Neurophysiology of Flexibility

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Introduction

Flexibility is an important factor for athletes as well as the general population. While joint range of motion (ROM) increases in response to acute and chronic stretching have been widely noticed [1], controversy still exists as to the exact mechanisms responsible. The "classical" idea of muscle extensibility relies heavily on mechanical tension that contributes directly to muscle length [2]. This model has been called into question in recent years due to evidence of stretch-induced strength loss and negative performance effects [3]. A more modern theory suggests sensation, proprioception and perception of pain or discomfort associated is the limiting factor in muscle extensibility [2]. This theory is still being developed in an attempt to explain holes in the mechanical properties research.

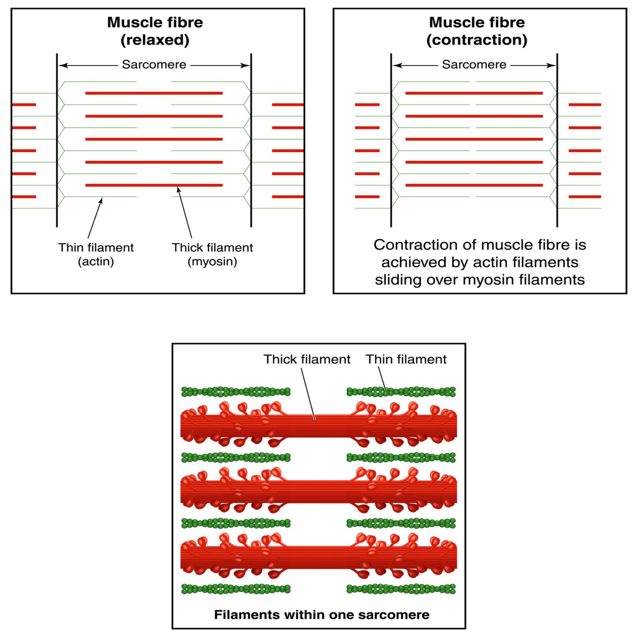

Figure 1. Muscle Contraction. Illustrates filament interactions within sarcomere during skeletal muscle contraction. Jules Mitchell, 2015, julesmitchell.com.

ROM Mechanism Theories

Viscoelastic Deformation Theory
Some evidence suggests that increased joint ROM following chronic stretching is due to mechanical accommodation [4].

Plastic Deformation Theory
Due to the performance loss associated with static stretching, many assume physical stress of stretching results in permanent connective tissue change or damage [1].

Neuromuscular Relaxation Theory
This theory asserts that repeated bouts of stretching result in accommodation of the stretch reflex. However, many studies using surface EMG have failed to establish evidence of sufficient EMG response [2].

Increased Sarcomeres in Series Theory
As shown in *Figure 1*. animal studies have concluded that adding sarcomeres impacts the overall length/tension relationship [2].

Modifying Sensation
Recent research has yielded more evidence for a CNS inhibition response to tissue stretching. changes in the perception of the stretch sensation contribute to increased ROM. Neural structures may impact stretch tension [5], [6].

Results

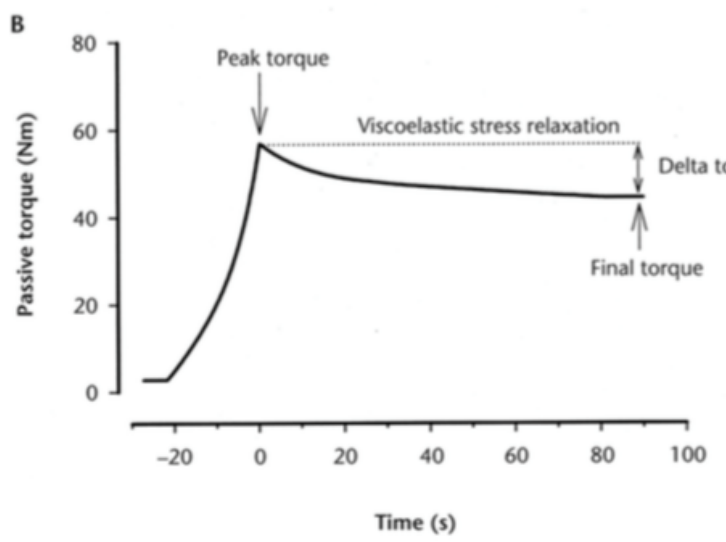

Figure 2. Viscoelastic stress relaxation during static stretch. Demonstrates the transient difference in peak torque and end torque effecting acute ROM. Weppler & Magnusson, 2010.

- Viscoelastic properties allow acute adaptation to tensile force.[1]
- Viscoelastic stress relaxation has not shown chronic benefits greater than 1 hour in short-term programs (3-8 weeks).[2]
- Lack of change in EMG activity due to stress provides counterevidence against neuromuscular reflex theory.[1]
- Both viscoelastic and reflex theories do not explain changes in ROM following non-local stretching.[3]

- Muscle lengthening would cause a right shift in the length/tension curve. Reduced stiffness would result in a decrease in linear curve slope.[2]
- Increased length shown in stretch studies correspond also to higher tension required to meet new length.[2]
- A static length/tension curve reduces likelihood for mechanical explanation and suggests a nervous component.

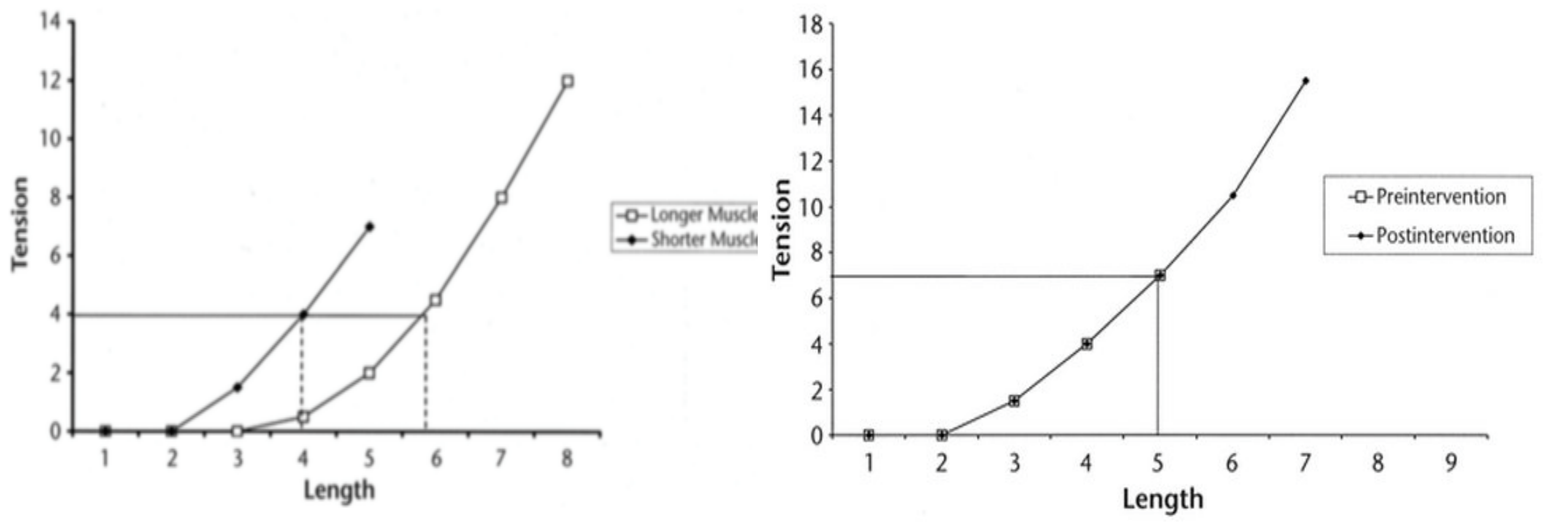

Figure 3. Model of shift in length/tension curve. Comparison between lengthened muscle and a muscle with increased stress tolerance. Weppler & Magnusson, 2010.

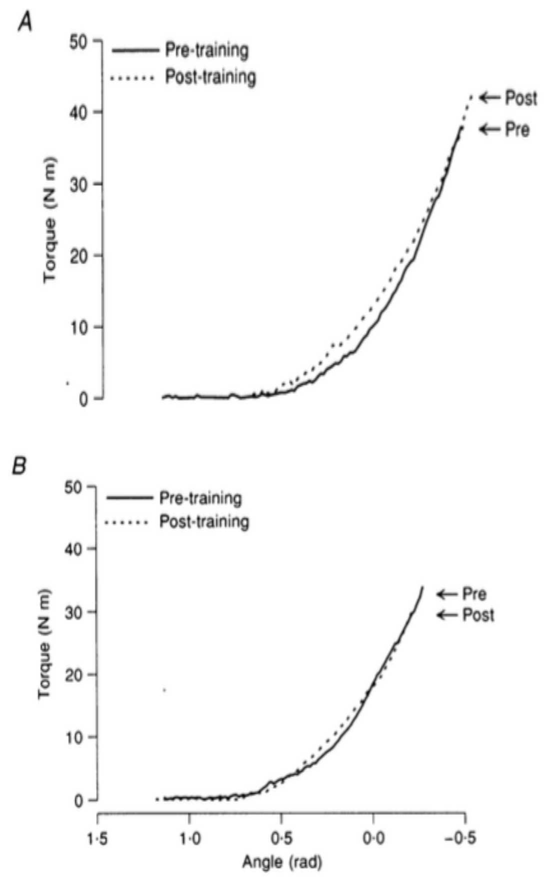

Figure 5. Angle/torque (length/tension) relationship following training. Illustrates the increased joint angle with accompanying increase in torque in the stretch side (A) versus control side (B) for 1 participant. Magnusson et al., 1996.

- Reduced spinal reflex excitability following muscle-tendon junction (MTJ) message provides evidence for golgi tendon organ involvement.[3]
- Non-local flexibility increase combined with non-local performance reduction supports CNS inhibition theory similar to non-local muscle fatigue (NLMF).[6]
- Hamstring torque is increased with neural tensioning, therefore nervous structures may be involved.[4]
- Significant changes between stretch tolerance tests lends evidence for sensation theory.[1]

Conclusion

These data call for radical modifications to the standard stretching model. While viscoelastic, plastic and electrical properties may contribute to muscle lengthening, the involvement of PNS and CNS receptors is undeniable.
Considering stretch-related strength loss and increased injury risk, plenty of evidence now favors a sensation-focused approach to stretching programs.

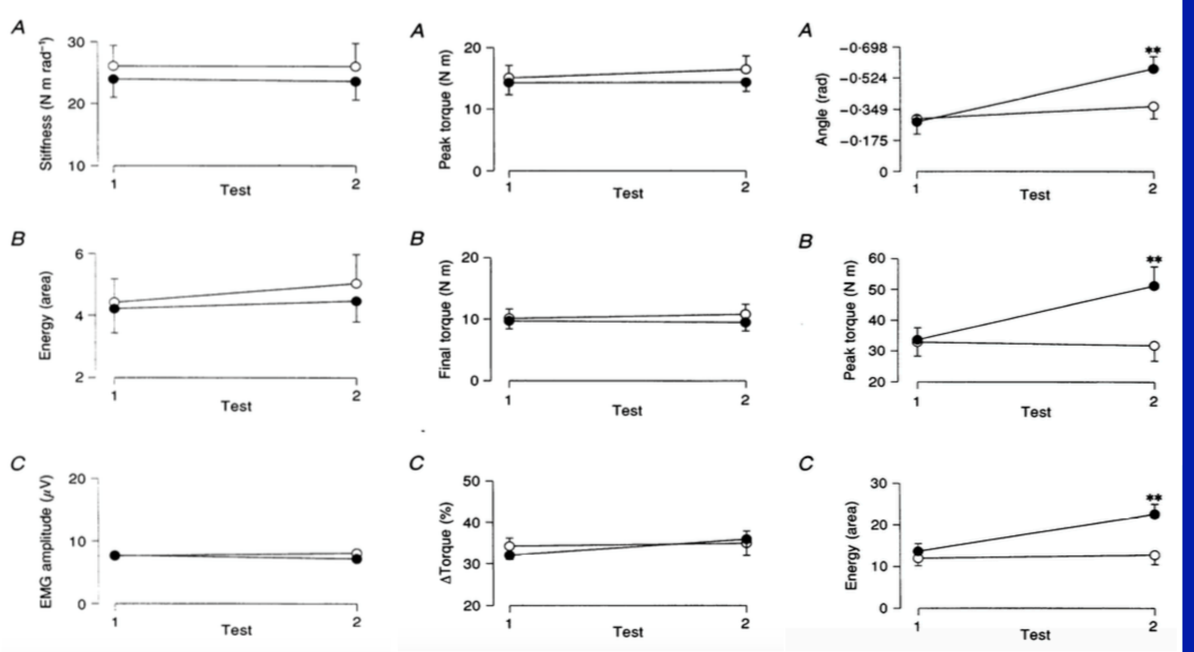

Figure 4. Results from static stretch versus stretch tolerance tests. Shows lack of difference between control and stretch side during static stretch protocol (columns 1&2). Significant difference is present in the stretch tolerance test protocol (column 3). Magnusson et al., 1996.

References

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