Section 40: Muscle Mechanics

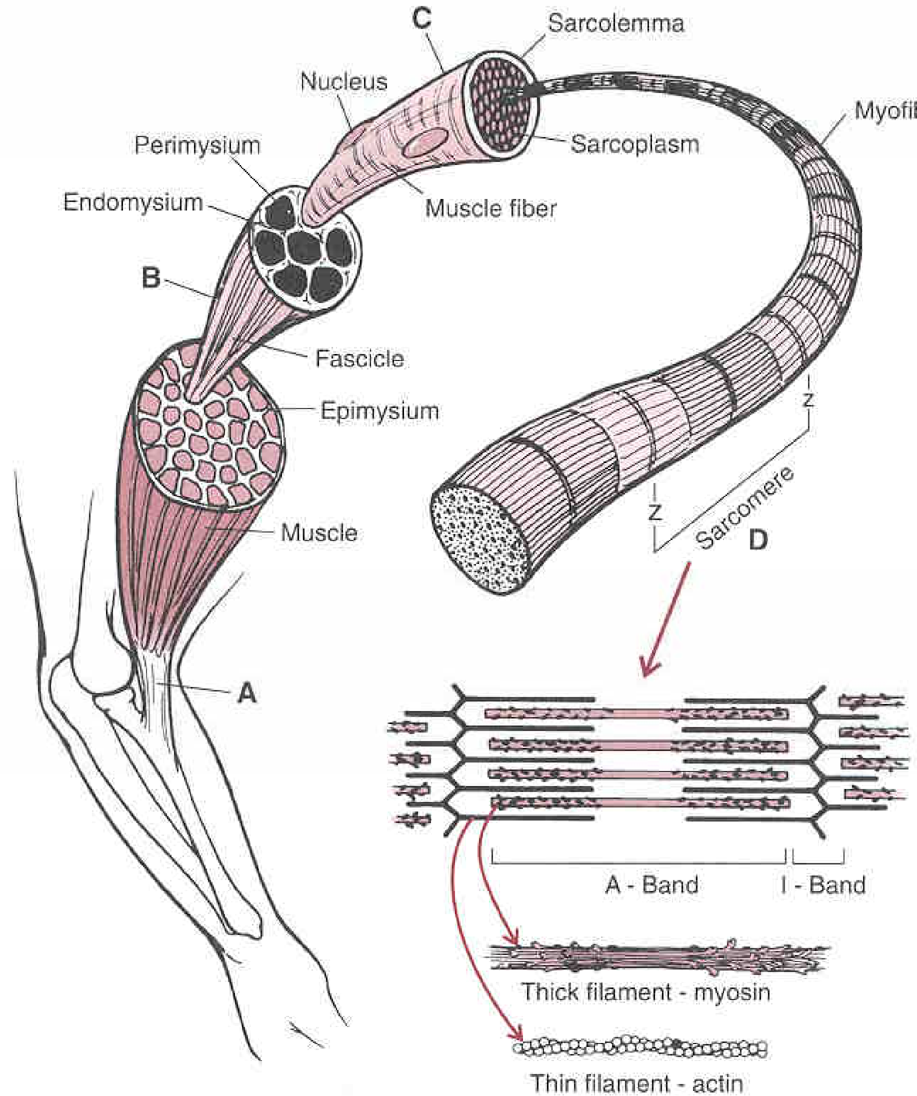


FIGURE 3–2. (A) Each individual muscle connects to the bone via a tendon or aponeurosis. (B) Within the muscle, the fibers are bundled together into fascicles. (C) Each individual fiber contains myofibril strands which run the length of the fiber. (D) The actual contractile unit is the sarcomere. Many sarcomeres are connected in series down the length of each myofibril. Muscle shortening occurs in the sarcomere as the myofilaments in the sarcomere, actin and myosin, slide towards each other.

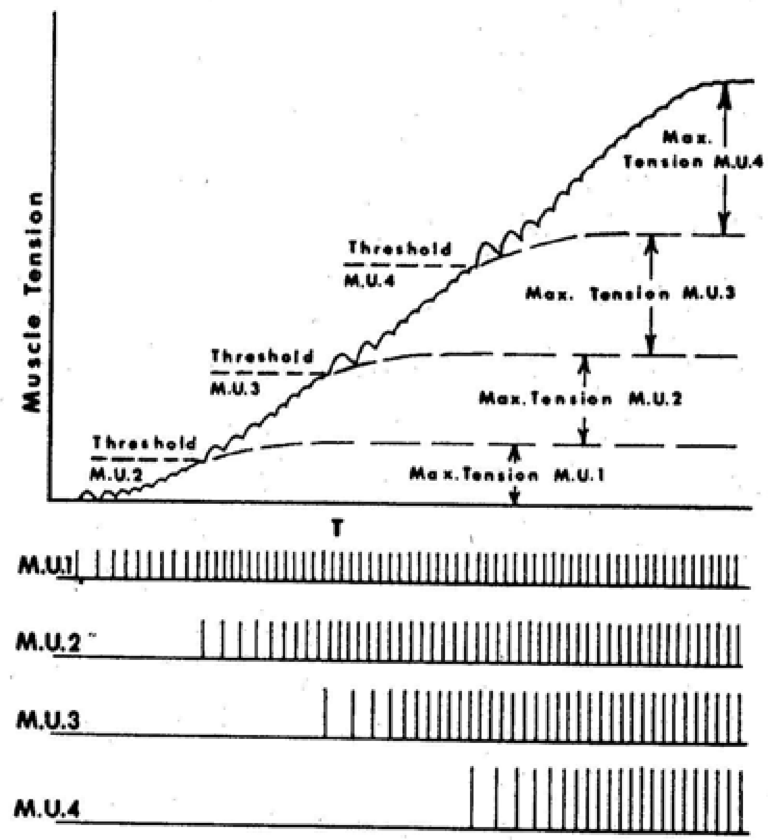
From: Hamill

•Smallest MU recruited at lowest stimulation frequency

•As frequency of stimulation of smallest MU increases, force of its contraction increases

•As frequency of stimulation continues to increase, but not before maximum contraction of smallest MU, another MU will be recruited

•Etc.



Size principle of recruitment of motor units. Smaller motor units are recruited first; successively larger units begin firing at increasing tension levels. In all cases the newly recruited unit fires at a base frequency, then increases to a maximum.

From: Brown

Recruitment proceeds from smallest fibers to largest
(**<u>the size principle</u>**)

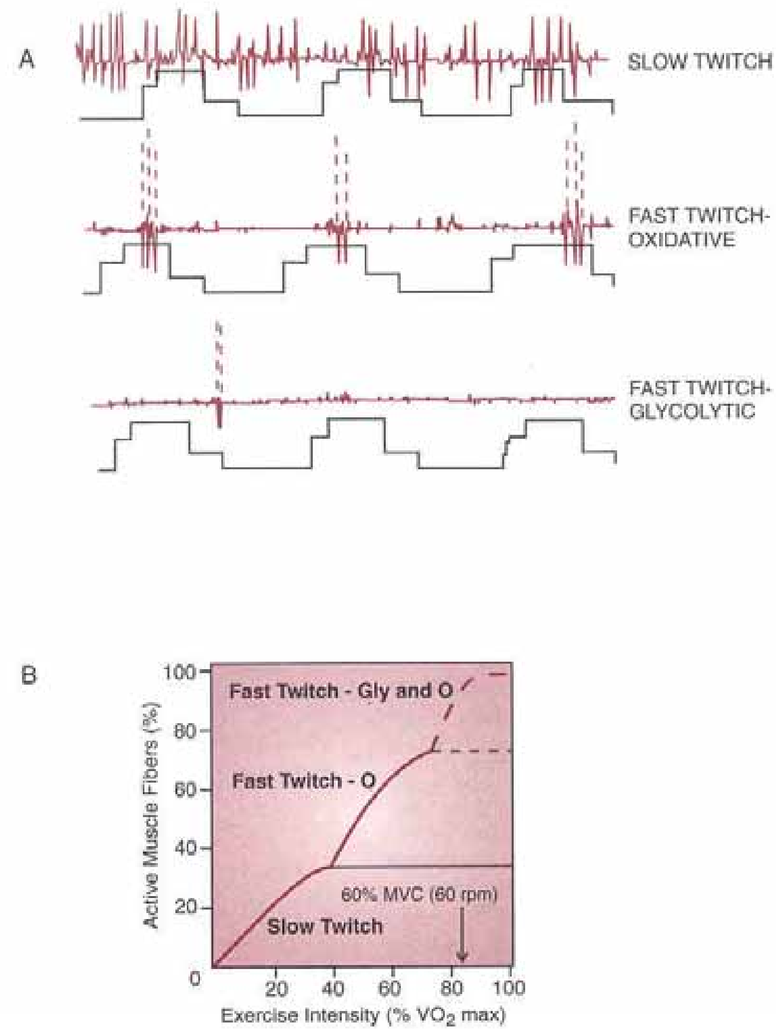


FIGURE 4–10. The order of activation of the motor units, termed recruitment, usually occurs following the size princip whereby the small slow-twitch fibers are recruited first, followed by the fast-twitch oxidative, and lastly by the fast-twitc glycolytic fibers. In (A), the muscle activity for the three muscle types is shown for three support phases in walking. Slow-twitch fibers are used for most of the gait cycle, with some recruitment of the fast-twitch fibers at peak activation times (From Grimby, L.: Single motor unit discharge during voluntary contraction and locomotion. *In* Human Muscle Power. Edited by N.L. Jones, N. McCartney, and A.J. McComas. Champaign, IL, Human Kinetics, 1986, pp. 111–129.) In (B), the recruitment pattern is similar, with slow-twitch fibers recruited for up to 40% of the exercise intensity, at whi point the fast-twitch oxidative are recruited. It is not until 80% of exercise intensity is reached that the fast-twitch glycolytic fibers are recruited (From Sale, D.G.: Influence of exercise and training on motor unit activation. Exercise ar Sport Science Reviews. *16*:95–151, 1987).

From: Hamill

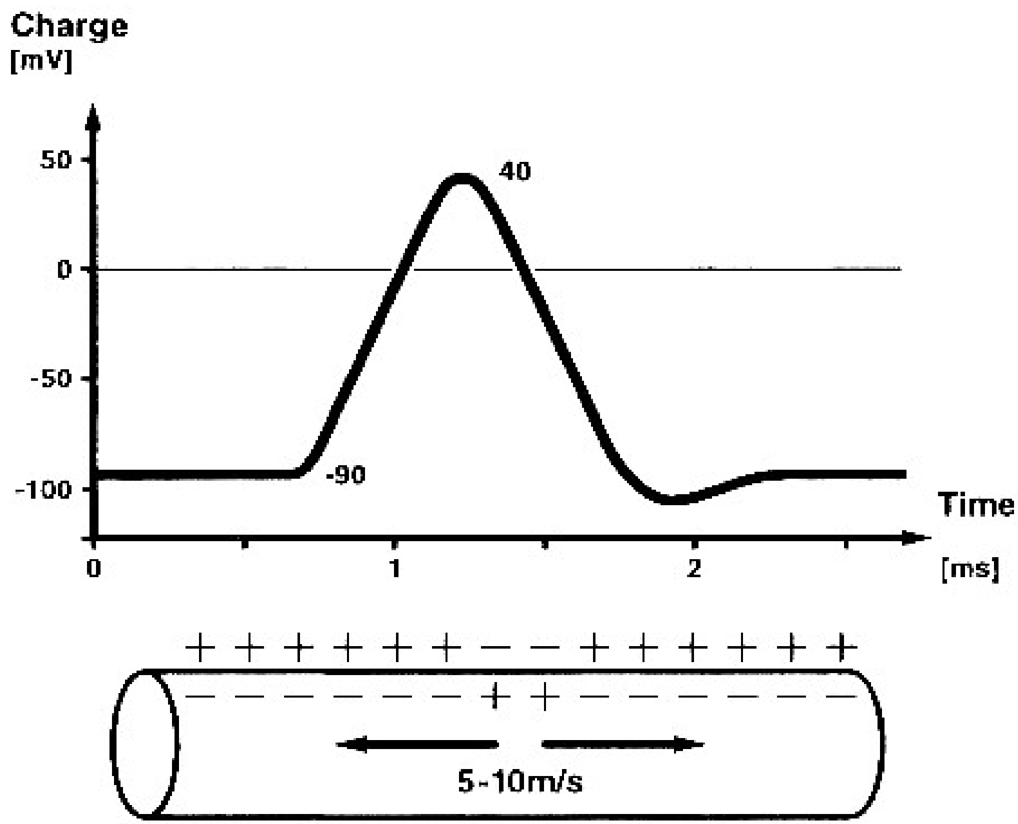


Figure 2.7.11 Schematic illustration of a single muscle fibre action potential (top) and the corresponding propagation of the action potential along the muscle fibre (bottom).

From: Garner

Nigg & Herzog, 1998

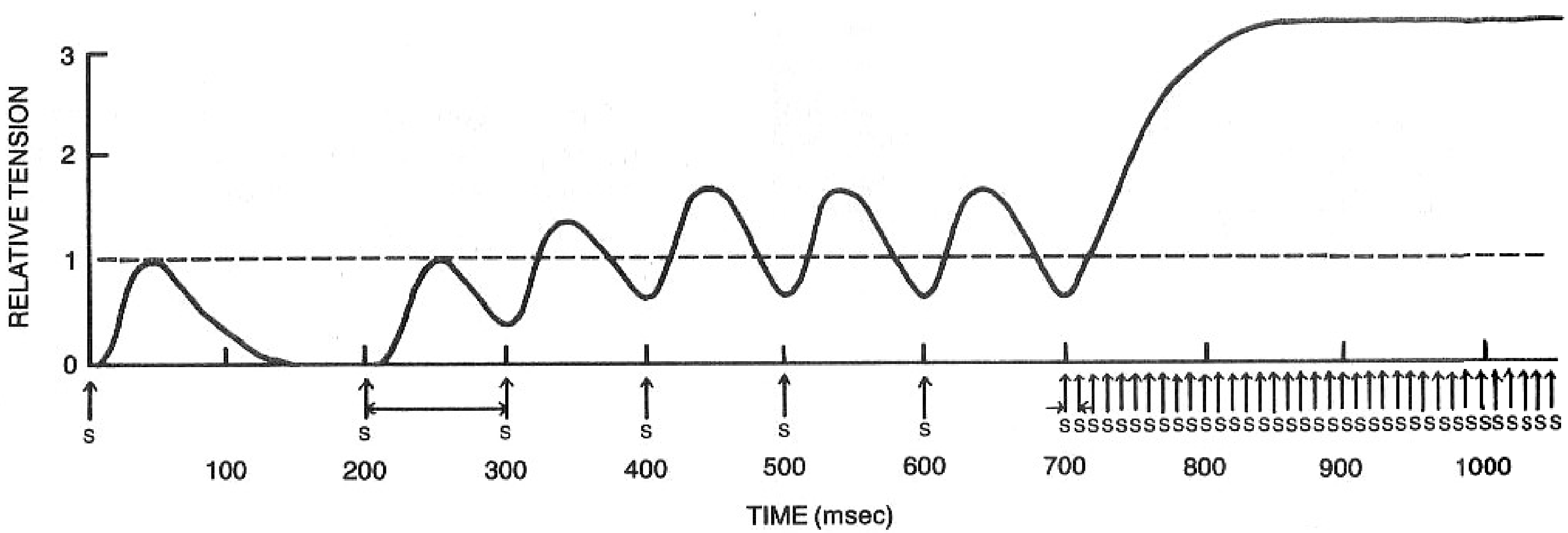
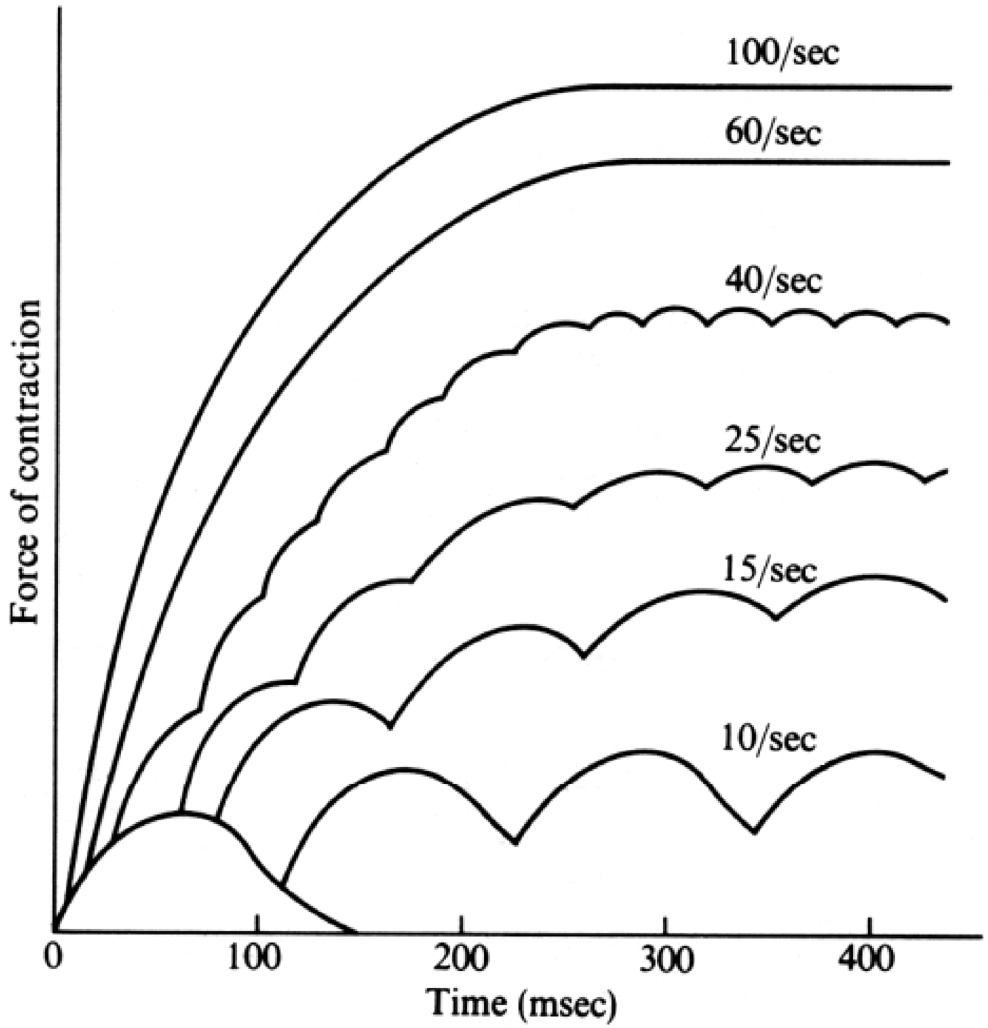


FIG. 5–7
Generation of muscle tetanus. As the frequency of stimulation (S) increases (i.e., the intervals shorten from 200 to 100 msec), the muscle tension rises as a result of summation. When the frequency is increased to 100 per second, summation becomes maximal and the muscle contracts tetanically, exerting sustained peak tension. (Adapted from Luciano et al., 1978.)

From: Garner

Nordin & Frankel (1989)

Wave summation & tetanization



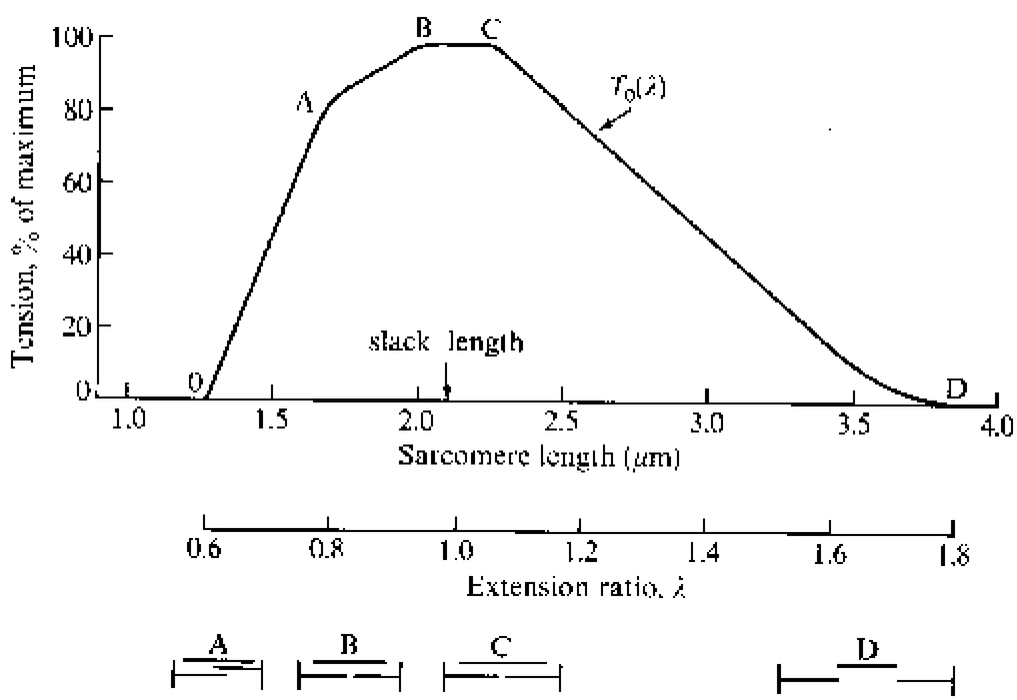
Critical frequency

From: Ju

Muscle Function

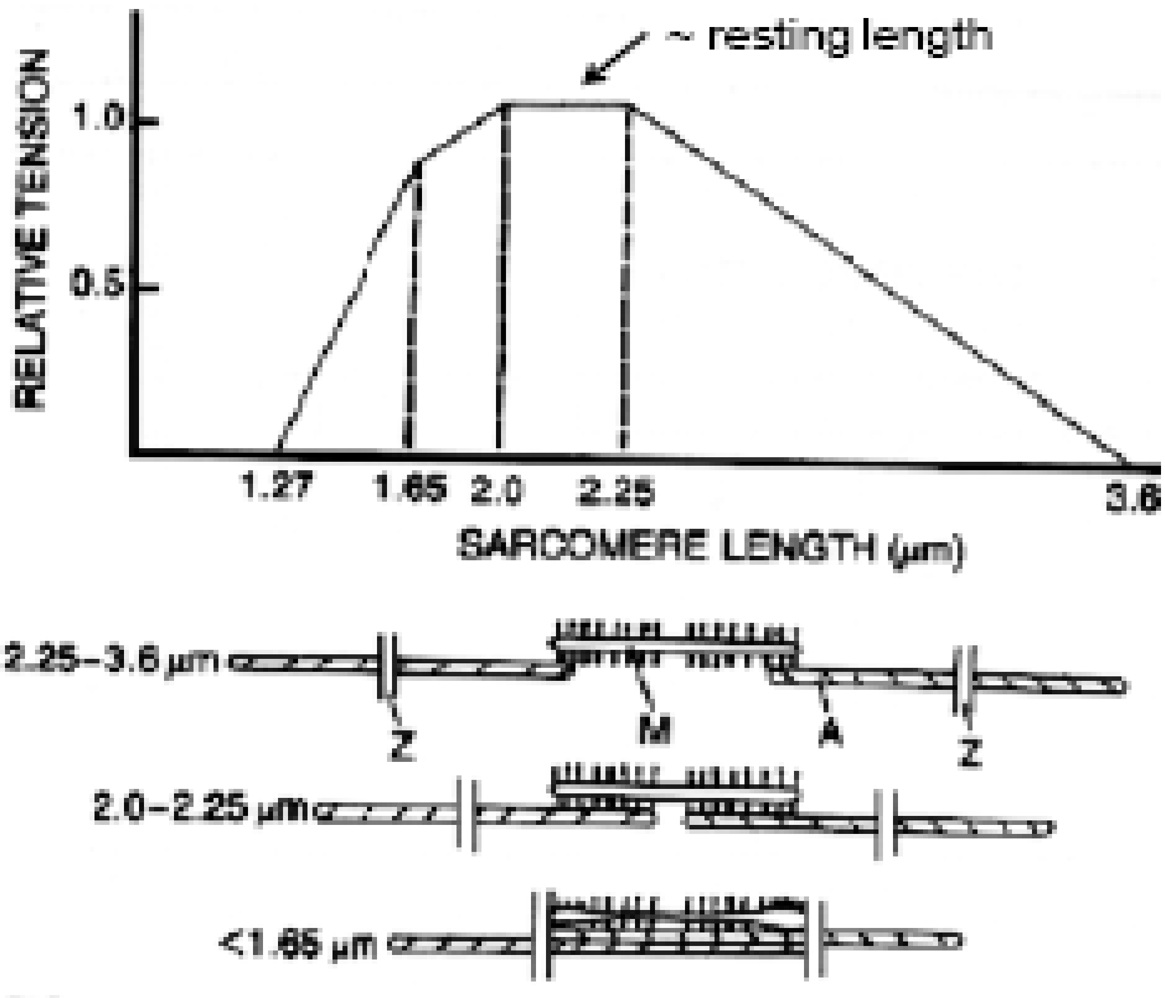
- Force – length relationship

Tension-Length Curve for Skeletal Muscle



From: Legh

Muscles Mechanics: Force-Length



Active force, developed in the sarcomere, depends on overlap between actin and myosin filaments; this overlap depends on sarcomere length

Besides actin and myosin filaments, what else is capable of producing force in the muscle?

From: Seeley

Frog skeletal muscle:

thick filament = 1.60 µm

thin filament = 0.95 µm

Z-disc (at end of thin) = 0.1 µm

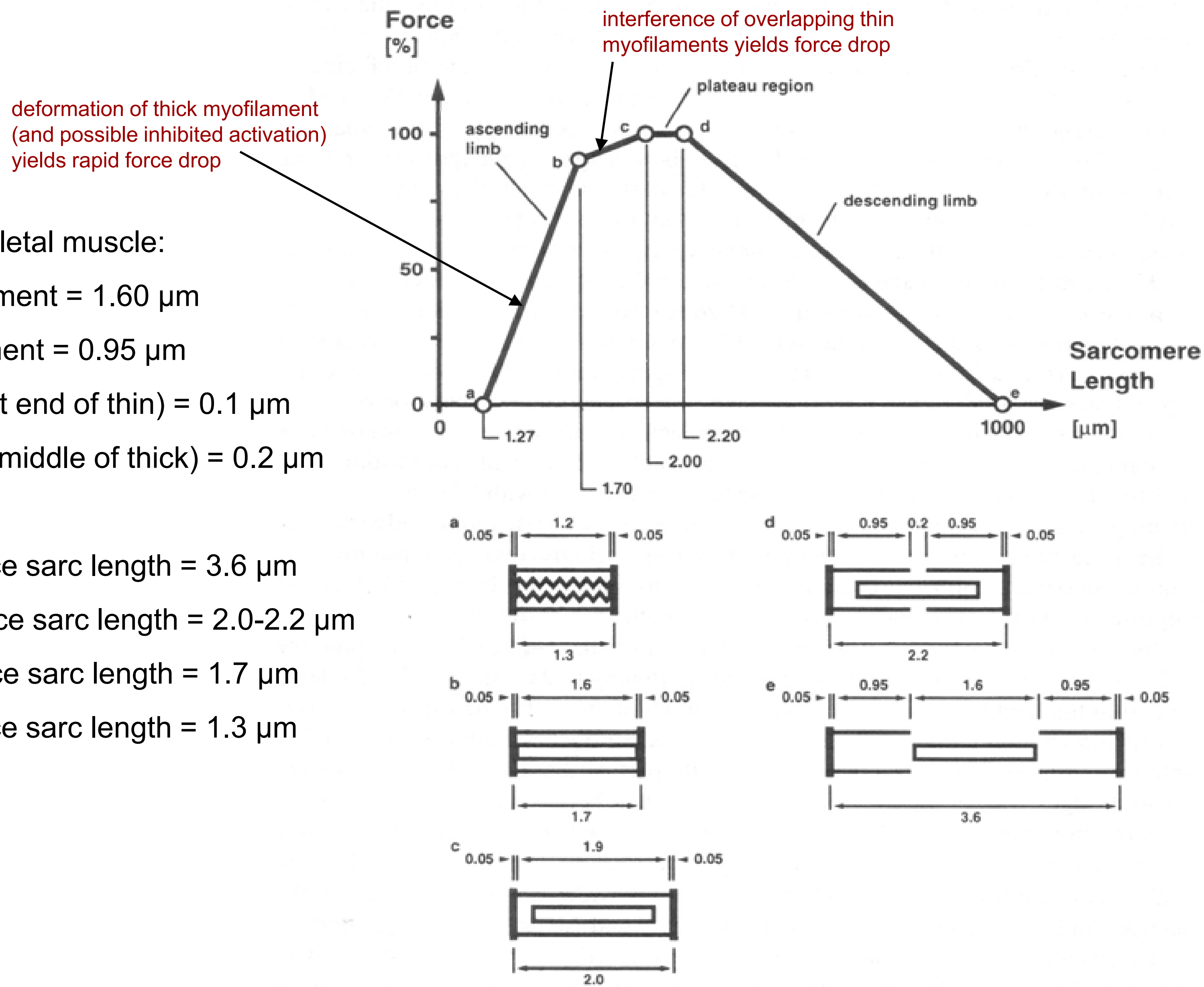
H-zone (middle of thick) = 0.2 µm

zero-force sarc length = 3.6 µm

peak-force sarc length = 2.0-2.2 µm

drop-force sarc length = 1.7 µm

zero-force sarc length = 1.3 µm



From: Garner

Nigg & Herzog, 1998