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Stiffness – Resistance to Change: Good or Bad?

In the realm of health and fitness, the term stiffness often has a bad connotation. In reality, being stiff can have positive benefits. When something is stiff, it is difficult to change. When the range of motion of a joint is limited, it is also described as stiff. There is an optimal range of motion for a joint but having too much motion or not enough stiffness can cause pain, instability and ineffective movement. Conversely, something stiff is considered poor at absorbing (attenuating) force. The challenge is to have optimal balance between stiffness and flexibility.

When the tire on a bike is pumped with a lot of air, the tire is stiff. If the bike tire is under-inflated, it is considered soft and relatively flexible. There are situations, such as in a race where a stiff tire would result in faster times. Whereas, if the tire had less air pressure and was softer, the bike would be slower but be more comfortable and would absorb force. Several investigations have looked at muscle/tendon stiffness as it relates to running economy.

Godges (1989) observed that moderately trained athletes increased their running economy when they increased their hip motion - flexion and extension. These findings are compatible with the general belief among runners and coaches that improved flexibility is desirable for increasing running economy.

In contrast Gleim (1990) found that untrained subjects who exhibited the lowest flexibility were the most economical when running at speeds ranging from 2 miles per hour to 6 miles per hour. He concluded elastic energy storage and energy return could be enhanced by having a tighter musculo-tendonus system.

Craib (1996) examined the relationship between running economy and trunk and lower limb flexibility in well trained male distance runners. Inflexibility in the hip and calf regions was associated with better running economy by minimizing the need for muscle stabilizing activity and increasing the storage and return of elastic energy.

Jones (2002) found that leg and trunk flexibility was negatively related to running economy in international standard male distance runners. Using a sit and reach flexibility test score the less flexible runner had better sub-maximal oxygen consumption values.

Taken collectively, the findings from these studies suggest there is an optimal level of muscle/tendon stiffness or flexibility from which running economy can benefit. The above studies assumed there is a strong relationship between the range of motion of a joint and muscle stiffness but there is controversy in the way muscle/tendon stiffness should be measured. Technically, muscle stiffness is measured as the change in tension per unit change in muscle length and it requires a strain gauge to measure tension. Studies have show there can be limited joint motion (limited muscle length) without an increase in passive stiffness. Passive stiffness of the hamstring muscle was measured using a strain gauge. A stretching exercise protocol was used to increase the range of motion of the hip joint, yet no change in hamstring muscle stiffness occurred.

Clinically, muscle/tendon stiffness can be assessed subjectively as the resistance felt in the examiners hand as a joint is passively moved through the range of motion. When the knee of a body builder or a ballet dancer is passively bent, the range of motion can be equal but the body builder will feel stiffer as the knee is bent. It would be analogous to pulling or bending a spring. The sensation of pulling or bending a spring with many coils feels different than pulling or bending a spring with fewer coils. Both springs can stretch or bend to the same length but it takes more force to stretch or bend the spring with many coils. The spring with many coils is stiffer.

If an individual is assessed as lacking sufficient muscle/tendon stiffness, what is the best method to optimally develop it? Avoid stretching/lengthening a muscle which is considered lacking stiffness or is too flexible. Like the soft bike tire which is under inflated, the muscle is likely under inflated. The term "pump the muscle up" applies. The more muscle tissue which can be stuffed in the muscle sheath the stiffer the muscle/tendon unit will be. Strengthening exercises can increase the volume/thickness of a muscle. Imagine if the leg bones were encased inside an inner tub. If the inner tube is pumped tight with air, the bones will not bounce around inside the inner tub as it rolls down the road and the inner tube will have better speed. The muscle surrounding the leg bones act like an inner tube. They need to be pumped up and tight in order to protect the bones as the inner tube speeds down the road.

Having the property of stiffness can be a good thing. Pump it up!