Moment Power Analysis

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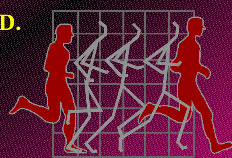

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Work of a Force

Work of a force is product of force (F) and linear displacement (s) of a body.

Work = F s (when F is parallel to s)

= F s cos ϕ (when F is not parallel to s and is ϕ angle between F and s)

or = $\underline{F} \cdot \underline{s} = F_x s_x + F_y s_y$ (dot or scalar product)

= P t (average power of force times duration of force application)

Work of a Moment of Force

Work of a moment of force is product of moment of force (M) and angular displacement (θ).

Work = M θ

= r F (sin ϕ) θ (ϕ is angle between r and F)

= P t (mean moment power times duration)

= Σ (M ω Δt) (time integral of moment power)

Average Power

Power is the rate of doing work.

measured in watts (W), 1 watt = 1 joule per second (J/s)

Power = work / time (work rate)

= $(E_f - E_i)$ / time (change in energy over time)

= (F s) / t = F v (force times velocity)

= (M θ) / t = M ω (moment of force times angular velocity)

Instantaneous Power of a Force or Moment of Force

Power = F v (when F is parallel to v)

= F v cos ϕ (when F is not parallel to v and ϕ is angle between F and v)

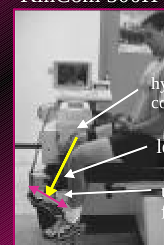
= $\underline{F} \cdot \underline{v} = F_x v_x + F_y v_y$ (dot or scalar product)

= M ω (moment times angular velocity)

Isokinetic Dynamometers

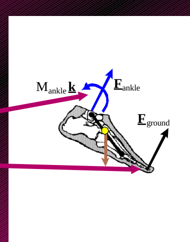
KinCom 500H

- controls speed of motion therefore lever has constant angular velocity (ω)
- measures force against a lever arm
- moment = force times lever arm
- instantaneous power = moment times angular velocity



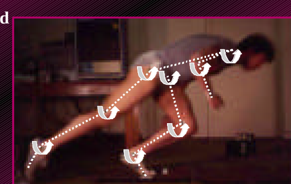
Inverse Dynamics Review

- divide body into kinematic chains
- divide chains into segments
- from free-body diagrams combine forces at each joint into a single "net force and moment of force"
- measure external forces and their points of application
- compute net forces and moments starting at distal segment then proceeding up the chain



External Work

- Inverse Dynamics Method
  - compute net moments of force at each joint
- Sum over all joint moments and over duration of movement
- External Work = $\Sigma\,(\Sigma\, M_j\, \omega_j\, \Delta t)$



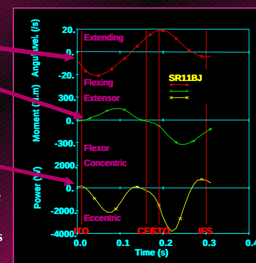
Total Mechanical Work

- take absolute values of moment powers
- sum over all joint moments and over duration of movement

- Total Mechanical Work = $\Sigma\,(\Sigma\,|\,M_j\,\omega_j\,|\,\Delta t)$
- Internal work = Total Mechanical Work – External work

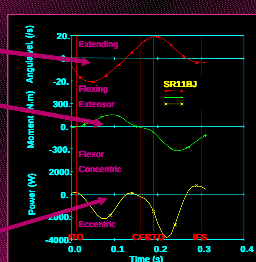
Joint Power Analysis

- compute the angular velocity of the joint
- compute the net moment of force at the joint
- multiply angular velocity and moment of force to obtain the "moment power"
- this is the power produced by the net moment of force acting across the joint
- it is mainly caused by muscle forces

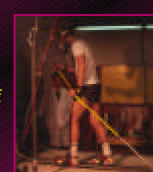


Joint Power Analysis

- angular velocity determines whether joint is flexing or extending
- net moment of force indicates which "muscle group" or "single equivalent muscle" is acting
- moment power tells what the moment of force is doing
- positive power shows "concentric work" while negative power shows "eccentric work"



Limitations



- can only be used on "free-ended" extremities or extremities where external forces can be measured (by force platforms or force transducers)
- assumes elastic storage and release of energy is due to muscle eccentric and concentric work, respectively
- cannot be used with closed kinematic chains (slap shot, golf swing, batting, etc.)
- ignores coactivation of muscles
- assumes no multijoint transfers of energy