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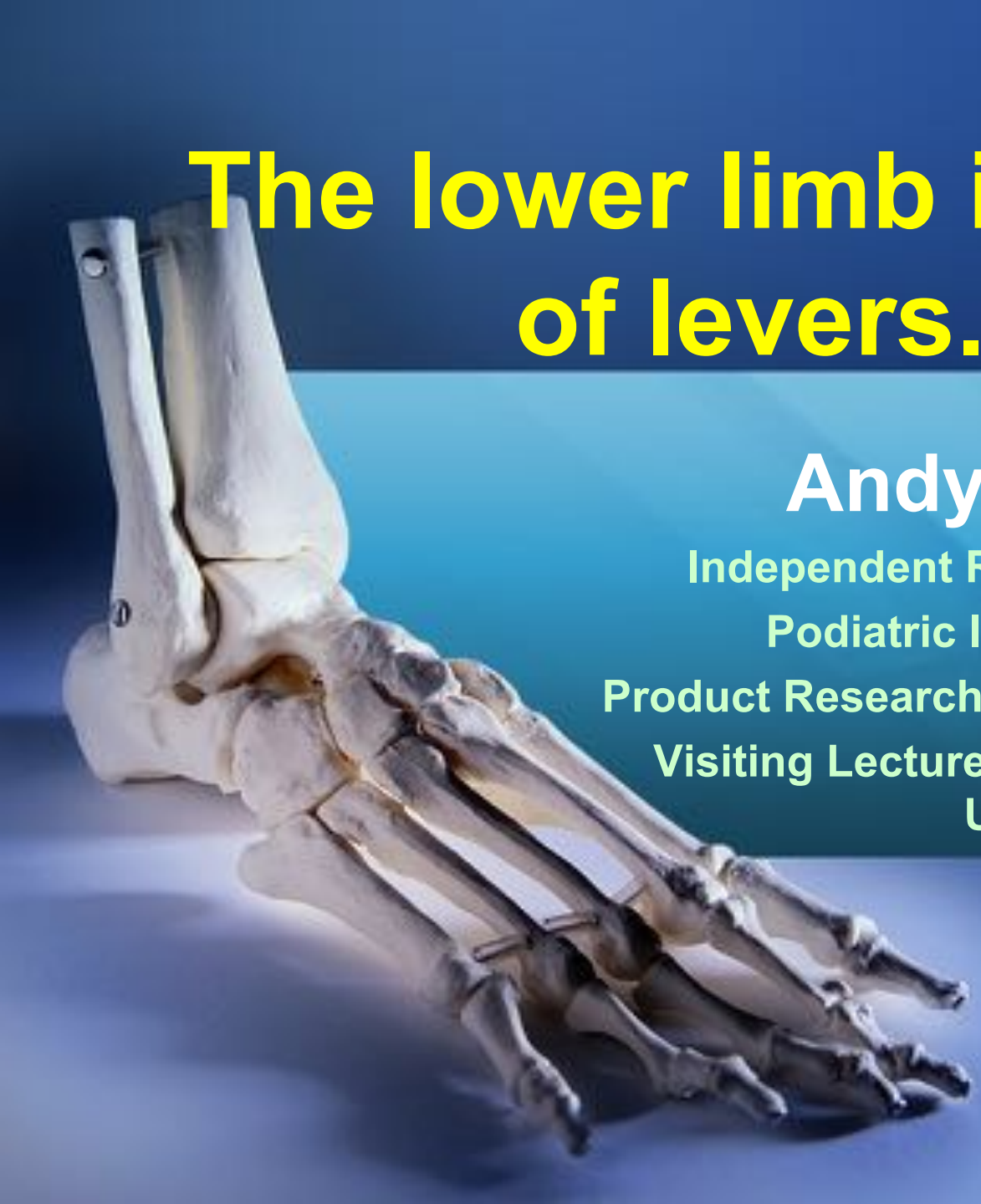
The lower limb is a system of levers. So what?



Andy Horwood

Independent Researcher & Lecturer.

Podiatric Innovations Limited

Product Research & Design HealthyStep Ltd

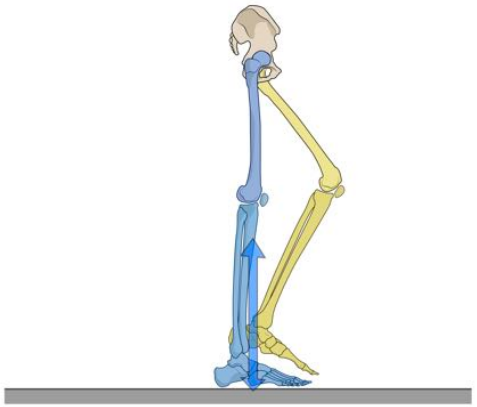
Visiting Lecturer & Fellow Staffordshire University

ARS SALUTARIS SCIENTIA

WHAT IS THIS LECTURE ALL ABOUT?

- Why do levers matter?
- What is stress?
- What is strain?
- What is angular moment?
- What are the classes of levers?
- Where are these lever classes in the lower limb?

- What influence does this piffle have on pathology?



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WHY DO LEVERS MATTER?

- ENERGETICS (the study of energy in systems)

Efficient Energetic = Efficient Biomechanics = Survival = Evolution = Efficient Energetics

- Levers effect mechanical efficiency = Effect our energetics.

Efficient Biomechanics + Healthy MSK Tissues = Efficient Energetics

Levers are ONE of the methods used to achieve mechanical efficiency

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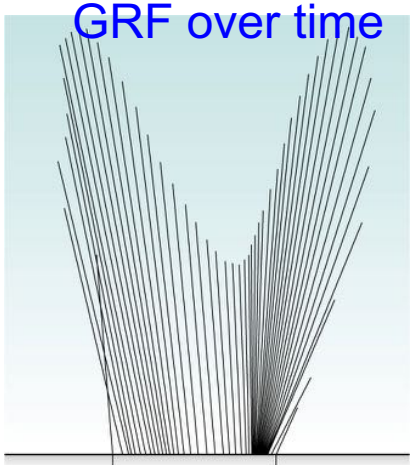
What is stress? = force applied a structure

- CONNECTIVE TISSUE TETHERING
- MUSCLE CONTRACTION
- EXTRINSIC FACTORS
- GRF
- Newton's 1st law of inertia/momentum
- Newton's 2nd law (F =M x A)
- Newton's 3rd law
  (every action has equal
  & opposite reaction)



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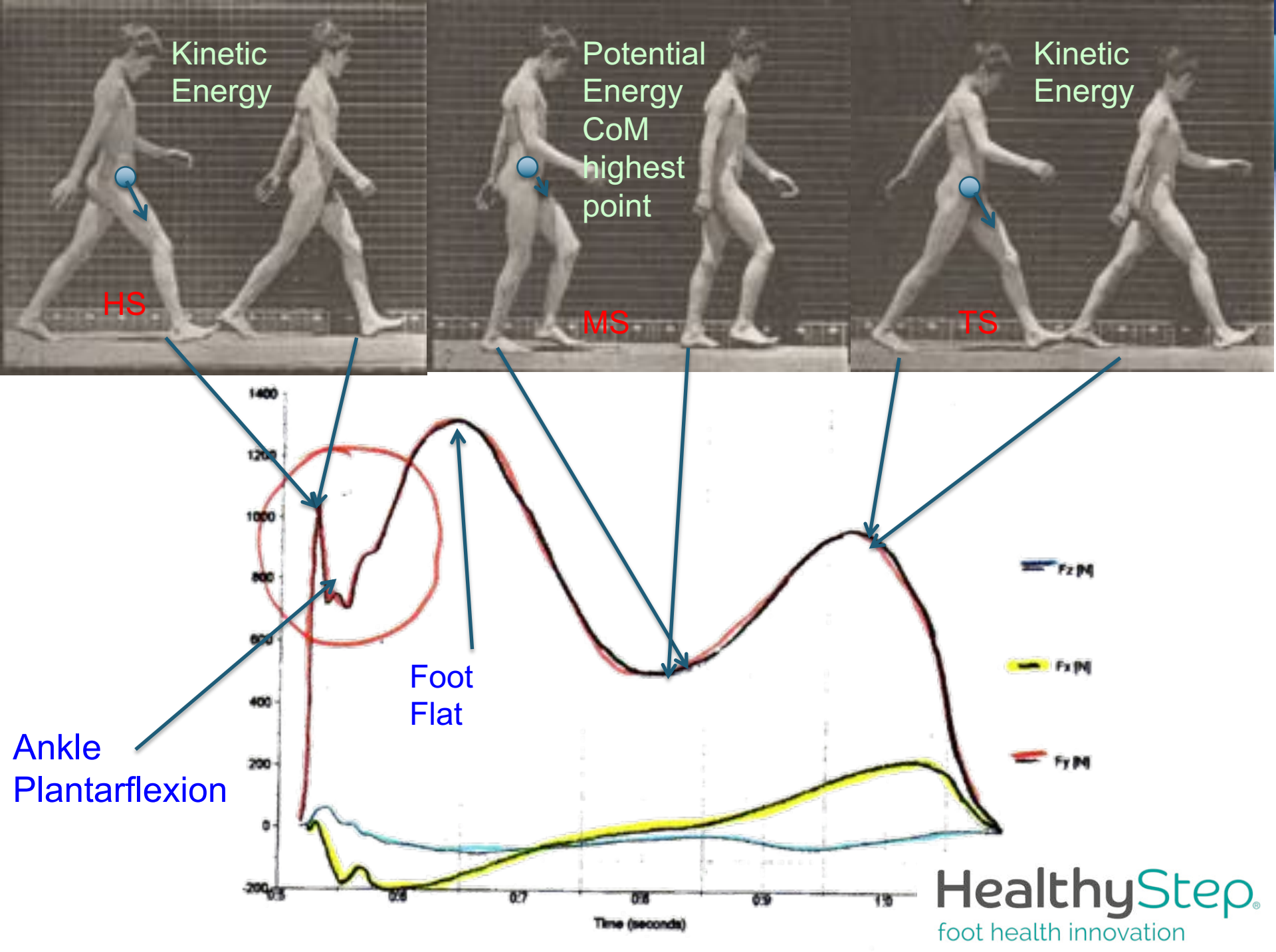

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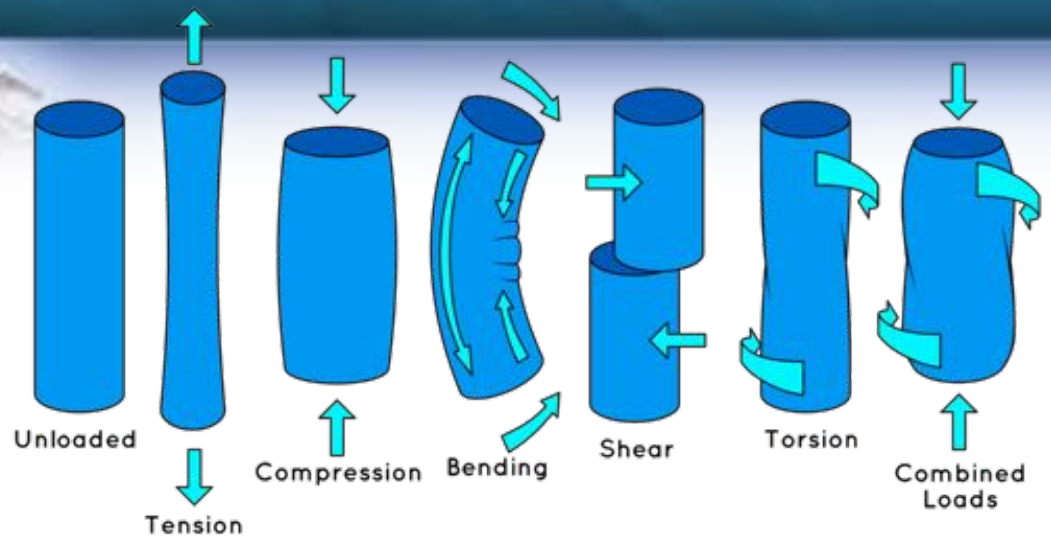
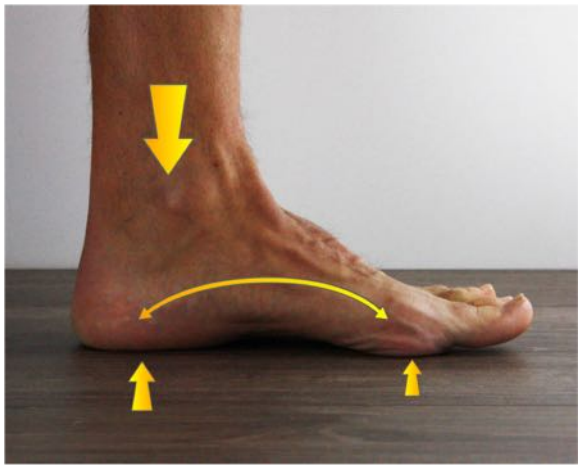
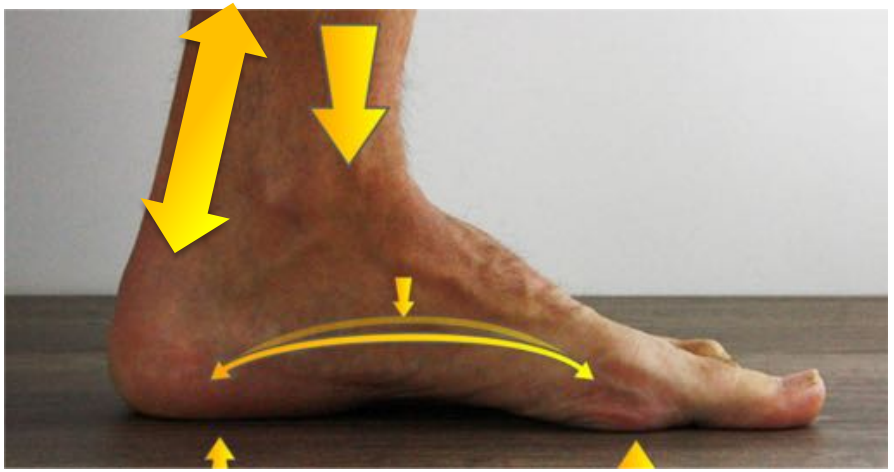
Strain = deformity = work done







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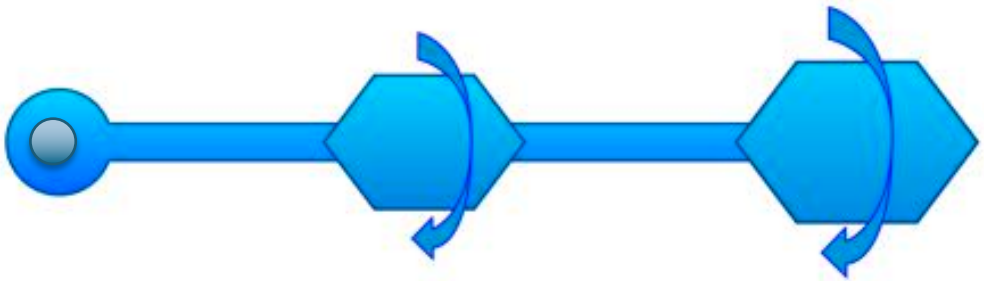
WHAT IS ANGULAR MOMENTUM?

- MOMENTUM ROTATING AROUND AN AXIS.

(remember joint axes are instantaneous).

- Moment of Inertia x Angular Velocity $I \times \omega = L$
- What is moment of inertia?
- Like mass but considers where the mass is distributed to the axis of rotation.
- $I = \Sigma$ (mn . r 2/n).



Angular velocity number of degrees (or rotations) per second.

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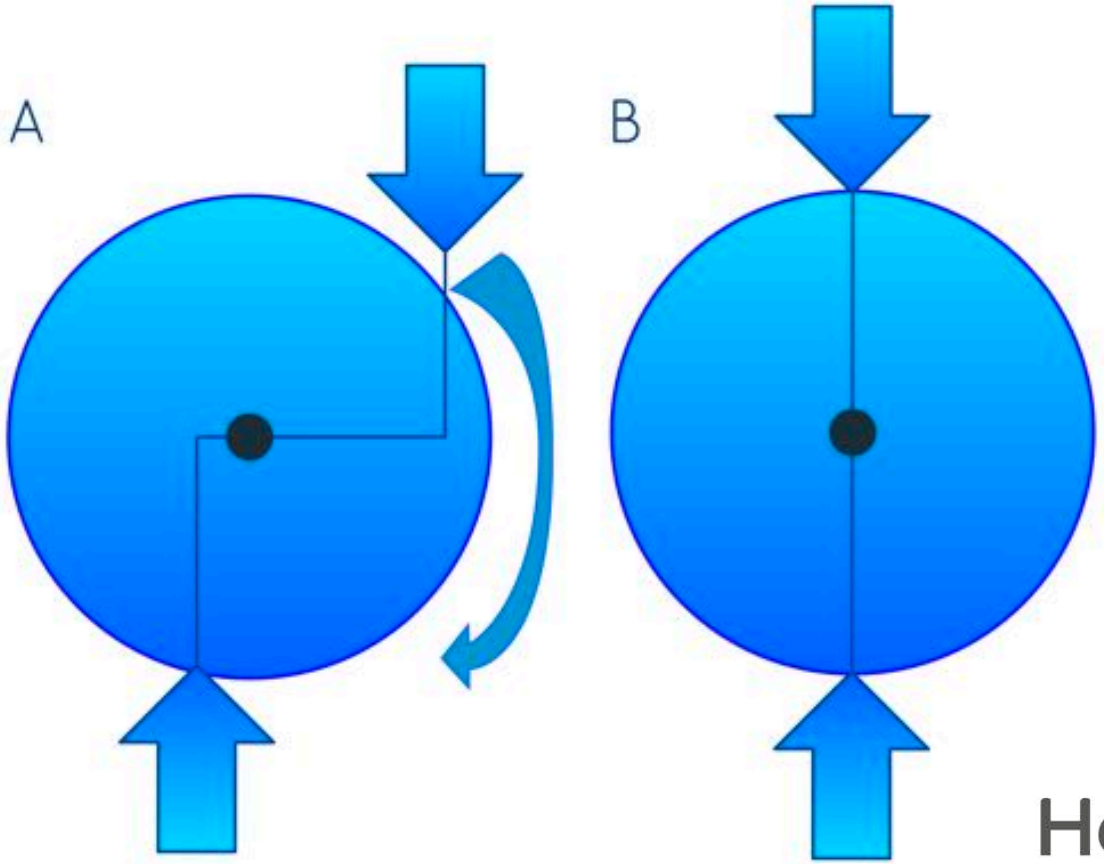
Angular momentum (presuming force equal)

IF FORCES EITHER SIDE OF AN AXIS = ROTATION A
IF FORCES AR OVER AXIS = NO ROTATION B



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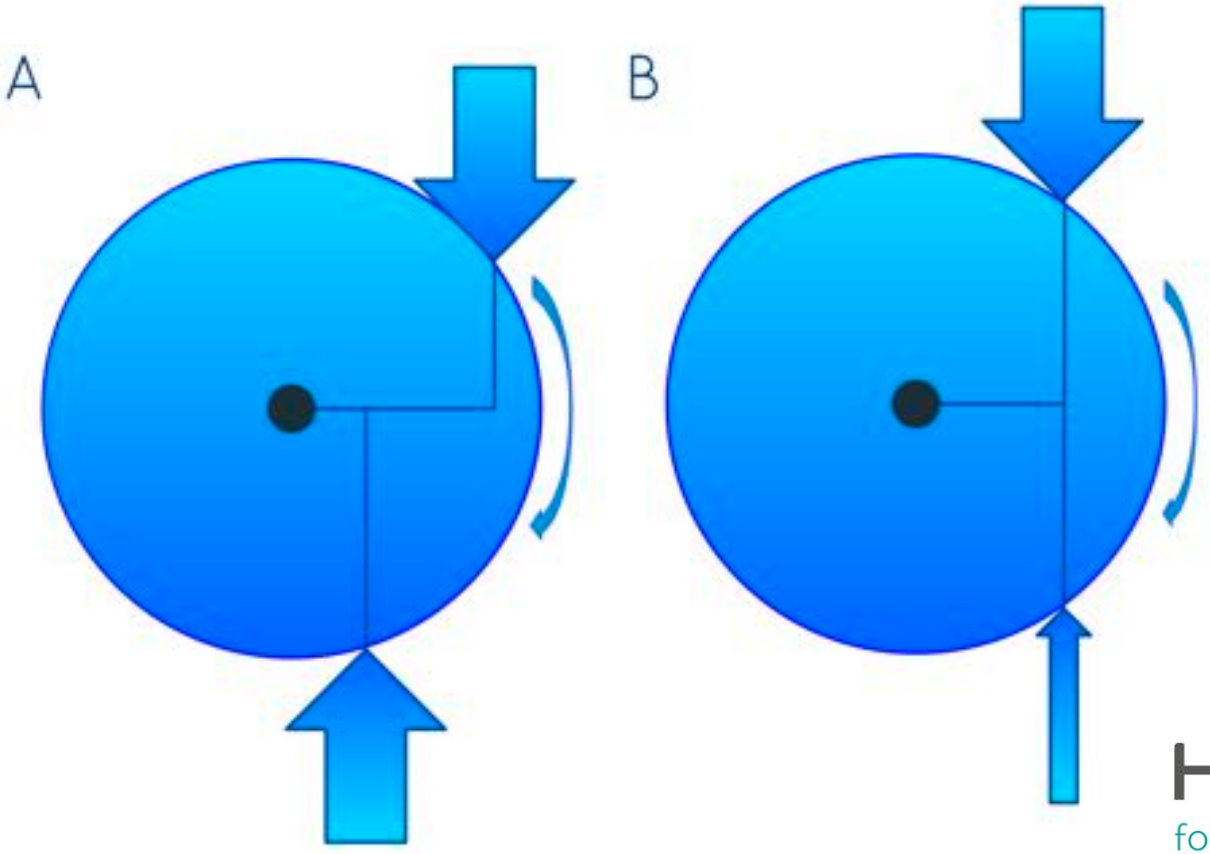
IF FORCES EQUAL ON SAME SIDE FORCES FURTHEST AWAY FROM AXIS CREATE THE DIRECTION OF ROTATION. A

IF UNEQUAL FORCES ARE EQUAL DISTANCE FROM AXIS THE LARGER FORCE CREATES THE DIRECTION OF ROTATION. B



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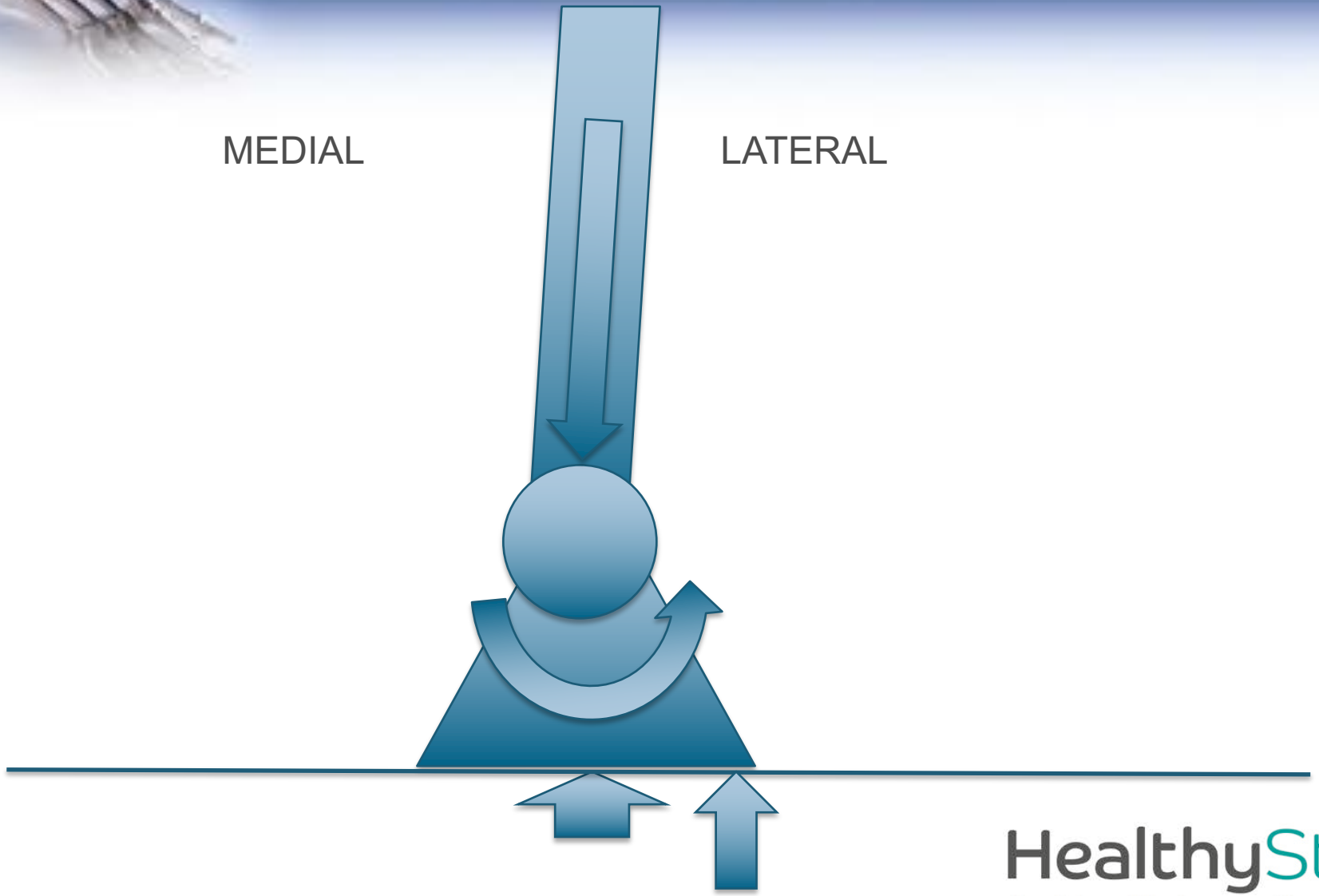
SIMPLE FOOT-ANKLE MODEL



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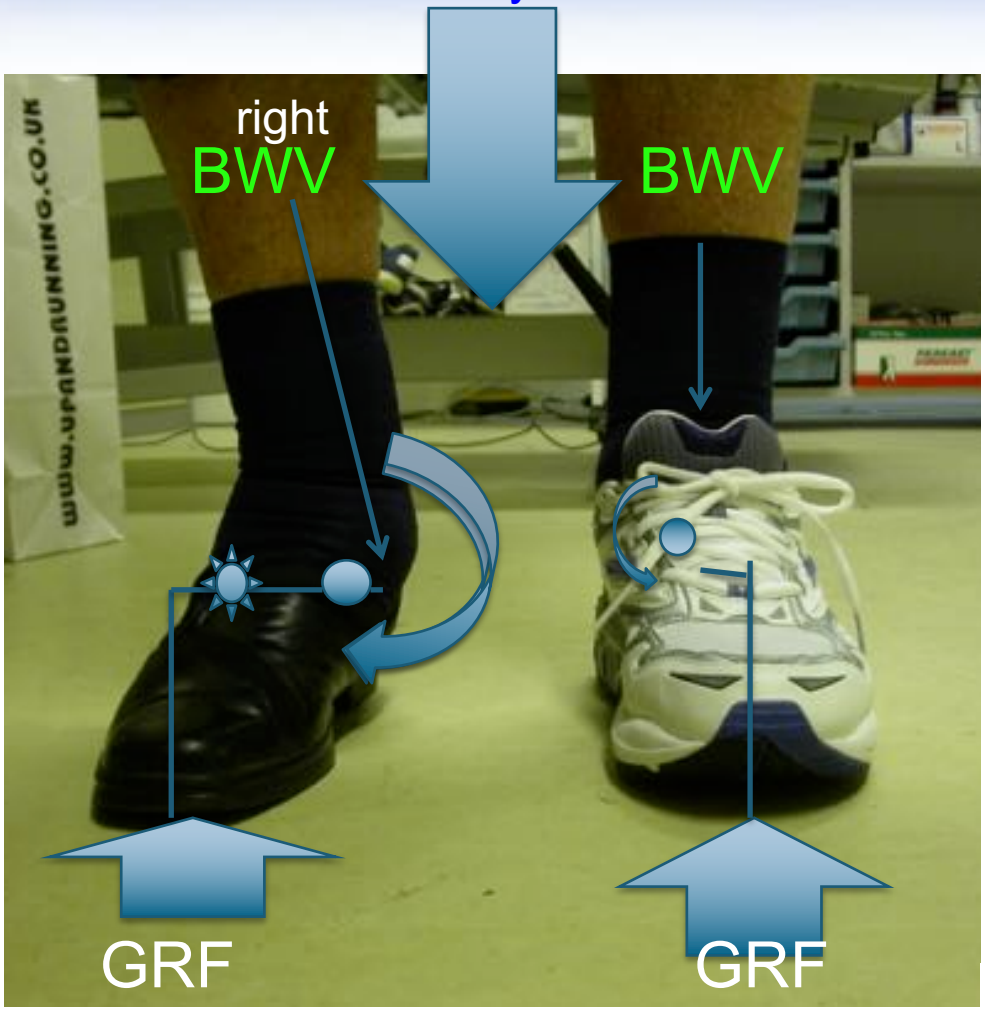
ANGULAR MOMENTUM TO PROVE WHY SHOES & LEG SHAPE MATTER

CoM & Gravity = CoG



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AND WITH THE RIGHT SHOE!

The nearer the forces to the axis the easier for muscles to control rotations. Shoes matter!

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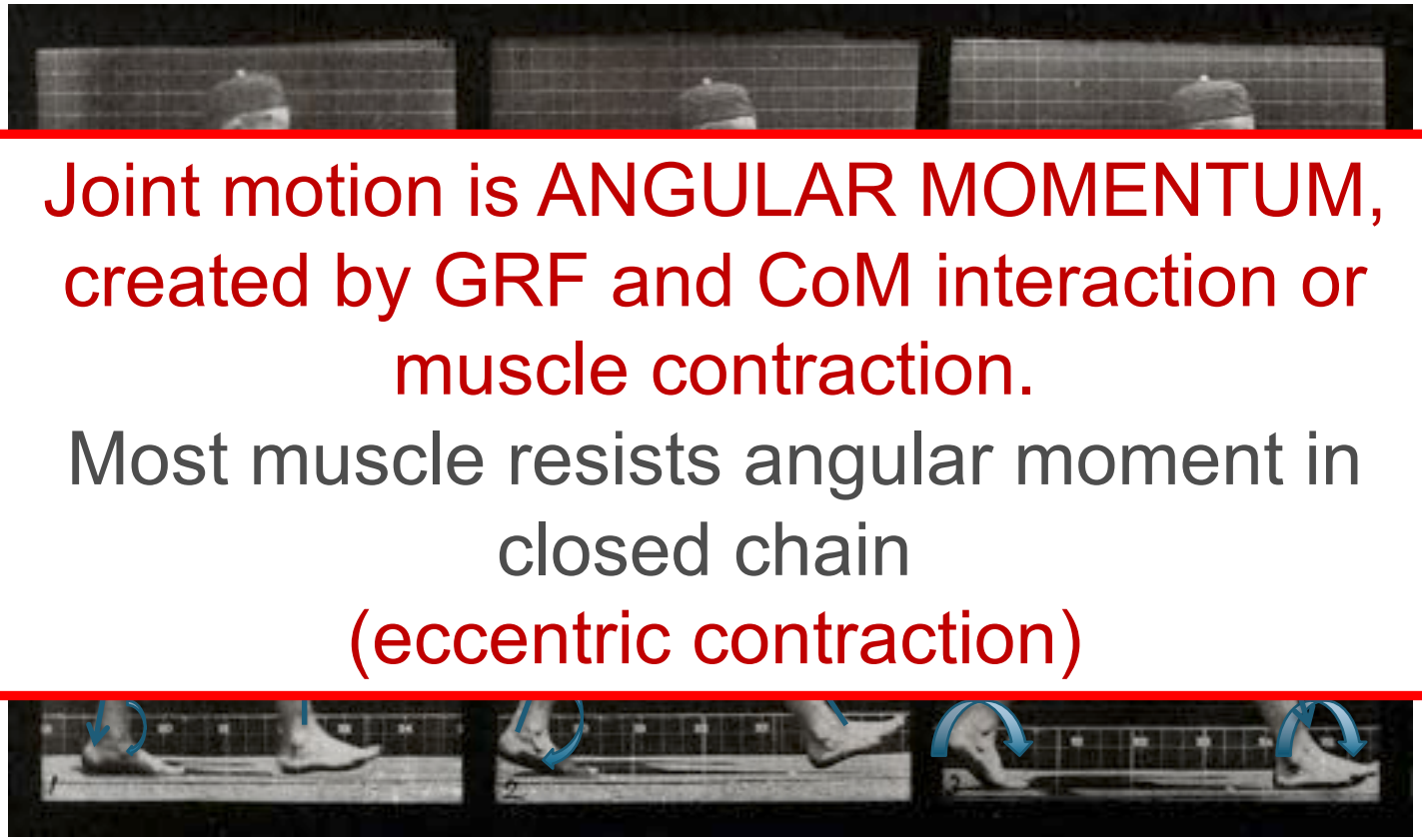
Linear Momentum

- FLEXION / EXTENSION (sagittal plane)

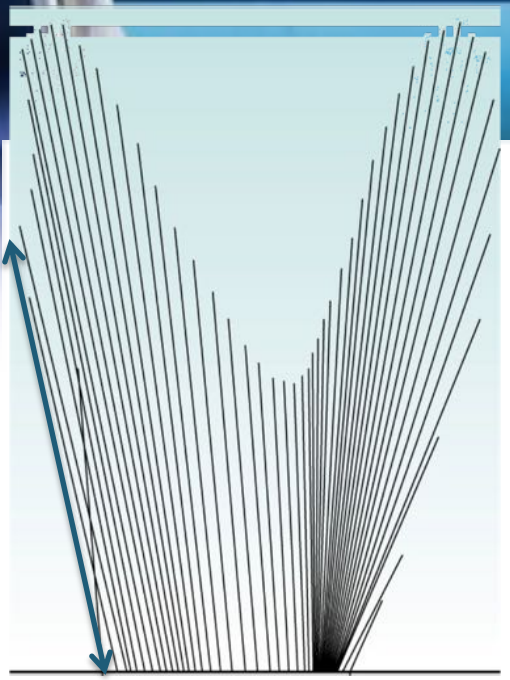


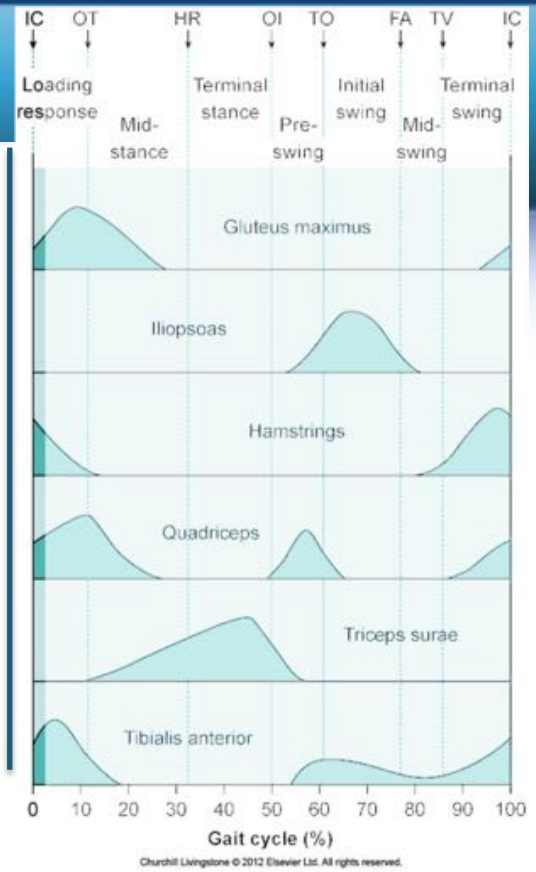
Joint motion is ANGULAR MOMENTUM, created by GRF and CoM interaction or muscle contraction.

Most muscle resists angular moment in closed chain

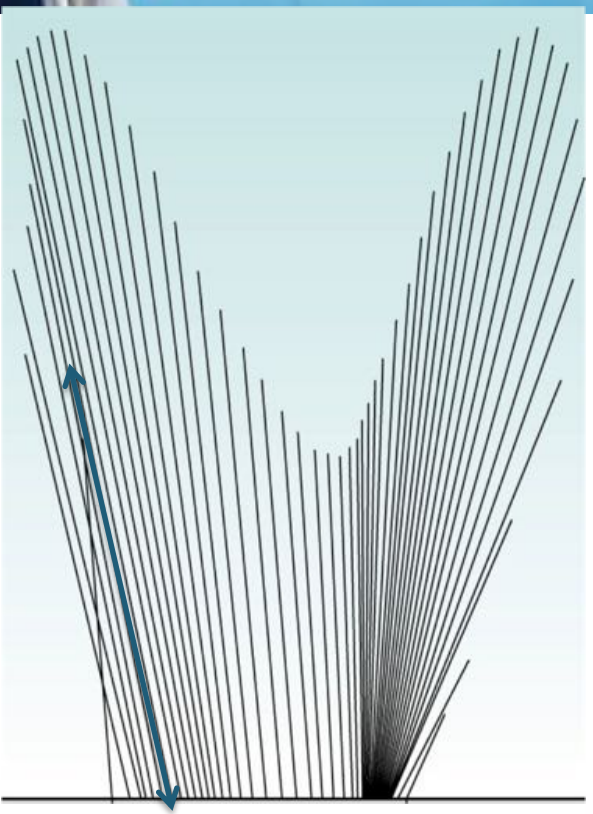
(eccentric contraction)

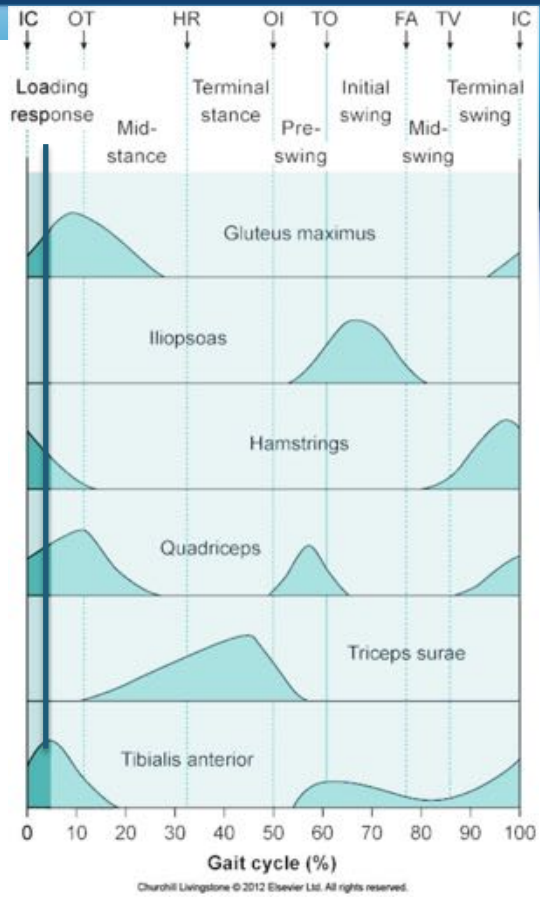
HEEL CONTACT



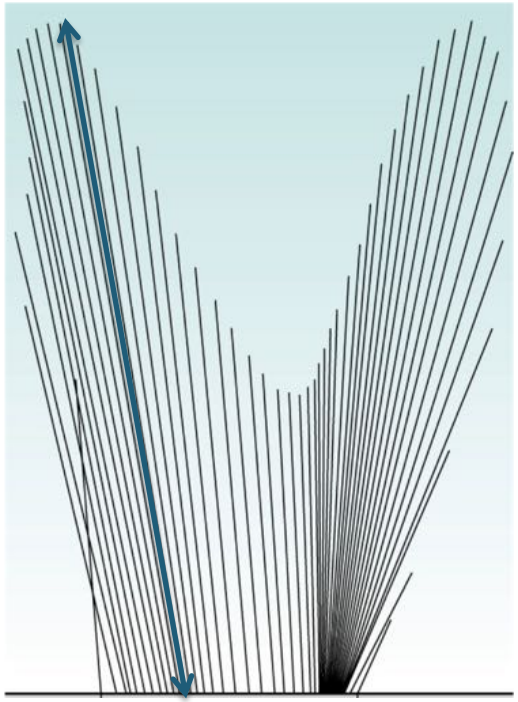


EARLY LOADING RESPONSE

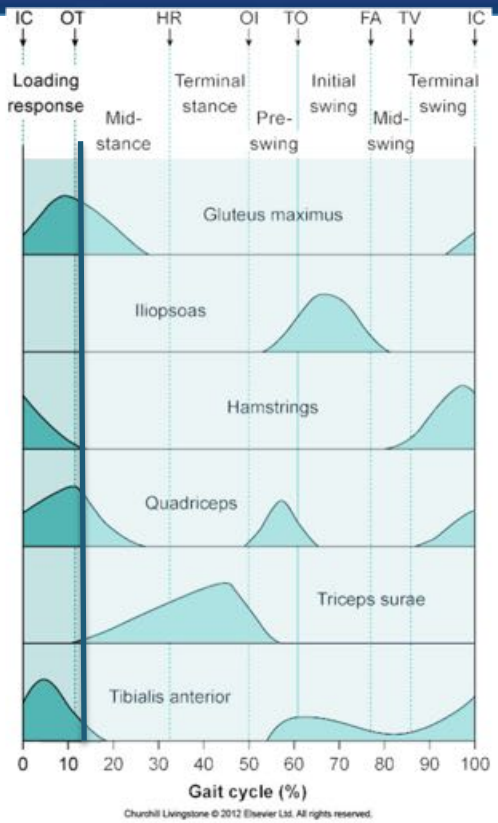




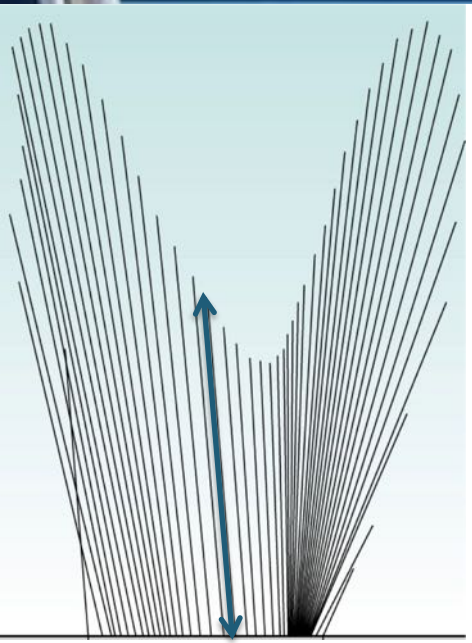
END LOADING RESPONSE



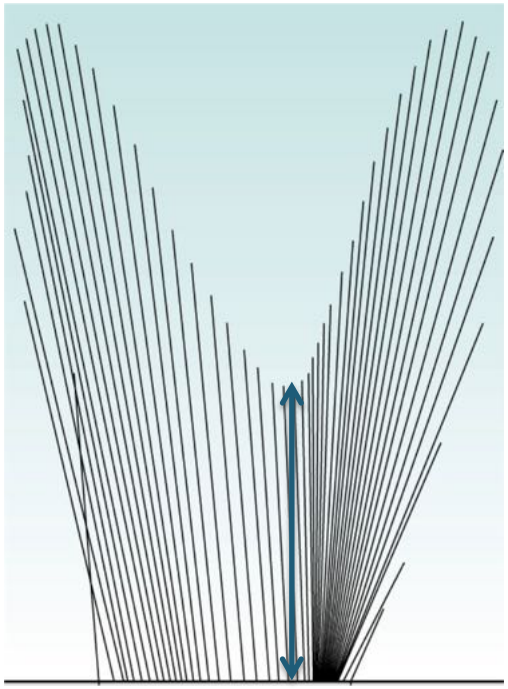
CoM lowest. Kinetic energy used up



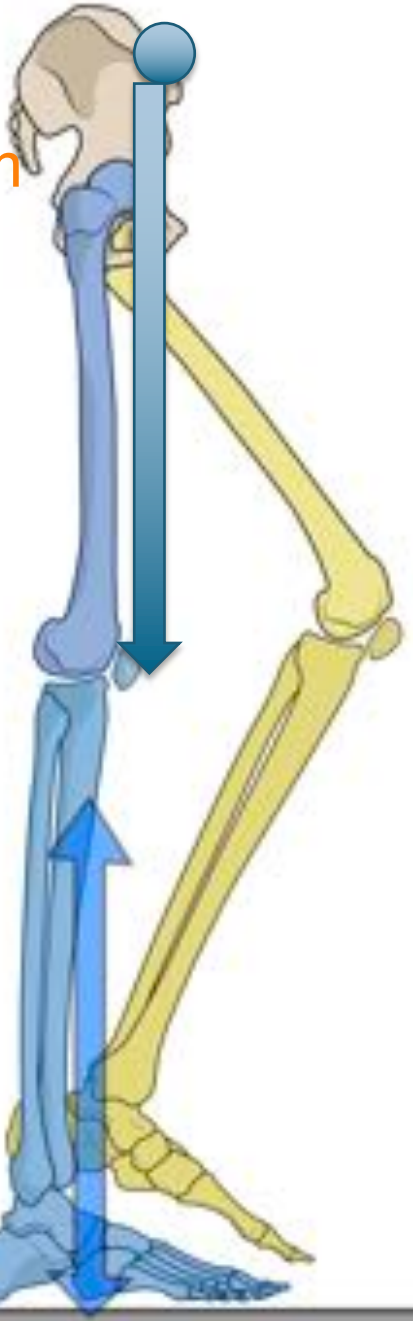
Foot flat

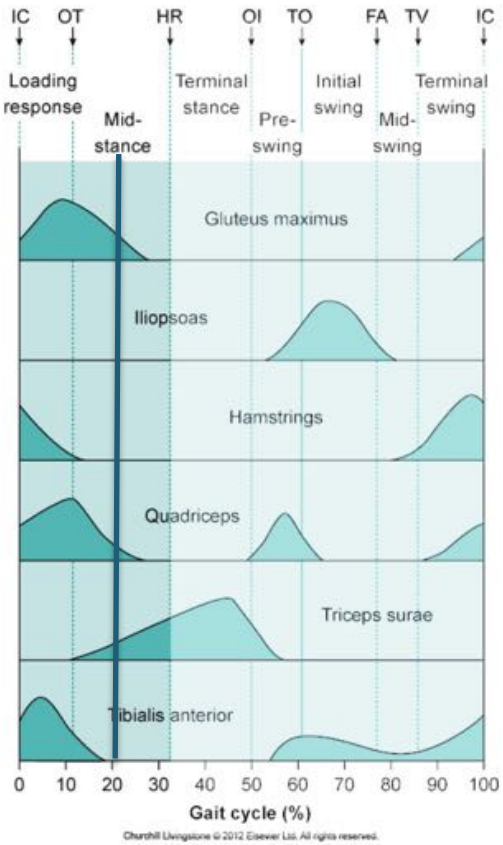


EARLY
MIDSTANCE

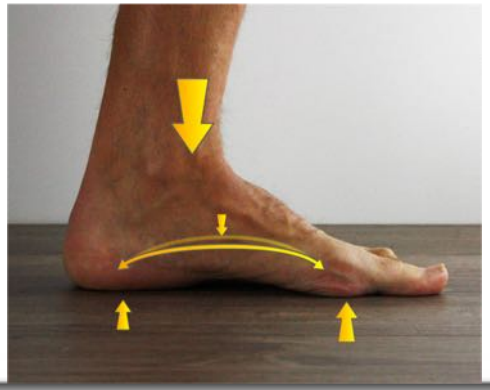


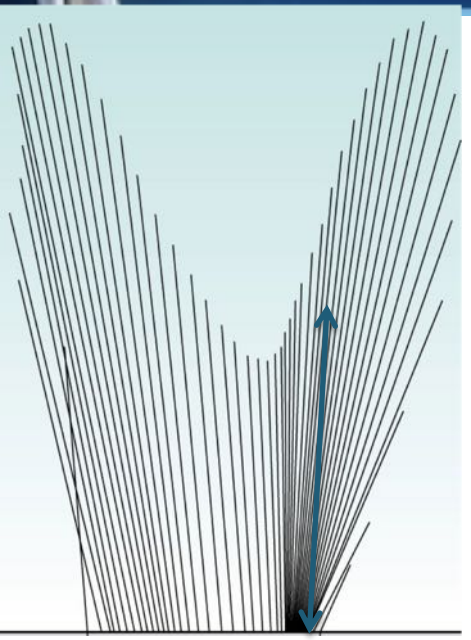
CoM at maximum height. High Potential energy





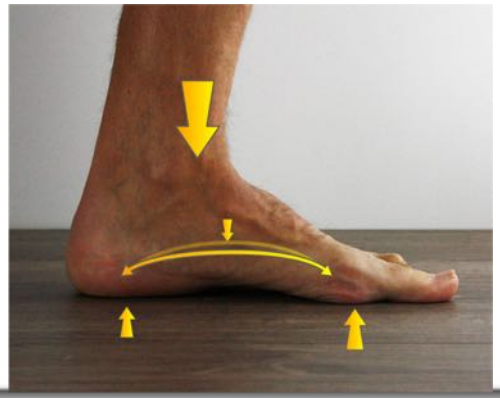
TRUE MID-STANCE

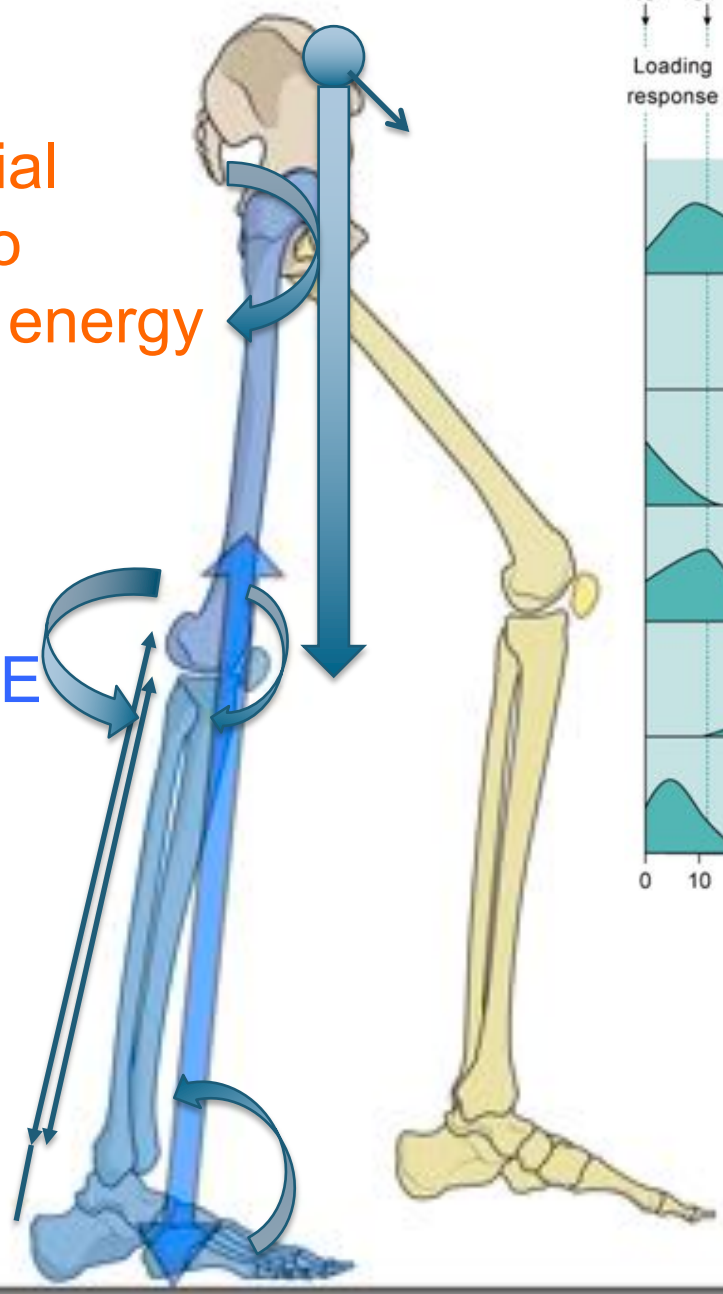


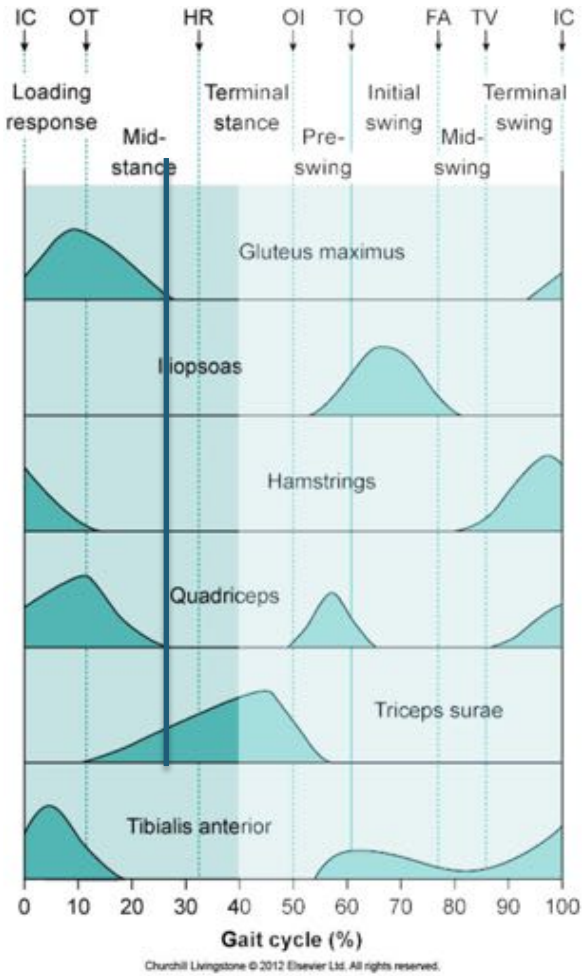


Potential turns to kinetic energy

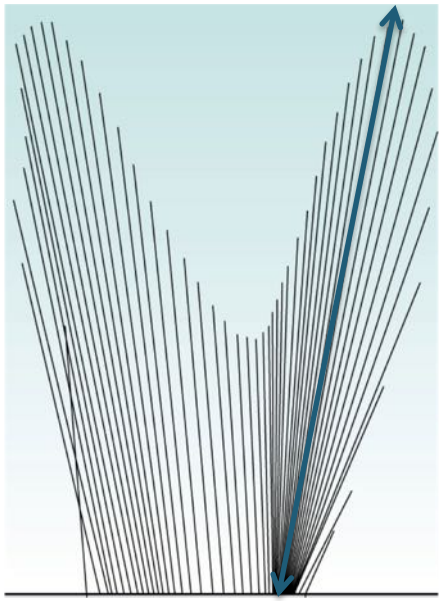
LATE MID-STANCE

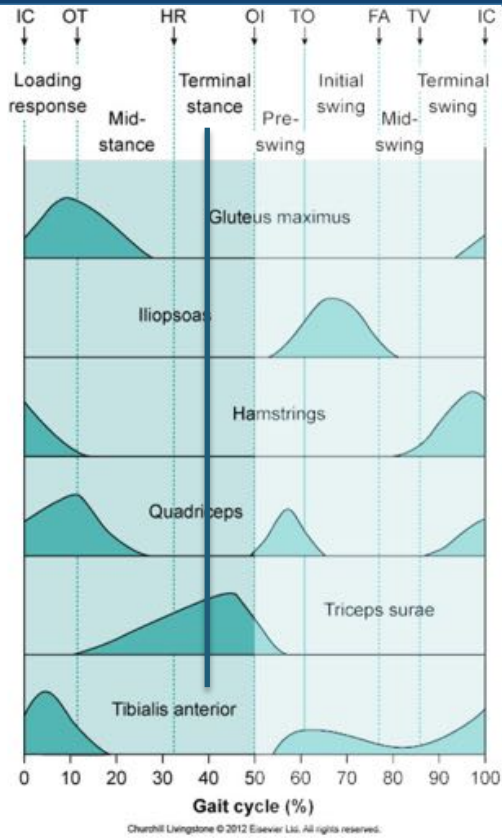






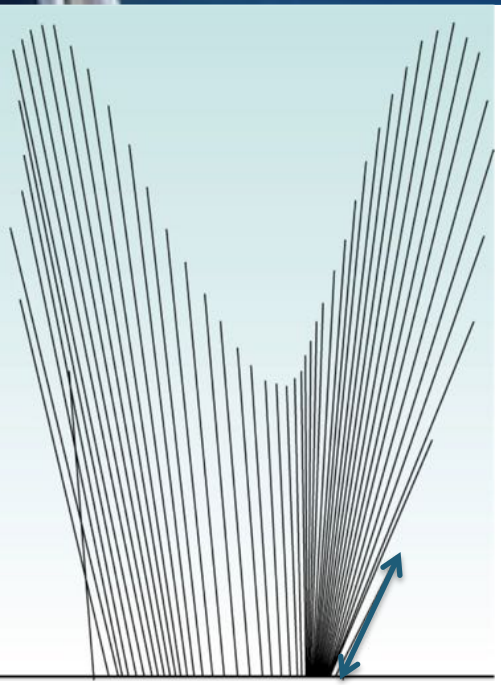
TERMINAL STANCE





(END) HEEL LIFT

E



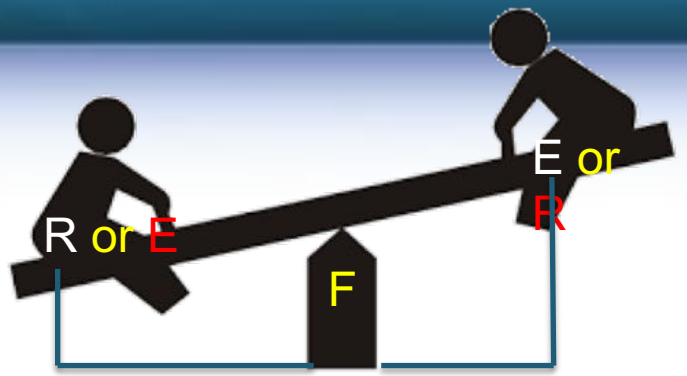
PRE-SWING

IC
OT
HR
OI
TO
FA
TV
IC
Loading response
Mid-stance
Terminal stance
Pre-swing
Initial swing
Mid-swing
Terminal swing
Gluteus maximus
Iliopsoas
Hamstrings
Quadriceps
Triceps surae
Tibialis anterior
0
10
20
30
40
50
60
70
80
90
100
Gait cycle (%)

CLASSES OF LEVERS

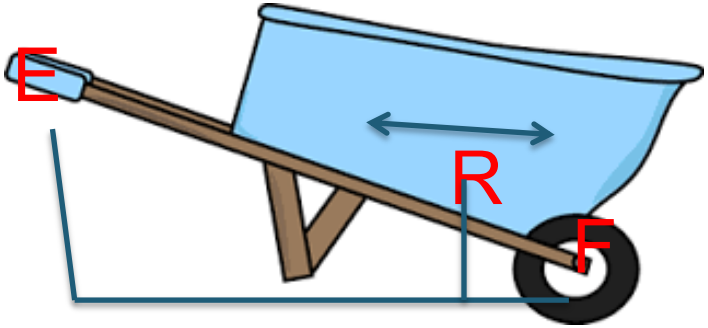
- 1st CLASS LEVER

Effort on opposite sides of fulcrum
(inefficient or efficient)



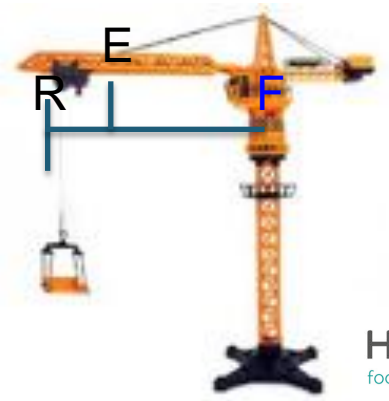
- 2nd CLASS LEVER

Effort furthest away from fulcrum
(efficient)



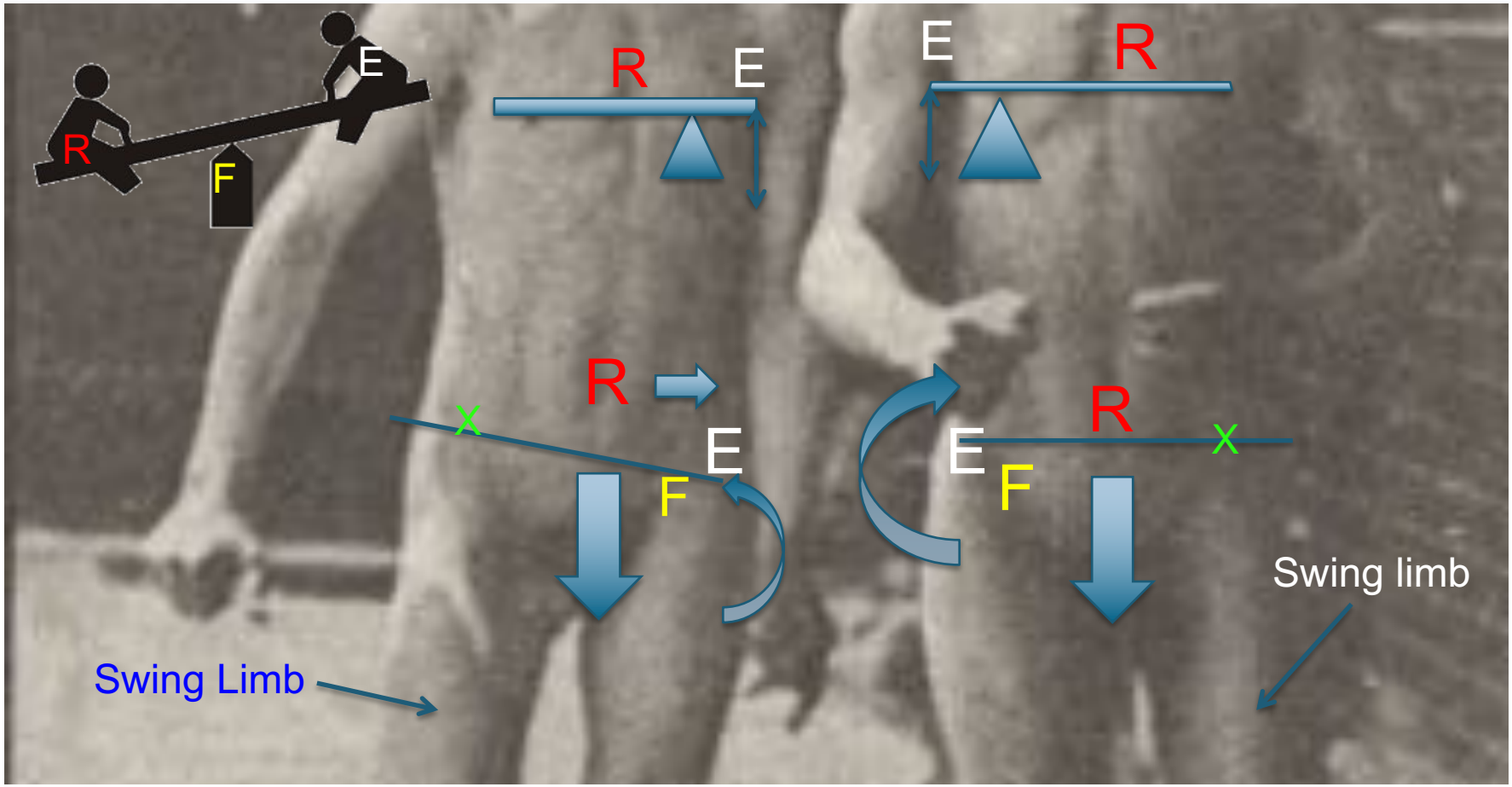
- 3rd CLASS LEVER

Resistance furthest away from fulcrum
(inefficient)



Lower Limb 1st Class Example

Hip Abductors in Single limb support



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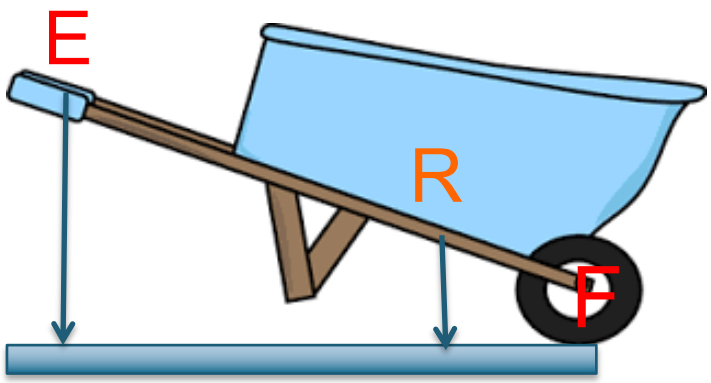
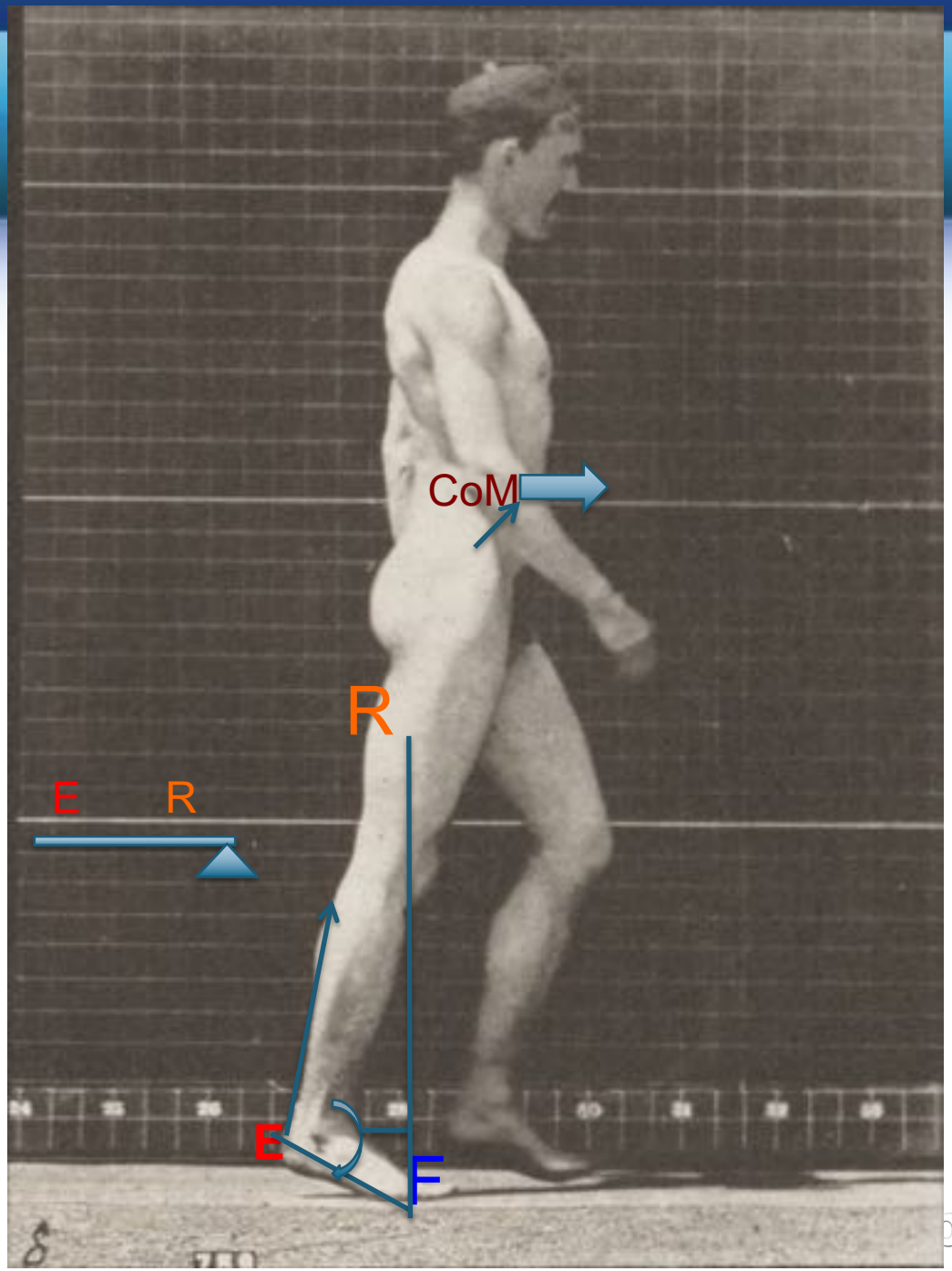
Lower Limb Example of 2nd Class

ACHILLES AT HEEL LIFT

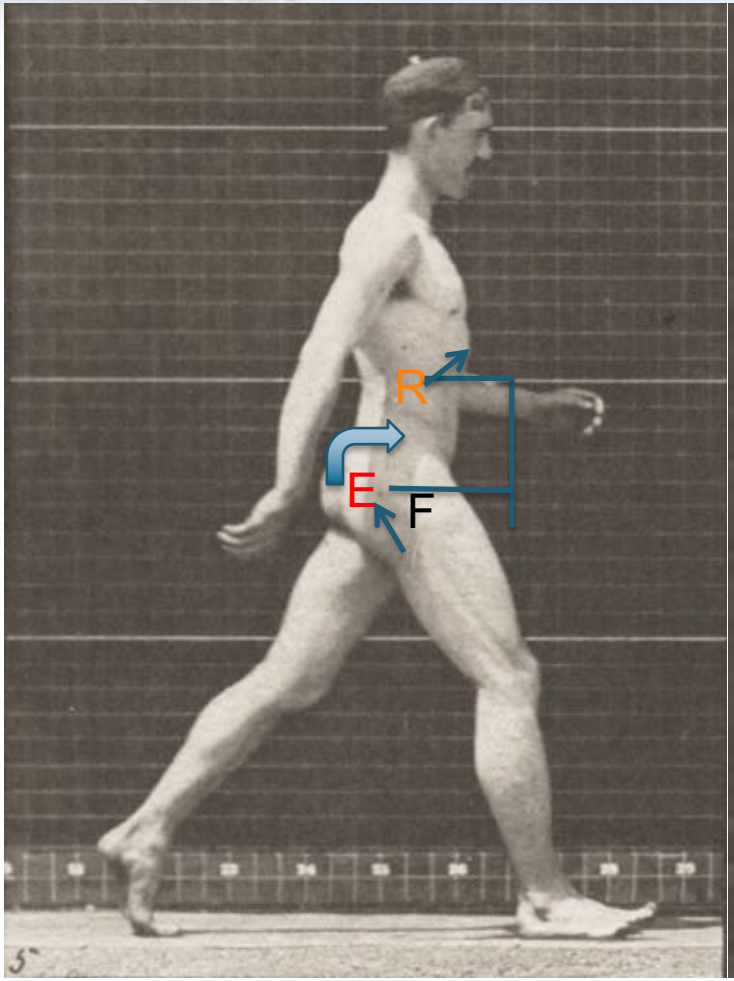
MTP JOINTS ARE THE FULCRUM(s)

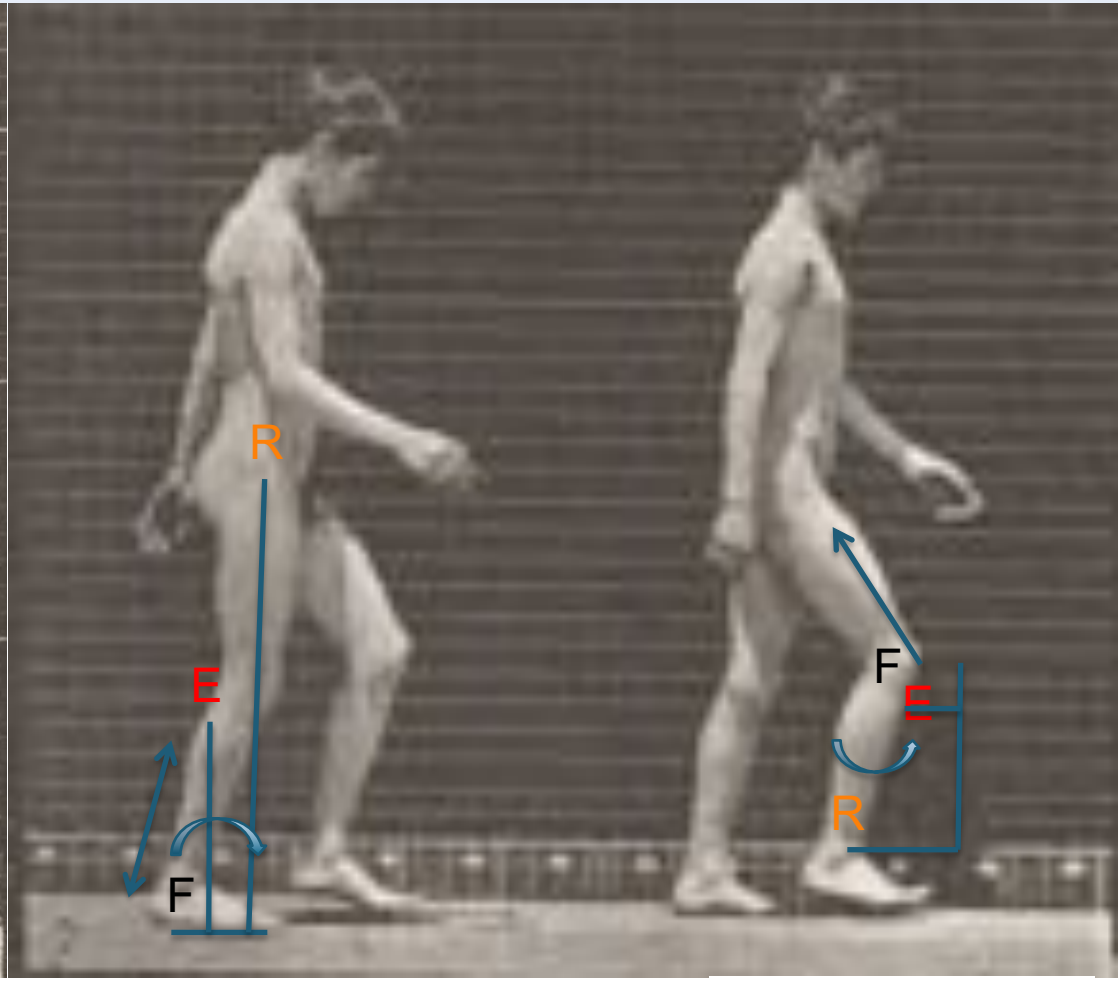




Lower limb examples 3rd class lever

Lots to choose from:





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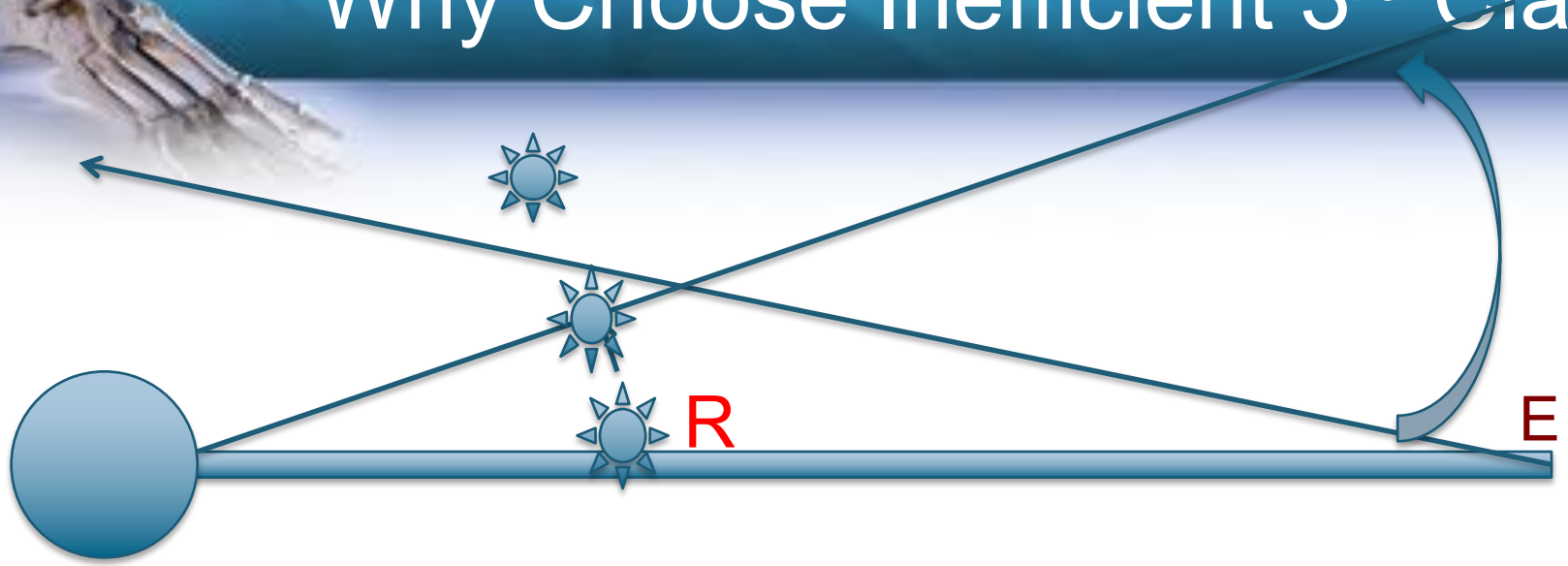
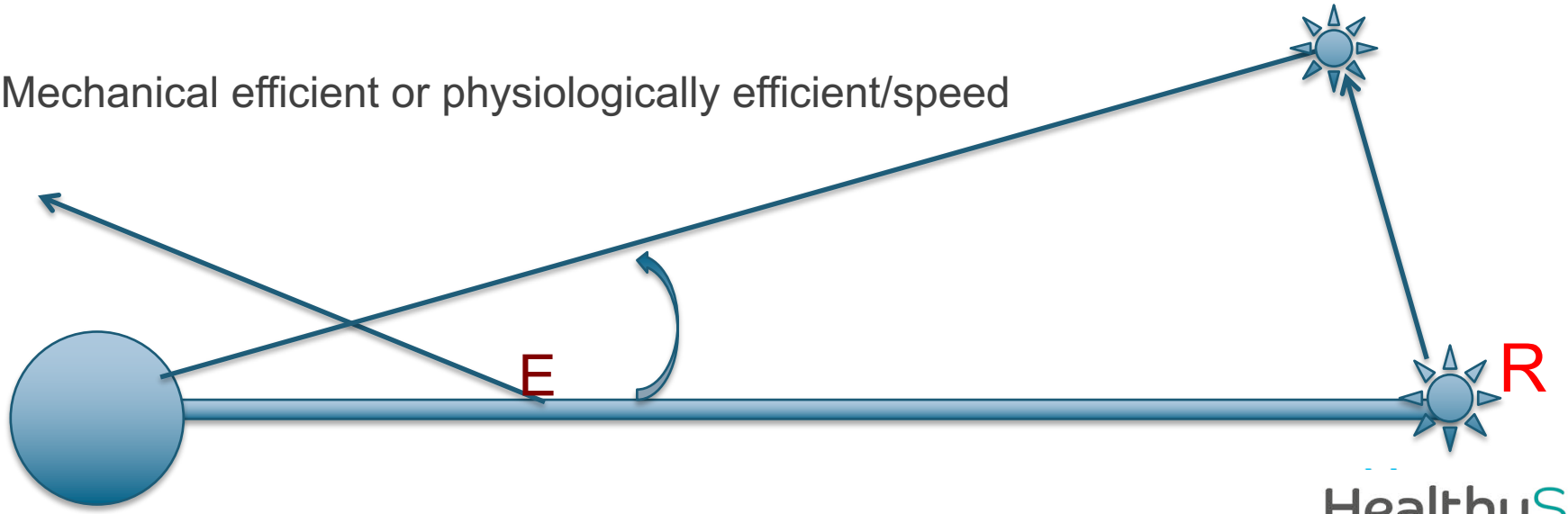
Why Choose Inefficient 3rd Class?



Mechanical efficient or physiologically efficient/speed



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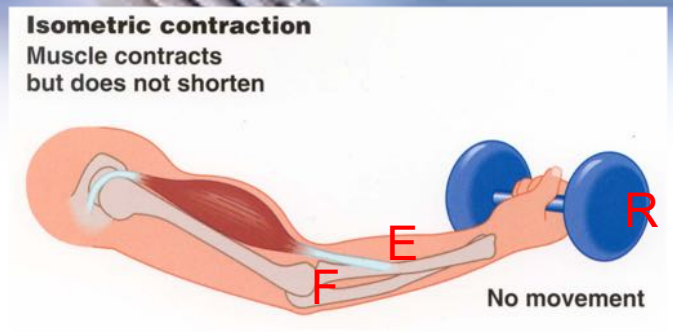
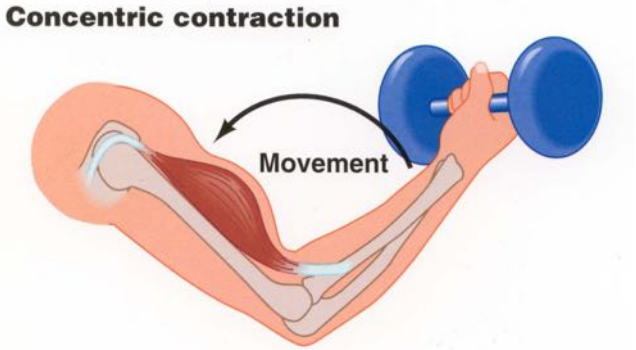
MUSCLE CONTRACTION BY PRINCIPLES OF LEVERS

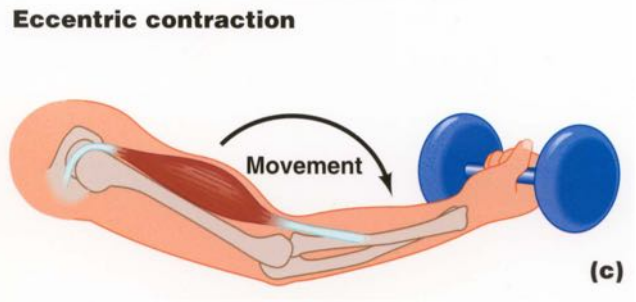


effort is = to the resistance

- ISOTONIC CONTRACTIONS



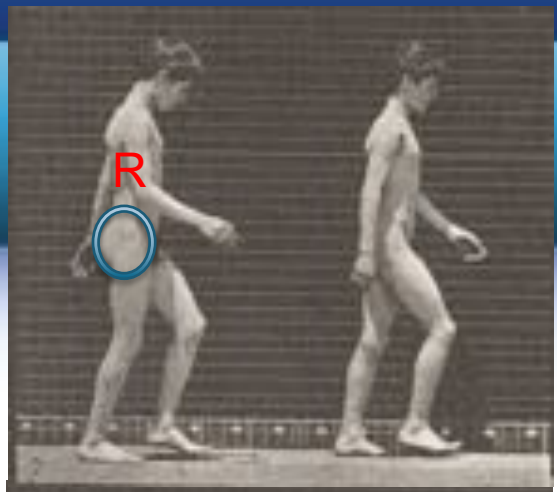
effort is > than the resistance

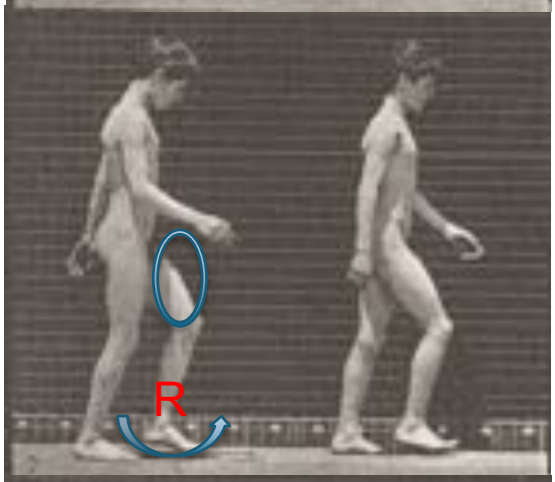


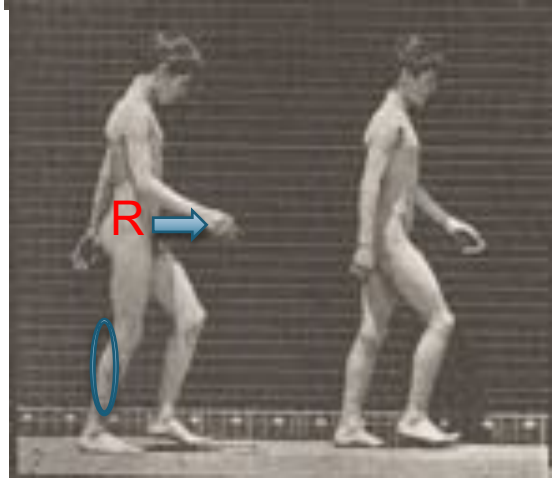
effort is < than the resistance

LOW ENERGY HIGH FORCE

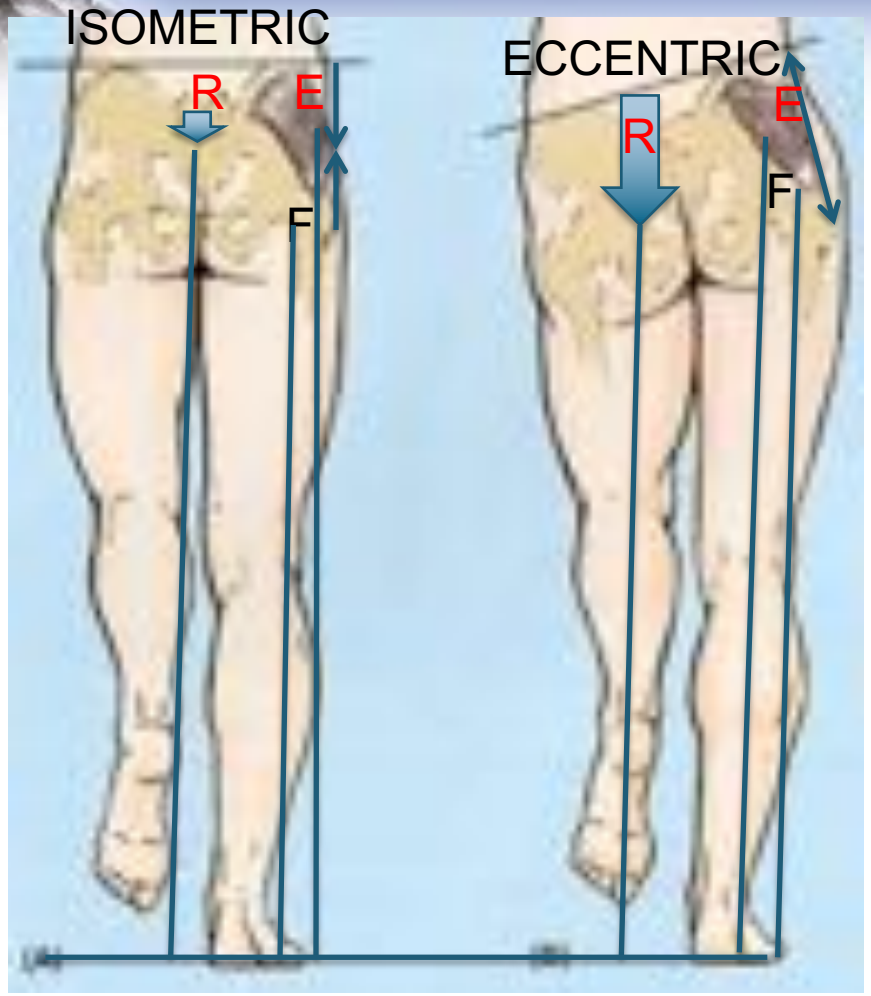
Excellent energetic

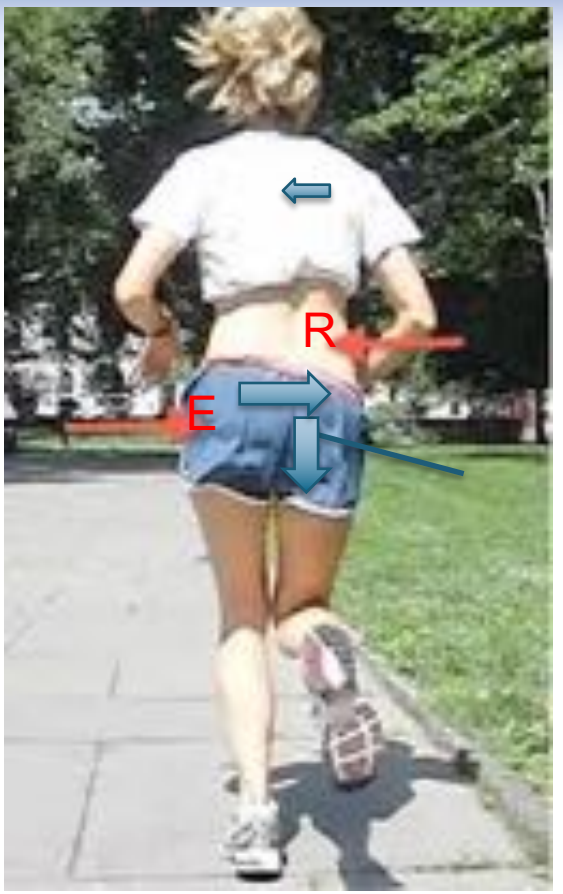






Class 1 Lever Pathomechanics. Hip Abductor Dysfunction





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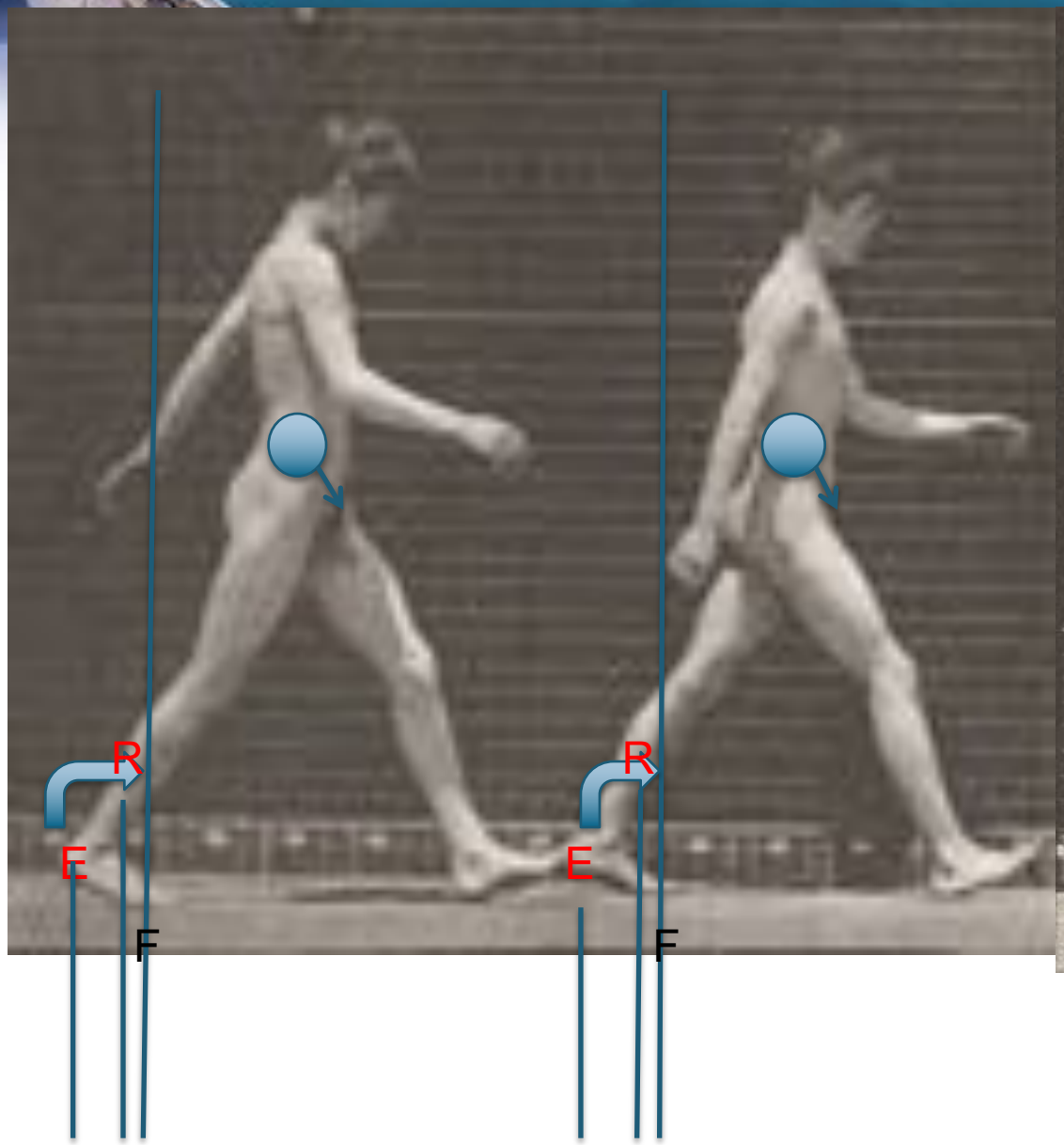
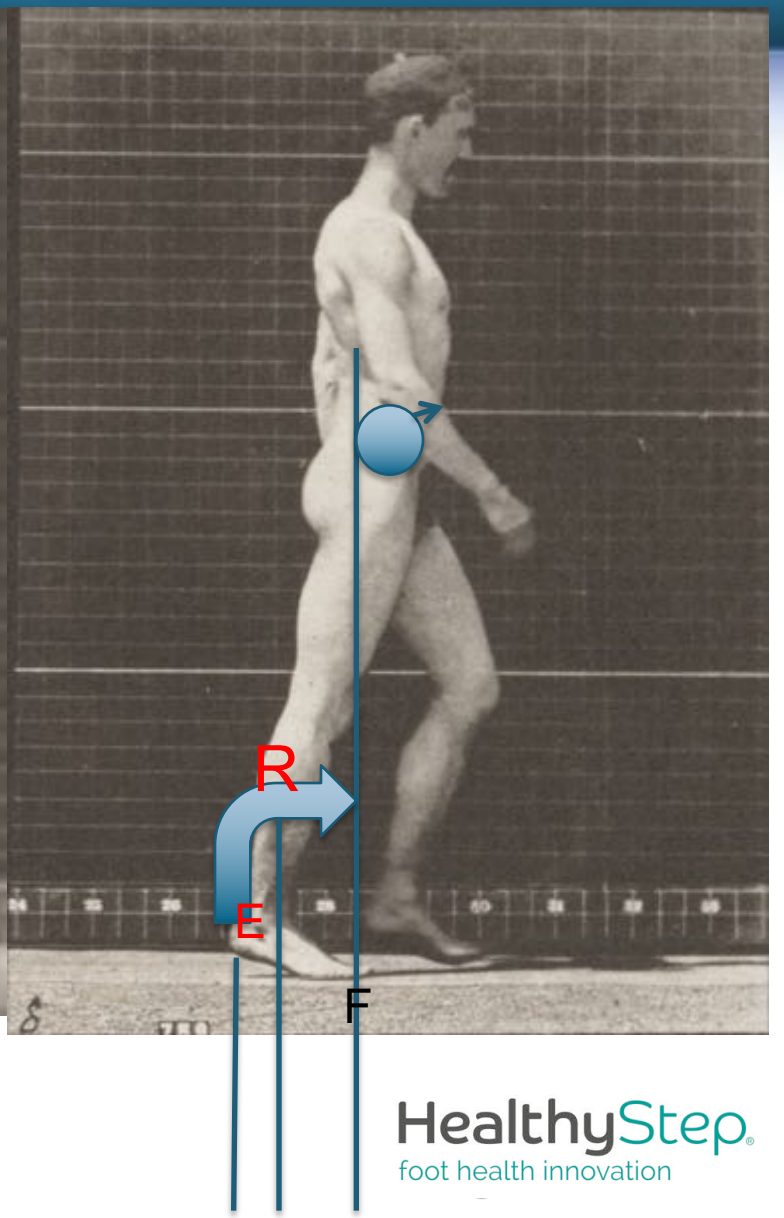
Class 2 Lever Pathomechanics.





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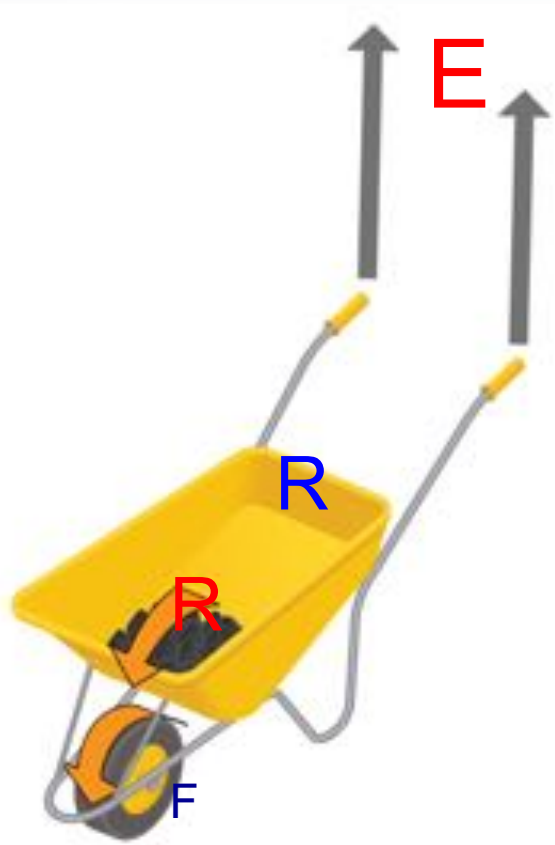
WHEELBARROW FOOT



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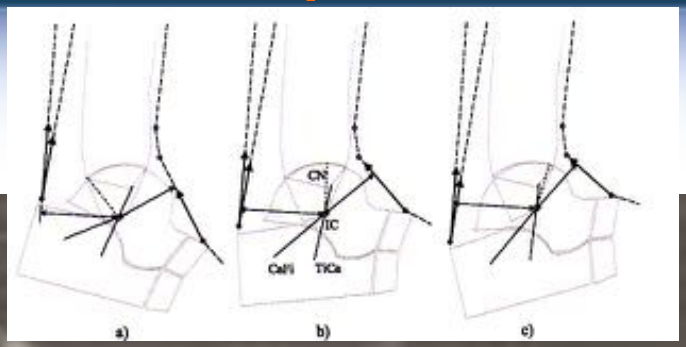
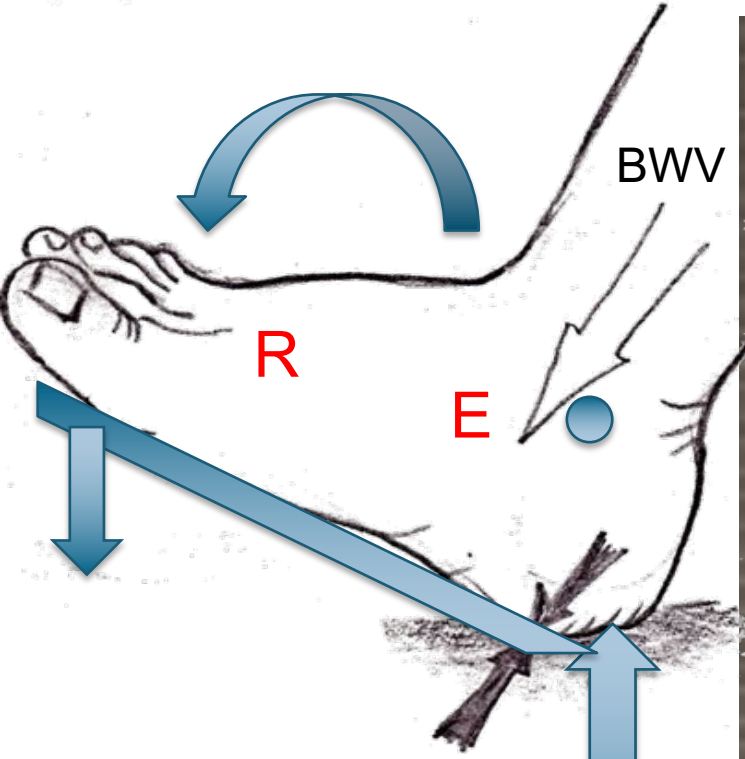
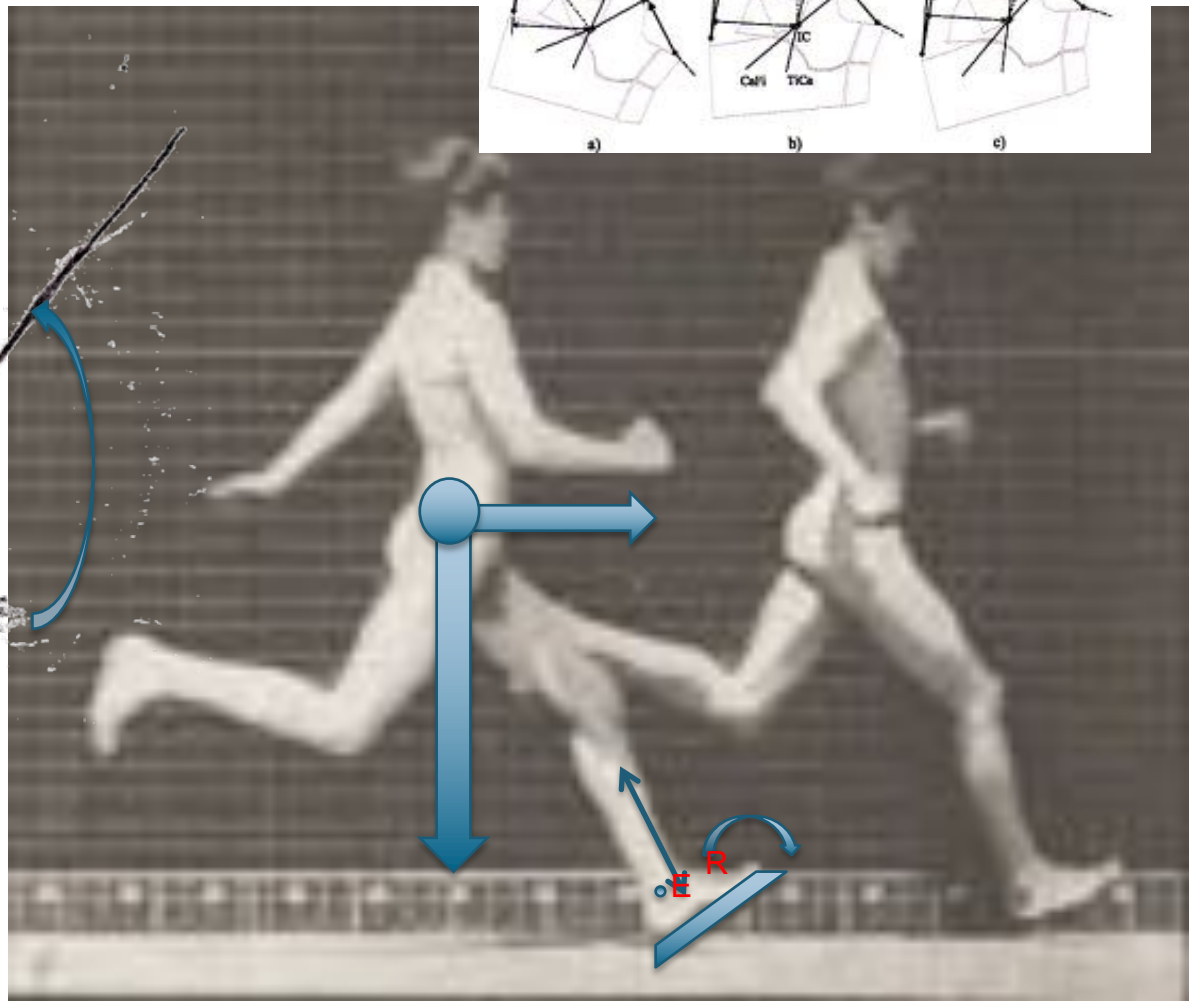
Class 3 lever dysfunction. Tibialis anterior tendinopathy / anterior shin splint



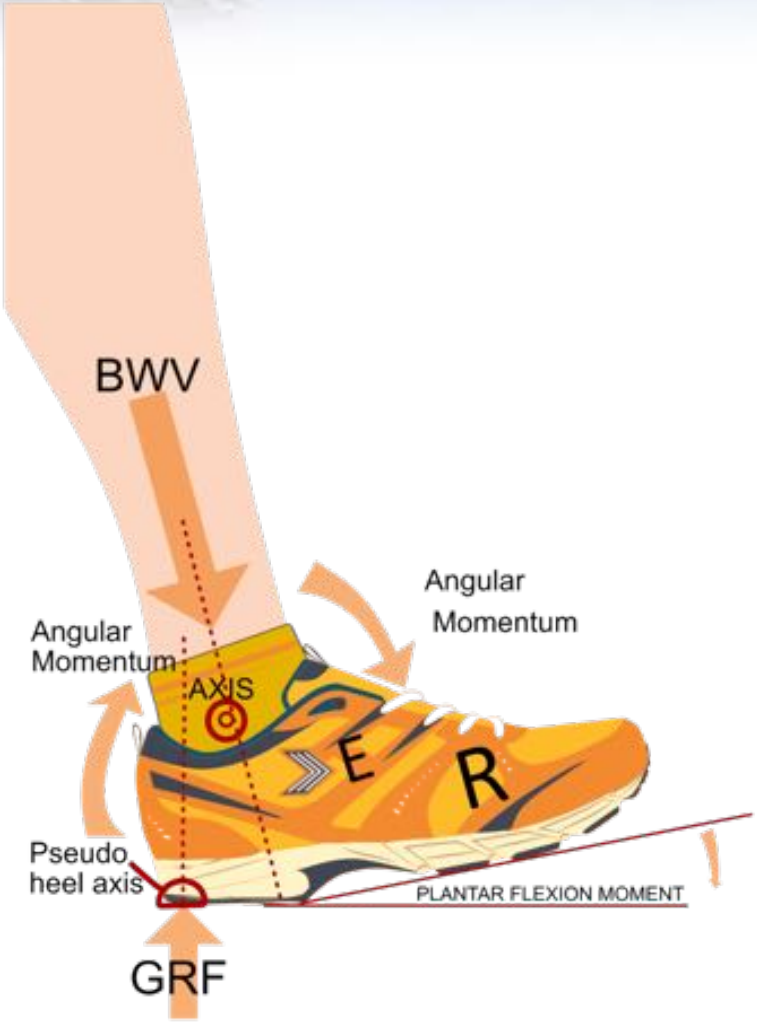


LOADING RATE
STRIDE LENGTH

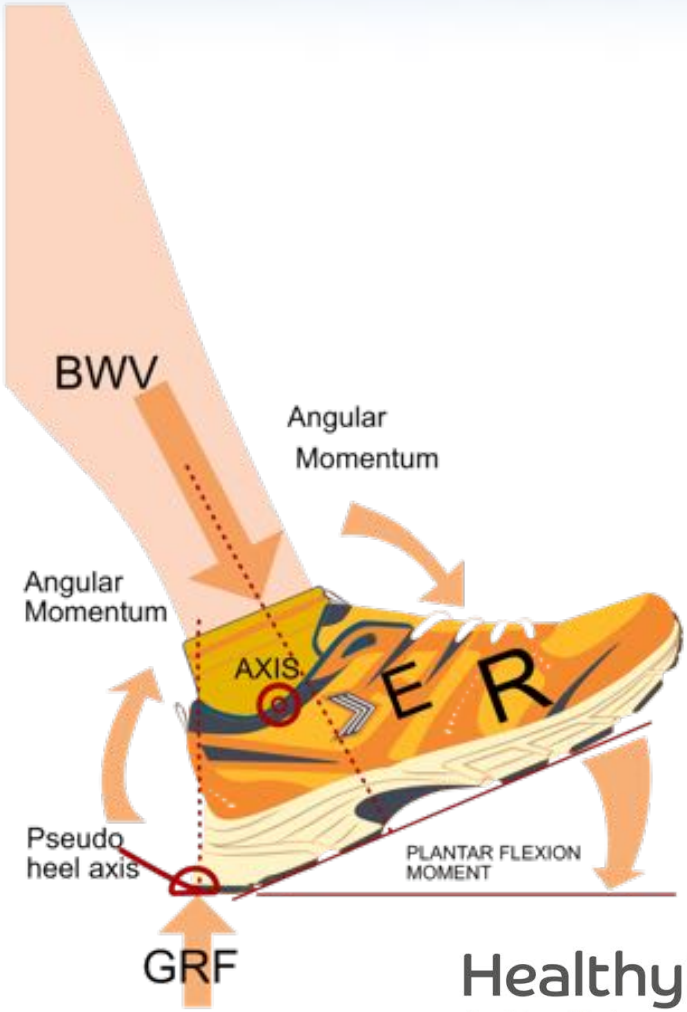
GRF



TIBIAL ANTERIOR STRESSES ACCEPTABLE
ANGULAR MOMENTUM CONTROLLED
LOADING RATE ACCEPTABLE



TIBIAL ANTERIOR STRESSES TO HIGH
ANGULAR MOMENTUM UNCONTROLLED
LOADING RATE TOO HIGH



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Thank You!

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