

Ligaments

A Source of Work Related Disorders

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2003 STAR Symposium

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Ligaments Are the Major Restraints of the Joints

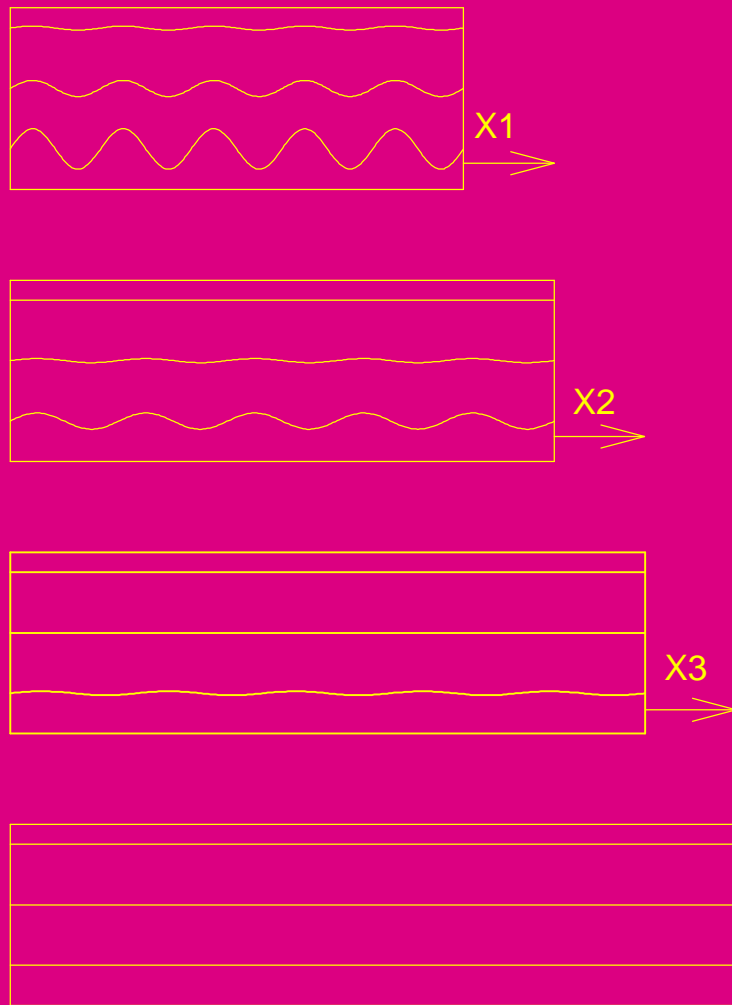
e.g.

- Keeping Bones Connected to Each Other
- Keeping Bones Moving Relative to Each Other on a prescribed Track
- Keeping Even Articular Surface Contact and Pressure

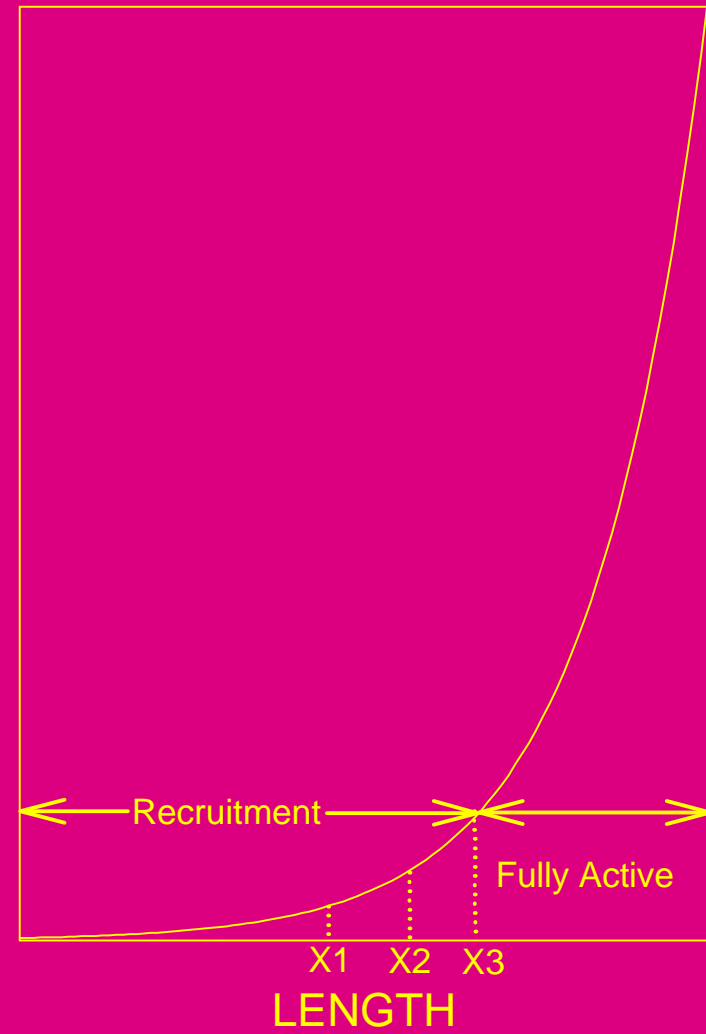
- Ligaments are composed of collagen fibers with helical wave along their axis
- Some fibers have deeper waves than others

Stretching a Ligament Results in a Fiber “Recruitment” Process

- Fibers with shallow wave straighten out first and become stiffer
- Fibers with gradually deeper wave stretch progressively to result in gradual stiffening



TENSION



Net Effect is a Non-linear Length-Tension Curve

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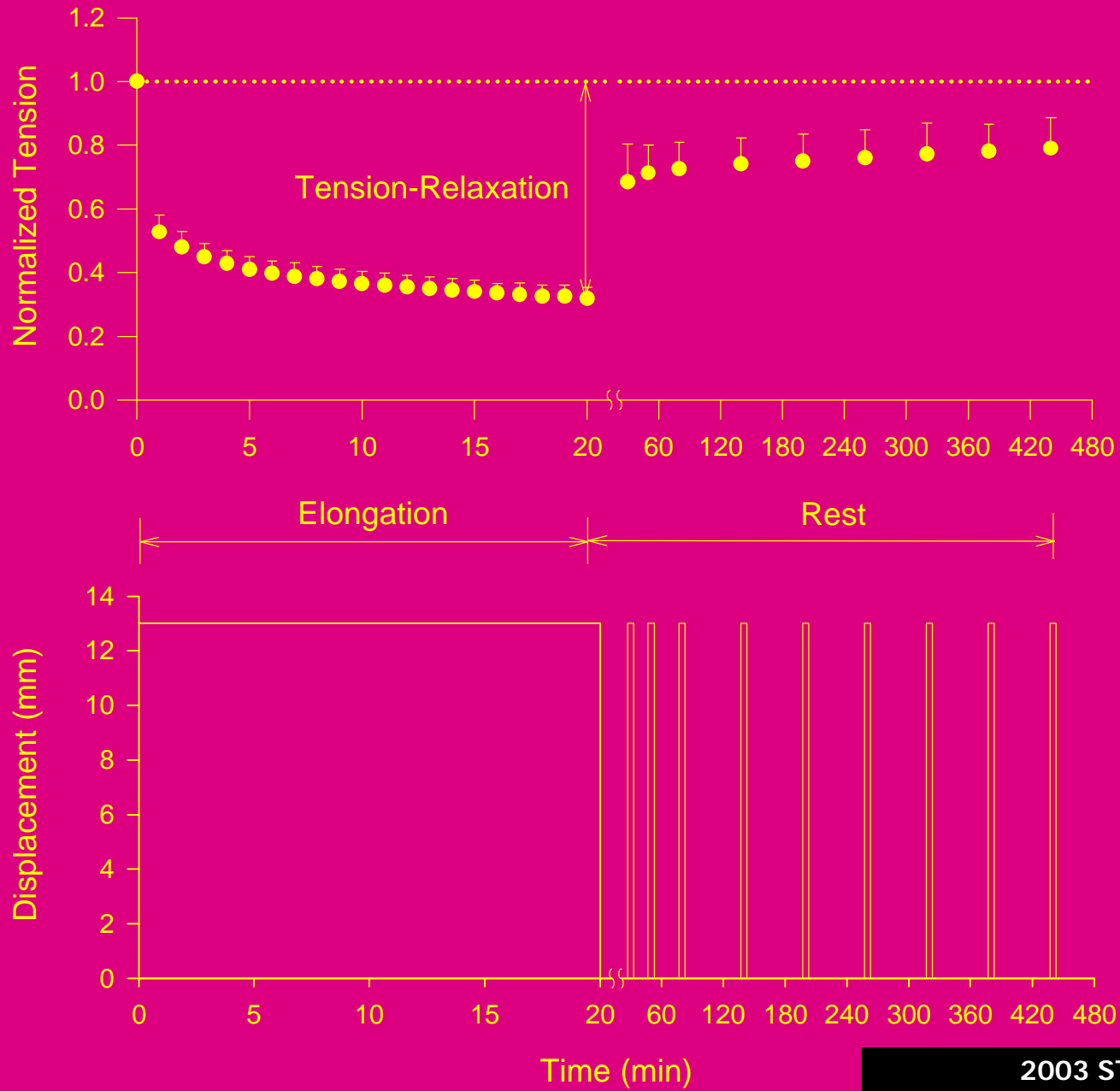
- Collagen is a viscoelastic substance
- As such it displays a common behavior consisting of:
 - Creep
 - Tension – Relaxation
 - Hysteresis
 - Time/Frequency Dependent Length–Tension

All of which lead us to suspect that disorders will be present with time, stretch and load

Tension–Relaxation and its Recovery

Example:

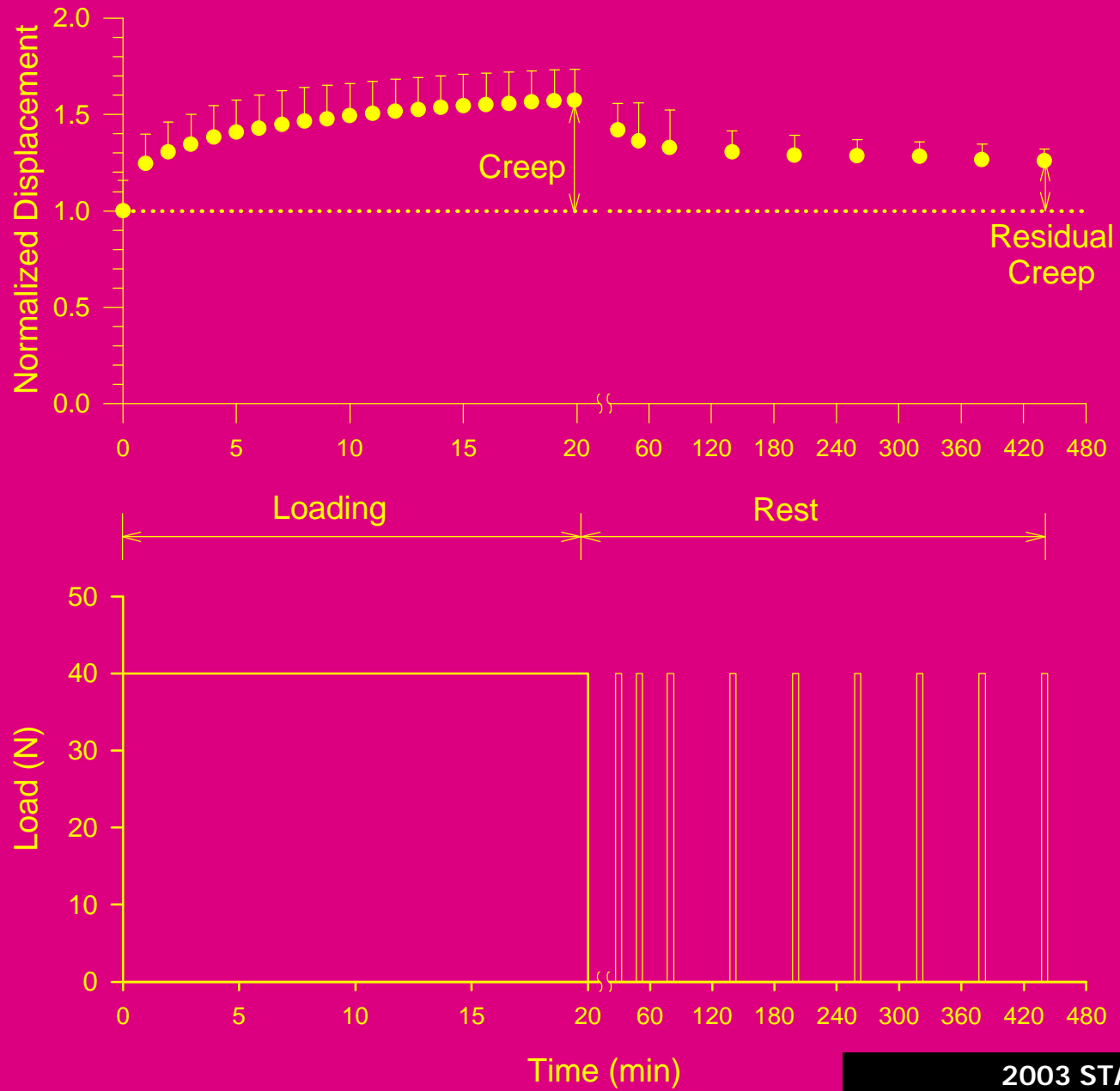
20 Minutes of static or cyclic stretch results in tension – relaxation which does not fully recover after 7 hours rest



Creep and its Recovery

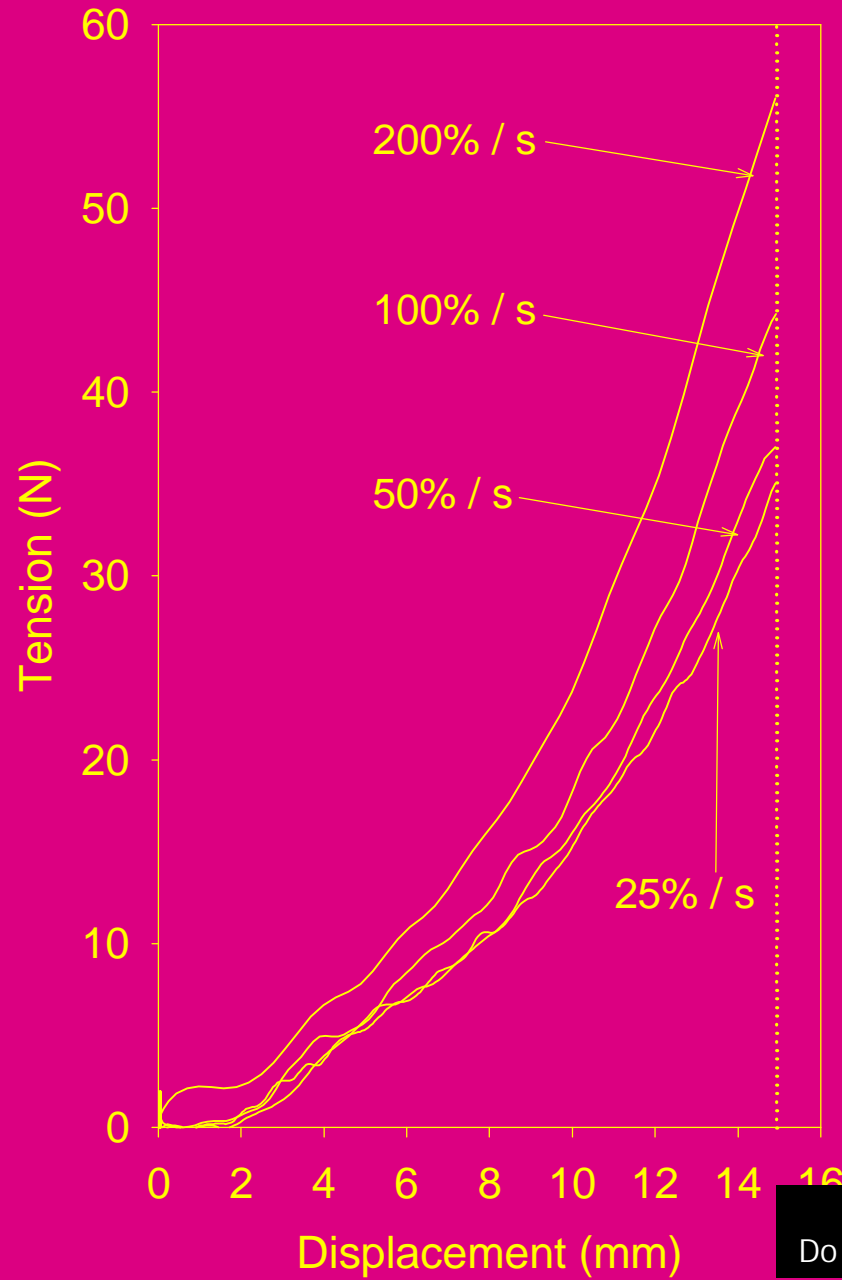
Example:

20 minutes of static or cyclic load application result in creep which does not fully recover after 7 hours of rest



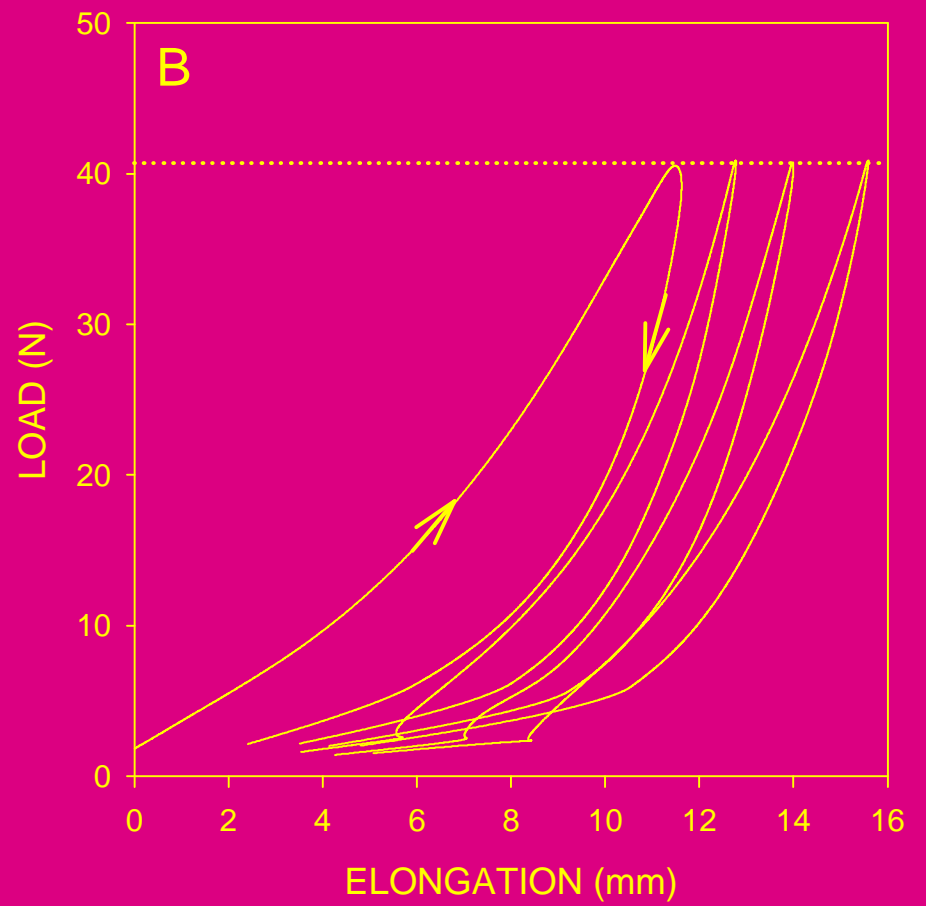
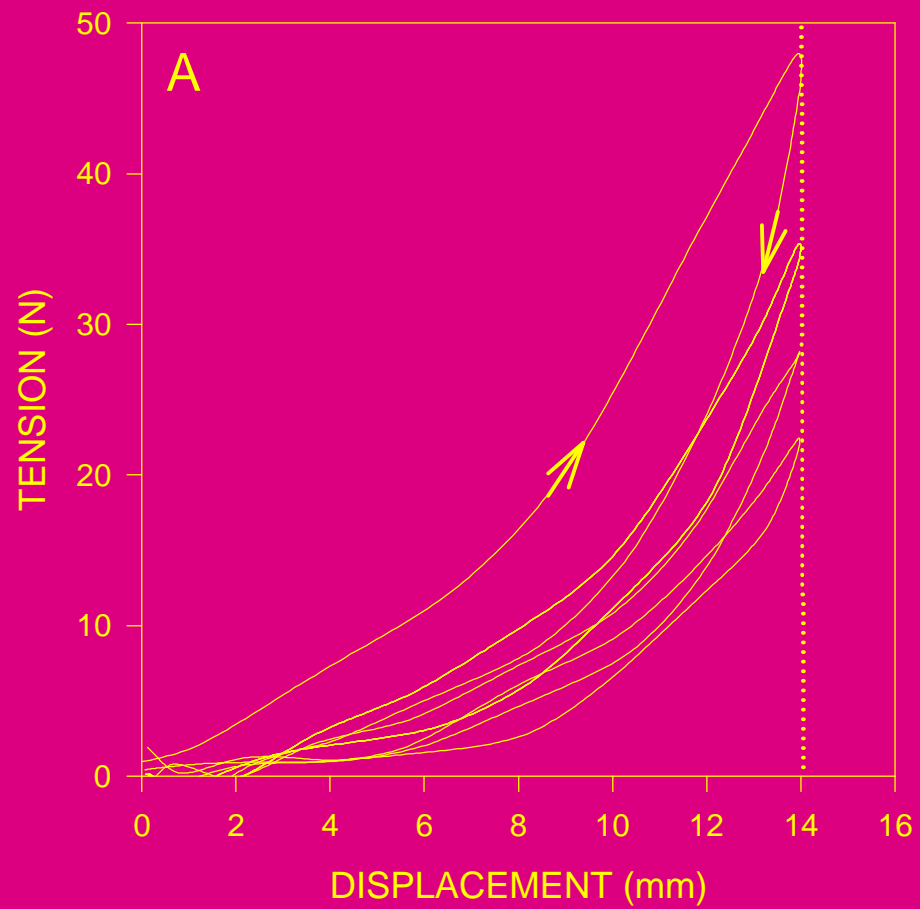
Ligaments Are Sensitive to Strain Rate

- Slow rate elicits low tension
- Fast rates elicits high tension



Hysteresis

Ligaments display hysteresis of
the length-tension behavior
during cyclic loading
e.g. length-tension is not on the
same curve during stretch and
release

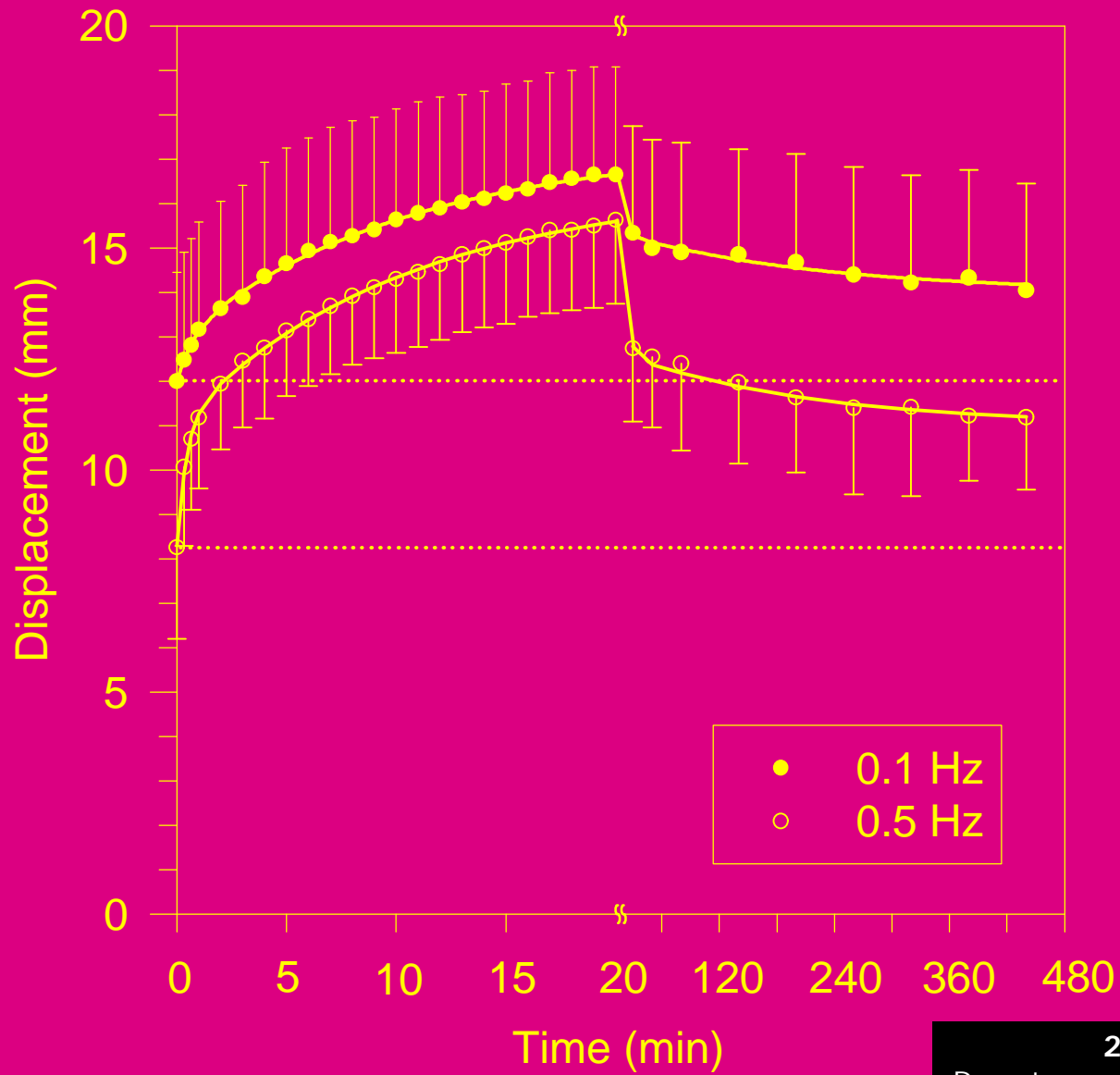


Ligaments display
cumulative build up of
creep in work-rest periods

- Due to long recovery time
needed to restore resting length

Ligaments behavior is sensitive to frequency of loading or stretching in repetitive task

- Higher frequencies result in larger creep



In General

Moderate Physical Activity Followed
with Sufficient Rest Result in:

- ◆ Collagen Fiber Hypertrophy
(Number, Diameter, Metabolism...)
- ◆ Increase in Maximal Strength

IMMOBILIZATION

Loss of Collagen Fiber Robustness

- Number, Thickness, Tension etc...
- Result in Weak, Atrophied Ligaments

IMPORTANCE

Return to Work After;

- ❖ Long Sickness
- ❖ Unemployment
- ❖ Long Holiday

Require Slow “**Build Up**” of
Exposure to Physical Activity

Ligaments Are Sensors

Afferents Found in Ligaments Are Common to Kinesthetic and Proprioceptive Sensation

- Golgi
- Pacinian
- Ruffini
- Bare Nerve Endings

Ruptured or Injured Ligaments

cause:

- Impaired motor functions
- Loss or impaired sensation
- Pain

Lead to:

- Deficient function
- Risk of additional injury

Afferents in Ligaments Trigger a Reflex Activation of Associated Muscles

- o Guanche 1995
- o Petrie 1997, 1998
- o Solomonow 1987, 1998, 2001,2002
- o Stubbs, 1998
- o Knatt, 1995
- o Dyhre-Poulsen, 2000

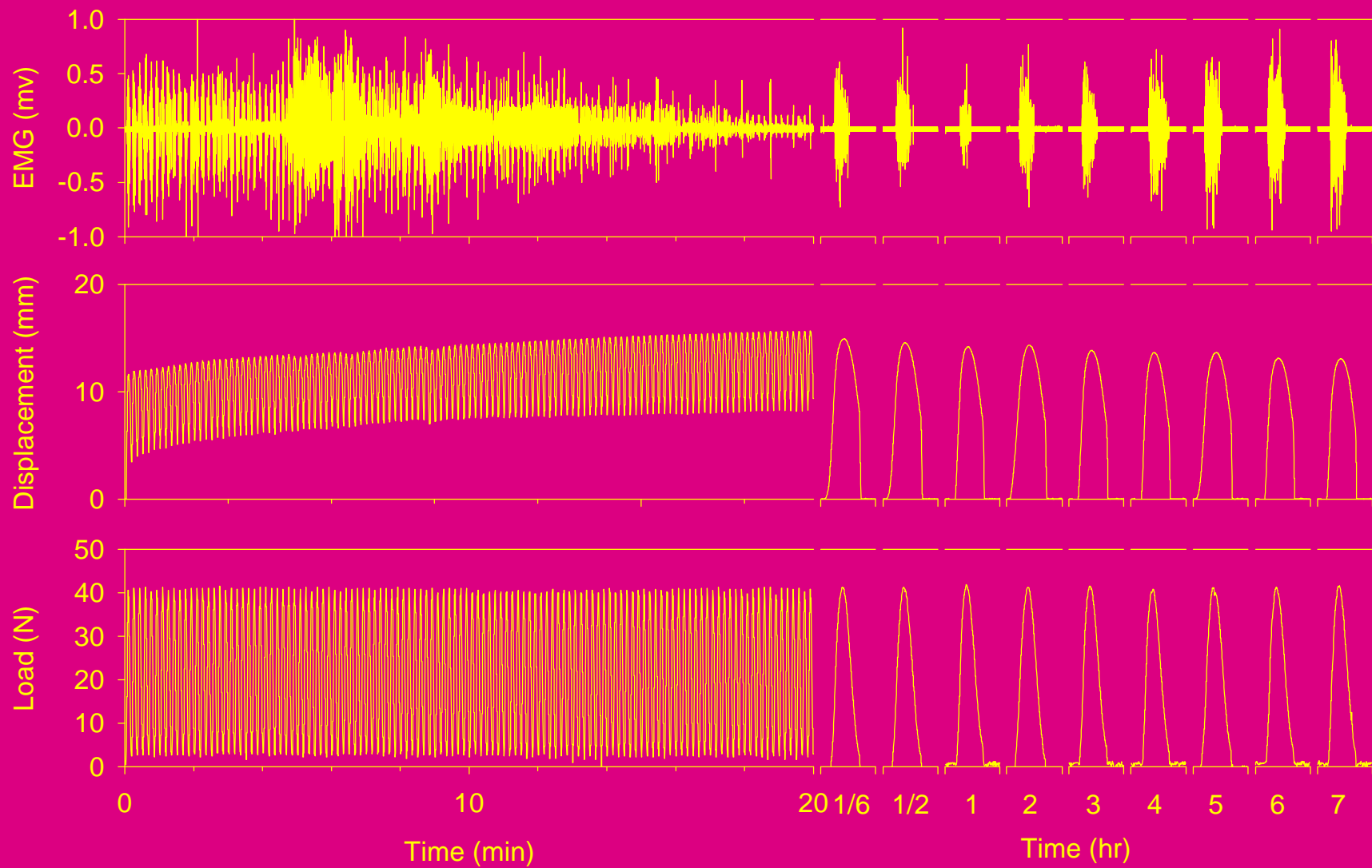
- Creep
- Tension-relaxation
- Hysteresis
- Time/frequency dependency

All Lead to:

- Shift in sensation thresholds
- Impaired sensation
- Impaired reflex muscular activation

For Example:
Cyclic Loading of the Lumbar
Spine Develops Creep in the
Ligament, over time, result in:

- Decreased reflexive muscle activity
- Spasms
- Initial hyperexcitability in following rest
- Delayed hyperexcitability
- Recovering muscular activity during rest

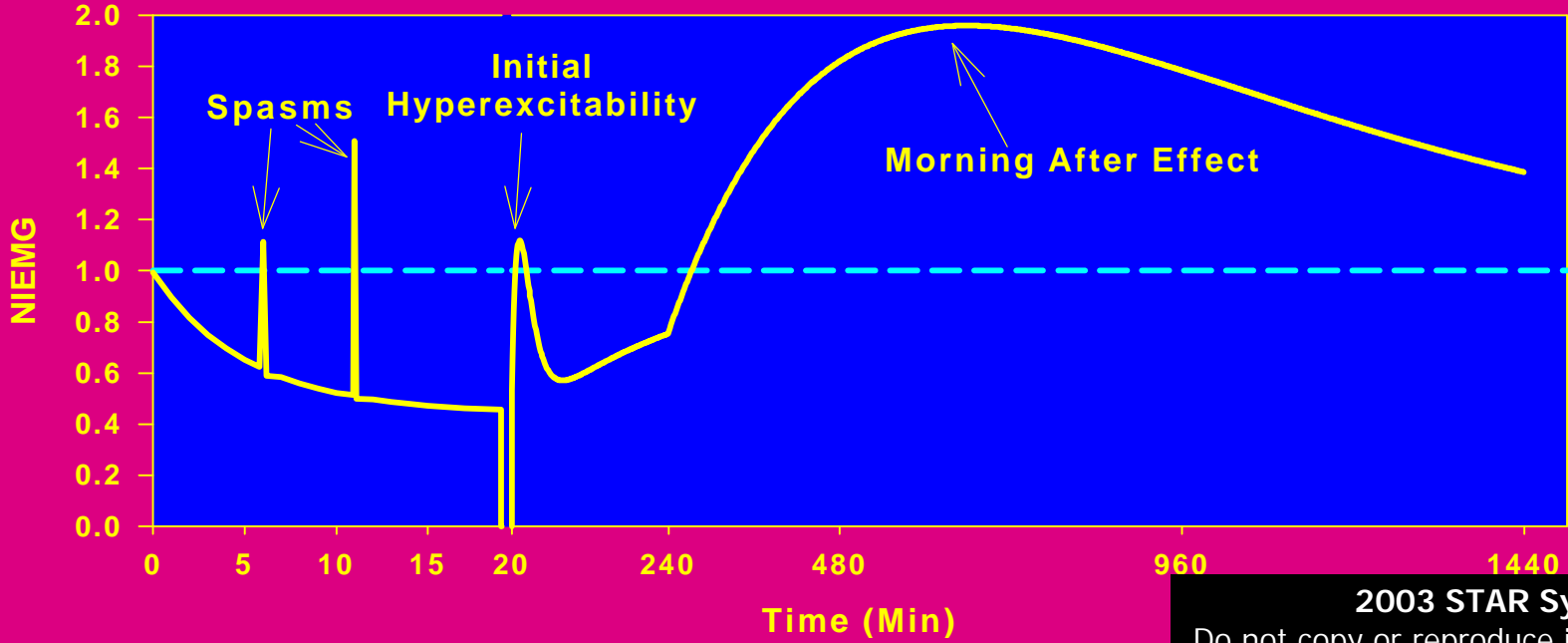
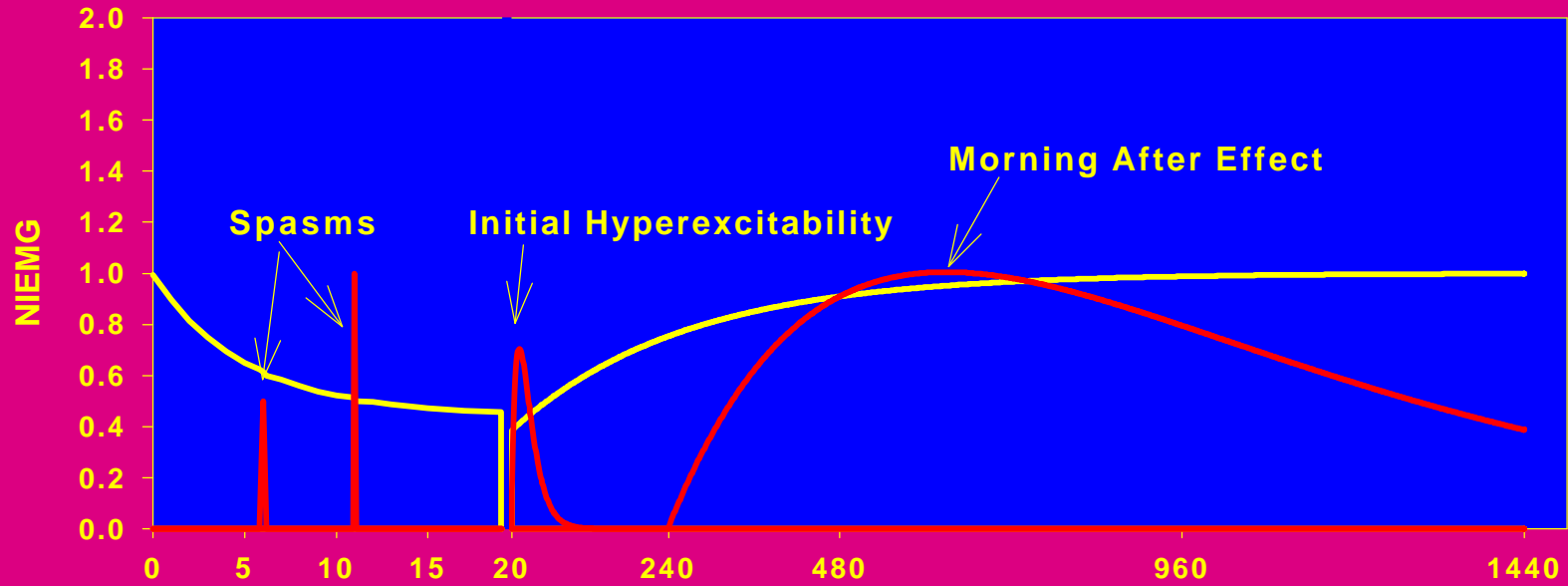




Five Component Neuromuscular Disorder

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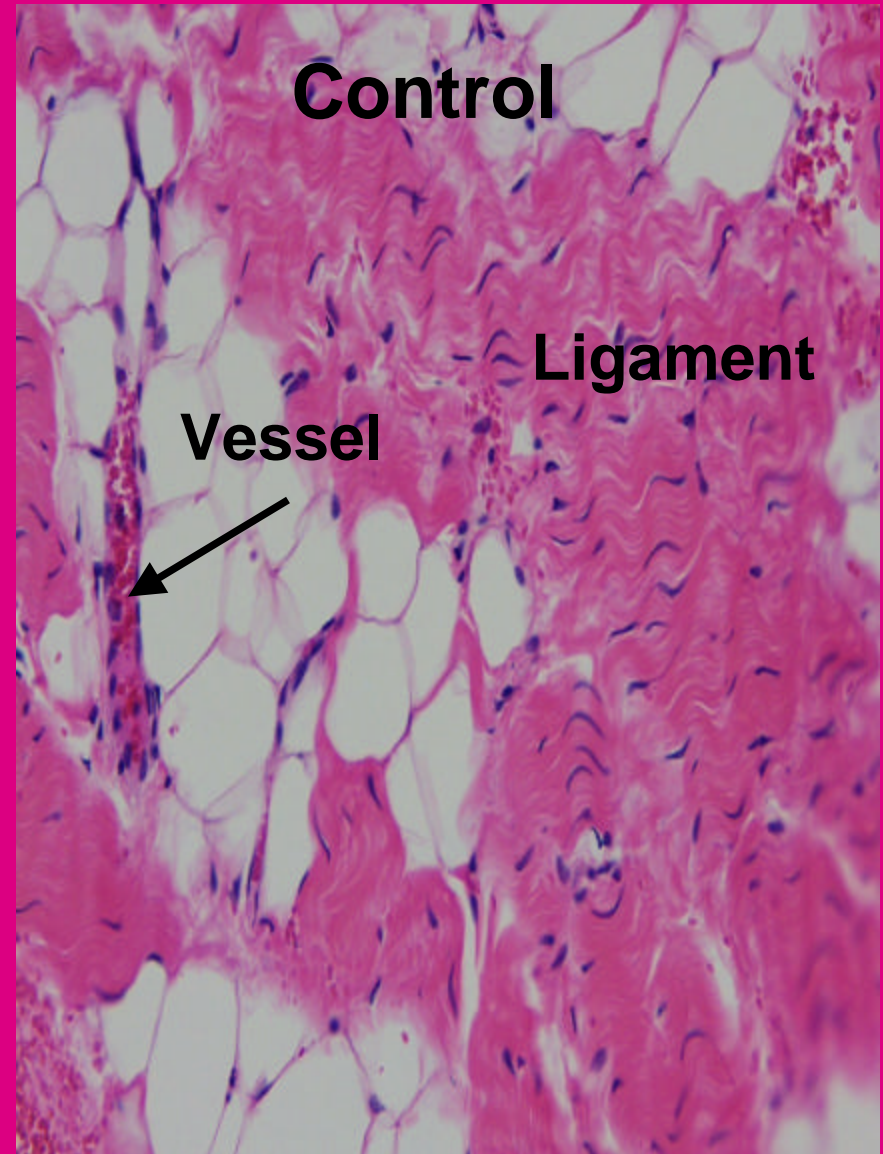
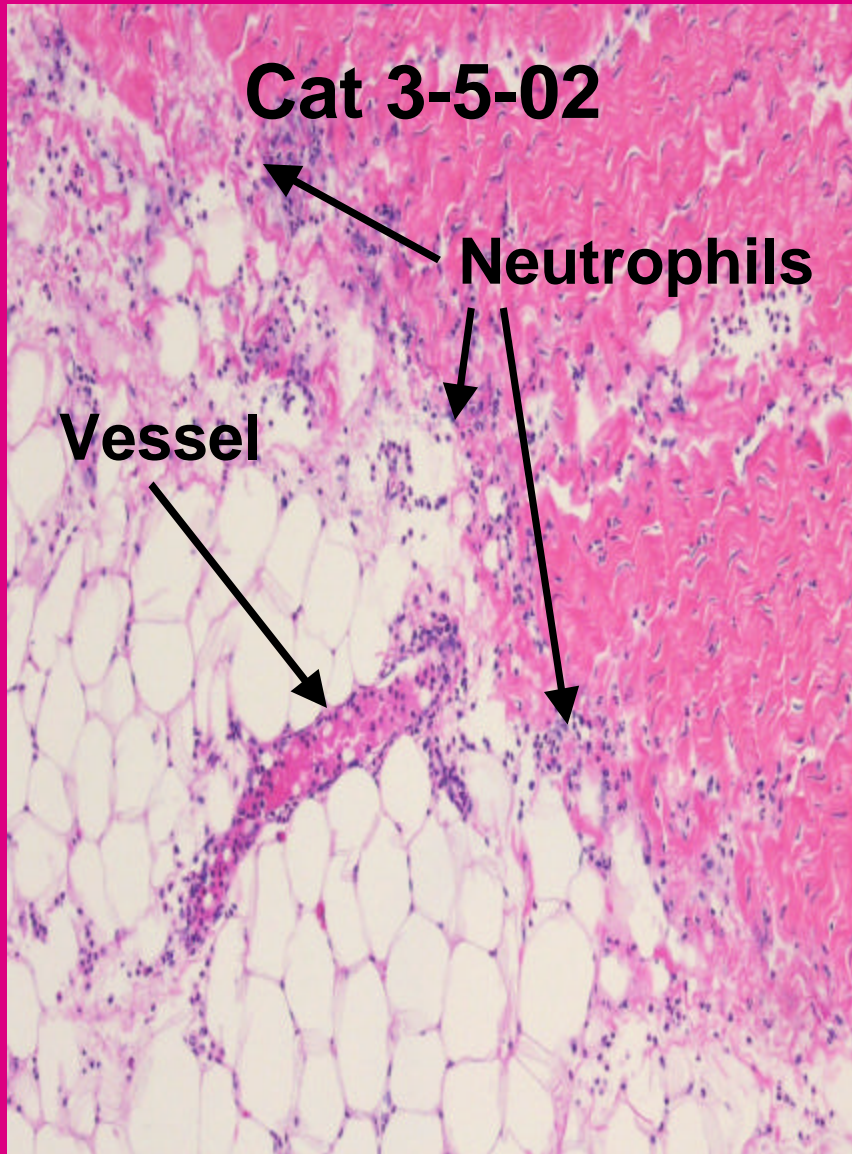
Sources of the Neuromuscular Disorder: Creep Microdamage in Collagen Fibers

Results in:

- Spasms During Creep Development
- Initial Hyperexcitability During Rest

Creep Microdamage Inflammation

Results in:
Delayed Hyperexcitability



Neutrophils / mm²

| | |
|----------------|-------|
| ➤ Control | 32 |
| ➤ @ 20 minutes | 36 |
| ➤ @ 2 hours | 160 |
| ➤ @ 7 hours | 3,680 |

Creep Acute Inflammation

(Cumulative Creep) dt Chronic Inflammation

Dose - Duration to Elicit
Chronic Inflammation
is not
known

Chronic Inflammation is a Permanent Disability

- Pain
- Muscle Stiffness
- Weakness of Affected Joint

Conclusions

Creep, Tension-relaxation, Hysteresis and
Time/Frequency Dependence of
Ligaments is a Source of Mechanical
Problems

- Joint Laxity
- Articular Surface Injury
- Potential Self Injury
- Potential Injury to capsule, tendons,
nerves and nearby tissue

Conclusion (Cont.)

As Organs in the Sensory-Motor Loop, the Same Mechanical Problems are a Source of Complex Disorders

- Deficient sensation
- Impaired motor performance
- Deficient synergy/reflex muscle activation
- Spams and Hyperexcitability
- Inflammation & neurological Implication
- Permanent disability

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