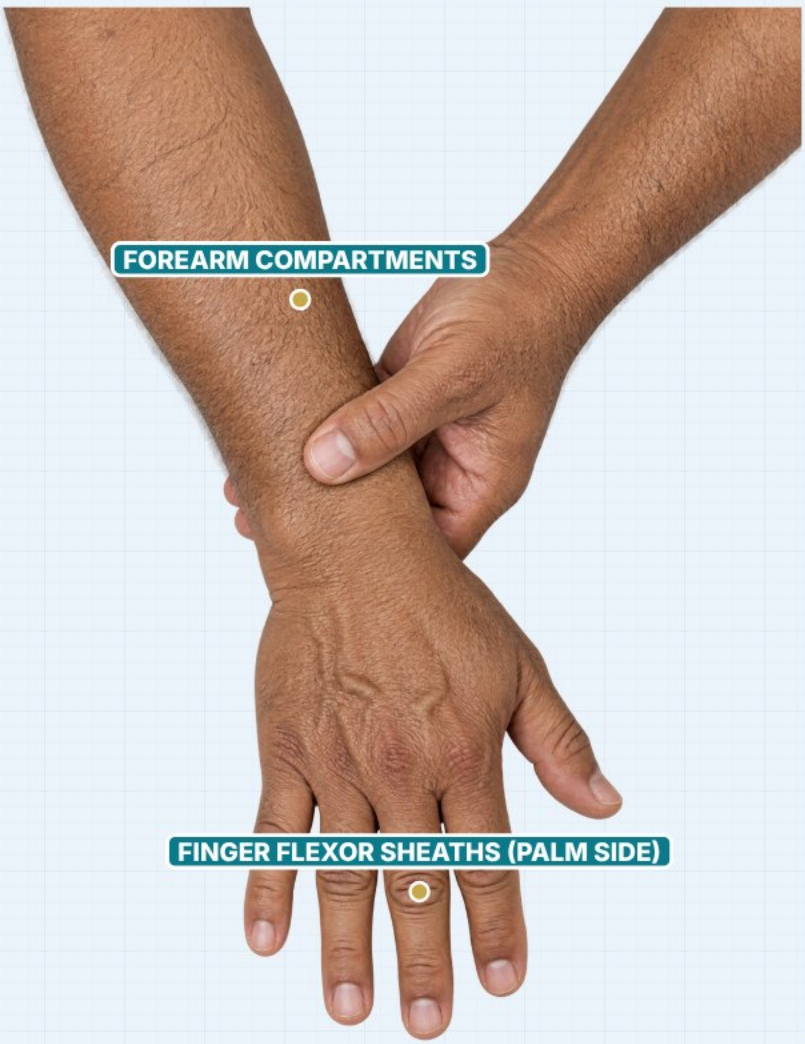
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C · FOREARM AND HAND, TOP



EYE-OPENER

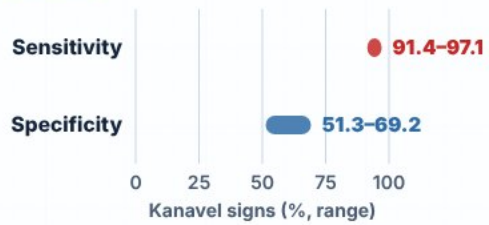
69% of acute compartment syndrome cases had an associated fracture.

164 patients over 8 years; about one in ten anticoagulated or with a bleeding disorder. McQueen et al. (2000).

Tight forearm, hot finger: same day

- Severe, escalating forearm pain after injury or a tight cast, pain on passive finger stretch and a tense forearm suggest compartment syndrome: emergency care.
- A hot, swollen finger held bent and painful to straighten suggests flexor sheath infection: same-day surgical assessment.

Kanavel signs catch most sheath infections



Pyogenic flexor tenosynovitis vs other finger infections, 5-year series. Kennedy et al. (2017).

Angles from landmarks placed on an illustrated figure (2-D, camera-plane); approximate. Anatomy labels placed on the figure for teaching. Educational, not diagnostic.

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A · Heart Call now

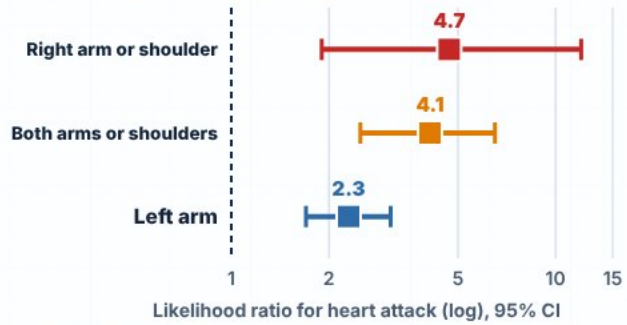


B · Fall Splint + image



C · Forearm Same day

Pain spreading to either arm counts



Radiation of chest pain and the likelihood of acute myocardial infarction. Swap & Nagurney (2005).

Decision pathway

1. **CALL NOW**
   Chest discomfort with arm, jaw or shoulder pain, sweating, nausea or breathlessness: call emergency services.
2. **SAME DAY**
   Escalating forearm pain after injury or a cast, pain on passive finger stretch, a hot bent finger, a cold pale hand.
3. **WITHIN DAYS**
   Thumb-side wrist pain after a fall: splint and further imaging even if the first X-ray is normal.

NOT RECOMMENDED

Exercising, stretching or waiting through these signs; red flags need medical care, not training.

SEEK ASSESSMENT IF

Progressive weakness, wasting or spreading numbness; neck–arm pain with clumsy hands; arm pain with fever, weight loss or constant night pain.

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