Nov 23rd 2012

Ben

PEKIN 3P10

Lecture 10

Angular Kinetics & Neuromuscular Biomechanics

Newtons Laws of angular motion

- Torque (T) depends on the size of the force (F) and the perpendicular distance (r) from the line of action of the force to the point of rotation
- 1st law (law of inertia): rotating body will continue in a state of uniform angular motion unless acted upon by an external torque (if $\Sigma T = 0$, $a = 0$)
- 2nd Law (Law of angular acceleration)
  - an external torque produces an angular acceleration that is proportional to and in the direction of the torque and inversely proportional to the moment of inertia
  - equation: $\Sigma T = I \cdot a$ (linear motion: $\Sigma F = m \cdot a$)
    - $I = \sum_{i=1}^{n} m_i r_i^2$ $\quad a = \frac{\Sigma F}{m}$ $\quad \alpha = \frac{\Sigma T}{I}$

Moment of Inertia (I)

- depends on mass & distribution of mass with respect to axis of rotation (not constant!)
  - if mass is located closer to rotation axis, smaller moment of inertia
  - based on $\Sigma T = I \cdot \alpha$, small I → greater angular acceleration

Newtons 3rd Law of Angular motion (law of action-reaction)

- for every torque exerted by one body on another body, there is an equal and opposite torque exerted by the latter body on the former
- example: ① when falling forward, rotate arms in same direction
  ② in reaction, torque in opposite direction to your trunk (counter act falling forward)

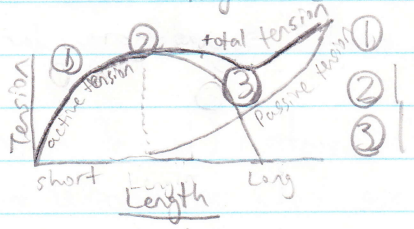
Neuromuscular considerations for human movement

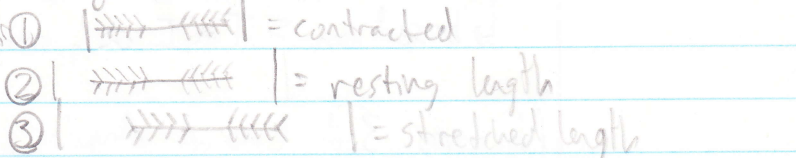
- ability of a muscle to generate force depends on many factors including: cross-sectional area, muscle fiber orientation, muscle length & velocity, prior activity, muscle fiber/motor unit composition

$T_{muscle} = F_{muscle} \cdot r_{muscle}$

1. Physiological cross-sectional area
   - ↳ force produced by muscle not simply dependent on number of myosin crossbridges
     - ↳ serial vs parallel arrangement of fibers & myofibrils
       - ↳ serial: adding muscles end to end (⊢——⊣)
         longer muscles stretch and shorten over greater lengths but are not any stronger than parallel arrangement
       - ↳ parallel: attached next to each other (▤)
         increasing the number of parallel fibers increases the strength of the muscle
     - ↳ human muscle can produce a force of ~30 N/cm^2 of cross-sectional area of active isometric muscle

2. Length-tension relationship
   - ↳ amounts of muscle force depends on its length
   - ↳ total force depends on:
     - ↳ active component
       - ↳ attachment of myosin cross-bridges to actin filament within a sarcomere





     - ↳ passive component
       - ↳ stretching of connective tissues (eg. sarcolemma, tendon etc.)

Note: all of this information is based from frog muscle

Example: Plantar flexor strength testing

① short medial & lateral gastroc.

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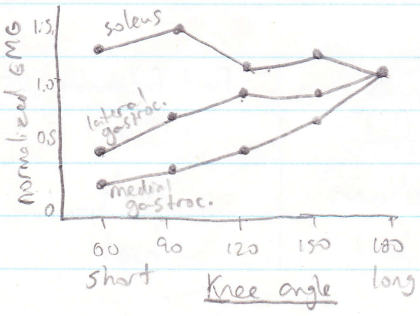
2. Length-tension relationship

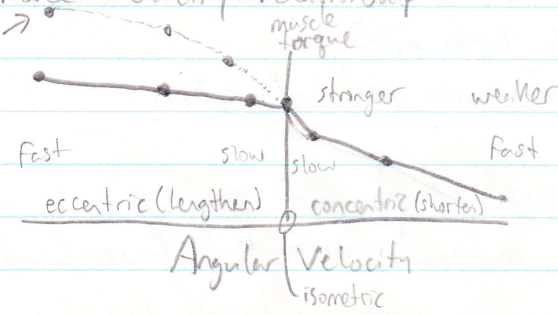
↳ if a muscle is at a non-optimal length, do we still try to contract it?

↳ measure activation through electromyography



- shortened muscles are not activated as much (less recruited)

3. Force-Velocity relationship



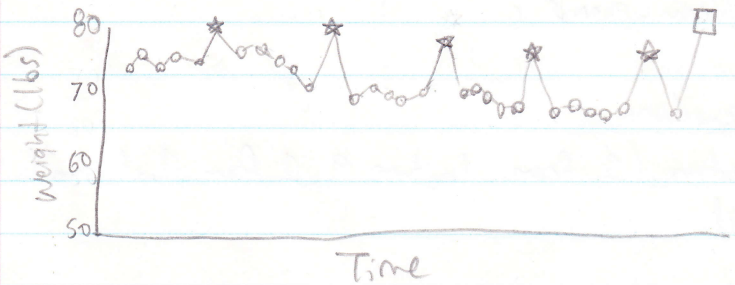
① dotted line represents an isolated muscle fiber of a frog

electrical stimulation produces more muscle torque in eccentric contractions

by limiting the amount of muscle force from eccentric contractions, the body does not harm itself from excessive eccentric contractions

4. Fatigue

↳ maximum tension gradually declines if muscle is continually activated



Strength is limited by fatigue processes and by psychological factors

○ = normal

☆ = gunshot

gunshot & shout stimulate nervous system during lowering & ellicit greater strength

5. Muscle fiber & Motor unit type
↳ Fatigue & rate of tension development within a muscle affected by type of muscle fiber & motor unit
↳ motor unit = single alpha motor neuron & all of the muscle fibers it innervates

	Slow (S)	Fast fatigue-resistant (FR)	Fast fatiguable (FF)
Contraction Speed	slow	fast	fast
Twitch force	low	medium	high
Fatigability	low	low	high

Implications for muscle strength
↳ Joint movements are based on development of muscle torque ($F_{muscle} \times Lever\ Arm_{muscle}$)
↳ many influences of muscle force exist
↳ muscle lever arm also varies over range of motion
↳ insertion point
↳ line of action of muscle and joint angle
↳ To produce "correct" or maximal amount of force (and torque) is very complicated!

Final Exam
↳ Monday Dec 18th from 9-11 am
↳ 35% of final grade
↳ Cumulative
↳ Similar format as midterm exams
↳ 10-12 MC
↳ 5-6 short answer questions
↳ 3 calculation questions (1 from Lecture 9, 1 from 1st half & 1 from 2nd half)
↳ equation sheet provided