This document has implications for injury prevention.

Please note we accept no liability for information contained herein. Use your own discretion before undertaking any physical activity

The scope of this document is for conditioning and injury prevention. It does not consider treatment of, or rehabilitation from, injury. The purpose of this document is to provide a continually developed resource reviewing the latest knowledge in the subject area. Please contribute but contacting us via the link at the top of the page. This document should be seen as a **narative review** as criteria for reference inclusion has been informal.

Overview

Stretching has been widely promoted for:
• Short term increase of range of motion about joints (ROM)
• Short term increase in muscle performance
• Short term injury prevention
• Short term relief of cramp and delayed onset muscle soreness (DOMS)
• Long term increase of ROM
• Long term increase in muscle performance
• Long term injury prevention

The types of stretching can be generally classified as static or ballistic (also know as dynamic). Static stretching stretches muscles at near zero speeds whereas ballistic stretching involves significant movement. Gradations of ballistic stretching based on speed can be made (e.g. dynamic versus ballistic) but since the references in this document do not tend to make these distinctions, neither does this document.

The term ‘stretching’ is slightly confusing since a muscle is always stretched to some degree throughout the whole of its ROM. What is regarded as a ‘stretch’ action is a stretch that sets the length of the muscle beyond the point at which the individual actively senses the stretch, up to pain levels.

Advocates of stretching hypothesise that stretch actions cause the muscle-tendon unit to adapt over either the short term (acute) or long term (chronic) to provide the gains listed at the beginning. This document examines the principals and research behind altering muscle-tendon performance.

Injury Prevention

Injury to the muscle-tendon unit (MTU) is in the form of mechanical failure. When a muscle is stretched it creates a passive resistance, just like a spring. Up to a point called the elastic limit the MTU will return to its original length when the load is released. Beyond the elastic limit the muscle will begin to plastically deform and will no longer return to its original length. After further stretching the MTU will rupture . Injuries usually occur at the junction of muscle and tendon .

The MTU is more complicated than a spring model, however, because it is viscoelastic whereas a spring is simply elastic. Viscoelasticity means the MTU has a

higher resistance to faster stretches. The elastic limit is determined by the amount of strain energy that the MTU can absorb in the stretch. Higher resistances cause higher strain energies (energy = force x distance) and so a fast moving stretch will fail at a shorter length than a slow stretch. See figure 1

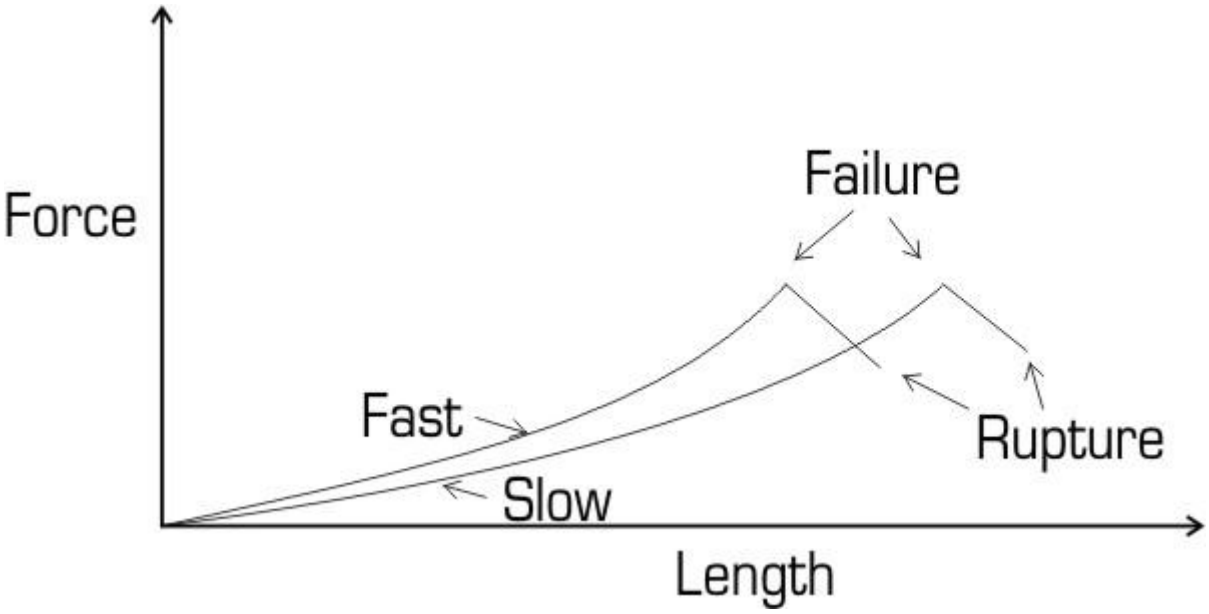

Figure 1: MTU failures. Slow versus fast stretching

Figure 1 shows failures based on the passive resistance of muscles. Active resistance produced by the contractile elements of muscle increases the amount of strain energy that can be absorbed by the muscle without effecting the elastic limit (1), see fig. 2. As such, the active components can work as an independent breaking mechanism protecting the muscle from stretching to the failure point.

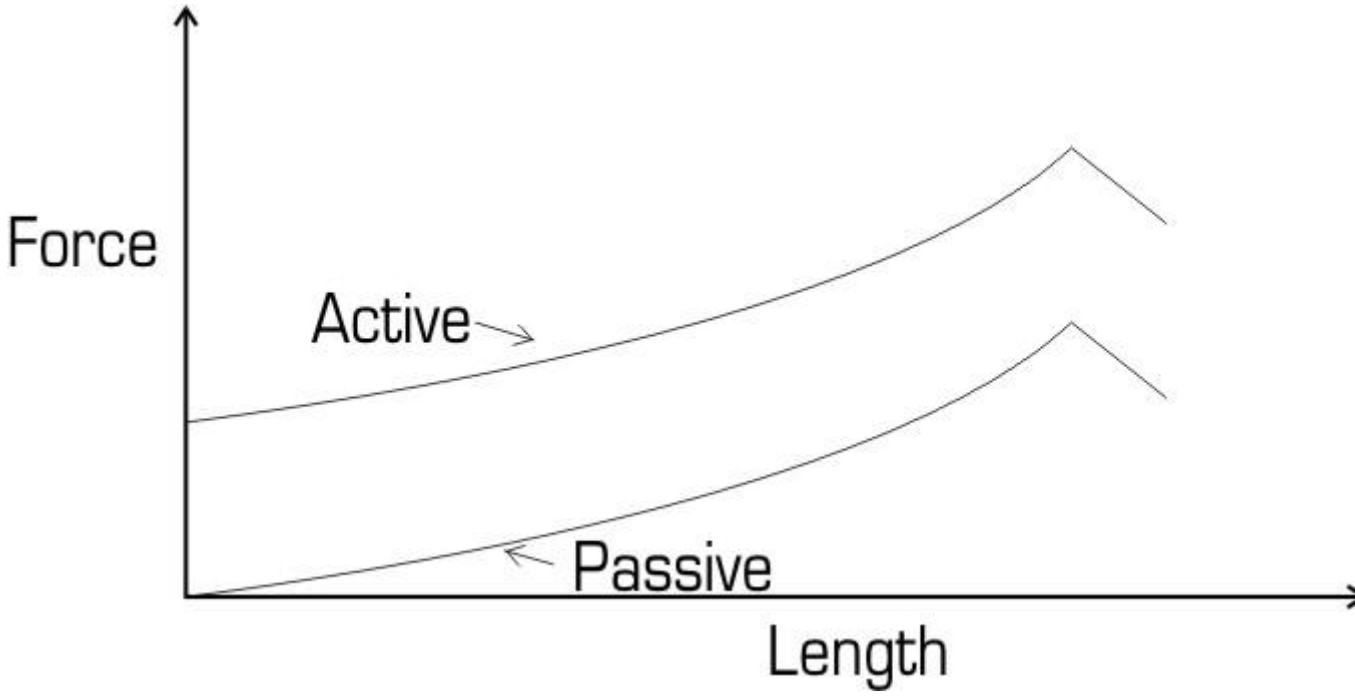

Figure 2: MTU failures. Active versus passive stretching

Theoretically the risk of injury could be reduced by altering one or more factors:

- increasing the strain energy that can be absorbed before failure
- increasing active resistance
- increasing length of failure (ROM) so active resistance has more time to work
- biomechanical improvements to avoid unusually loads to be introduced

These can be affected by:

- **Strength gain**: as strain is inversely proportional to cross-sectional area, any training regime that causes muscle hypertrophy should theoretically reduce injury rates. Also, strength is by definition an increase in active resistance so again should reduce injury rates. However, literature searches have failed to find supporting data for (or against) this. This lack of evidence was also noted in . However does find evidence linking left/right and agonist/antagonist strength imbalances to higher injury rates but the same review could not establish support for corrective training regimes resulting in injury improvements
- **Warm-up**: although there is conflicting evidence over the effects of warm ups there is support for an increase in the length of failure (ROM). This should allow more time for active resistance to absorb the strain energy. Warming up of a muscle is done by activating it so warm-ups must be sport specific
- **Activity specific endurance training**: reduction in fatigue will benefit active resistance and biomechanical safety. This document currently does not investigate this area of injury prevention
- **Action technique**: technique (e.g. shot technique) may have an impact on biomechanical safety. This must be a consideration for action design but is not

covered by this document. It would be interesting to see if there is a trade-off between safety and performance

- **Stretching**: despite popular belief, there are potentially major problems with stretching. It has been found that both static and ballistic pre-exercise stretching can cause an acute decrease in muscle force - as much as 28% with effects lasting in excess of 60 minutes.

  A decrease in muscle force will reduce the protective abilities of active resistance and may introduce biomechanical problems, especially while fatiguing. It should be noted that the research so far into pre and post exercise stretching and injury rates mostly indicates no statistical relationship (although the author has seen references to a study on marathon runners that links stretching to increased injury rates in Caucasian males but has been unable to source the paper). Caution should still be advised because research is needed into the effects of pre performance stretching on high power events before it can be passed as safe for Badminton.

  It is thought that often, much of the perceived gain in ROM following a stretch is actually due to an analgesic effect called stretch tolerance. This brings question marks of the theoretical effectiveness of stretching to alter ROM and also raises safe concerns. Could stretch tolerance inhibit stretch reflex and allow damage to occur to antagonist MTUs and joint structures?

  Real decreases in viscosity of the MTU have been noted following acute stretching which may be beneficial to the rapid movements of Badminton but, in conversation, the author would not be drawn on whether these were benign improvements or indicative of mechanical failure (e.g. plastic deformation). More research is needed to understand the mechanisms at work.

  Some research has found reductions in stiffness due to chronic stretching There has been research associating different muscle tightness levels with varying injury rates and this may provide a use for chronic stretching. According to a comprehensive review there are varying profiles for injury rate against tightness for different muscles in the body. Sometimes there was a statistically significant U shape to the graph with too tight or too loose relating to increased injury rates. It may be found that chronic stretching of the ‘too tight’ muscles may lead to fewer injuries but this needs to be supported by research, including establishment of ideal tightness levels. Care should also be taken that increases in flexibility do not result in performance decreases such as strength.

  Another safety concern is over ballistic movements that, due to their nature, have an associated level of risk. There is a question mark over whether acute stretching affects dynamic movement at all which is of prime relevance to movement sports such as Badminton.

Another property of muscles that increases resistance is thixotropy. Thixotropy is a property of some gels, such as the MTU, where stiffness is reduced as the material is mixed up. It is thought that stable bonds form in muscles when they are inactive. Until these bonds are broken there will be an increase in resistance. The way to break these

bonds is through movement. This will automatically happen in a sports specific warm-up routine.

Performance

For performance we are concerned with maximum voluntary contraction of muscle (MVC), muscle power, stretch shortening cycle ability (SSC), and potentially ROM.

As we have seen, MVC and power can be reduced by acute stretching. Chronic flexibility gains may also harm MVC and power production. This may be in part due to sub-optimal positioning of sarcomeres in more flexible muscles and partly to do with more efficient transfer of contractile force to the skeleton.

The ability to use the potential of the stretch shortening cycle may have a complex relationship to flexibility. It may be that different intensity levels of SSC benefit from different stiffnesses. For example, long distance runners adapt to the mechanical ware of endurance activity by thickening the involved tendons which has the added benefit of more efficient running . However the SSC in counter movement jumps performed by these runners was worse than control.

In another study, although sprinters were not statistically different to non-sprinters in terms of tendon stiffness, sprint times were correlated with stiffer tendons– an important consideration for Badminton. Acute stretching appears to harm in jumps An opposing view found compliance of tendons helped SSCs

With further research there may be identified areas where an increased compliance is useful for SSCs. However, until such research unequivocally states when and where, stretching should not be used to affect change in this area. It is probably reasonable to expect that activities designed to emphasise SSC in a similar way to a game situation (e.g. plyometrics) may produce the desired adaptations. More research is needed.

Range of motion is often thought to be desirable. However, this is a very sport specific conjecture and there has not been any research conducted in Badminton to identify where an increased ROM may be useful. It is reasonable to conclude that for Badminton the notion of ‘reach’ is most applicable here. The only action identified by the author that could be limited by ROM is the lunge. Stride length is probably limited more by optimisation of force moments by the nervous system than ROM. Arm reach is limited by arm length rather than joint ROM.

Given what we have learnt about stretching, is it safe to increase the ROM? Is there a trade off in strength? Is the increase in reach significant? Without answers to these questions, stretching should not be recommended for ROM.

In discussing this document, the possibility of offsetting potentially deficits of stretching by increasing strength through training was suggested. This would be done if there were benefits to be had in increased ROM and a stretching regime was shown to produce increased ROM. However, increased strength requires a certain amount of hypertrophy. This increased muscle mass will be detrimental to performance as it increases the weight of the individual whilst not providing a performance boost (it exists to cancel out a negative). Therefore, it is important to demonstrate a real benefit

before recommending this.

Cramp and DOMS

Cramp is the last element to consider. It is clear to everyone who experiences cramp that stretching causes immediate relief. However, we do not have research that cramp is prevented through stretching.

Relief from or prevention of DOMS by any form or regime of stretching has repeatedly not been found

Conclusions

Stretching is a surprisingly complex subject and a disappointingly under researched topic. In this document we have raised possible avenues for research into the use of stretching but also several theoretical, and some data driven, concerns.

Stretching before performance, either static or ballistic, should be advised against. There are several pieces of research that indicate strength reductions due to stretching which will reduce performance and might increase risk of injury.

Risk of injury in general has not been demonstrated to be affected by stretching either way. However, studies need to be carried out to understand the effect of risk in high power sports like Badminton. Stretching may reduce injury when targeted to abnormally stiff muscles or unbalanced left/right muscle pairs.

Additional avenues of research exist for stretch related benefits to SSCs and ROM for the Badminton lunge.

In general we have found insufficient support for any use of stretching at this time. However, more research should be commissioned into the possible benefits outlined in this document.

Instead of stretching, acute preparation should consist of a sport specific warm that activates all the muscles that will be used in the performance. No conclusive evidence exists to prescribe chronic training but the muscle hypertrophy, strength training and sport specific endurance training that is carried out for performance improvements may also help injury rates.

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