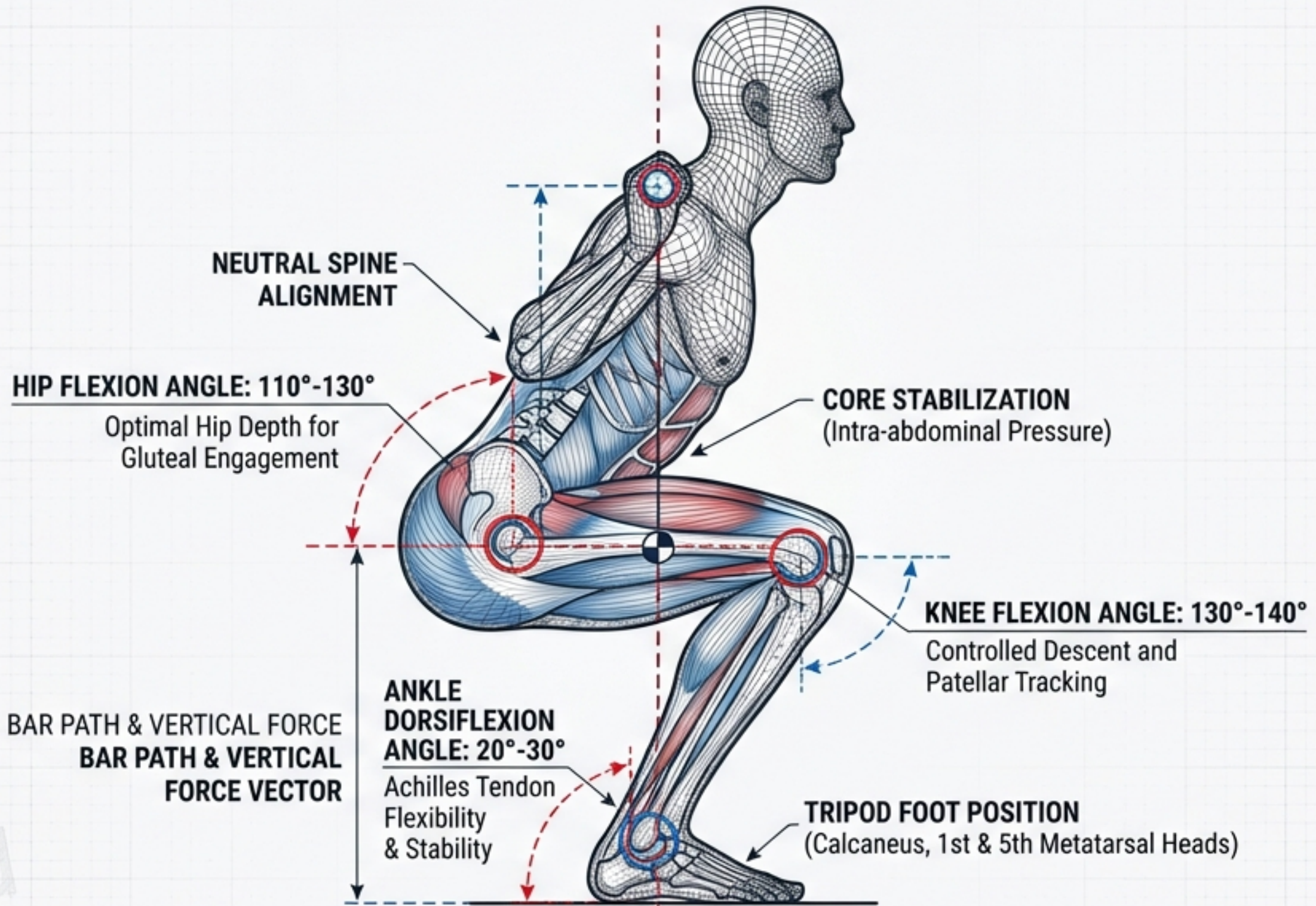


The Biomechanical Blueprint: Optimizing the Squat

Injury Prevention, Kinetic Chain Analysis, and Performance Protocols

RV	REV	REV
1		
REVISION 1	REVISION 2	

REV	REV	REV
CENTER OF MASS (COM)		
HUMAN ANATOMY		
5	5	5
12	12	12



SCALE: 1:1 HUMAN ANATOMY	
PROJECT: HUMAN KINETICS OPTIMIZATION	
DRAWING NO: ZMD-SQT-001	REV A

The Clinical Reality of Knee Pathology

THE EPIDEMIC

25–40%

of all clinical knee cases are Patellofemoral Pain Syndrome (PFPS).

GENDER DISPARITY

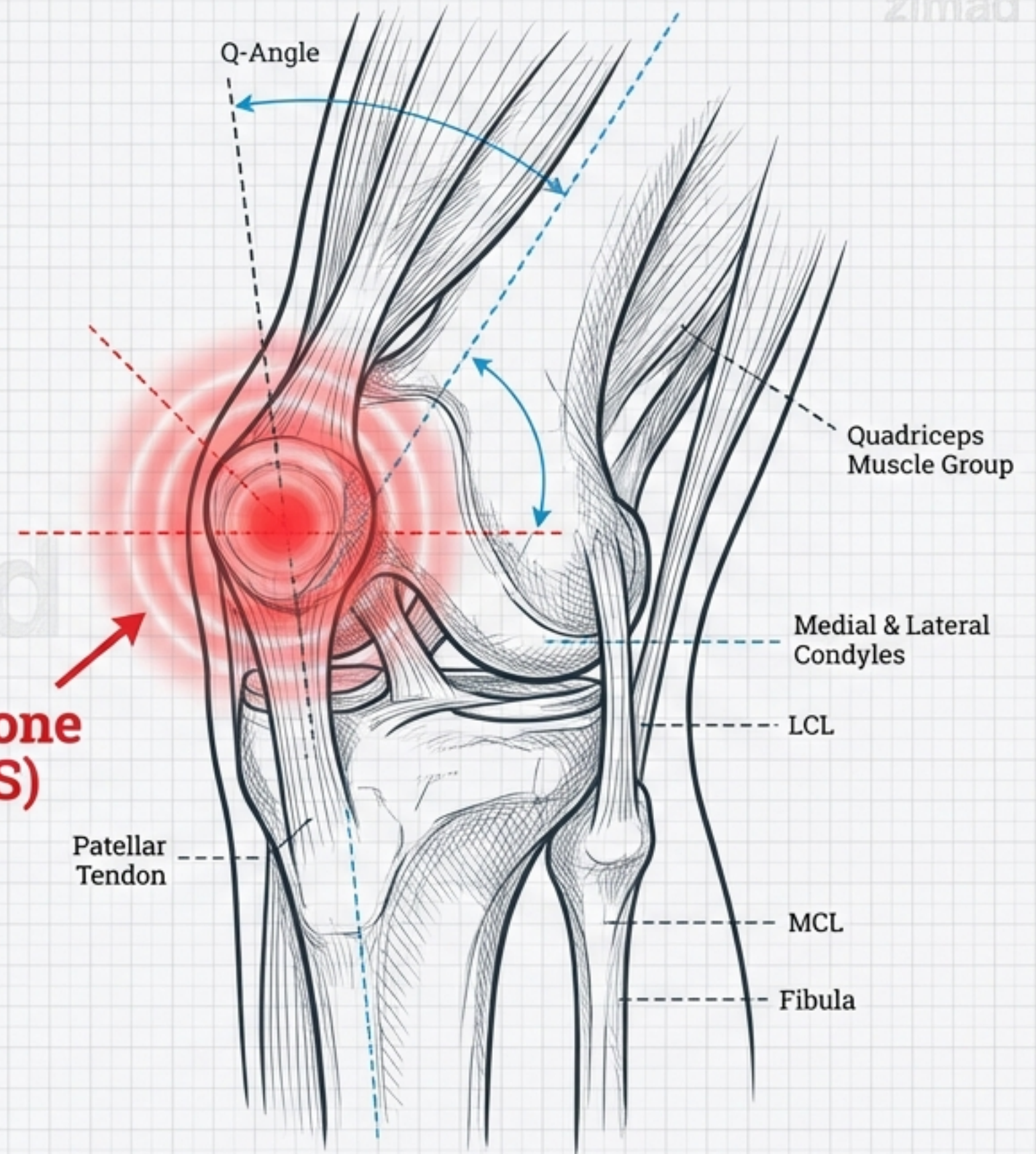


Women experience PFPS at a **2:1 ratio** compared to men.

SPORT CONTEXT

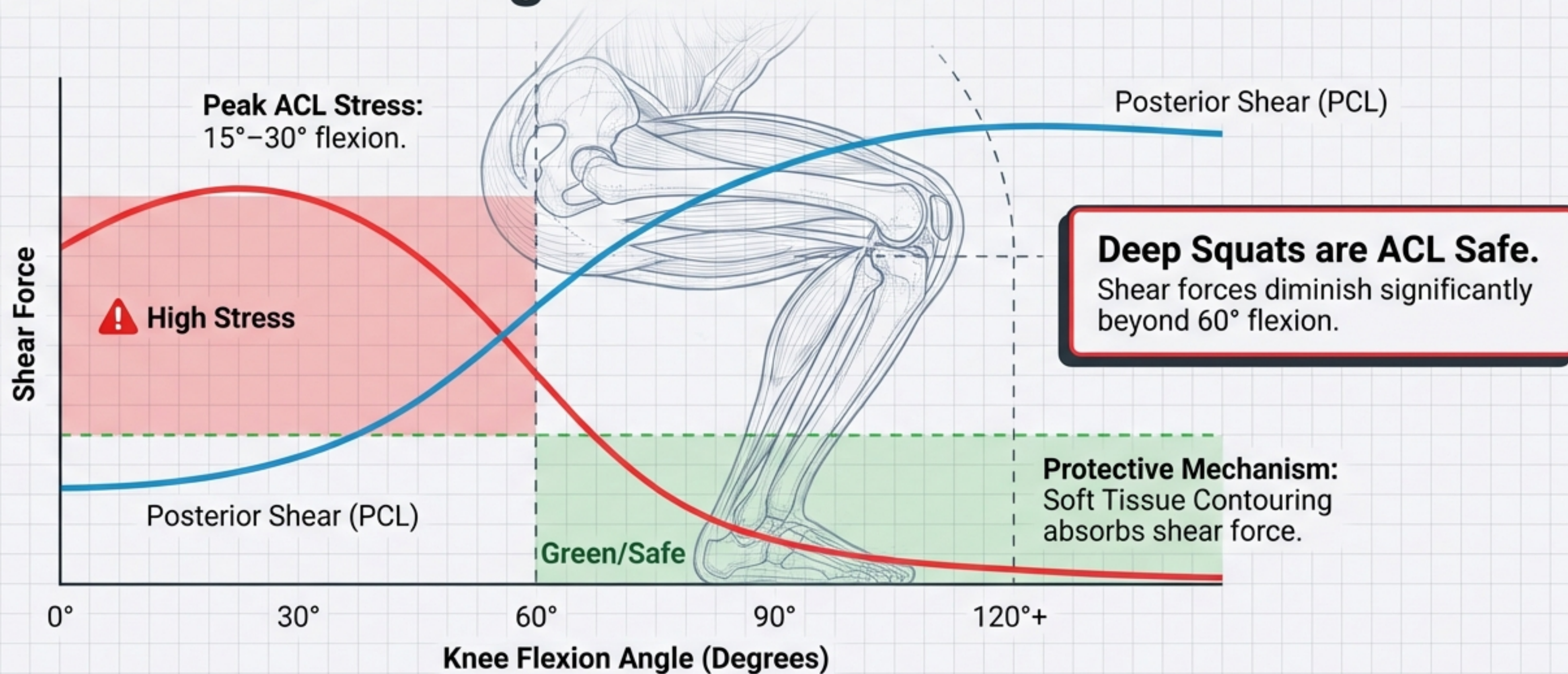
Weightlifting injury rate: **2.4 to 3.3 injuries** per 1000 training hours.

Pain Zone (PFPS)



Tibiofemoral Kinetics: Shear Forces & Ligament Load

zimad



Source: Escamilla (2001)

The Pressure Paradox: Compressive Forces

Load Magnitude

In elite lifters, compressive forces can exceed 20x Body Weight.

The Adaptation

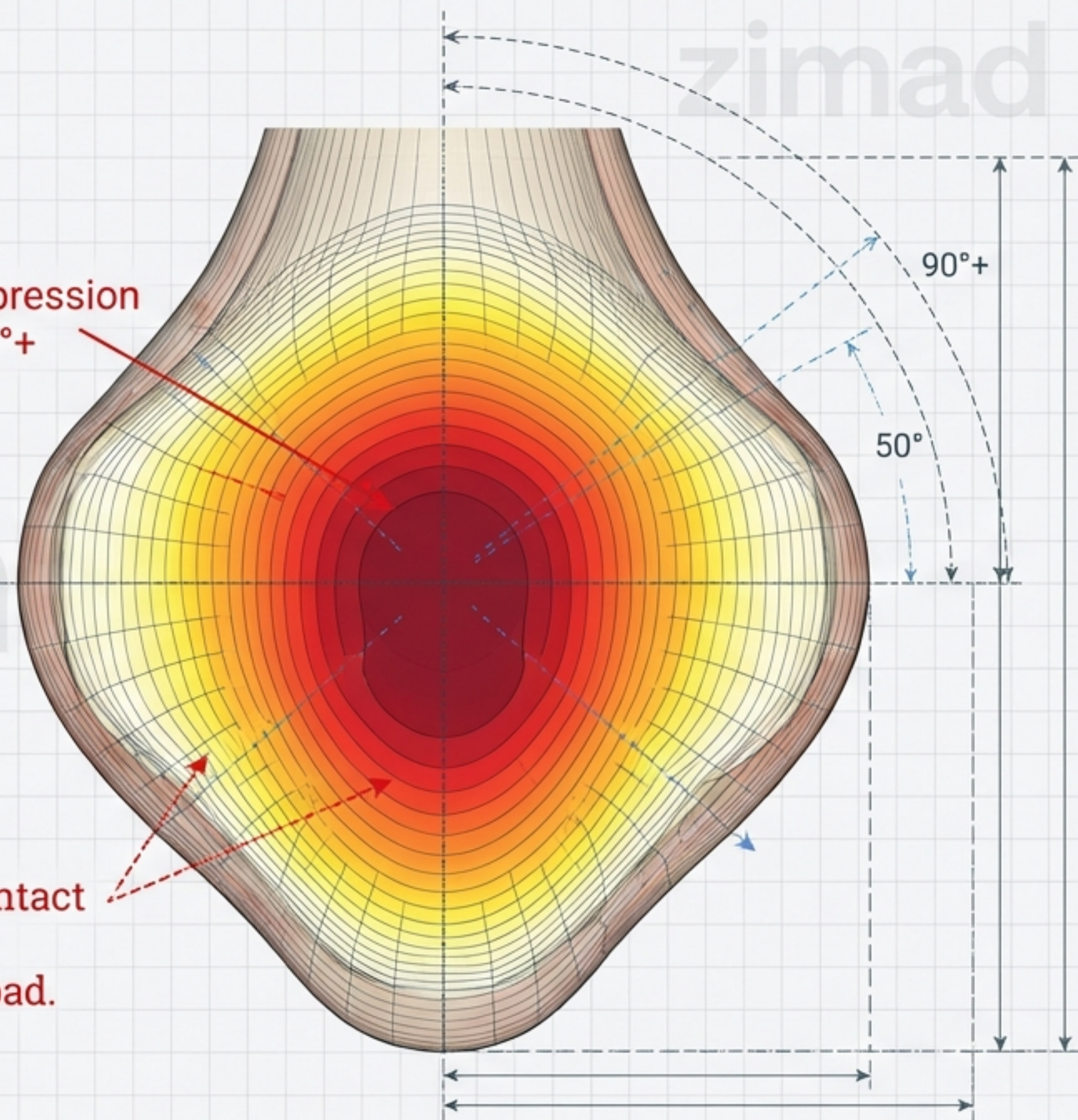
The body adapts by increasing contact surface area at depth to lower pressure per square inch.

Clinical Caveat

Limit depth to 50° for patients with existing Chondromalacia or Arthritis.

Peak Compression
at 90°+

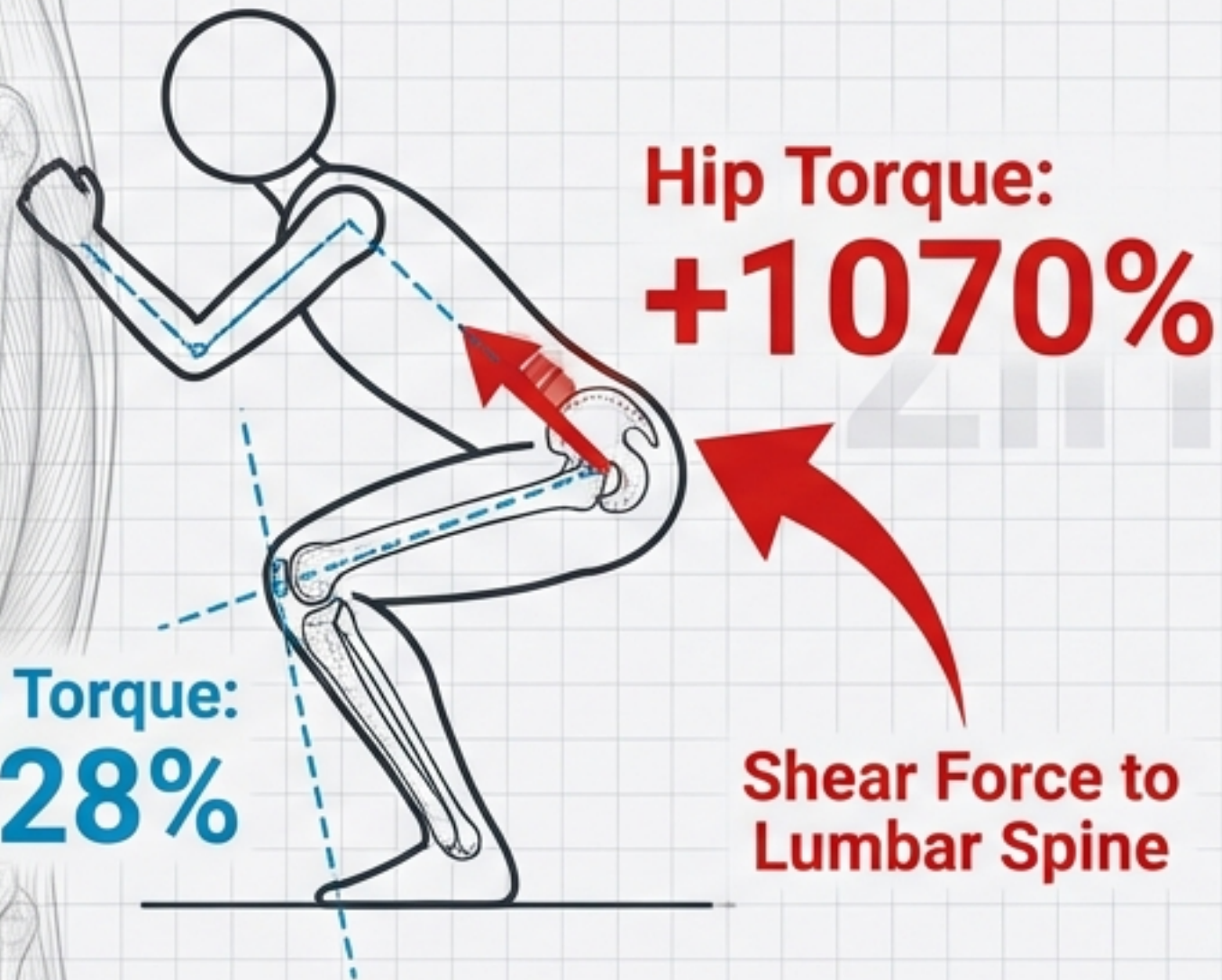
Increased Contact
Surface Area
distributes load.



The Cost of Restriction: 'Knees Over Toes' Analysis

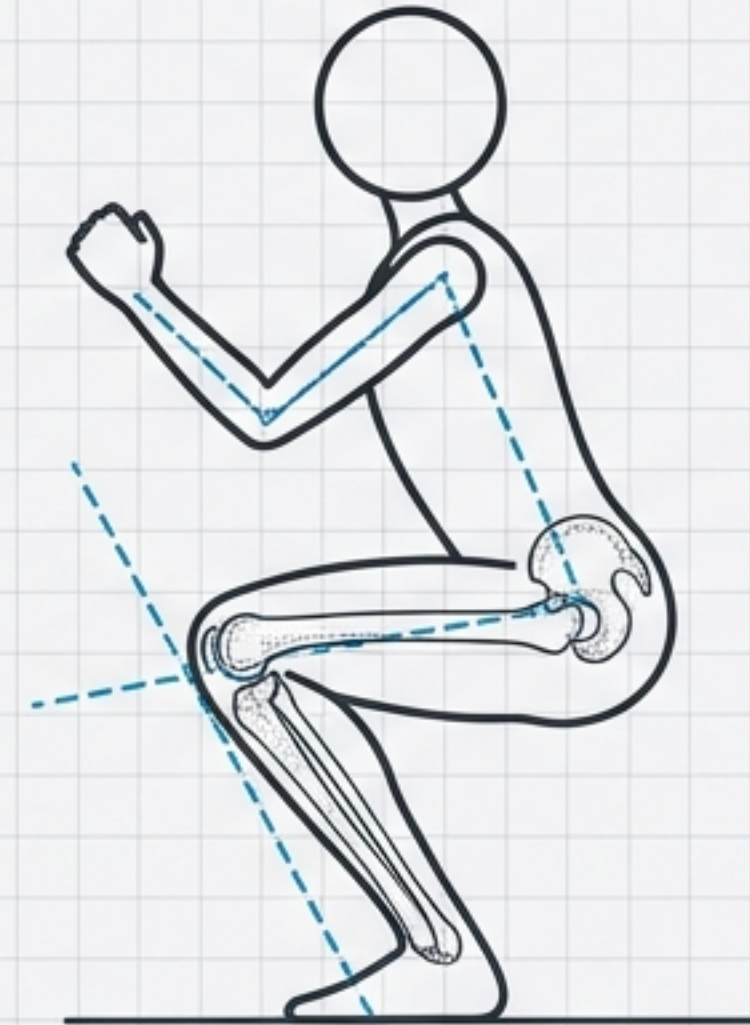
RESTRICTED MECHANICS:

Knees Stopped at Toes



NATURAL MECHANICS:

Knees Past Toes (Upright Torso)



Natural Mechanics: Balanced Load Distribution.

Conclusion: Allow natural forward knee travel to maintain an upright torso and protect the spine.

The Primary Enemy: Dynamic Knee Valgus

Definition



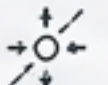
Hip Adduction +
Internal Rotation.

The Root Cause

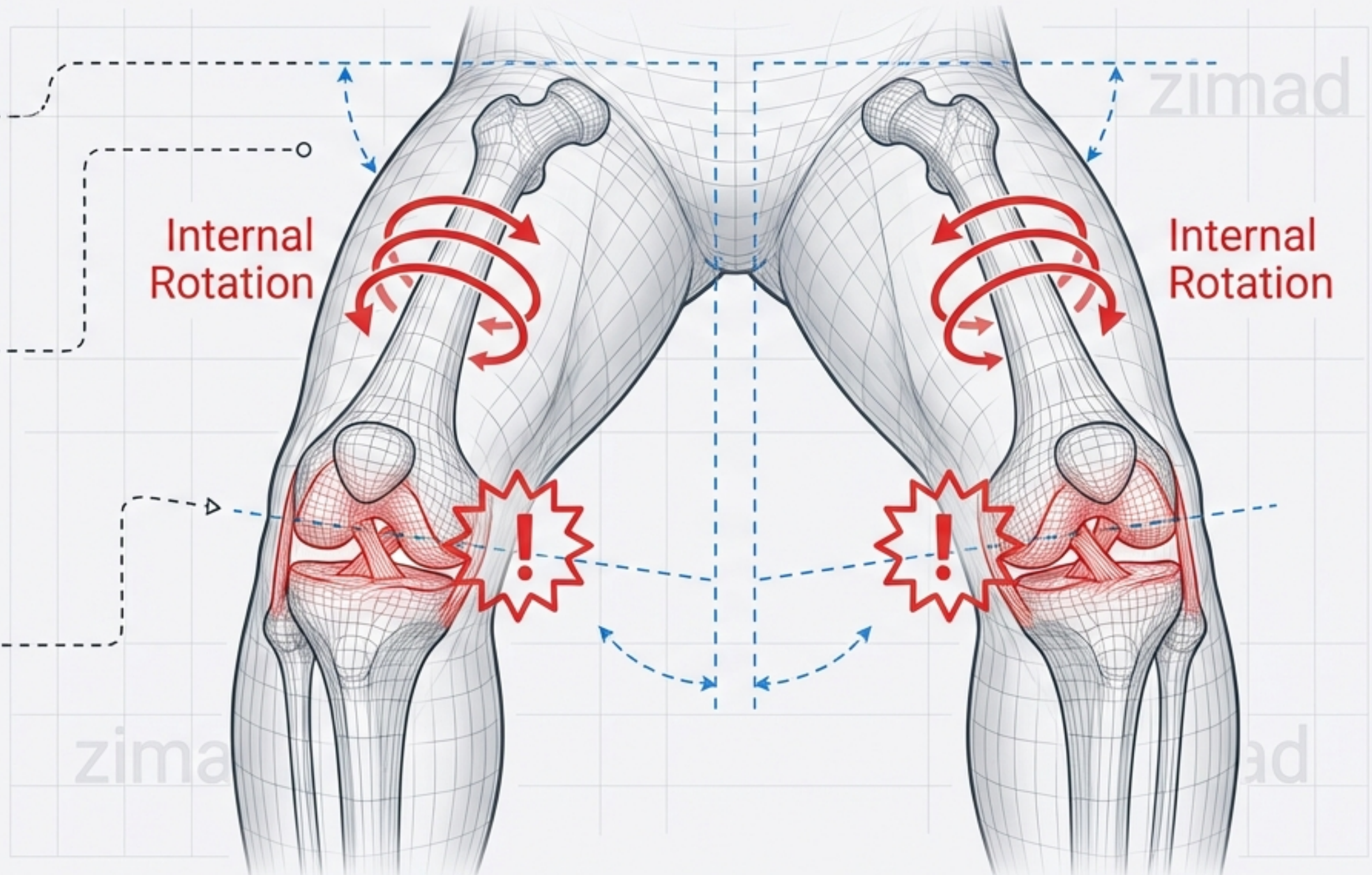


Weakness or inhibition of
the Gluteus Medius and
Maximus (External Rotators).

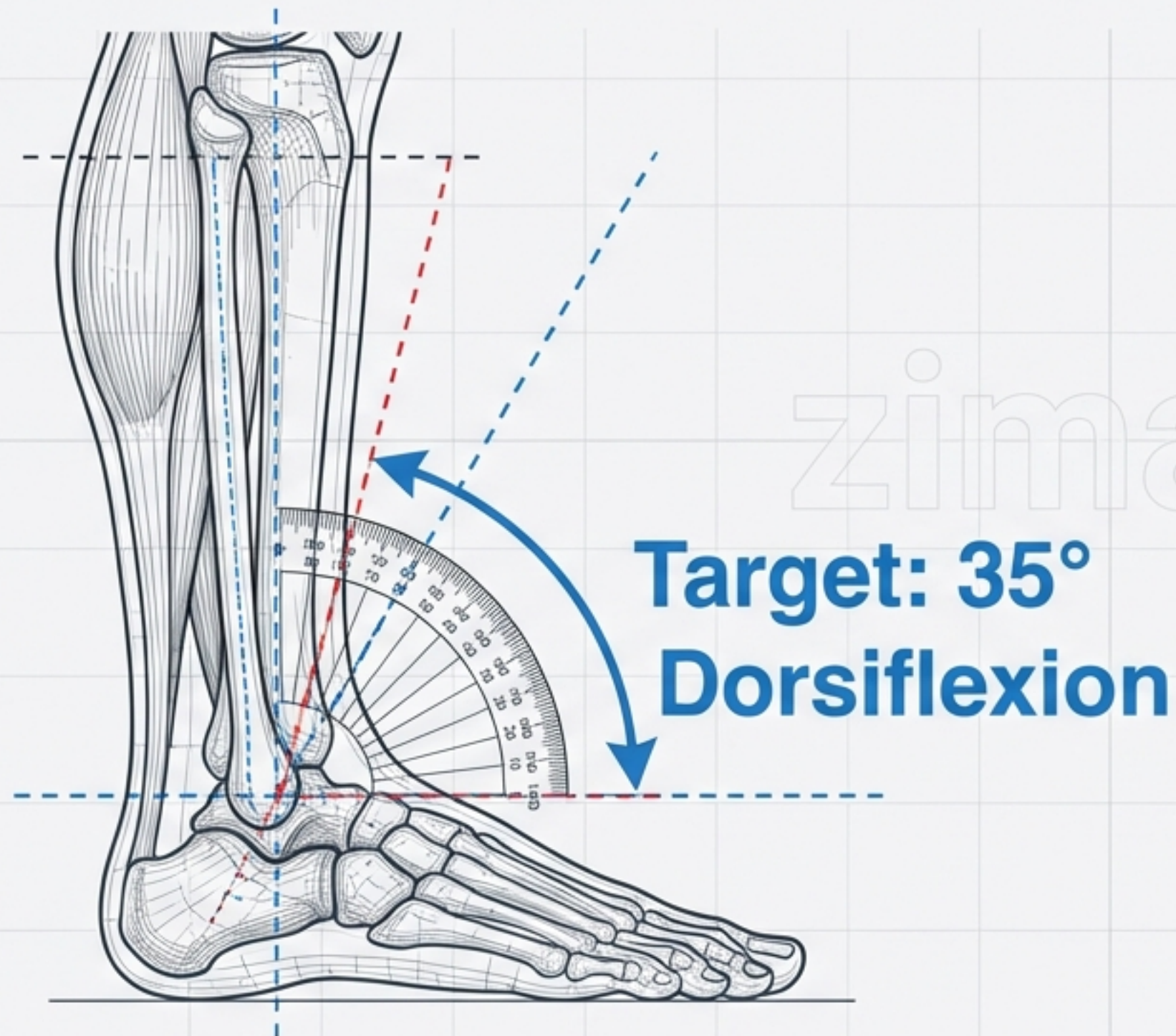
Mechanism



The Glute Max fails to
prevent femoral internal
rotation during descent.



The Foundation: Ankle Dorsiflexion Requirements



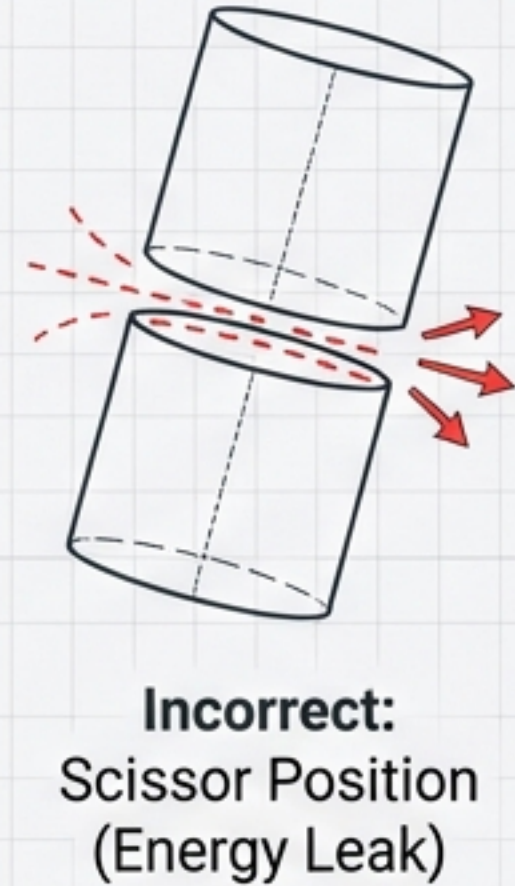
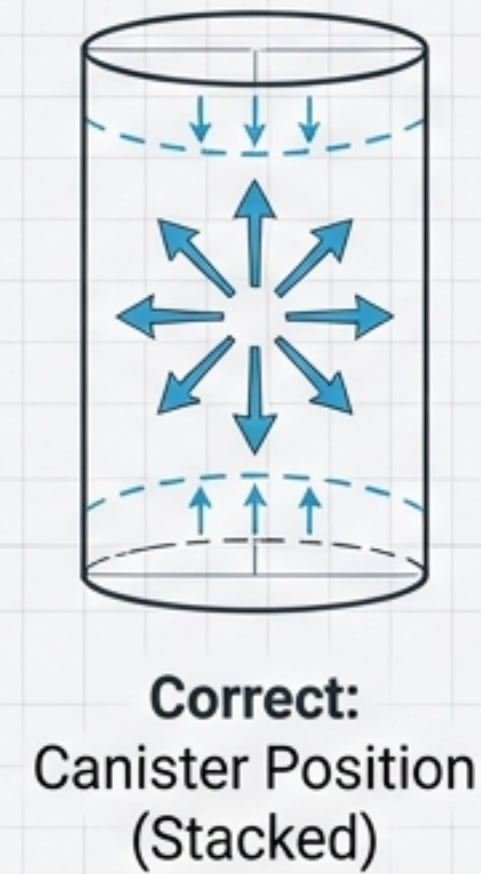
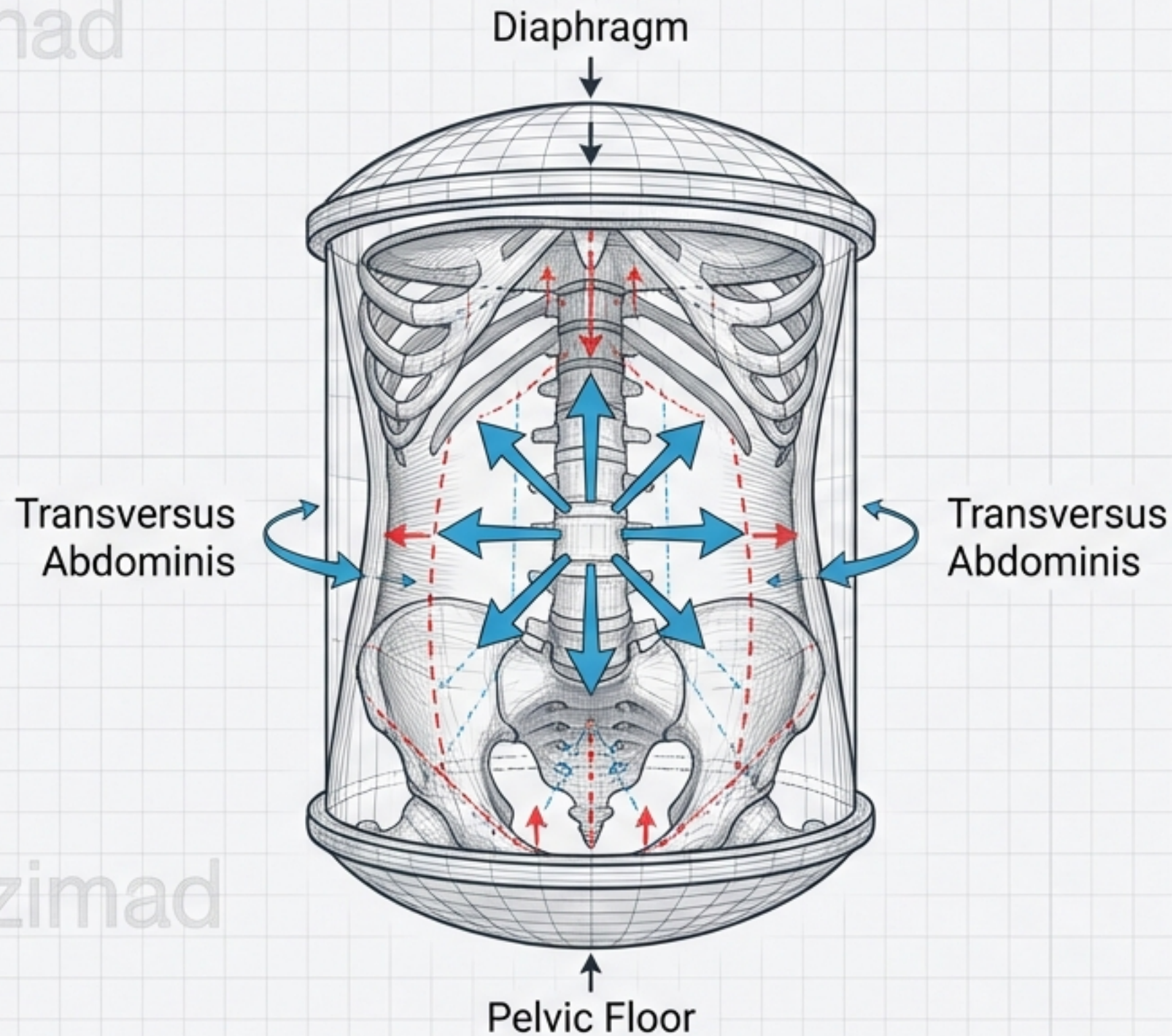
Stiff Ankle ($<35^\circ$)

Compensation:
Heel Lift or Pronation

Result:
Kinetic Chain Collapse
(Valgus or Butt Wink)

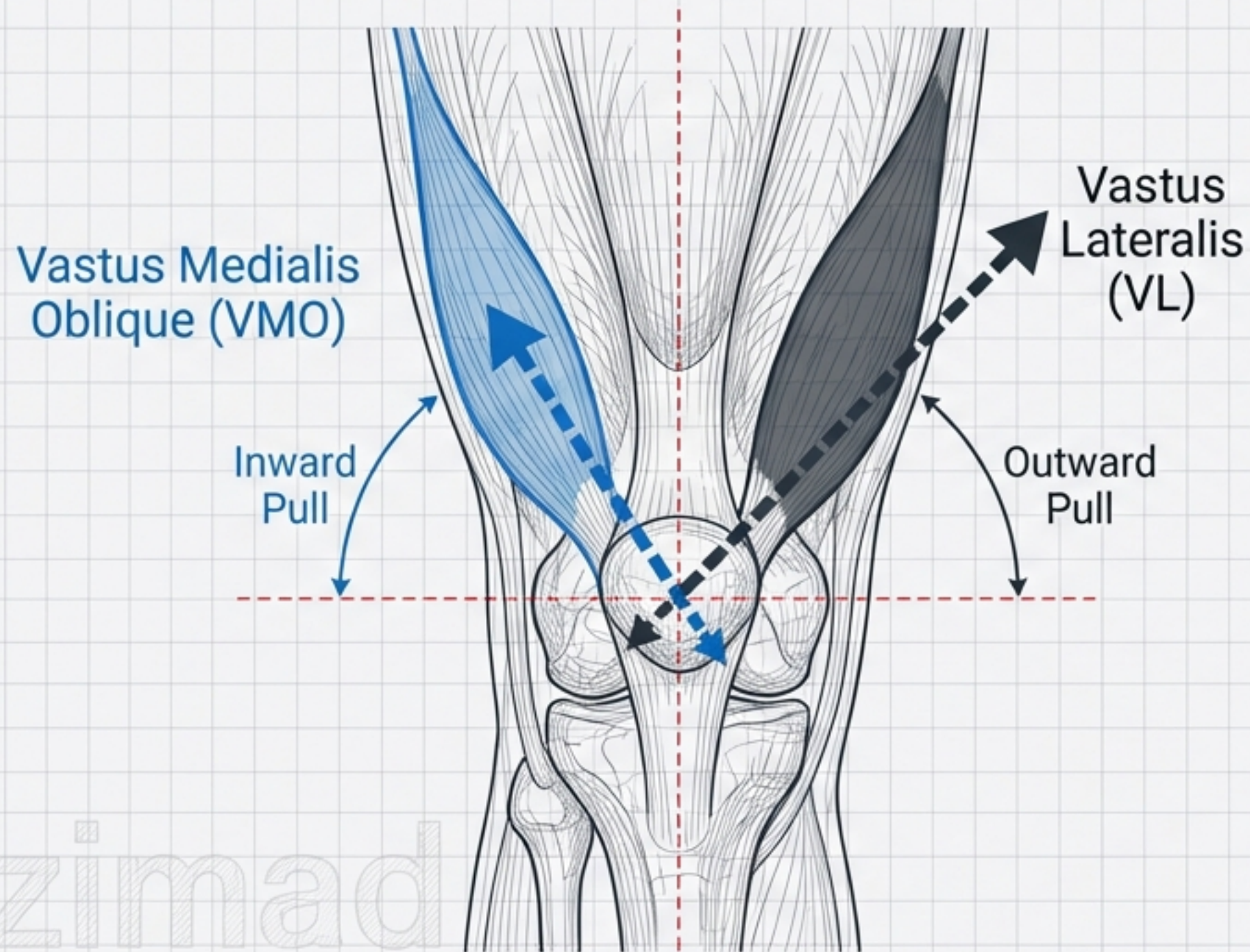
Source: Hemmerich (2006)

Core Stability: The Intra-Abdominal Pressure (IAP) Vessel



IAP stiffens the spine, preventing energy leakage and reducing shear forces on the lumbar vertebrae.

Patellar Tracking: VMO vs. VL Balance



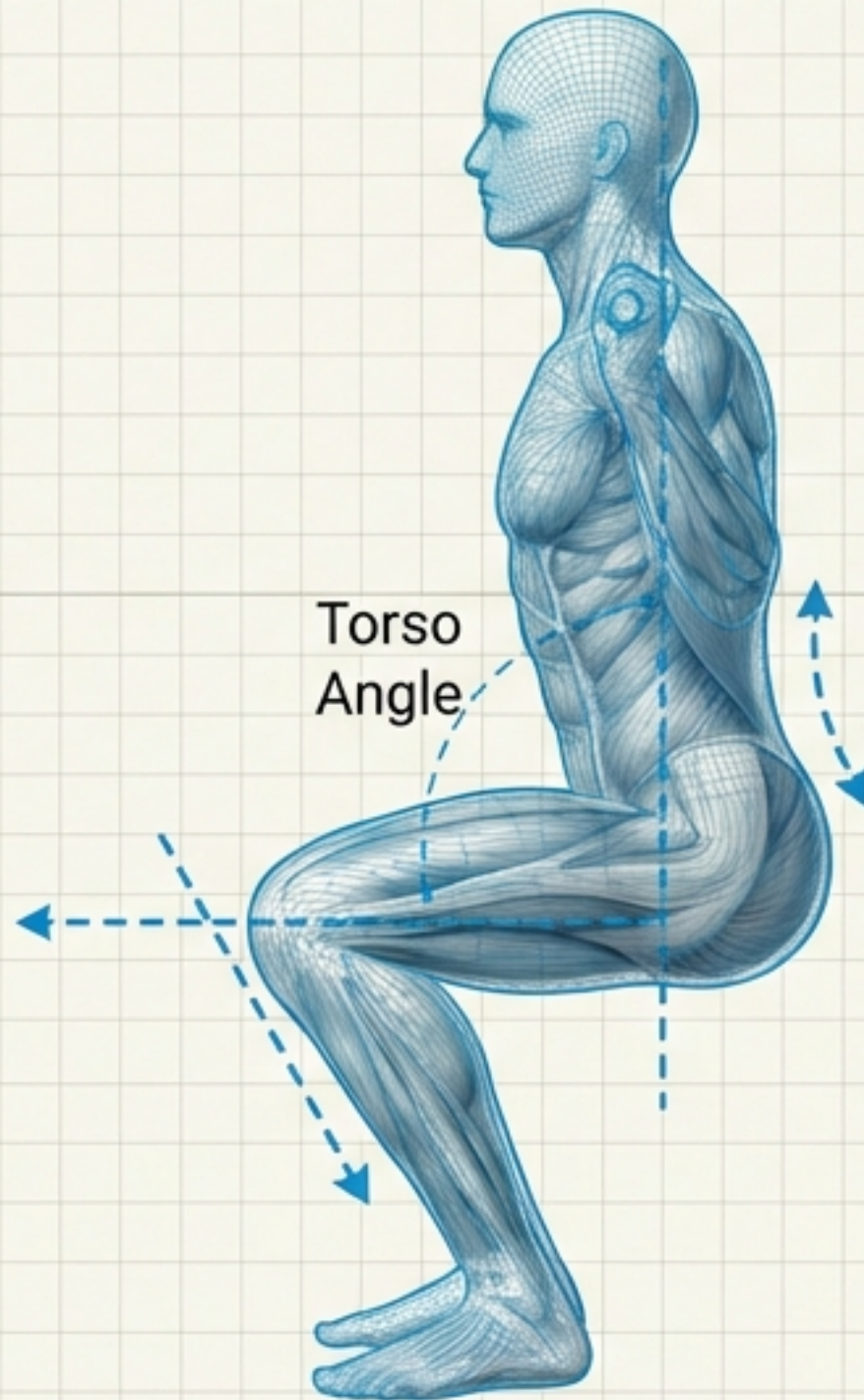
Healthy Ratio	1 : 1	(Balanced)
PFPS Patient Ratio	0.54 : 1	(VMO Weak/Delayed)

Correction: Cue hip external rotation to facilitate VMO activation.

Structural Selection: Front Squat vs. Back Squat

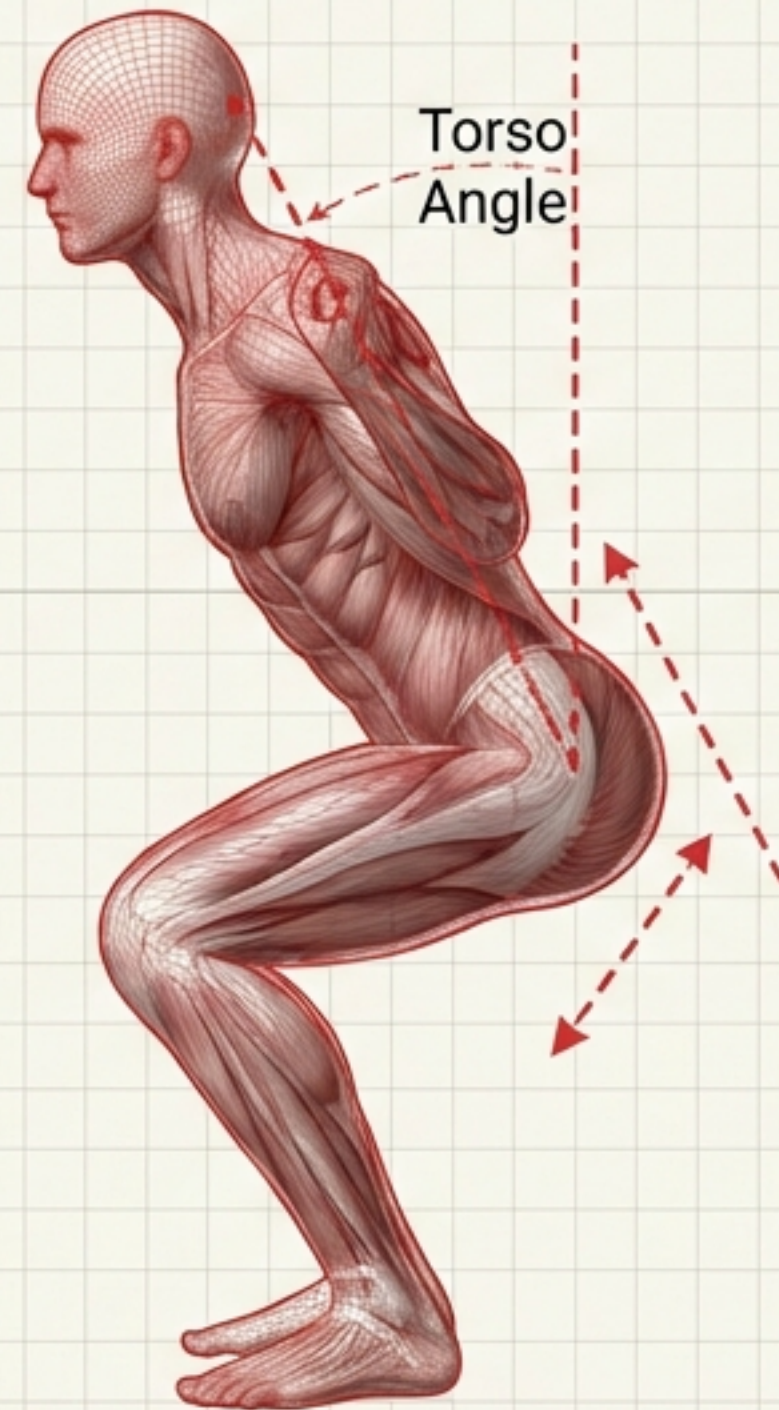
Front Squat

Vertical Torso.
High Quad Activation.
Indication: Rehab / Low
Lumbar Shear.

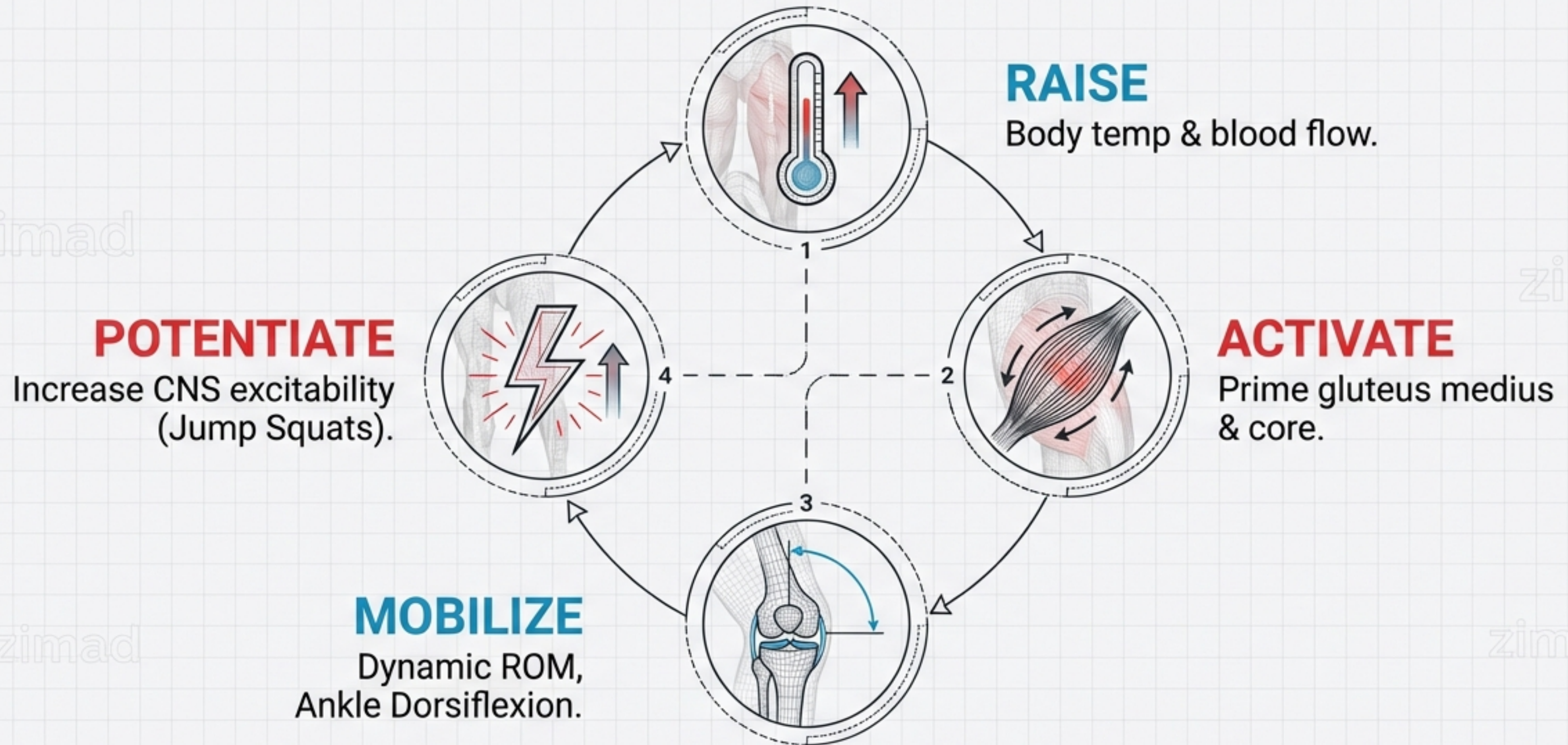


Back Squat

Increased Trunk Lean.
Posterior Chain Loading.
Indication: Max Strength.



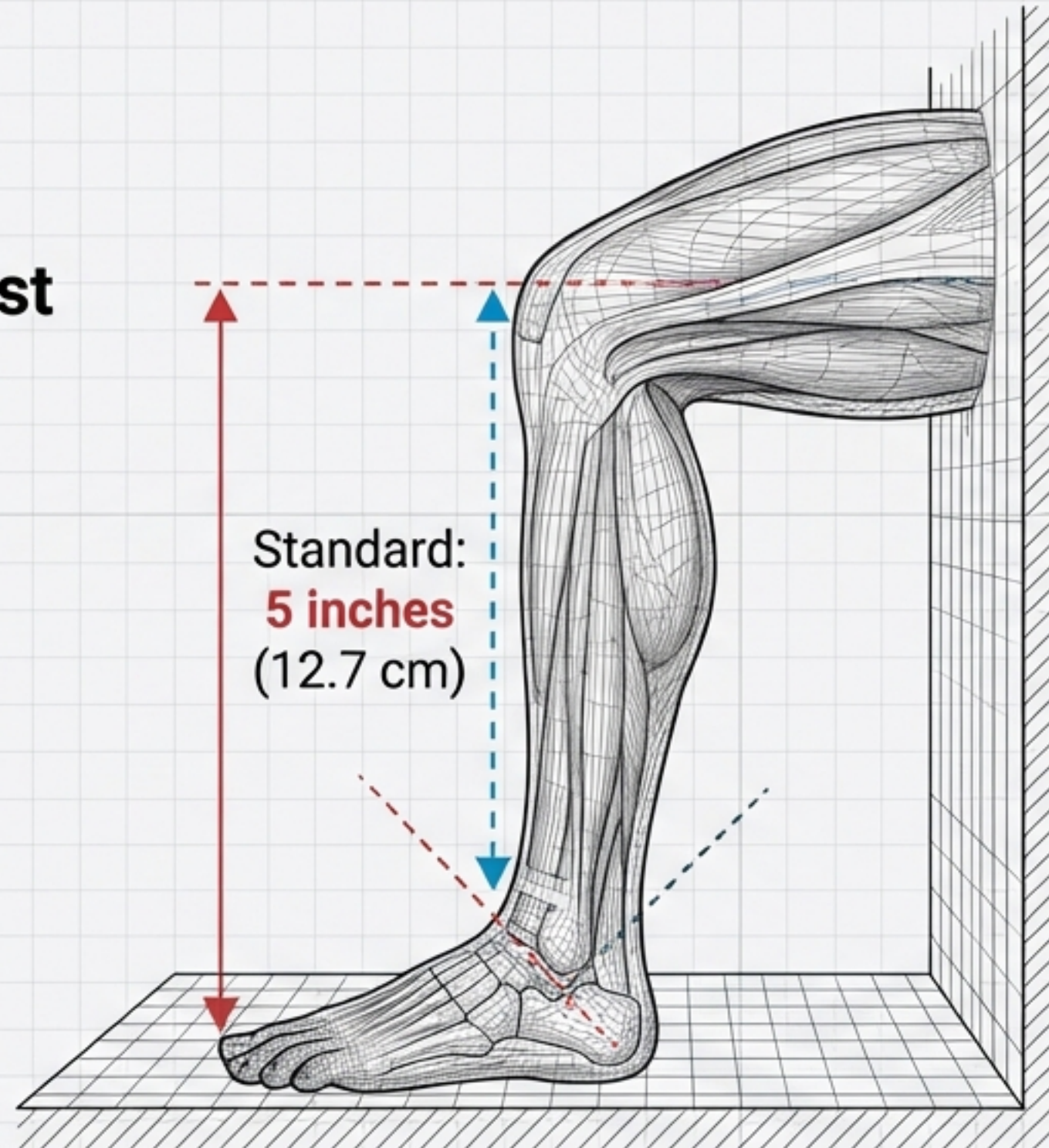
Preparation Protocol: The RAMP Method



Source: Jeffreys (2006)

Diagnostics & Correction: The Ankle Chain

Knee-to-Wall Test



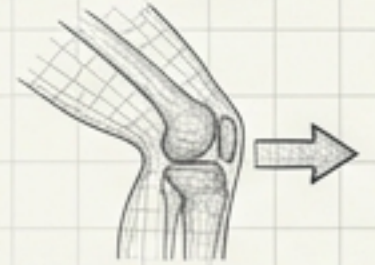
The Fixes

1. **SMR:** Foam roll
Gastrocnemius/Soleus.
2. **Banded Mobilization:**
Posterior talar glide.
3. **Mechanical Aid:**
Weightlifting shoes or
temporary heel lift.

The Safety Checklist & Conclusion



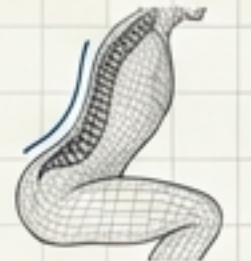
Pathing: Allow natural forward knee travel.



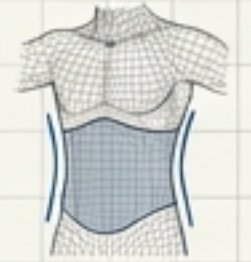
Alignment: Knees track over 2nd toe (No Valgus).



Depth: Maintain lumbar curve (No Butt Wink).



Stability: Maintain IAP (Canister position).



Proper biomechanics transform the squat from an injury risk into a rehabilitative tool.