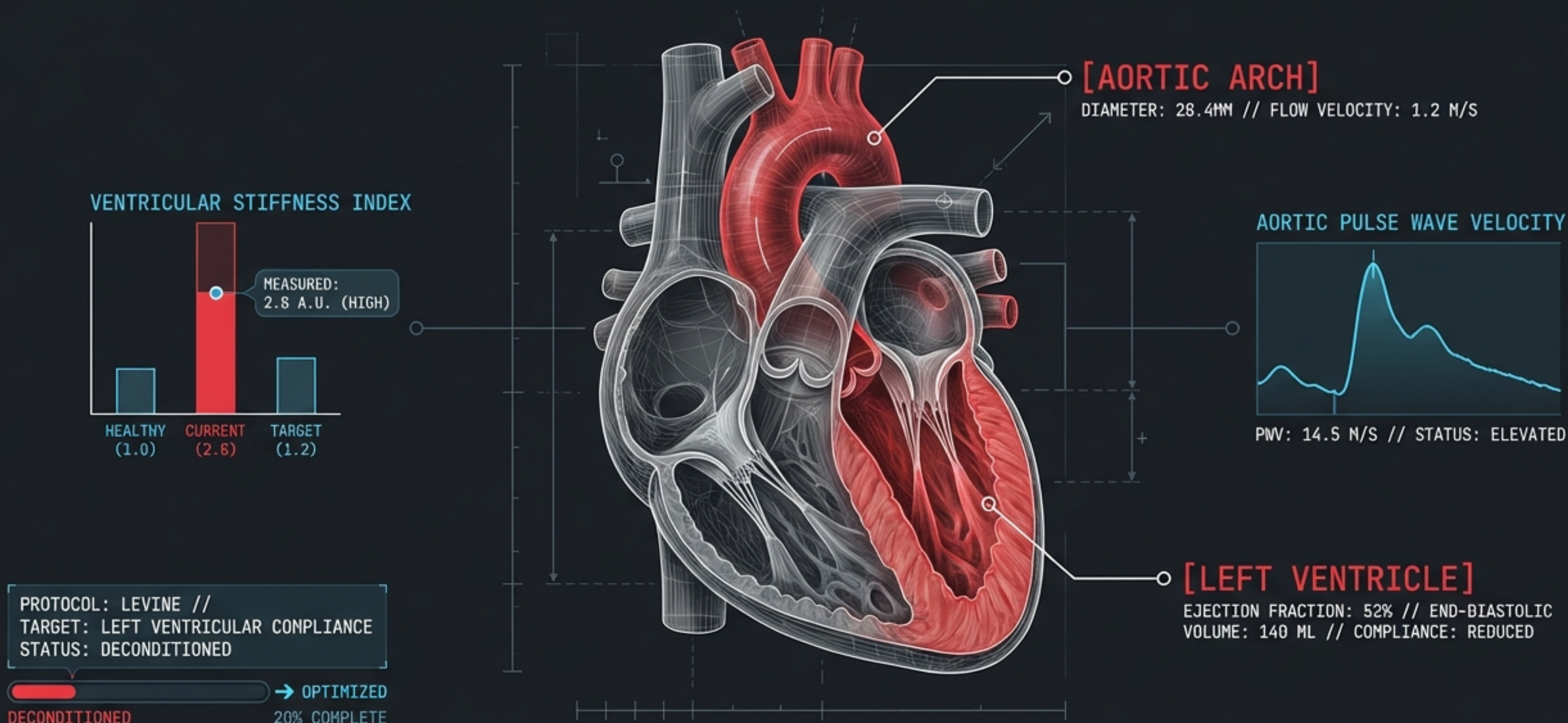


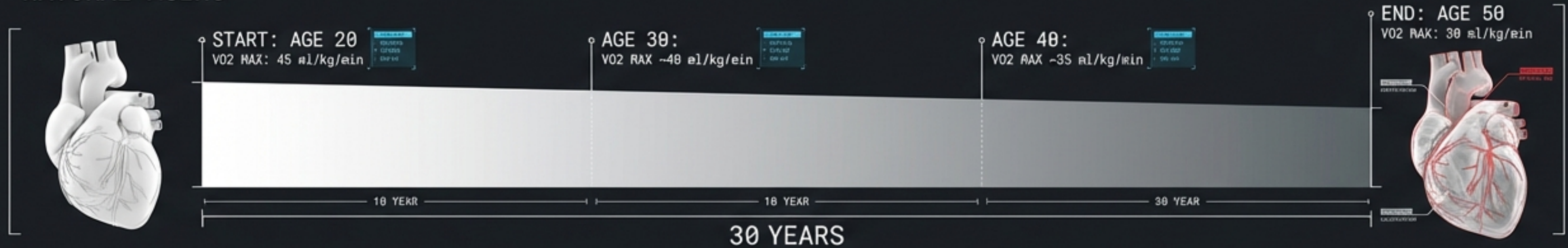
THE PLASTIC HEART

Reversing Cardiovascular Aging Through Structural Remodeling

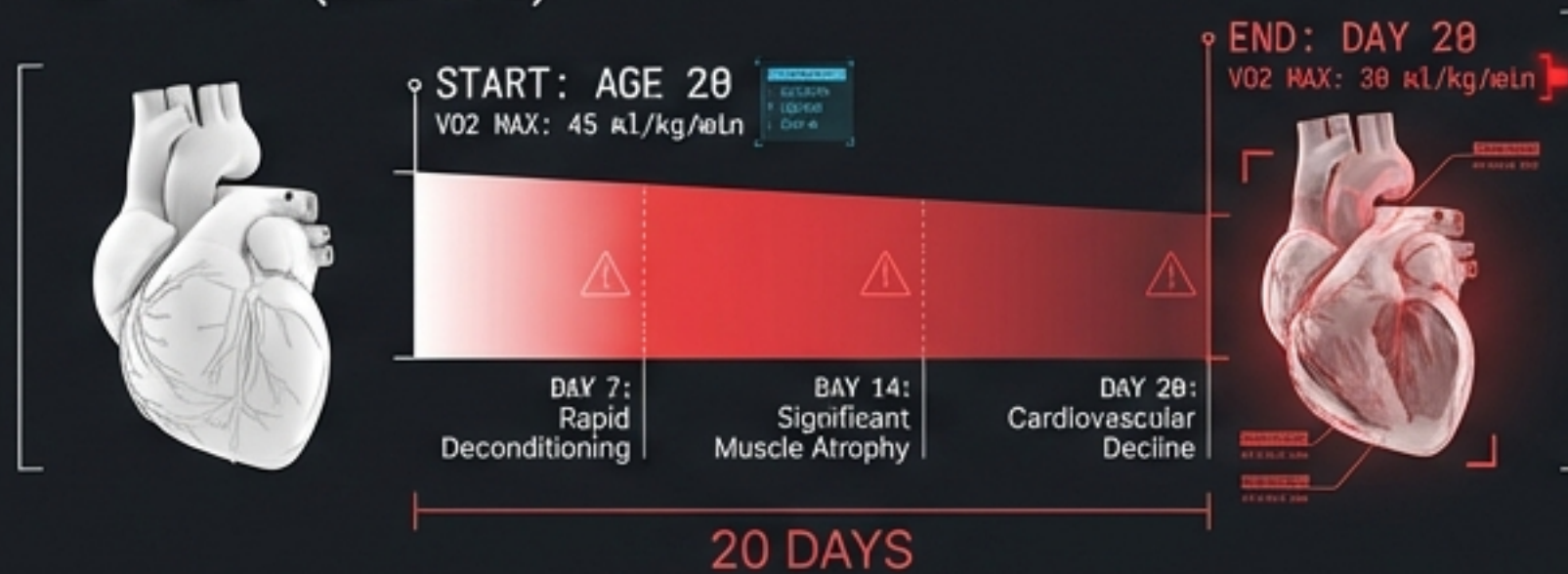


THE SEDENTARY ACCELERATOR

NATURAL AGING



BED REST (DISUSE)

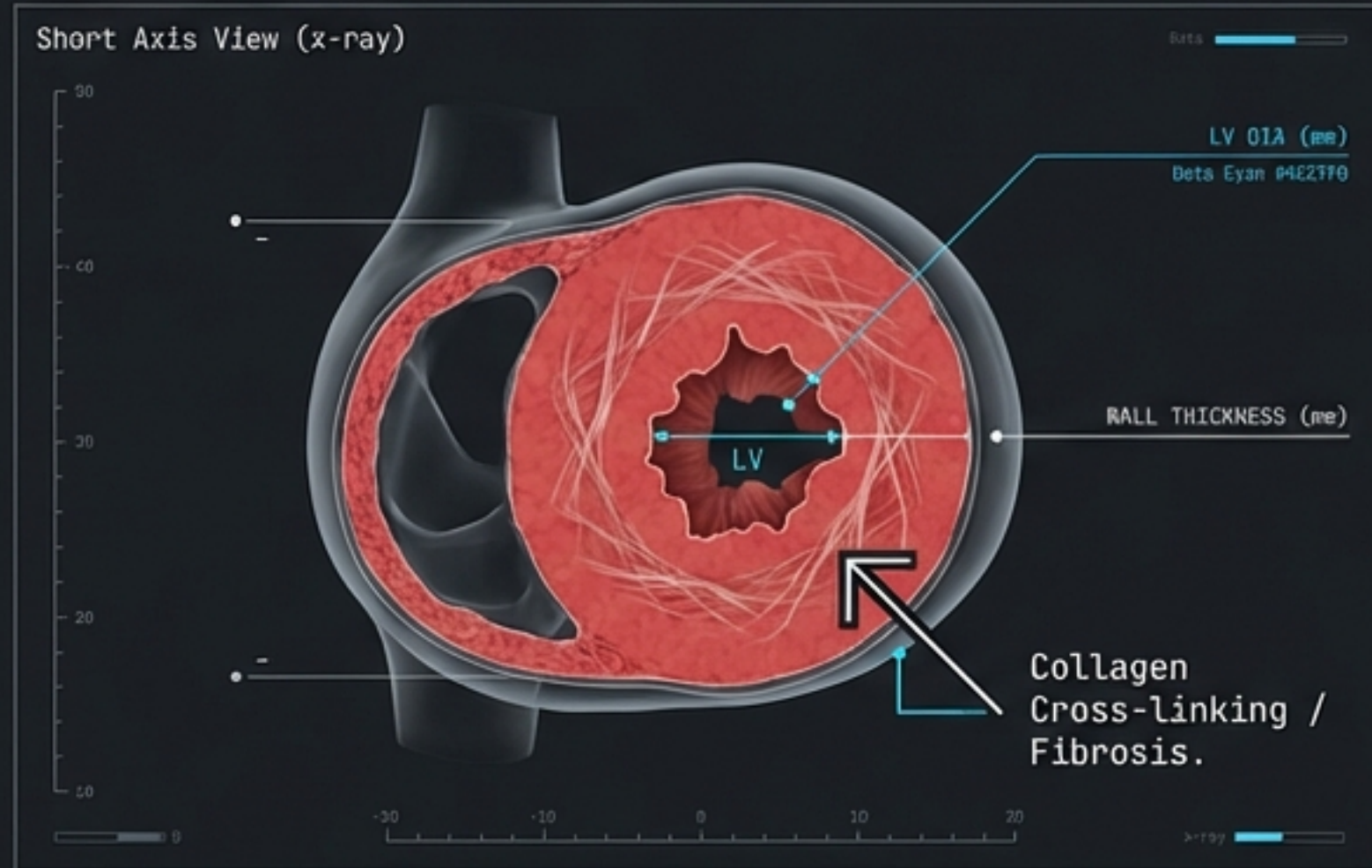


DATA SOURCE:
DALLAS BED REST STUDY.
20 days of bed rest in
20-year-olds caused a loss of
cardiovascular capacity equivalent
to 30 years of natural aging.

Chronological Age ≠ Biological Age.
Decline is driven by deconditioning.

THE SMALL HEART PHENOTYPE

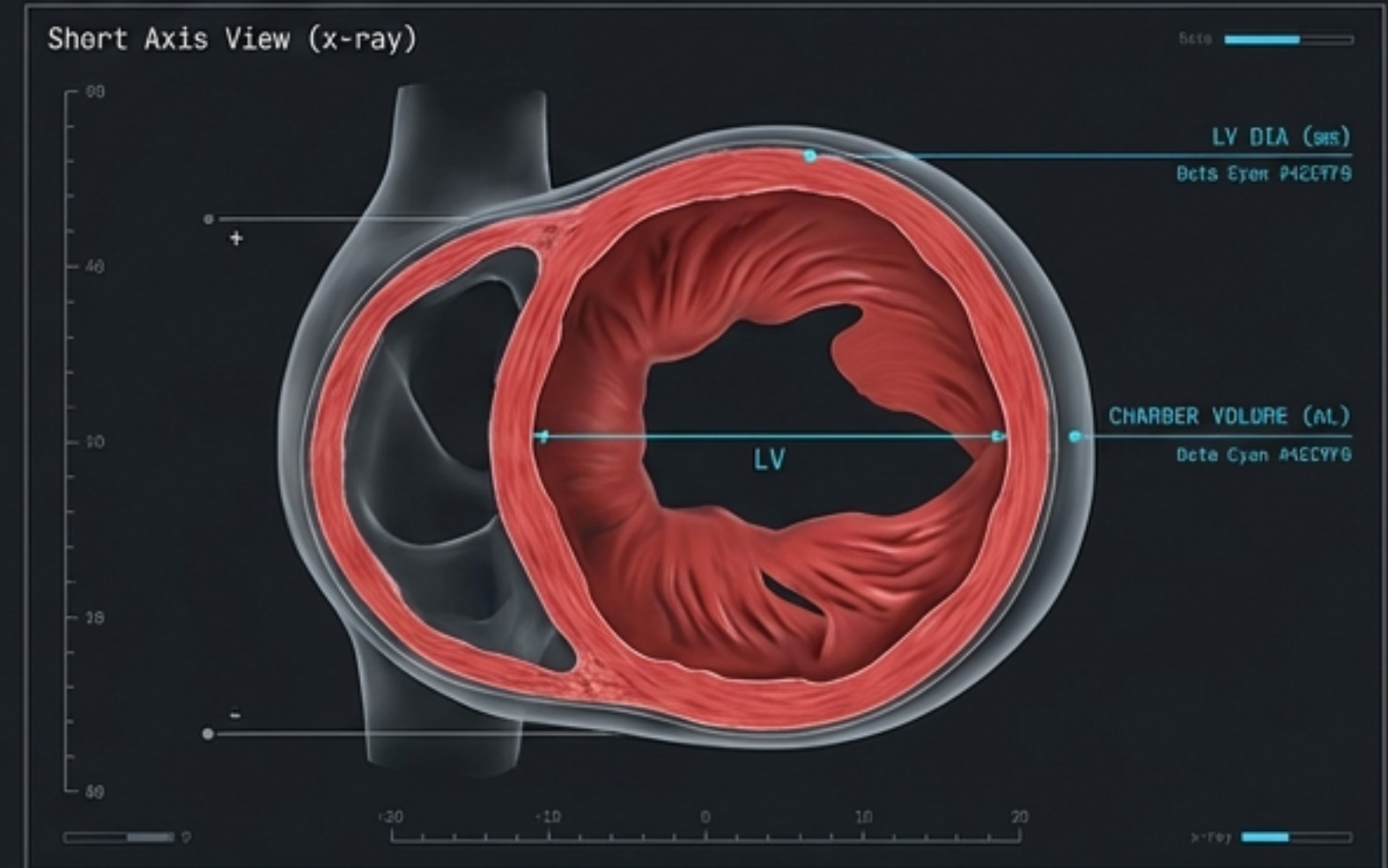
THE SEDENTARY HEART



ATROPHY & STIFFNESS

The sedentary heart physically shrinks. The Left Ventricle loses the chamber size required to pump effectively against systemic pressure.

THE ATHLETIC HEART

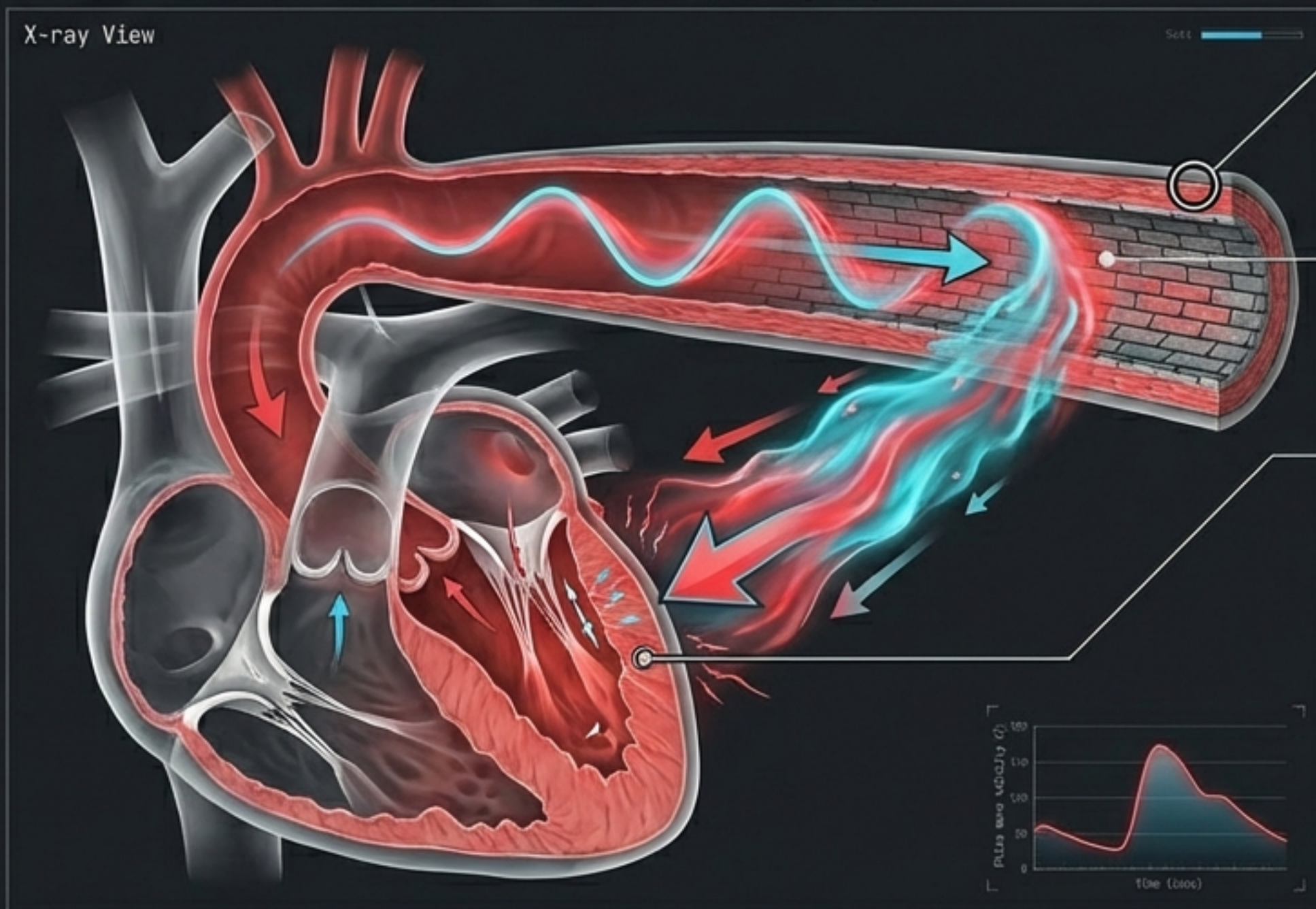


COMPLIANCE & VOLUME

THE STIFFNESS CASCADE

Effective Arterial Elastance (E_a)

X-ray View



Mechanism: Loss of Elastin
→ Collagen Cross-linking.

Collagen

Result: Increased Pulse Wave
Velocity. [PWV: >12 m/s (High)]

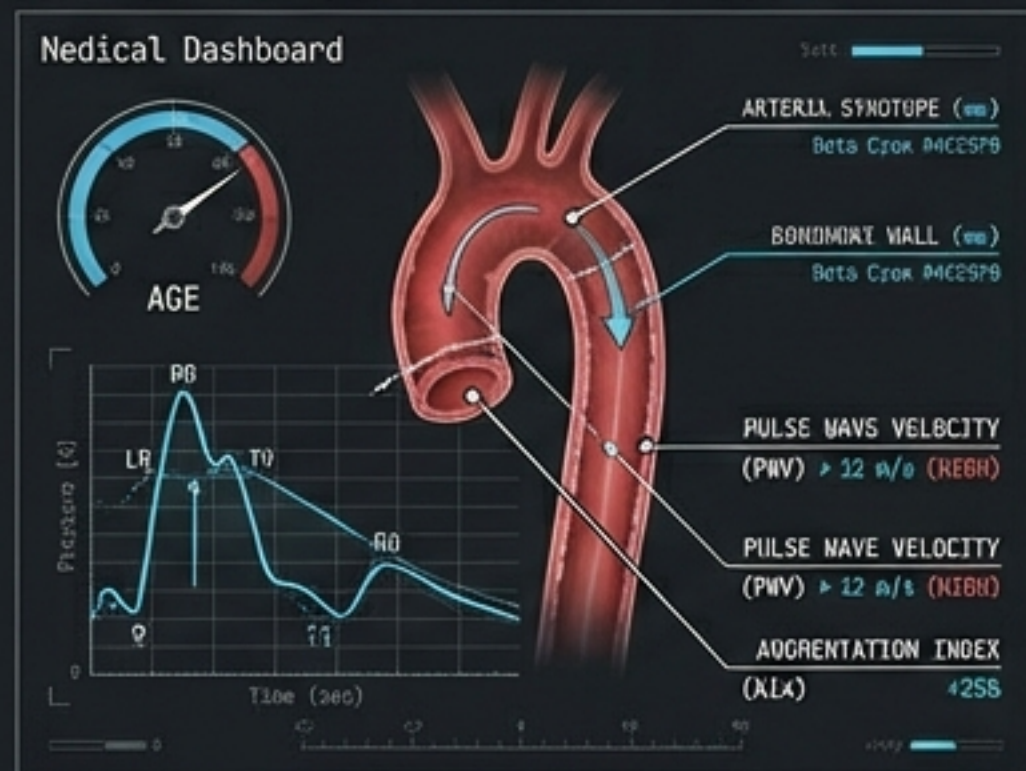
Consequence: HFpEF (Heart Failure
with Preserved Ejection Fraction).

The heart pumps against a brick wall.
Stiff arteries reflect energy back
too early, increasing the afterload
on the Left Ventricle.

Stiffness Progression

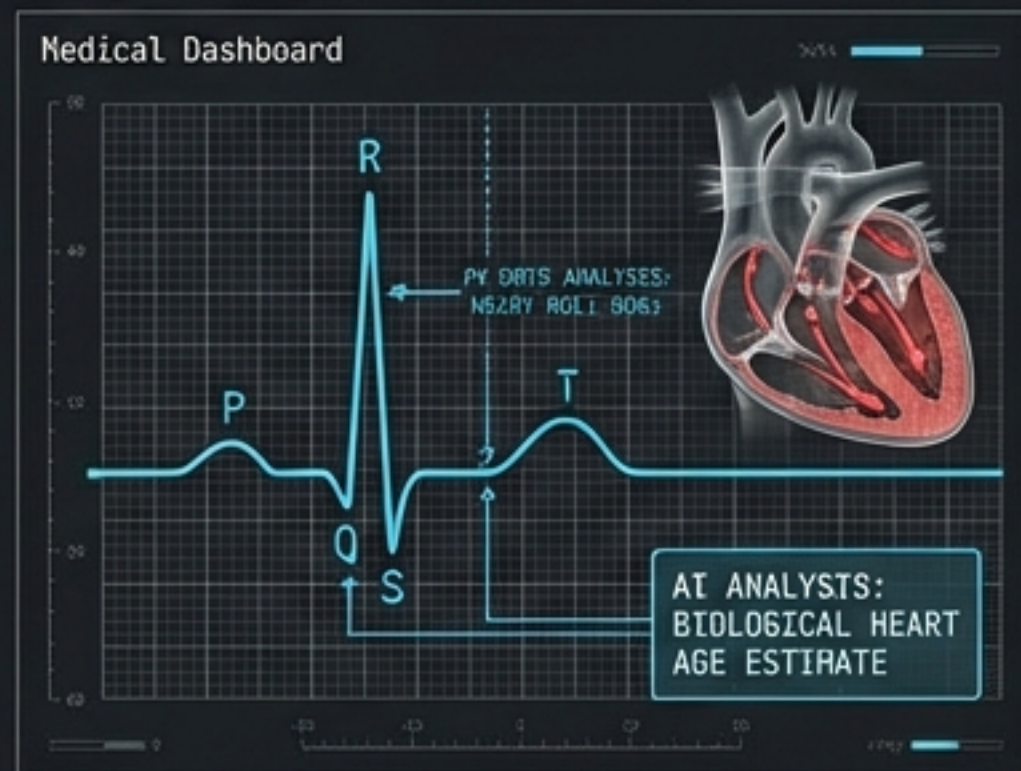
QUANTIFYING BIOLOGICAL AGE

MODELFLOW AORTIC AGE



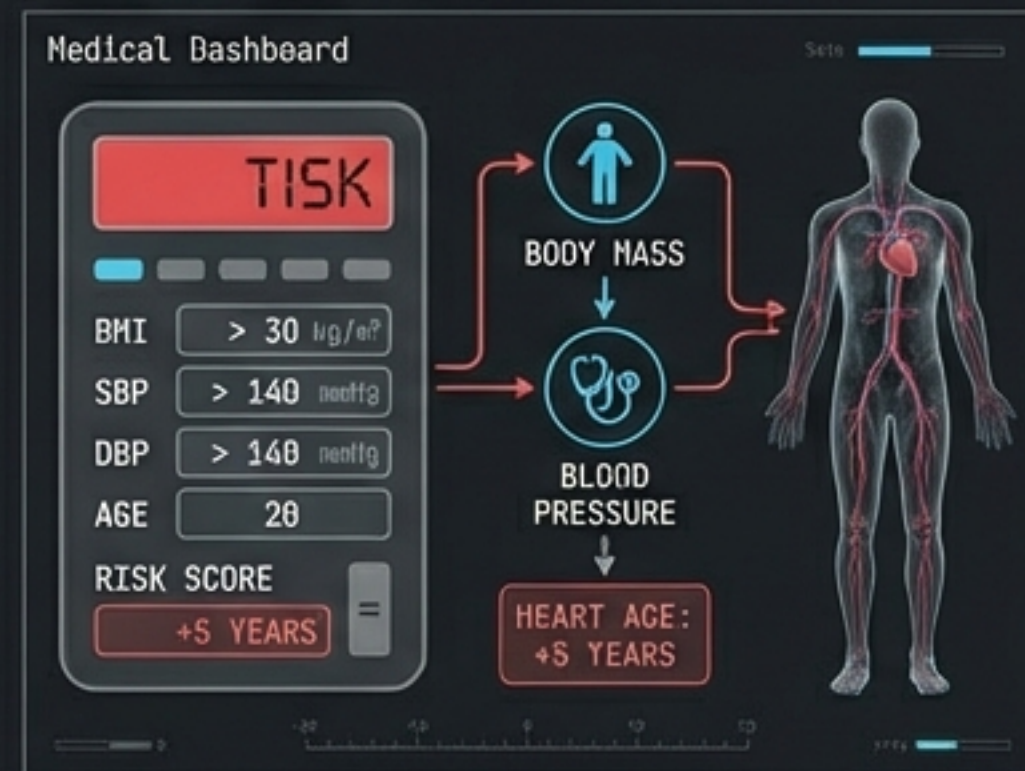
The Gold Standard. Measures intrinsic stiffness.

ECG HEART AGE GAP



AI Analysis. Gap = 7-14 years in at-risk patients.

FRAMINGHAM RISK



Based on BMI/BP. Excess BMI = +2 Years Heart Age.

BENCHMARK: Masters Athletes (>25 years training) possess aortas biologically 25-30 years younger than chronological age.



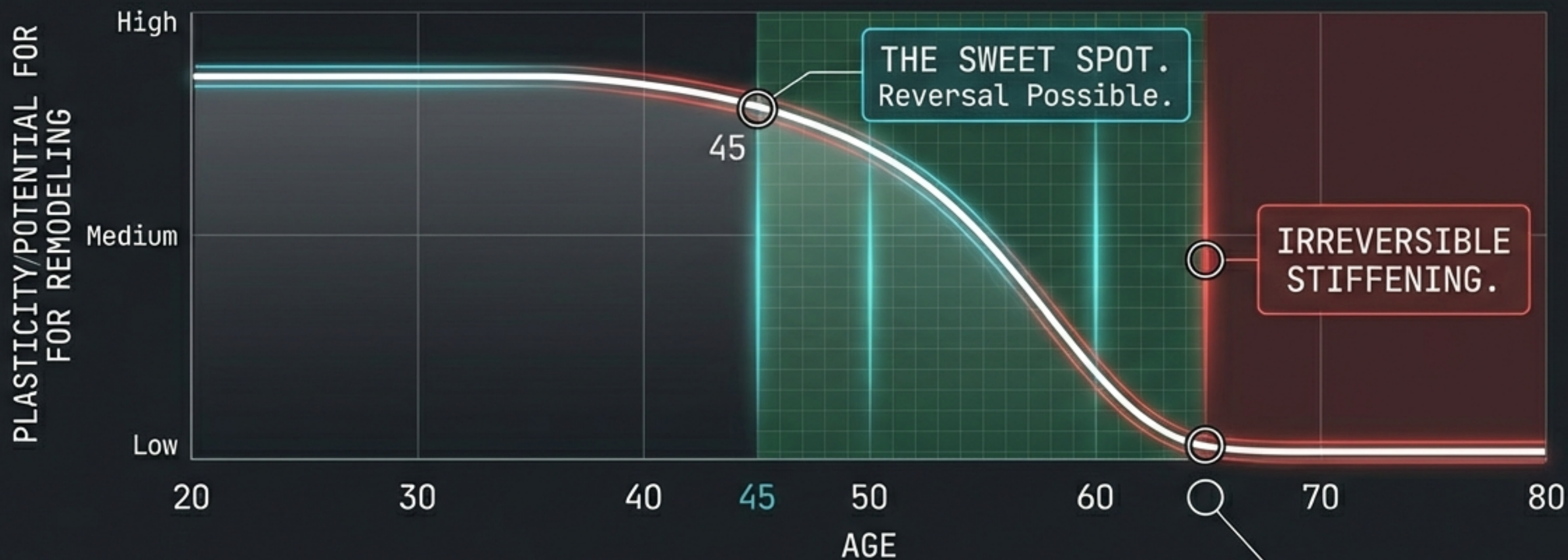
CHRONOLOGICAL AORTA (AGE 50)



MASTERS ATHLETE AORTA (AGE 50)

ELASTICITY PRESERVED

THE CRITICAL WINDOW



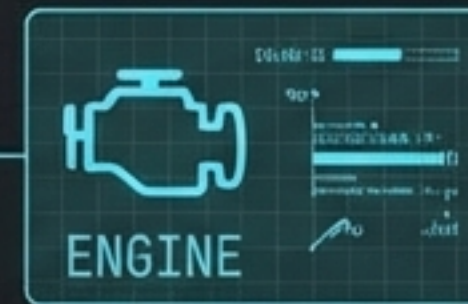
After age 65, collagen cross-linking becomes permanent.
You must intervene while the heart is still malleable.

THE DOSE-RESPONSE RELATIONSHIP

AORTA.
Requires "Committed"
Exercise (4-5 days/week).

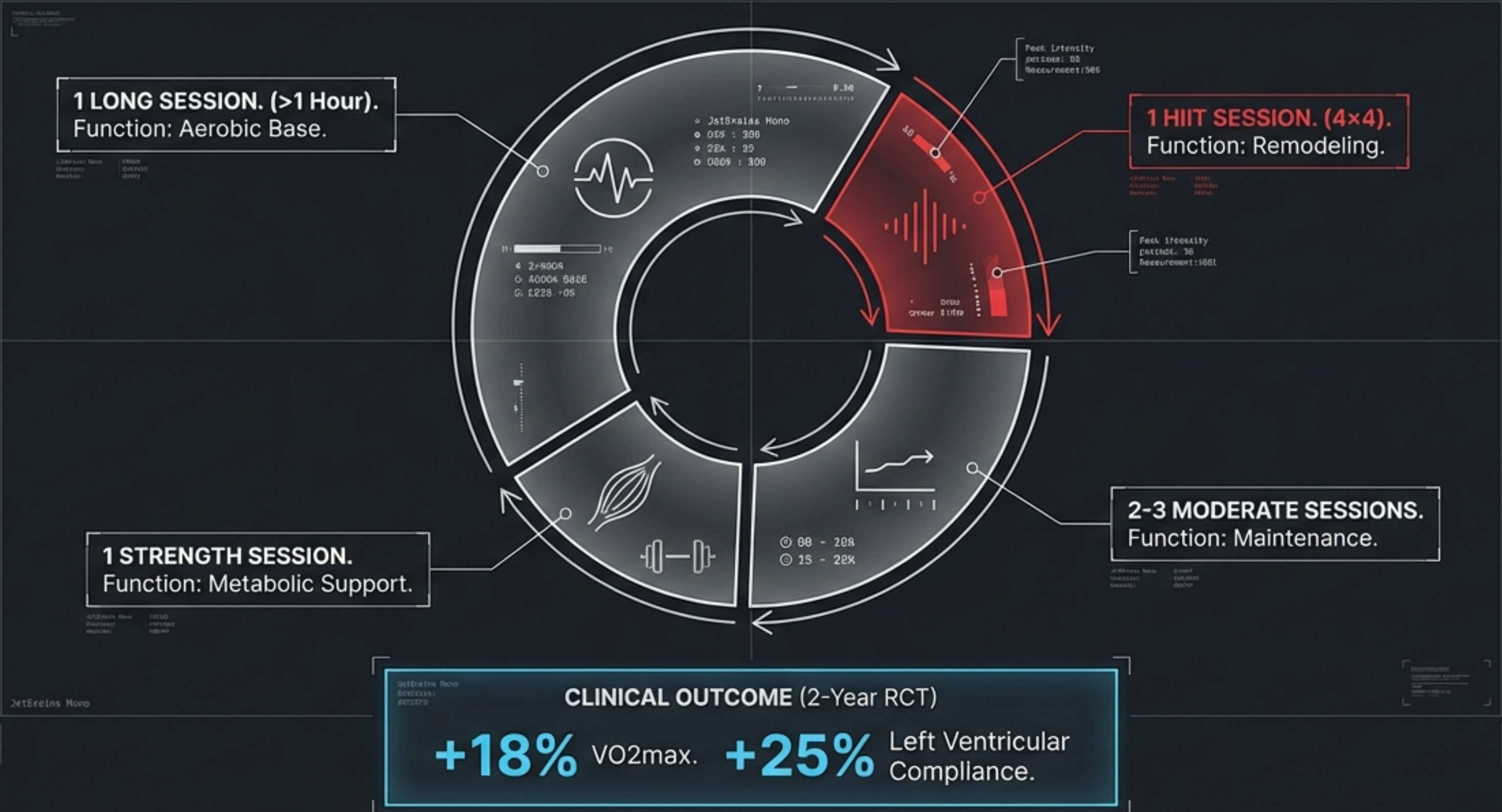
CAROTID.
Saved by "Casual" Exercise
(2-3 days/week).

PERIPHERAL.
Low response to
exercise.



KEY INSIGHT: Casual exercise saves the neck arteries but leaves the central heart stiff. Only committed exercise preserves the engine.

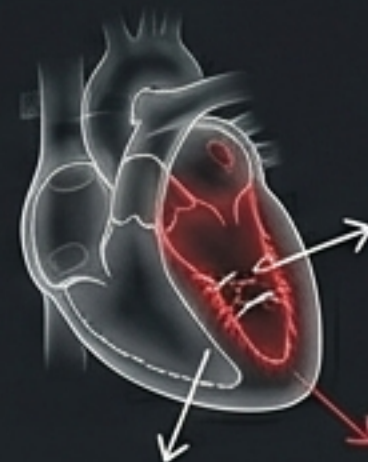
THE LEVINE PROTOCOL



ENGINE OF REMODELING: 4x4 HIIT

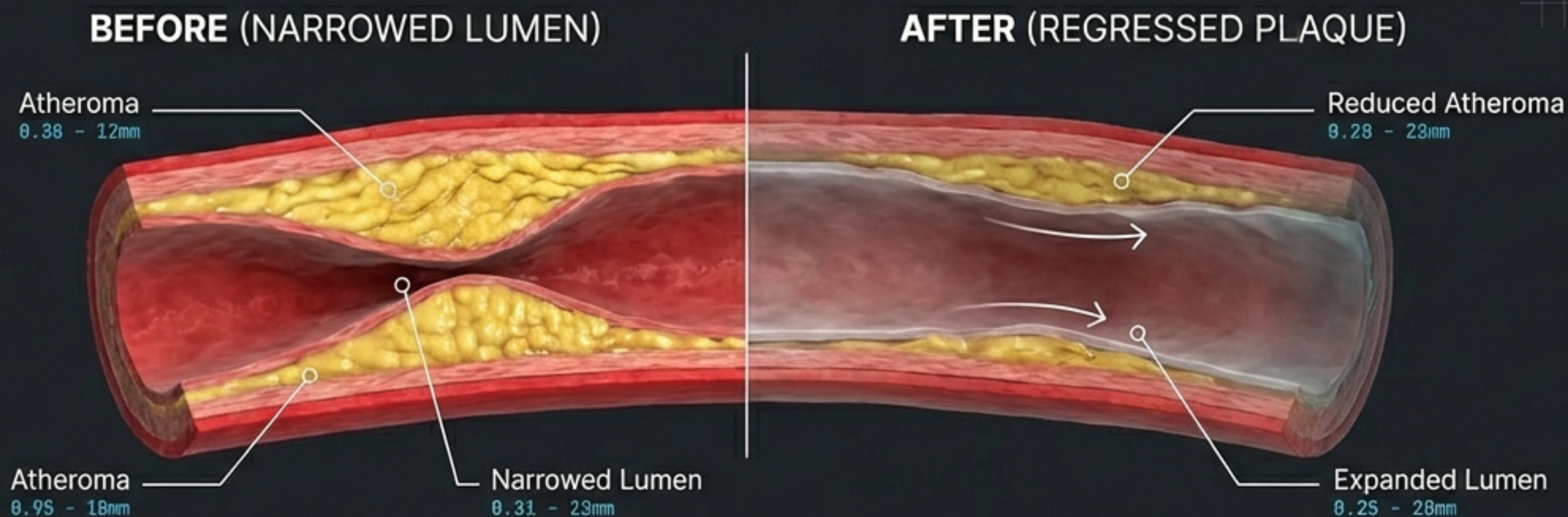


MECHANISM: Maximal stroke volume stretches the Left Ventricle, breaking collagen cross-links and restoring the 'snap'.



Intensity: Conversation is impossible.

REVERSING ATHEROSCLEROSIS



CENIT TRIAL: HIIT reduced total atheroma volume by 1%.

LIFESTYLE HEART TRIAL: 7.9% regression of stenosis over 5 years (vs. 27.7% worsening in controls).

TAKEAWAY: Plaque volume is not permanent. It can be regressed.

THE ATHLETE'S PARADOX

IMAGE A (SEDENTARY)

VULNERABLE PLAQUE

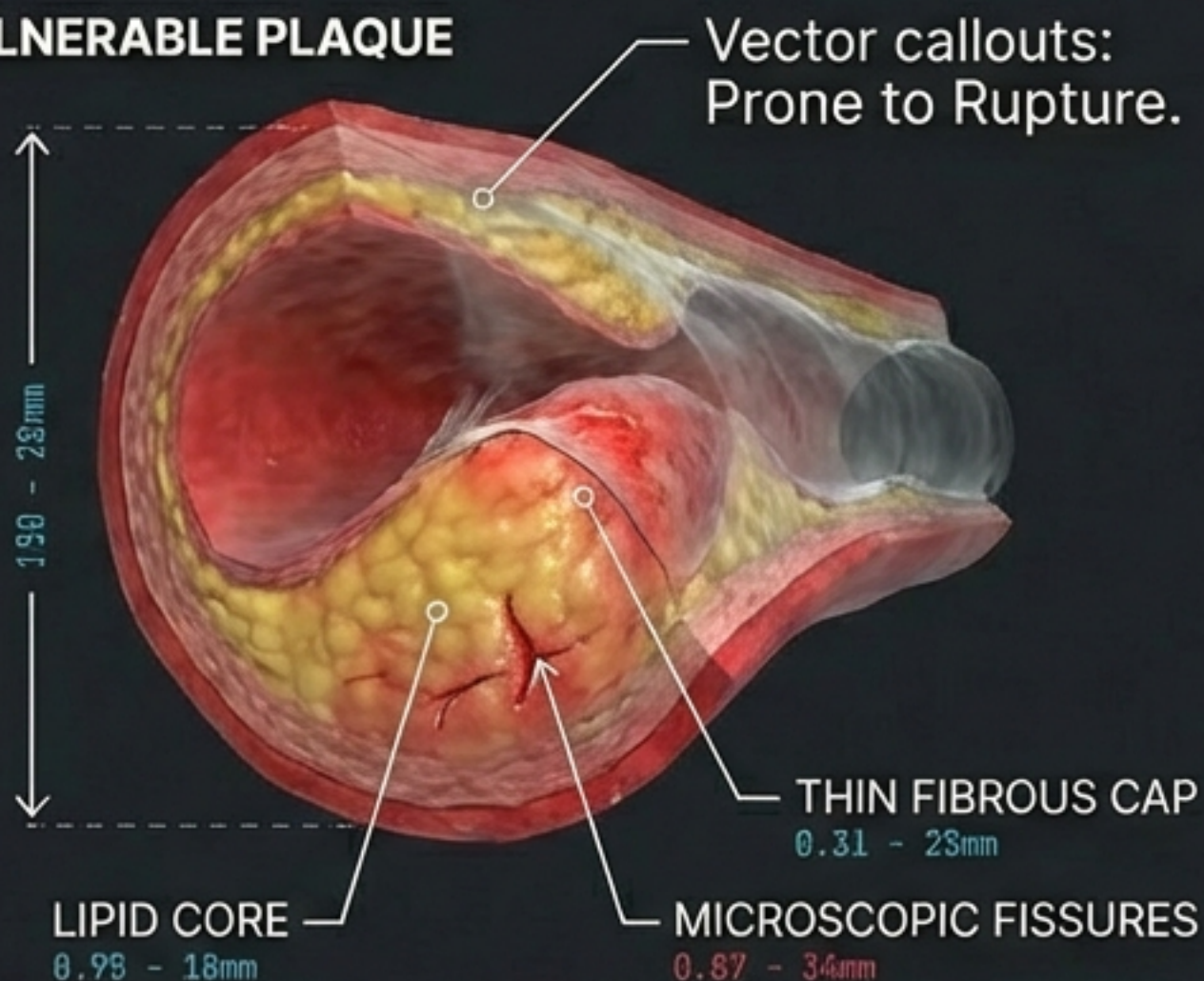
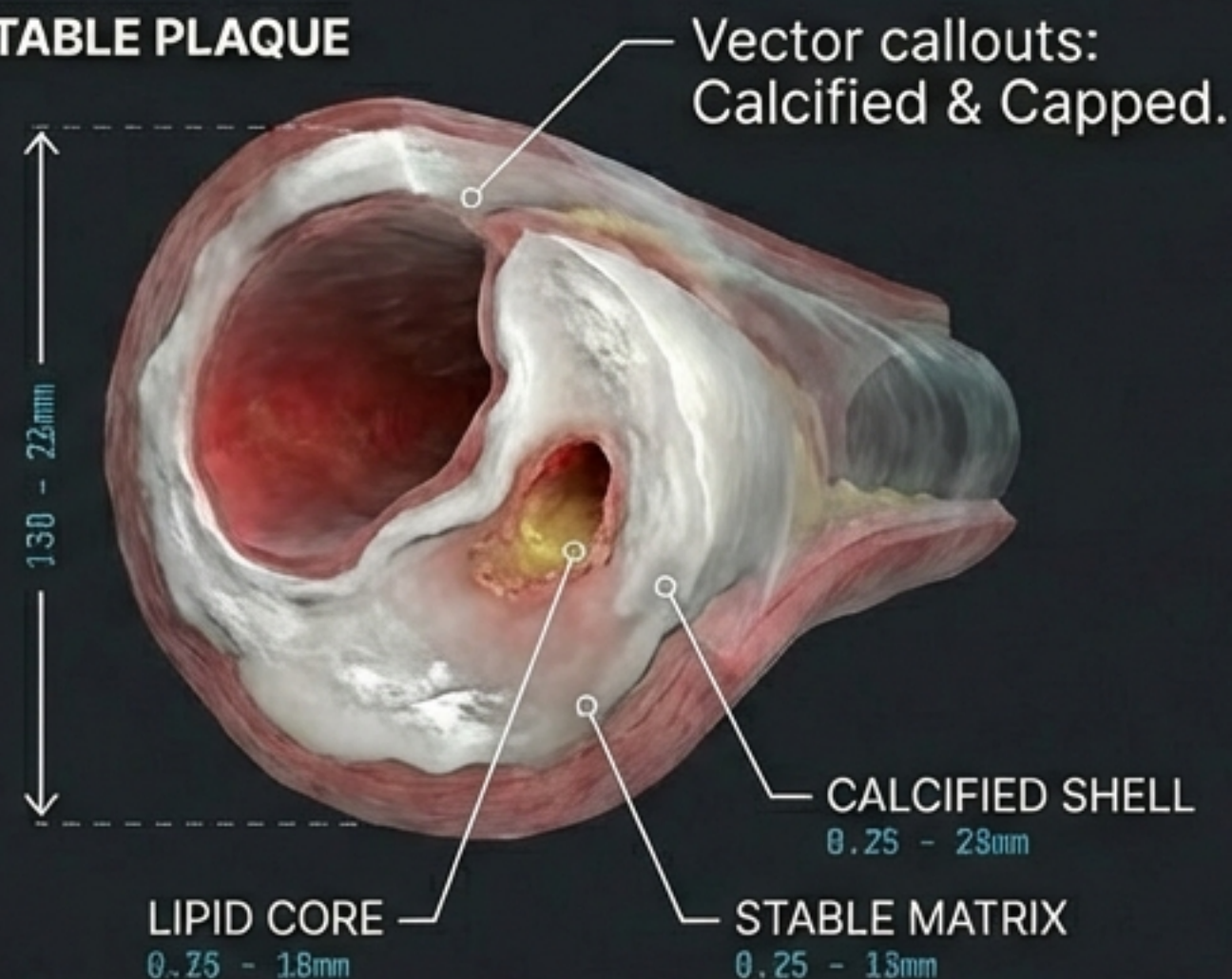


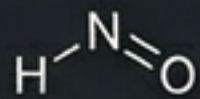
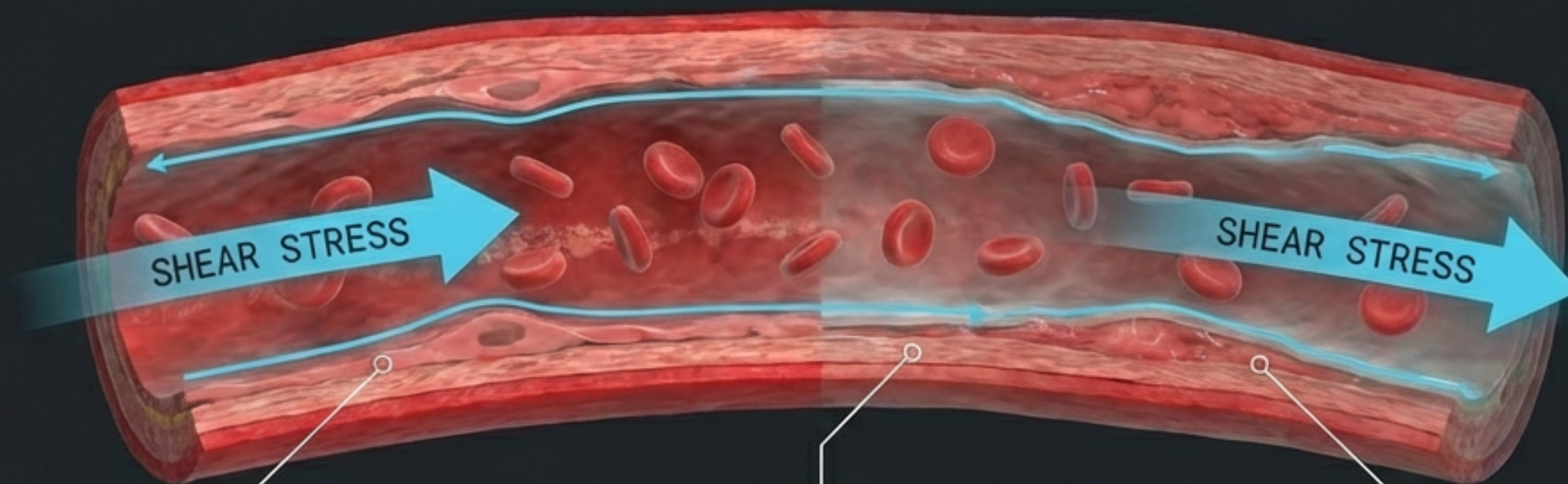
IMAGE B (ATHLETE)

STABLE PLAQUE



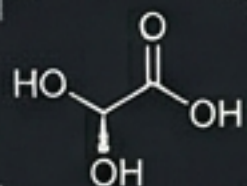
High-intensity exercise may increase Calcium Scores (CAC),
but it transforms dangerous soft plaque into stable scars.
It is a stabilization mechanism, not active disease.

THE MOLECULAR PHARMACY



NITRIC OXIDE (eNOS):
Vasodilation &
Anti-inflammation.

CONCENTRATION: 5.4 μM



LACTATE:
Polarizes Macrophages
to M2 (Healing) State.

ACTIVITY: +286%

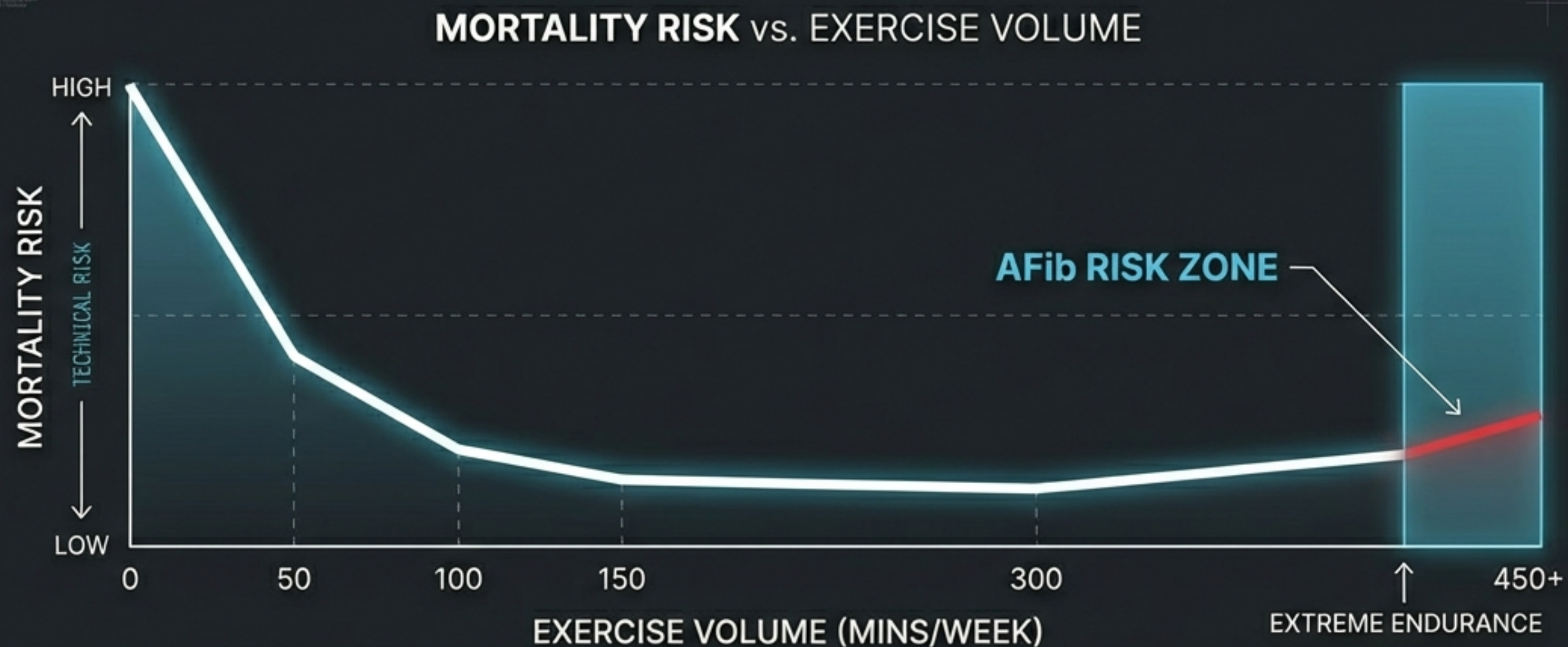


OGG1 ENZYME:
Repairs DNA damage
and genomic lesions.

ACTIVITY: +288%

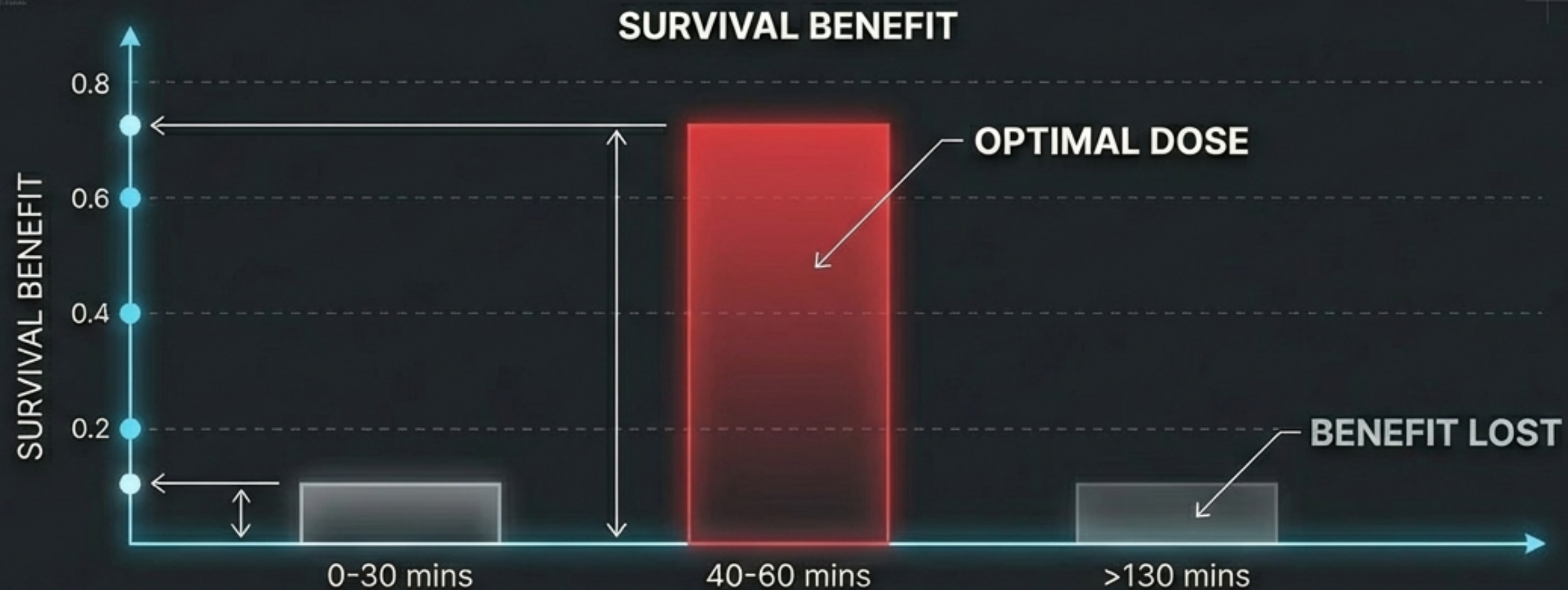
TAKEAWAY: Exercise acts as a systemic drug, altering gene expression and triggering cellular repair.

THE LIMIT: REVERSE J-CURVE



Chronic excessive stretching of the **ATRIA** (upper chambers) increases **Atrial Fibrillation** risk in extreme endurance athletes. Benefits cap at ~150 mins vigorous activity/week.

STRENGTH: THE GOLDBLOCKS ZONE



Resistance training is vital for mitochondrial health, but toxic in excess. 40-60 minutes per week is the maximal effective dose.

THE REJUVENATION BLUEPRINT

- ✓ **TIMING:** Start before age 65 (The Window)
- ✓ **DOSE:** 4–5 days/week (Committed Status)
- ✓ **KEY DRIVER:** 4x4 HIIT (Left Ventricle Stretch)
- ✓ **GOAL:** Revert Heart Age by 20+ years.

THE HEART IS PLASTIC. THE DECLINE IS A CHOICE.