

Flexibility changes with aging – What can we do?

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MUSCLE-TENDON FLEXIBILITY CELLULAR CHANGES WITH AGE

First the bad news!!

There are a whole bunch of undesirable changes that take place within muscular/tendinous tissue that without intervention will decrease key physical attributes (eg size, strength, power, flexibility).

Some of these changes include:

- An increased amount of calcium deposits, adhesions, and cross-links in muscle/tendon tissue.
- An increase in the level of fragmentation and dehydration of tendon/ligaments.
- Changes in the chemical structure of the tendon/ligament tissues.
- Loss of suppleness due to the replacement of muscle fibers with fatty, collagenous fibers.
- Loss of water in our tissues and spine,
- Increased stiffness in our joints and
- Loss of elasticity throughout the muscle tendons and surrounding tissue.

As we age, we typically increase in BMI (Body Mass Index) which in turn can increase the thickness of fascia (connective tissue surrounding muscles) which can change the tensile stiffness of the tissue (particularly in the lumbar spine region) resulting in reduced Range of Motion (ROM) throughout the core/hip complex and associated reduction in hamstring flexibility (as tested by sit & reach), which then modifies gait and associated proprioception (balance) .

Some additional research on losses of ROM in specific joints with age highlighted:

- A 1% decline per year (approximately 1.2 degrees per year), in shoulder abduction range of motion of older men and women was reported.
- A decline of 1.5 degrees per year have been reported for lower back flexion, and the greatest decline appears to occur with trunk extension.

Research has also clearly shown that there can be an **increase** in ROM with regular exercise. This "increase in muscle/tendon length" has been proposed to occur through the following physiological/neurological changes:

1. Viscoelastic deformation,
2. Plastic deformation,
3. Increased sarcomeres in series, and
4. Neuromuscular relaxation.
5. Reduced Tendon stiffness

Viscoelastic Deformation (VED)

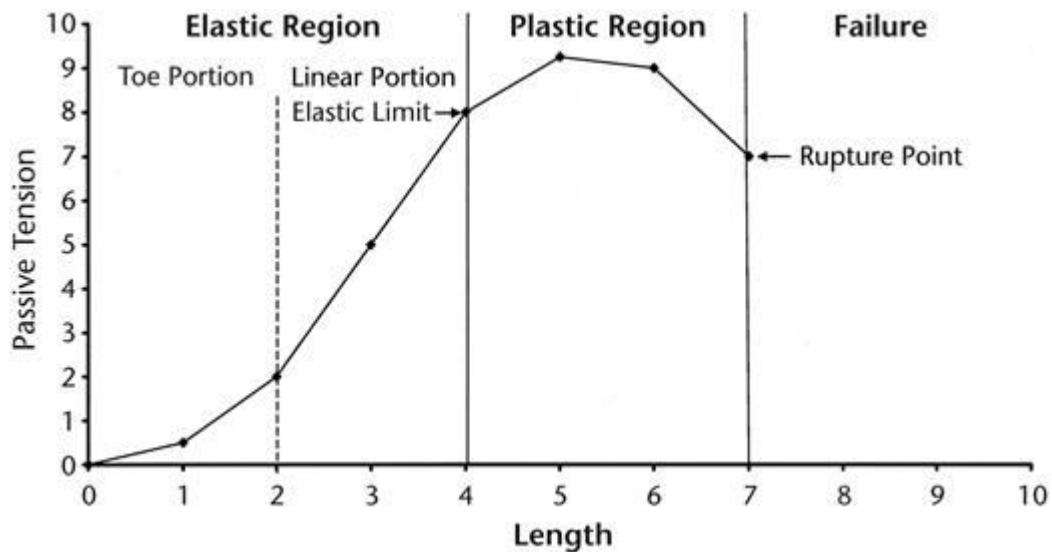
With stretch application typical of that practiced in rehabilitation and sports, the biomechanical effect of viscoelastic deformation can be quite minimal and so short-lived that it may have no influence on subsequent stretches. In one hamstring muscle study, a static stretch of 45 seconds' duration was found to have no significant effect on the next stretch performed 30 seconds later. With 3 consecutive 45-second static stretches (30-second rest intervals between stretches), each stretch showed VED of 20% during the static holding phase. However, the muscles had already recovered from the relaxation by the next stretch.

This study indicated that "normal" day to day stretching doesn't increase muscle length.

Plastic Deformation of Connective Tissue

(Plastic Deformation means the tissue doesn't return to its resting length once the tension has been removed)

The classical model of plastic deformation would require a stretch intensity sufficient to pull connective tissue within the muscle past the elastic limit and into the plastic region of the torque/angle curve so that once the stretching force is removed, the muscle would not return to its original length but would remain permanently in a lengthened state.



Studies of muscle demonstrate a markedly different curve. A plastic deformation phase would be reflected on the passive length/tension curve by a decrease in its slope. (Indicating that there isn't as much passive resistance to stretch as expected) And as such, a classic plastic deformation phase doesn't seem to be occurring in muscle meaning stretched muscle almost always returns to its resting length state post stretch.

Increased Sarcomeres in Series

Animal studies have demonstrated that the number of sarcomeres in series of a muscle can be changed by prolonged immobilization in extreme positions. That is, when muscles are immobilized in fully extended positions, there is an increase in the number of sarcomeres in series.

This theory has been successfully applied to short term intermittent stretching (that which you would do as part of a stretching routine) with the view that this type of stretching regime will cause similar increases in sarcomeres in series and a concurrent increase in length of the stretched muscle.

Neuromuscular Relaxation

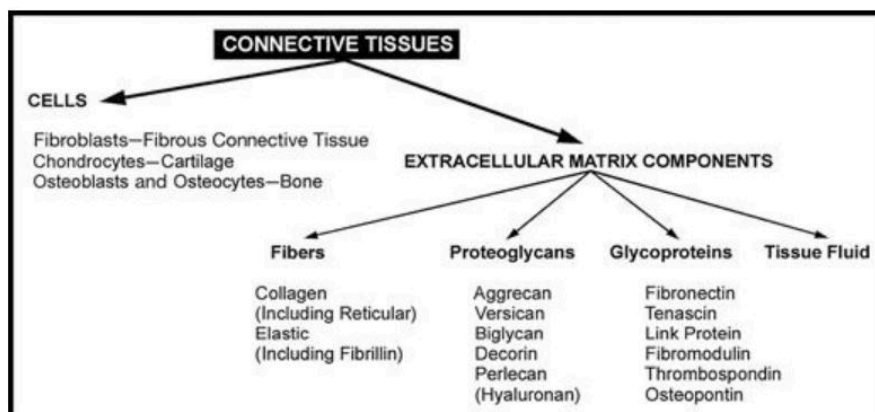
At one time it was believed that through the activation of the Muscle Spindle/Golgi-Tendon complex within all muscle/tendon units that increased flexibility could be attained.

This form of stretching has been shown to be short term only with no current research indicating that neuromuscular stretching increases long term flexibility.

Reduced Tendon Stiffness

As per my last blog article ([Tendon changes with aging & how to reduce the chance of Injury](#)) I indicated that tendon structure changed with aging but that regular exercise (importantly during maturation but also of value post maturation phase) was important to keep tendons functioning and keeping the collagen content aligned and well lubricated.

Additional tendon information that is important to overall muscle health and flexibility is the content of the tendon (in particular the Extracellular Components) – Of interest is that of the collagen fibres and elastic fibres (see image below).

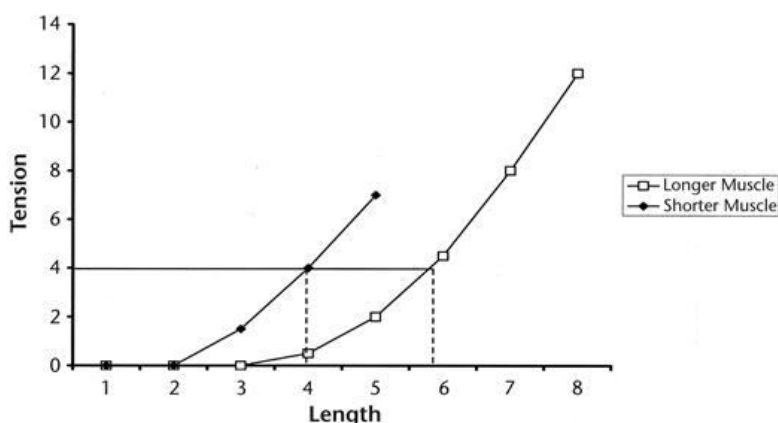


The striking feature of collagen is its ability to resist tensile loads. Generally, it shows minimal elongation (less than 10%) under tension; a proportion of this elongation is not the result of true elongation of individual fibers, but of the straightening of fibers that are packed in various 3-dimensional arrays. In contrast, elastic fibers may increase their length by 150%, yet still return to their previous configuration.

This indicates that the Tendon when healthy will stretch substantially (but will always return to resting length). As the tendon ages, there is a general and progressive loss in collagen and an increase in the concentration of mature crosslinks (increasing the “stickiness” of the tissue – fibres not able to slide as smoothly b/w themselves). Such alterations in collagen characteristics, are responsible for the toughening of muscle (less pliable) with age.

Sensory Theory for Increasing Muscle Extensibility

There has been a number of recent studies suggesting that increases in muscle extensibility (Range of Motion through a joint) observed immediately after stretching and after short-term (3- to 8-week) stretching programs are due to an alteration of sensation only and not to an increase in muscle length.



From the above graph, when muscle lengthening occurs, the curve shifts to the right, reflecting a longer muscle length at a given passive tensile force (tension muscle applies whilst being stretched).

After any stretching protocol, without a concurrent right shift in the above torque/angle curve, there is therefore no evidence of an increase in muscle length.

Many studies have shown instead that the only change observed in passive torque/angle curves was an increase in end-range joint angles and applied torque. Because the endpoint of these stretches was subject sensation (pain onset, maximum stretch, or maximum pain tolerated), the only observable explanation for these results was that subjects' perception of the selected sensation occurred later in stretch application.

In other words, the increased length of the muscle after a stretching protocol was largely due to the subject simply having an increased tolerance to their muscles being stretched.

ROLE OF EXERCISE AND FLEXIBILITY

Regardless of how the increased ROM occurs, there are plenty of research papers highlighting the importance of maintaining or increasing ROM as we age and that there can be positive increases in flexibility no matter how late you start a stretching routine.

Results from a recent study indicated that range of motion increased significantly for the female subjects throughout the 5-year study. These data indicate that aging women can improve and/or maintain shoulder and hip range of motion through participation in regular exercise done three times per week for 5 years.

A five-year longitudinal study demonstrated that baseline and follow-up thoracolumbar flexibility values were higher in older adults participating in a Chinese conditioning program of repeated motions and postures with range of motion warm-up versus a sedentary control group. Further, while both groups showed an age-related decline over the five years, the control group had a larger decline in flexibility, supporting a positive role of physical activity in attenuating the decline in flexibility with age.

Another study highlighted that short-term strength training increases flexibility and strength in sedentary adult women. They concluded that strength training may contribute to the development and maintenance of flexibility even without the inclusion of additional stretching, but strength and flexibility can be prescribed together to get optimal improvements in flexibility.

SUMMARY

Like all physical attributes, the better developed they are prior to the onset of serious aging (~40+yrs), the easier it is to maintain the attribute into older age.

But, positively, research is showing that with a well constructed conditioning routine, physical attributes like flexibility can be improved upon even as we age.

By combining both strength and flexibility training into your routine, you ensure that any increase in joint ROM is supported by an increase in the strength of the muscles that control this joint.

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