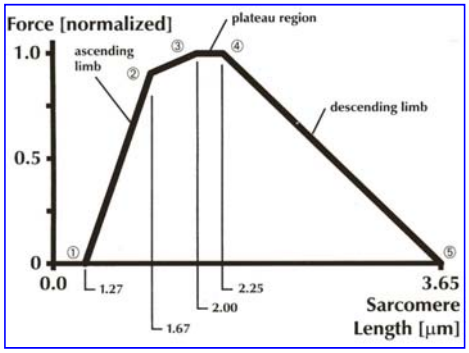
HHS 402g

Muscle Biology

Force-Length Properties

Sept 13, 2017



Epstein and Herzog, 1998

Force-Length Property

Maximum <u>isometric</u> force that a muscle ***<u>can</u>*** exert as a function of its length.

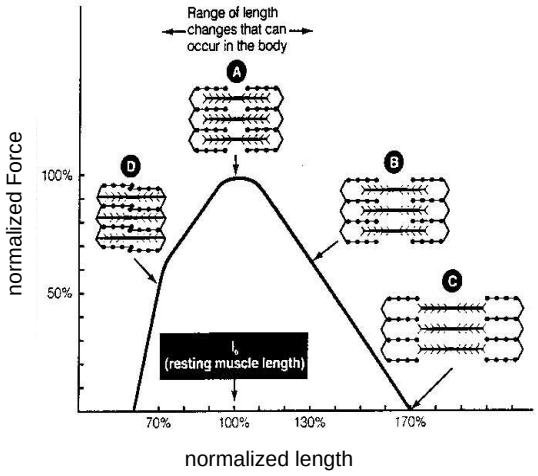
Length-dependence of muscle force known since Blix (1894)

Force-Length (F-L) properties have been determined in:

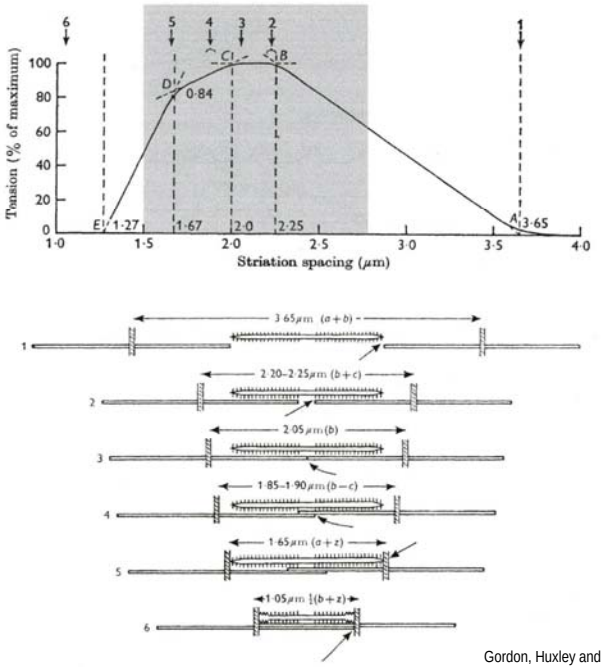
- sarcomeres [Gordon, Huxley & Julian 1966]
- isolated fibers [Ramsey and Street 1940]
- whole muscle [e.g. Goslow et al. 1982]

Force production modulated/influenced by many factors:

- muscle length



FLR:



Gordon, Huxley and Julian, 1966

Force-Length: Sarcomere

F-L for sarcomere:

- depends on lengths of thick and thin filaments
- can be calculated based on cross-bridge theory

Not smooth like whole muscle, but piecewise continuous with distinct linear regions.

∴ gain/lose tension linearly

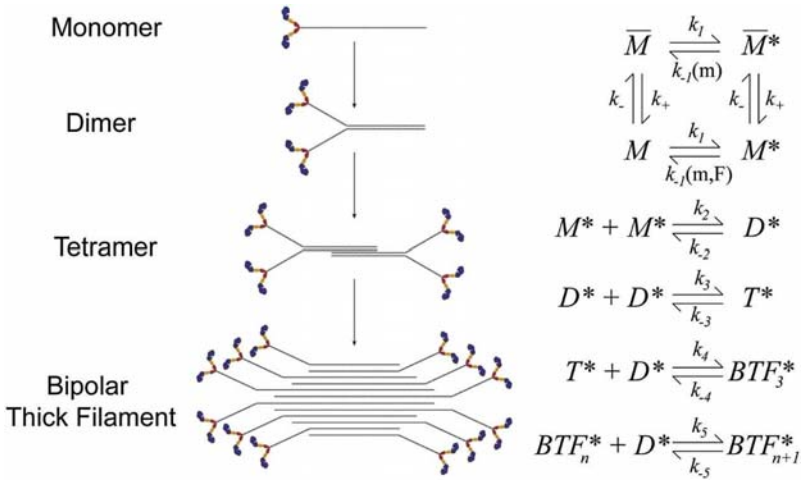
Composed of:

- ascending limb (not a positive slope)
- plateau (area where change in length has no effect on peak F_i)
- descending limb (not a negative slope)

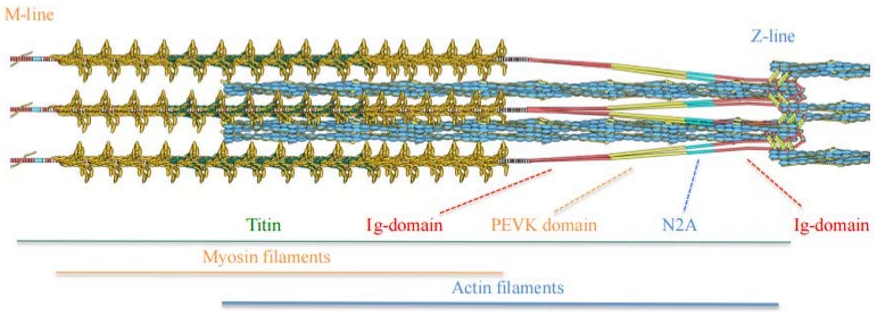
Example, sarcomere F-L from frog skeletal muscle:

$L_{myosin} = 1.6\mu m$ and $L_{actin} = 1.025\mu m$

Why does the FLR exist?

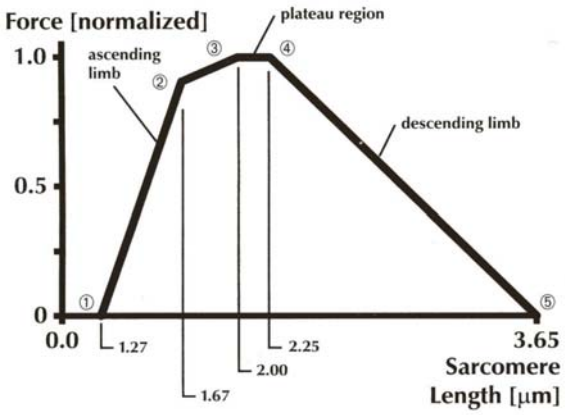


Schematic representation of the main protein within the sarcomere



Myosin (thick filaments), actin (thin filaments) and titin comprised of several different domains. By Dilson E Rassier. Sarcomere mechanics in striated muscles: from molecules to sarcomeres to cells. *Am J Physiol Cell Physiol*; Published 24 May 2017. **DOI:** 10.1152/ajpcell.00050.2017

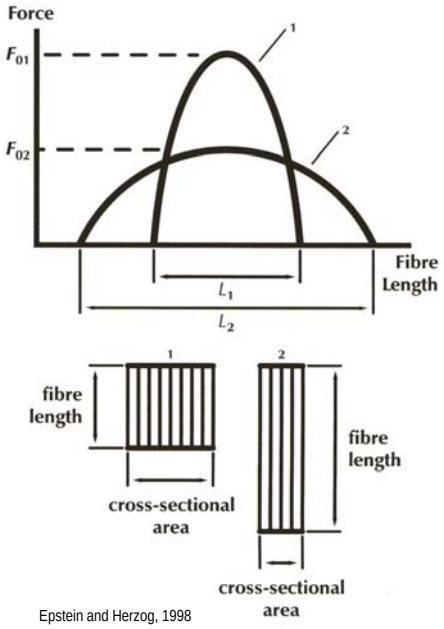
Force-Length: Sarcomere



$F = -2.667 + 2.1\ SL$ $\quad 1.27\ \mu m \leqslant SL < 1.67\ \mu m$
$F = 0.04 + 0.48\ SL$ $\quad 1.67\ \mu m \leqslant SL < 2.00\ \mu m$
$F = 1.0$ $\quad 2.00\ \mu m \leqslant SL < 2.25\ \mu m$
$F = 1.592 - 0.71\ SL$ $\quad 2.25\ \mu m \leqslant SL < 3.65\ \mu m$

Epstein and Herzog, 1998

Force-Length: Examples



Epstein and Herzog, 1998