What Happens When you Stretch?

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Several types of adaptation result from proper and regular stretching. First, as stated earlier, when a muscle is suddenly stretched, the stretch reflex is initiated and the muscle being stretched contracts. However, through training, the critical point at which the stretch reflex is initiated can be "reset" to a higher level. Consequently, your muscles relax farther into the stretch. Research into the field of neurophysiology has demonstrated adaptive plasticity in the central nervous system (Wolpaw and Carp, 1990). Specifically, the magnitude of the spinal stretch reflex can be uptrained (increased), downtrained (decreased), or even trained to reverse the changed response. Wolpaw and Carp's study (1990) has even substantiated the hypothesis that altered reflex activity eventually modifies the plasticity of the spinal cord neural circuits.

Second, with increased stretching over time, the number of sarcomeres is thought to increase in series. These new sarcomeres are added onto the end of the existing myofibrils. Research has substantiated that an addition of sarcomeres is responsible for an increase in muscle length (Goldspink 1968; Williams and Goldspink 1971). However, additional research is needed to substantiate that and increase in the number of sarcomeres actually results from a traditional stretching program used in an athletic setting.

Third, with increased stretching over time the fascial sheathes encasing your muscles - The epimysium, endomysium, and perimysium - may undergo semipermanent changes in length. Other tissues adapting to the stretch are the tendons, ligaments, fascia and scar tissue..

Fourth, stretching exercises are known to increase passive range of motion and extensibility of the hamstrings. However, research has also shown that stretching exercises do not make short hamstrings less stiff. Rather, increased extensibility is attributed to an increase in stretch tolerance (Halbertsma and Goeken 1994; Halbertsma, van Bolhuis, and Goeken 1996)

Fifth, research suggests that muscle cells may control and modulate stiffness and elastic limit coordinately by selective expression of specific titin isoforms (structural variants) (Wang et al. 1991); that is, muscles that express greater titin isoforms tend to initiate tension at longer sacromere lengths, and develop the lowest tension. Such control and modulation may be influenced by training.

Sixth, stretching is thought to stimulate the production and retention of gel like substances called glyco aminoglycans (GAGs). The GAGS, along with water and hyaluronic acid, lubricate connective tissue fibers, maintaining a critical distance between them. This prevents the fibers from touching one another and sticking together. As a result, excessive cross linkages are not formed (Akelson, Amiel, and Woo 1980).

Seventh, x-ray studies (Nikolic and Zimmerman 1968) have demonstrated that training can modify the bone and joint structures in dancers; hence, range of motion can be enhanced, and stretching is one way to do this.

Last, recent research suggests that mechanical stimulation (e.g., stretching or resistance training) of muscle and connective tissues may effect gene expression (Simpson et al. 1994; Sutcliffe and Davidson 1990). This, in turn, may modulate tissue variants and thus influence muscle and connective tissue extensibility.

Stretching Techniques
Stretching refers to the process of elongation. Stretching exercises are performed in a variety of ways, depending on your goals, abilities, and state of training. For example a world-class gymnast or black belt in karate may perform more advanced stretches than individuals who are beginning stretching programs simply to improve their personal health and fitness. There are five basic stretching techniques: static, ballistic, passive, active, and proprioceptive.
Static Stretching

Static stretching involves stretching to the farthest point and holding the stretch. Splits are a good example of static stretching. This method of stretching is not only the safest, but has also been test proven for centuries by practitioners of hatha yoga as a means of enhancing flexibility. Other advantages are that it:
- is simple to learn and easy to execute
- requires little expenditure of energy
- allows adequate time to reset the sensitivity of the stretch reflex
- permits semipermanent change in length, and
- can induce muscular relaxation via firing of the GTO's (Golgi tendon organs) if the stretch is sufficiently intense.

The major disadvantage of static stretching is it's lack of specificity. During the early 1960's, the S.A.I.D. Principle, developed by Wallis and Logan (1964), put forth the idea that ideally athletes should develop their strength, endurance,

and flexibility based on the principle of specific adaptation to imposed demands; that is, one should stretch at not less than 75 percent of maximum velocity through the exact plane of motion, through the exact range of motion, and the precise joint angles used while performing skills in a specific activity. Research studies substantiate the concepts of sport specificity and the S.A.I.D. Principle. Because most activities and movements are dynamic in nature, static stretching does little to enhance coordination and does not offer optimal specificity in training. Remember, muscle has two types of receptors: The primary endings measure both velocity and muscle length, whereas the secondary endings measure length alone. Thus, dynamic stretching must be used to condition the primary endings for their desired response.

In addition, one study (Rosenbaum and Hennig 1995) suggested that it is advisable not to apply solely static stretching routines because of "a potentially impairing effect on muscle performance" (p. 489). Specifically, their research found stretching had a negative effect on active force production. A possible rationale for this negative effect may be due to mechanical characteristics changes of the damping ratio (the ability to absorb and dissipate shock loading) and mechanical stiffness (the ability to resist deformation) of soft tissues (Siff 1993a).

Ballistic and Dynamic Stretching
Ballistic stretching involves bobbing, bouncing, rebounding, and rhythmic types of movement. As mentioned earlier, in ballistic stretching, momentum is the driving force that moves the body or limb to forcibly increase the ROM (range of motion). This technique is the most controversial stretching method because it can cause the most soreness and injury.

Other disadvantages are that it:
- fails to produce adequate time for the tissues to adapt to the stretch; and
- initiates the stretch reflex and thereby increases muscular tension, making it more difficult to stretch the connective tissues.

Based on the above disadvantages, athletes may choose to incorporate dynamic rather than ballistic stretching into their training regime. The key difference between ballistic and dynamic stretching is that the latter does not end with bouncing or jerky movements. Instead, the movements are under control. Research has demonstrated that both ballistic and dynamic stretching enhance flexibility; however, dynamic stretching develops optimum dynamic flexibility, essential for all sports. Remember, flexibility must be velocity specific to condition and train the velocity specific stretch receptors.

A safe ballistic (dynamic) stretching program has been developed by Zachazewski (1990). He recommends a progressive velocity flexibility program (PVFP) preceded by a warmup. Then, over time, the athlete goes through "a series of stretching exercises in which the velocity and range of lengthening are combined and controlled on a progressive basis" (p.228). This gradual program permits the muscle and the musculotendinous junction to adapt progressively to functional ballistic movements, hence reducing the risk of injury. Zachazewski briefly describes the program as follows:

The athlete progresses from an environment of control to activity simulation, from slow-velocity methodical activity to high-velocity functional activity. After static stretching, slow short end range(SSER) ballistic stretching is initiated. The athlete then progresses to slow full range stretching (SFR, fast short end range (FSER) and fast full range (FFR) stretching. Control and range are the responsibility of the athlete. No outside force is exerted by anyone else (p.228)

In contrast, Tom Kurz, a leading flexibility instructor, challenges the generally accepted belief that static stretching should be employed after an initial warm-up routine. He contends that "doing static stretches before a workout consisting of dynamic actions is counterproductive." Instead, he advocates using dynamic stretches first and static stretching when the major part of the workout is completed and it is time for a cool-down (Kurz 1994).

Passive Stretching
Passive stretching is a technique in which you are relaxed and make no contribution to the range of motion. Instead, an external force is created by a manual or mechanical agent. Passive stretching is preferred when the elasticity of the muscles and the connective tissues to be stretched (antagonists) restricts flexibility and for muscles or tissues undergoing rehabilitation. Among the advantages associated with passive stretching are the following:
- It is effective when the agonist (the primary muscle responsible for the movement) is too weak to respond.
- It is effective when attempts to inhibit the tight muscles are unsuccessful.
- It allows stretching beyond one's active range of motion.
- It provides a reserve for increasing the joint's active mobility.
- Direction, duration, and intensity can be measured when more advanced stretching machines and modalities are used in rehabilitative therapy.
- It can promote team camaraderie when the athletes stretch with partners.

Athletes need to recognize several disadvantages with regard to passive stretching. First, there is a greater risk of soreness and injury if a partner applies the external force incorrectly. In addition, passive stretching may initiate the stretch reflex if the stretch is too rapid. Another important disadvantage is that the likelihood of injury increases with greater differences between the ranges of active and passive flexibility (Iashvili 1983). But perhaps most important for the athlete, research has demonstrated that passive flexibility values have a lower correlation to the level of sport

achievement than active flexibility (Iashvili 1983). The solution, then, is to develop your active flexibility also.

Active Stretching
Active stretching is accomplished using your own muscles and without any assistance from an external force. Active stretching can be divided into two major classes: free active and resistive. Free active exercise or stretch occurs when muscles produce movement without application of additional external resistance. An example of free active stretching is standing upright and slowly lifting one leg to a 100 degree angle. In resistive active exercises, the athlete uses voluntary muscle contractions to move against an applied resistance. Using the previous example, a manual resistance or weight can be applied to the leg being lifted. Active stretching is preferred when the weakness of those muscles producing the movement (agonists) restricts flexibility.

Active stretching is vital to the athlete because it develops active (and potentially dynamic) flexibility, which in turn has been found to have a higher correlation with sport achievement than does passive flexibility (Iashvili 1983). As active stretching is most specific to a given discipline, it has the greatest potential value for the athlete. Moreover, active stretching may be easier to work into a stretching routine, as it does not require a partner or other equipment. The major disadvantages of active stretching are that it may initiate the stretch reflex and that it may be ineffective in the presence of certain dysfunctions and injuries such as severe sprains, inflammation, or fractures.

In recent years, a modified version called active-assisted stretching has become increasingly popular. With active-assisted stretching, the range of motion is completed by a partner or device (inner tube or towel) when one's limit of flexibility is reached. The advantage of this modified technique is that it can activate or strengthen the weak agonist opposing the tight muscle, help establish the pattern for coordinated motion, and allow stretching beyond one's active range of motion. Research is needed to quantify and substantiate claims of enhanced performance for athletes.

Proprioceptive Neuromuscular Facilitation
Proprioceptive neuromuscular facilitation is another broad strategy that can be implemented to improve your range of motion. A modified version of one of the PNF techniques is referred to in osteopathic medicine as a muscle energy technique. PNF was originally designed and developed as a rehabilitative physical therapy procedure. Today, several different types of PNF are being used in the arena of sports medicine. Names and descriptions of PNF techniques vary according to the source; therefore, comparisons are often difficult to assess. In this text, we have adopted the terminology and description of Moore and Hutton (1980). Two of the more prevalent PNF strategies in athletic training are the contract-relax and contract-relax-agonist-contract techniques.

Contract-Relax (CR) Technique. The contract-relax technique (also called hold-relax) starts with the athlete's tight muscle group (antagonist) in a lengthened position. Assume for the sake of illustration that your hamstrings are tight. The tight hamstrings are first gently stretched and gradually contract isometrically, building to a less than maximum effort for 6 to 15 seconds against a partners resistance. As the contraction is isometric, there is no change in the muscle's length or movement of the joint. This contraction is followed by a brief period of relaxing the hamstrings. Then the partner slowly lengthens the tight muscle group (hamstrings) by passively moving the extremity through its gained range of motion.

The rationale for the contract-relax technique is that the initial contraction of the antagonists (hamstrings) in the stretched position is thought to promote a subsequent relaxation phase of the same muscle. In part, this relaxation may be a result of the inhibitory activity from the GTOs. Still, it is important to perform PNF relaxation techniques rapidly to achieve the desired inhibitory (relaxation) effect. Because the effect of the maximal depression lasts less than one second and 70 percent recovery occurs within 5 seconds, Moore and Kukula (1991) suggests that the "stretch increments should be applied immediately after the voluntary contraction, preferably within the first second and certainly by 5 seconds post contraction."

Contract-Relax-Agonist-Contract (CRAC) technique. The contract-relax-agonist-contract technique is similar to the Cr technique except that the relaxation phase is followed be an active contraction of the agonist (i.e., the antagonist of the tight muscle group, which in this instance are the quadriceps muscles). This last phase can also be assisted by the partner. Then the entire procedure is repeated.

The CRAC technique is based on the neurophysiology of reciprocal inhibition; that is, when the agonists (quadriceps) contract, the antagonists (hamstrings) relax. In addition, the CRAC method has been found to produce the greatest range of motion compared to other techniques (Moore and Hutton 1980). Another potential advantage is the facilitation of active flexibility. The major disadvantage of the CRAC method is more discomfort and perceived pain.

Two frequently asked questions regarding the contraction phase of PNF exercises deal with its intensity and length of time. The originators of PNF and most early literature used the term maximal to describe the proper amount of resistance. However, many PNF instructors now consider the terms optimal or appropriate more accurate (Adler, Beckers, and Buck, 1993). This text uses less than maximal isometric contractions as recommended by McAtee (1993). The advantages include safety, less soreness, less tiring for the partner, and partners being able to work together despite differences in size and strength (McAtee 1993).

Length of time has been analyzed in a study comparing isometric contraction periods of zero, three and six seconds. The research supported the hypothesis of the superiority of longer isometric contractions in active PNF groups; however, this superiority is absent from passive PNF groups (Hardy 1985). Further study of this complex issue is necessary.

PNF techniques offer a wider range of advantages and benefits than other conventional stretching methods. Most significant, PNF seems to be the most successful method for developing flexibility. The technique is also praised because it enhances active flexibility and helps establish a pattern for coordinated motion. It is also considered superior because it uses several important neurophysiological mechanisms, such as reciprocal innervation and the inverse myotatic reflex. PNF techniques are also thought to help reset the stretch reflex level or alter stretch perception (Magnusson et al. 1996). However, many of these assumptions have been challenged (Moore and Hutton 1980).

Unfortunately, PNF techniques have several disadvantages. Most important is the greater risk of injury, ranging from a pulled muscle to certain cardiovascular complications. Furthermore, the technique requires a knowledgeable and well-trained partner, which can be uneconomical in a practice session because one athlete (the partner) in neither stretching or resting (Kurz 1994).

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We thank Patty Lehn, Publicity Manager, Human Kinetics for allowing us to share this excerpt with our members. For more information on this and other titles, please visit their website; www.HumanKinetics.com .