MUSCLE MECHANICS

Muscle model
Muscle tension and generation of joint torque

inactive muscle

activated muscle

stretched elastic component

F = "muscle tension"

r · F = elbow joint torque

joint center
Force on an external object

Depends on intensity of muscle activation, but also on “external leverage”.

Good leverage:

\[
\Sigma T = 0
\]

\[
\Sigma T \bigcirc = \Sigma T \bigcirc
\]

\[
0.2 \cdot 30 + 0.5 \cdot 70 = 0.1 \ F_m
\]

\[
F_m = 410 \text{ N}
\]
Bad leverage:

\[ \Sigma T = \text{zero} \]
\[ \Sigma T \bigcirc = \Sigma T \bigcirc \]
\[ 0.4 \cdot 30 + 0.8 \cdot 70 = 0.1 \, F_m \]
\[ F_m = 680 \, \text{N} \]

In both examples, the force made by the hand on the shot was 70 N.

- With good leverage, this required 410 N of muscle tension.
- With bad leverage, the same job required 680 N of muscle tension.
Question: Using a muscle tension of 680 N but good leverage, how heavy a shot would the subject be able to hold?

In the last two examples, the muscle tension was 680 N.

- With good leverage, this produced a 124 N force exerted on the shot.
- With bad leverage, this produced a 70 N force on the shot.
Some conclusions about external leverage

- For a given force exerted on an external object, the better the external leverage, the smaller the muscle tension needed. ← good for preventing injuries

- For a given muscle tension, the better the external leverage, the larger the force exerted on an external object. ← good for achieving high performance
Some applications of leverage principles

\[ r_1 \cdot F_1 = r_m \cdot F_m \]
Three squats, and use of hip and knee muscles
Factors that affect force exerted on an external object

Factors that affect muscle tension

- Amount of effort

  The harder you try, the more tension the muscle can exert.
- Speed of muscle shortening or lengthening

A muscle is able to exert a larger tension when it is not allowed to shorten at a fast rate.
• Mechanical effect of stretching
  
  • Muscle tension is increased.
  
  • Reason: When a muscle is stretched, the parallel elastic component makes a large force.
  
  • The effect is immediate.

• Muscle potentiation

  • Muscle tension is increased.
  
  • Reason: Stretch reflex.
  
  • The effect comes after a short lag.
There is another type of muscle potentiation. It does not use the nervous system.

- **Pre-tension**

Limit in rate of muscle tension development creates a problem: Sub-maximal tension in early part of motion.

Solution: Pre-tensing of muscle.
2 mechanisms for pre-tensing:

- Pre-tensing through mechanical restraint of motion

- Pre-tensing through “countermovement”