Stretching Flexibility Exercises 1: What science has to say about the performance benefits of flexibility training

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Page **1** 2

Flexibility training, or stretching, is used in varying forms by practically every coach, athlete and physiotherapist on a regular basis. That is to say, a form of stretching is likely to take place at some point in every training or therapy session. In spite of this, flexibility training is probably the least understood of all the fitness components, in terms of its scientific basis. This article will discuss the latest research findings and recommendations to explain why and how stretching should best be carried out

What does it mean?
Flexibility is defined as the static maximum range of motion (ROM) available about a joint. The largest limiting factor of static ROM is the structure of the joint itself. Thus, even after endless stretching exercise, there will be a limit as to how much movement is available. In addition, joint structures can vary between individuals, and this must be recognised when assessing flexibility standards in athletes. Most of the variability in static ROM is due to the elastic properties of the muscle and tendons attached across the joints. 'Stiff' muscles and tendons reduce the ROM while 'compliant' muscles and tendons increase ROM. It is these elastic properties that are altered after stretching exercises. When a muscle is held for some times under tension in a static stretch, the passive tension in the muscle declines, ie, the muscle 'gives' a little. This is called a 'viscoelastic stretch relaxation response'. Passive tension is defined as the amount of external force required to lengthen the relaxed muscle. Obviously, the less external force required, the more pliable the muscle. This increased pliability is maintained for up to 90 minutes after the stretch (Moller et al, 1985)

In the long term, regular static stretching will bring about permanent increase in static ROM, which is associated with a decrease in passive tension. Experimentally, this was shown by Toft et al (1989), who found a 36% decrease in passive tension of the plantar flexors after three weeks of regular calf stretches. The relationship between static ROM and passive tension has been further supported by McHugh et al (1998). These researchers demonstrated that maximum static hip flexion ROM was inversely correlated with the passive tension of the hamstrings during the mid-range of hip flexion. This suggests that the ease with which the muscle can be stretched through the mid-ROM is increased if the maximum static ROM is improved. The concept that increased static ROM results in more pliant mechanical elastic properties of the muscle suggests that static stretching is beneficial to sports performance

Flexibility and performance
Research into the effects of flexibility of stretch-shortening cycle (SSC) movements (plyometrics) has shown that increased flexibility is related to augmented force production during SSC movements. In contrast, running studies have shown that flexibility has little performance effect, which is odd because running is a kind of SSC movement. For example, De Vries (1963) showed that while pre-stretching increased static ROM in sprinters, it had no effect on speed or energy cost during the 100-yard dash. Interestingly, it has been shown that stiffer leg muscles in endurance athletes may make them more economical in terms of oxygen consumption at sub max speeds

The reason for these converse findings is probably related to the principle of specificity, which seems to underlie all sports training. The sprints and running studies above compared static ROM and stretches with performance, while the SSC research compared active stiffness with performance. Holding a maximum static stretch, and reducing passive tension, is a completely different mechanical action to those practised in actual sports, where joints are moving at fast speeds and muscles are contracting while they are changing length. Thus static ROM may not be an appropriate flexibility measurement to relate to performance. On the other hand, active stiffness is a measurement of the force required to stretch a previously contracted muscle, and is therefore more sports-specific. It seems logical that the ease with which a contracted muscle can change length will have an impact on the performance of an SSC movement, so active stiffness is a more appropriate parameter to measure flexibility for sports performance.

Along the same lines, Iashvili (1983) found that active ROM and not passive ROM was more highly correlated with sports performance. In this instance, active ROM is defined as the ROM that athletes can produce by themselves, which will usually be less than the passive ROM, which is the maximum static ROM available when assisted manually or by gravity. For example, active ROM would be the height an athlete could lift his or her own leg up in front using the hip flexor muscles, whereas the passive ROM would be maximum height the leg could be lifted by a partner. Athletes must be able to generate the movement themselves, and this suggests that for improving sports performance it is active ROM that should be developed and not passive ROM. A sprinter must have enough active ROM in the hip flexors and hamstrings to comfortably achieve full knee lift and full hip extension at the toe-off point of the running gait to ensure a good technique and full stride length. Arguably, any further passive static ROM developed through passive static stretching will not provide any extra benefit, especially since the joint angular speeds during sprinting are very high.

How to improve active ROM
The research suggests that, to improve sports performance, active stiffness should be reduced and active ROM should be improved. This will be more specific than static

stretches which reduce passive tension, since sports involve both movement and muscular contractions. Unfortunately, I have found no studies looking at training methods to reduce active stiffness, but one can assume that they will be similar to the methods used to improve active ROM. Alter (1996) suggests that the active ROM can be improved by any kind of active movement through the available active range of motion. For instance, weight-training exercises have been shown to improve active ROM (Tumanyan & Dzhanya, 1984). Ballistic stretches will also develop the active ROM and are endorsed by sports coaches because they have the advantage of being executed at sports-specific speeds. But ballistic stretches must be performed with extreme caution, or they can cause muscle or tendon-strain injuries. If you use them, make sure you begin slowly and with a small ROM, building up speed and full ROM only towards the end.

It seems that, as with endurance, strength and speed training, flexibility training follows the specificity principle. This means that if you want to improve your ability to actively move through a full ROM, then active and ballistic mobility exercises, and not static stretching, are the answer. This supports the use of exercises employed by swimmers and runners during their warm-up routines, such as shoulder circles, bum kicks and high-knee skips. These exercises actively take the joints through their available ROM and thus help to prepare them and the muscles to be more pliable during the subsequent activity. Modern coaching techniques advocate the use of dynamic active mobility exercises as essential components of a warm-up routine in the belief that this kind of exercise will be more beneficial to sports performance and less likely to cause injury than static passive stretches. Unfortunately there is little research to support this. Nevertheless, based on the fact that these exercises will be more specific than static stretches and that, through experience, I have found them to be very beneficial, I would strongly recommend them.

Let's take a specific example. To warm up the lower leg before any kind of running activity, I would first walk 20 yards on the toes with straight legs to warm up the calves, then walk on the heels 20 yards to warm up the dorsi flexors. I would then do 20 ankle flexion exercises with each leg. This involves holding one leg up so the ankle is free to move, first fully flexing the ankle bringing the toes right up and then fully extending the ankle pointing the toes away. Start slowly and then speed the movement up, so you flex and extend quickly throughout the full range of motion. This would be an open-chain exercise.

The next exercise would be to walk with an exaggerated ankle flexion extension, pulling the toes up on heel contact and pushing right up on to the toes at toe-off. Then finally, do the same while skipping, ensuring the full ankle movement is performed at sports-specific speed. The same rationale can be applied to the knee, hip and shoulder, warming up each joint by taking it through the full range of motion, first slowly and then fast, using both open and closed kinetic chain exercises which are specific to your sport. If you perform these kinds of exercises regularly, you should find that, as well as providing an effective warm-up, they will improve your active ROM and specific mobility patterns during sport.

Injury and flexibility

The well-established general rule is that insufficient ROM, or stiffness, will increase muscle-strain risks. More specifically, athletes in different sports have varying flexibility profiles and thus varying flexibility needs in order to avoid injuries. Gleim & McHugh et al (1997) review various studies relating flexibility measures or stretching habits to injury incidence. Studies of soccer players show that flexibility may be important for preventing injuries. For example, one study showed that those who stretched regularly suffered fewer injuries, while another showed that tighter players suffered more groin-strain injuries, and a third showed a relationship between tightness and knee pain.

These findings seem to confirm the correlation between muscular tightness and increased muscle-strain risks. Yet studies of endurance runners have not shown the same results. For instance, in one famous study by Jacobs & Berson (1986), it was found that those who stretched beforehand were injured more often than non-stretchers. Other running studies have found no relationship whatsoever between flexibility or stretching habits and injury. On the other hand, one study of sprinters found that 4° less hip flexion led to a greater incidence of hamstring strain. The reason for these apparently contradictory findings is the specific nature of each sport. With endurance running, the ankle, knee and hip joints stay within the mid-range of motion throughout the whole gait cycle and therefore maximum static ROM will have little effect. Sprinting and football involve movements of much larger ROM and so depend more heavily on good flexibility

There are other established biomechanical relationships between flexibility and injury. For example, ankle ROM is inversely related to rear foot pronation and internal tibia rotation. In other words, tight calf muscles are associated with greater amounts of rear foot pronation and lower-leg internal rotation. In excess, these two factors can lead to foot, lower-leg and knee problems. Poor flexibility in the hip flexor muscles may lead to an anterior pelvic tilt, where the pelvis is tilted down to the front. This increases the lumbar lordosis, which is the sway in the lower back. This in turn can lead to a tightening of the lower-back muscles and predispose the back to injury

Similarly, tight pectoral muscles can lead to a round-shouldered upper-back posture called kyphosis. During throwing and shoulder movements, this forward alignment of the shoulder can increase the risks of shoulder-impingement problems. A flexibility/injury relationship also exists for young adolescents. During the pubertal growth spurt, the tendons and muscles tighten dramatically as they lag behind the rapid bone growth. For young athletes this poor flexibility may lead to injury problems, especially tendinitis-type injuries such as Osgood Schlatters. Thus regular stretching is essential for young athletes. Remember it is biological age that counts, so children in the same team or squad may need to pay extra attention to flexibility at different times

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