# The Biomechanics of Stretching

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**Abstract**

This narrative review examined the biomechanical effect of stretching exercises on skeletal muscles. While there is a long history of clinical research on the effect of stretching on flexibility, there have only been a few years of research on the acute and chronic effects of stretching on the biomechanical parameters of muscle function. The acute effect of stretching appears to be a significant increase in range of motion primarily due to increased stretch tolerance and significant reductions in most all forms of muscular performance. Stretching also creates significant acute reductions in passive tension (stress-relaxation) in the muscle, but does not appear to affect its stiffness/elasticity. Stretch training significantly increases range of motion, but it also tends to increase the passive tension and stiffness of the musculature. Future research of human muscle *in vivo* during stretching and normal movement using ultrasound promises to help clarify the effects of stretching on the active and passive components of muscle and the many biomechanical variables of muscular performance.

Key Words: **Elasticity, Flexibility, Muscle, Stiffness, Tendon, Viscoelastic**

## Introduction

Stretching is an important therapeutic and exercise training modality for increasing joint range of motion. There has been extensive research on the effects of various stretching programs that have documented the clinical effectiveness of these techniques in modifying flexibility *(Knudson et al. 2000; Harvey et al., 2002; Shrier, 2004; Decoster et al., 2005).* Improvements in soft tissue imaging and force measurement technology have only recently begun to allow biomechanical studies to document the mechanisms of the effect of stretching on the muscle-tendon unit and muscular performance. This review will summarize the biomechanical research on the effects of stretching on the muscle-tendon unit. These studies provide important basic science evidence that compliments clinical studies to help guide professionals in prescribing stretching exercises.

### *Biomechanics of Muscle Tension*

The tension created by skeletal muscle can be classified as originating from two mechanical sources, active and passive. Active tension represents the contractile effects or the force generated by the interaction of actin and myosin filaments. Passive tension arises from the connective tissue components of skeletal muscle when elongated beyond their resting length. Active and passive tension cannot be considered separate structural elements of muscle because the connective tissue matrix of muscle is quite complex (within muscle and between muscles in anatomical compartments) and actin cross-bridges have elastic properties *(Proske and Morgan, 1999).* Many readers will be familiar with the electro-mechanical delay and hyperbolic force-velocity properties of muscle (*Hill, 1938)* that also complicate the