The Physiological Effects of Stretching

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Table of Contents

Introduction

Human athletes have long understood the benefits of stretching, especially related to improving athletic ability and performance. Likewise, applied regularly, stretching horses can enhance physical fitness and the ability to learn and perform skilled movements; increase the range of movement, suppleness and circulation; reduce the risk on injury to joints, muscles and tendons; increase mental and physical relaxation; enhance development of body awareness and reduce muscular soreness and tension. In the hands of a suitably trained professional stretching can also be used in the rehabilitation of a horse from injury. Mimi Porter (1998) says that manual stretching can increase the stretch tolerance of muscles and connective tissues, adapting them for the demands of sport. Given stretching can achieve so much, it is important to understand the physiology of stretching in order to maximise these benefits; in particular how the composition of muscles and connective tissues; processes such as the sliding filament mechanism and proprioceptors all contribute to the stretch reflex, the lengthening reaction and reciprocal inhibition.

The Anatomy of a Muscle

Generally speaking, a muscle has a point of origin (anchor), belly (power) and a point of insertion (motion). A skeletal muscle consists of individual muscle fibres bundled into fascicle and surrounded by connective tissue layers that are extensions of the deep fascia. At a micro level, these muscle fibres are made up of myofibrils which are in turn composed of dark and light filaments called sarcomeres. The sarcomere is the contractile element of the fibre. (Hale, Margham, Saunders 1995) Each sarcomere is made of overlapping thick and thin filaments called myofilaments and the thick and thin myofilaments are made up of contractile proteins.

The Sliding Filament Mechanism

The sliding filament mechanism is when the protein filaments (thick myosin and thin actin) slide past each other or overlap during contraction of the muscle. An increase in calcium ion concentration in the sarcoplasm initiates the sliding filament system. In essence, it causes the sarcomere to shorten which generates force.

A contraction of the muscles is the result of billions of sarcomeres in the muscle shortening at the same time. A decrease in calcium ions stops the filaments sliding.

As the sarcomere contracts, the area of overlap between thick and thin myofilaments increases. Conversely, as it stretches, the area of overlap decreases, allowing the muscle fibre to elongate. Once the muscle fibre is at its maximum resting length, additional stretching places force on the surrounding connective tissue. As the tension

increases, the collagen fibres in the connective tissue align themselves along the same line of force as the tension. Hence, when you stretch, the muscle fibre is pulled out to its full length, sarcomere by sarcomere and then the connective tissue takes up the remaining slack. When this occurs, it helps to realign any disorganized fibres in the direction of the tension. This realignment is what helps to rehabilitate adhered tissue back to health. (Appleton 1996) According to Scully (2000), when a muscle is stretched, some of its fibres lengthen, but other fibres may remain at rest. The current length of the entire muscle depends upon the number of stretched fibres. The more the fibres are stretched, the greater the length developed by the stretched muscle.

Stretch Receptors

Stretching can enhance the awareness of the proprioceptors. (Denoix & Pailloux 1996) Proprioceptors are situated in the ligaments, tendons, muscles and joints (Denoix et. al 1996) and are the nerve endings that relay all the information about the musculoskeletal system to the central nervous system. Proprioceptors are the source of all proprioception: the perception of one's own body position and movement. (Appleton (1996)) The proprioceptors detect any changes in physical displacement (movement or position) and any changes in tension or force within the body. This means that stretching can assist in the horse's perception of their body position and movement and hence co-ordination.

The primary proprioceptors in the muscle are called stretch receptors and they detect any changes in movement, position, tension or force, within the body and relay that information to the brain. According to Clayton (1991), the stretch receptors located in the muscles and tendons protect against injury due to excessive tension (stretching). Stretch receptors found in muscles are called muscle spindles and are the primary proprioceptors in the muscle. (Appleton 1996)

Stretch receptors in the tendons near the end of the muscle fibre are called the golgi tendon organ. A third type of proprioceptor, called a pacinian corpuscle, is located close to the golgi tendon organ and is responsible for detecting change in movement and pressure within the body. (Appleton (1996))

The Stretch Reflex

The stretch reflex also called the myotatic stretch reflex results in the contraction of the muscle when stretched. It is triggered by the stretch receptor or proprioceptors of the muscle spindle organ. The muscle spindle receptor, located in the belly of the muscle, sends information about the change in length of the muscle and how fast the change occurred to the central nervous system. This triggers the stretch reflex, which attempts to resist the change in muscle length by causing the

stretched muscle to contract, the faster and stronger the stretch, the great the reflex shortening. (Clayton 1991) According to Clayton (1991), rapid stretching of a muscle is used in strength training as it produces such a strong reflex contraction. In humans this active, fast stretch is called ballistic stretching. If a ballistic stretch is performed passively with horses, there is an increased risk of injury. Scully (2002), therefore recommends that an ballistic, fast stretch is only ever done actively and never passively in a horse. A slow stretch is used to elongate the muscles and connective tissue as it minimises the reflex contraction allowing a stretch to be held for a longer period of time. Lengthening of the muscles occurs when a stretch is held for a prolonged period of time because as you hold the muscle in a stretched position, the muscle spindle becomes accustomed to the new length. (Scully (2002))

The stretch reflex is a monosynaptic reflex (Tortora et.al 2000) and has both a dynamic and static component. The static component of the stretch reflex persists as long as the muscle is being stretched. The dynamic component of the stretch reflex lasts for only a moment and is in response to the initial sudden increase in muscle length. A muscle spindle consists of 3-10 specialised muscle fibres called intrafusal muscle fibres which are enclosed in a spindle shaped connective tissue capsule. They contain little or no actin and myosin and therefore have no contractile properties. (Tortora et.al 2000)

According to Appleton (1996), there are two types of intrafusal muscle fibres

1. Nuclear chain fibres are responsible for the static component of stretching. They lengthen steadily and are long and thin.
2. Nuclear bag fibres are responsible for the dynamic component of the stretch reflex which can be described as a strong nerve impulse to trigger contraction of the muscle at the onset of a rapid increase in muscle length, followed by a slightly higher than normal signaling which gradually decreases as the rate of change of the muscle length decreases. This is possible because the nerve endings for the fibres wrap around the centre of the muscle causing it to bulge out in the middle, where they are most elastic and they lengthen quickly when the fibre is stretched. In contrast, the outer areas gradually extend under prolonged tension after initially resisting fast stretching. In this way, the nerve that senses stretching in these fibres fires rapidly with the onset of the fast stretch, then slows as the middle section of the fibre is allowed to shorten again.

A muscle trigger point (knot) can be caused by a chronically irritated muscle spindle. Slow stretching increases the metabolism in the muscle

spindle elevating its oxygen consumption allowing it to relax cause the trigger point to reduce. (Porter 1998)

The Tendon Reflex

The stretch reflex that occurs within the tendon is called the inverse myotatic reflex or lengthening reaction. When muscles contract, they produce tension at the point where the muscle is connected to the tendon, at the point where the golgi tendon organ is located. Like the muscle spindle, the golgi tendon organ senses a change in tension and how fast the change occurred. When tension exceeds a certain threshold, it triggers a lengthening reaction. This inhibits the muscles from contracting and causes them to relax, helping to protect the muscles, tendons and ligaments from injury. The lengthen reaction is possible only because of the signaling of the golgi tendon organ to the spinal cord is powerful enough to overcome the signaling of the muscle spindles telling the muscle to contract. (Appleton (1996)) That is, the Tendon Reflex overrides the Stretch Reflex contraction which is why holding a stretch for an extended period of time (10-20 seconds) is important – it allows the lengthening reaction to occur. Deep relaxation of the muscles results and allows further elongation of the muscles. As Appleton says (1996), it is easier to stretch, or length a muscle when it is not trying to contract.

Reciprocal Inhibition

Reciprocal inhibition is sometimes called reciprocal innervation and prevents conflict between opposing muscles, which is important for coordinating body movement. (Tortora et. al. 2000) It is the term used to describe the action of agonist and antagonist in muscles. (Scully 2000) Agonists cause movement to occur and antagonists act in opposition and are responsible for returning the muscle to its initial position. When an agonist contracts, the antagonists usually relax. This phenomenon is called reciprocal inhibition because the antagonists are inhibited from contracting (Appleton 1996) As previously mentioned, it is easier to stretch a muscle that is relaxed, than to stretch a muscle that is contracting.

Conclusion

The muscle spindle organ and the golgi tendon organ act as a stretch receptors to trigger the stretch reflex when a muscle in stretched. The myotatic reflex operates as a feedback mechanism to control muscle length by causing muscle contraction. In contrast the inverse myotatic reflex operates as a feedback mechanism to control muscle tension causing muscles to relax before muscle force becomes so great that they or the tendons might tear. A fast stretch of a muscle can increase the strength of the tissue due to the strong reflex action it triggers, however this type of stretch is not recommended for horses. A slow stretch can elongate the muscle as the muscle spindle organ becomes

used the new length of the muscle as it is held. The physiological effects of stretching described combine to provide the benefits of injury prevention, increased suppleness and improvement of performance which reinforces that stretching should form and integral part of any training regime.

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