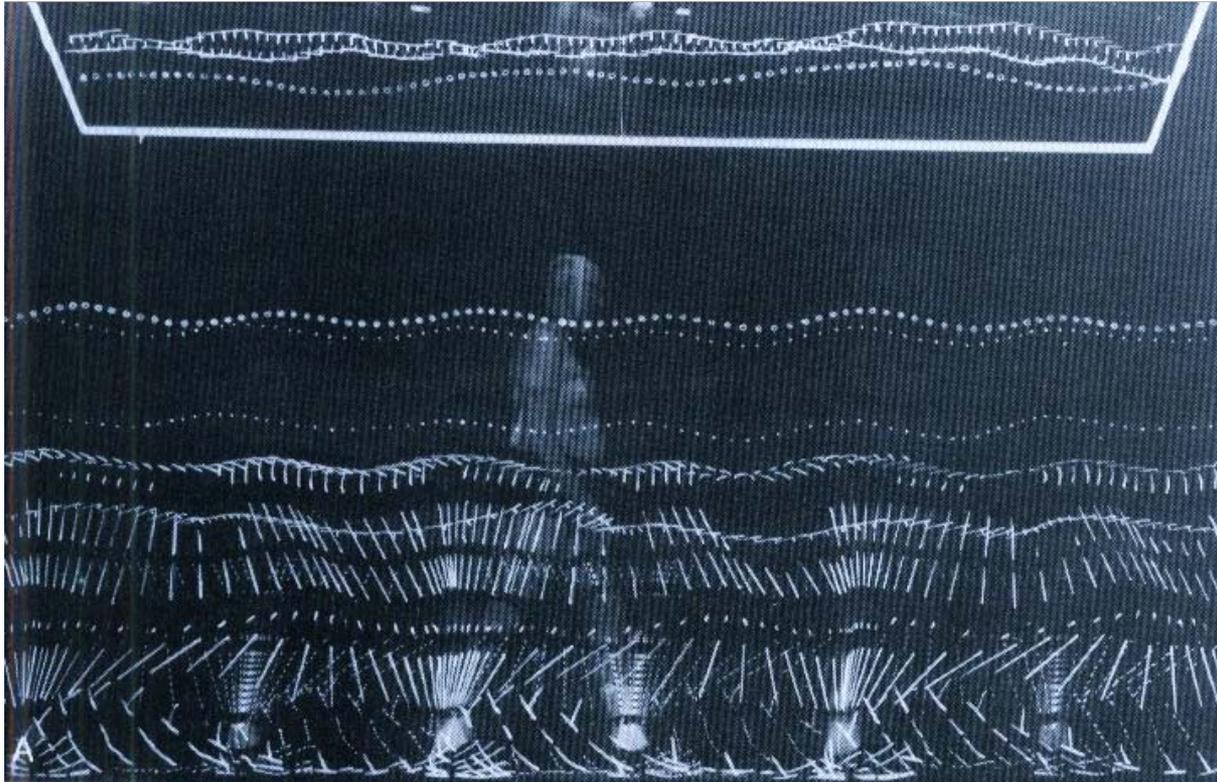




# VARIABLES BIOMECÁNICAS

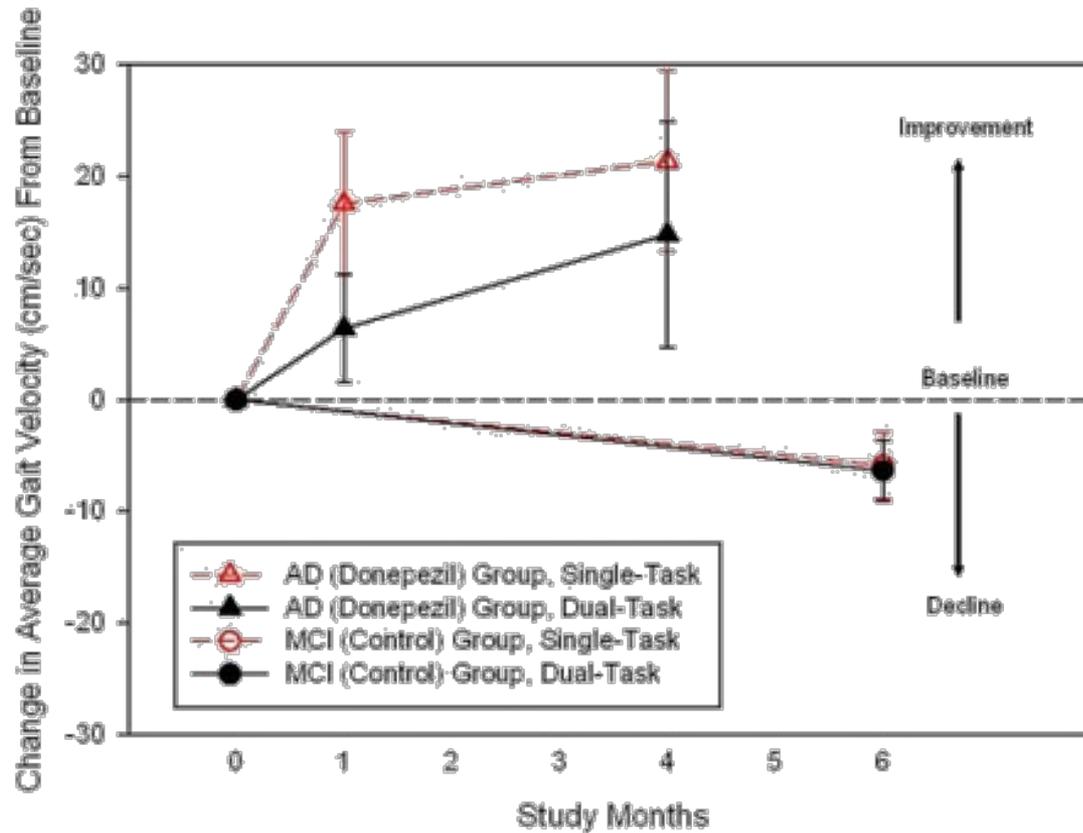
***Ft. MARIA SOLANGE PATIÑO SEGURA***  
***Docente Escuela de Fisioterapia***  
***Maestría en Fisioterapia***

# CINEMÁTICA



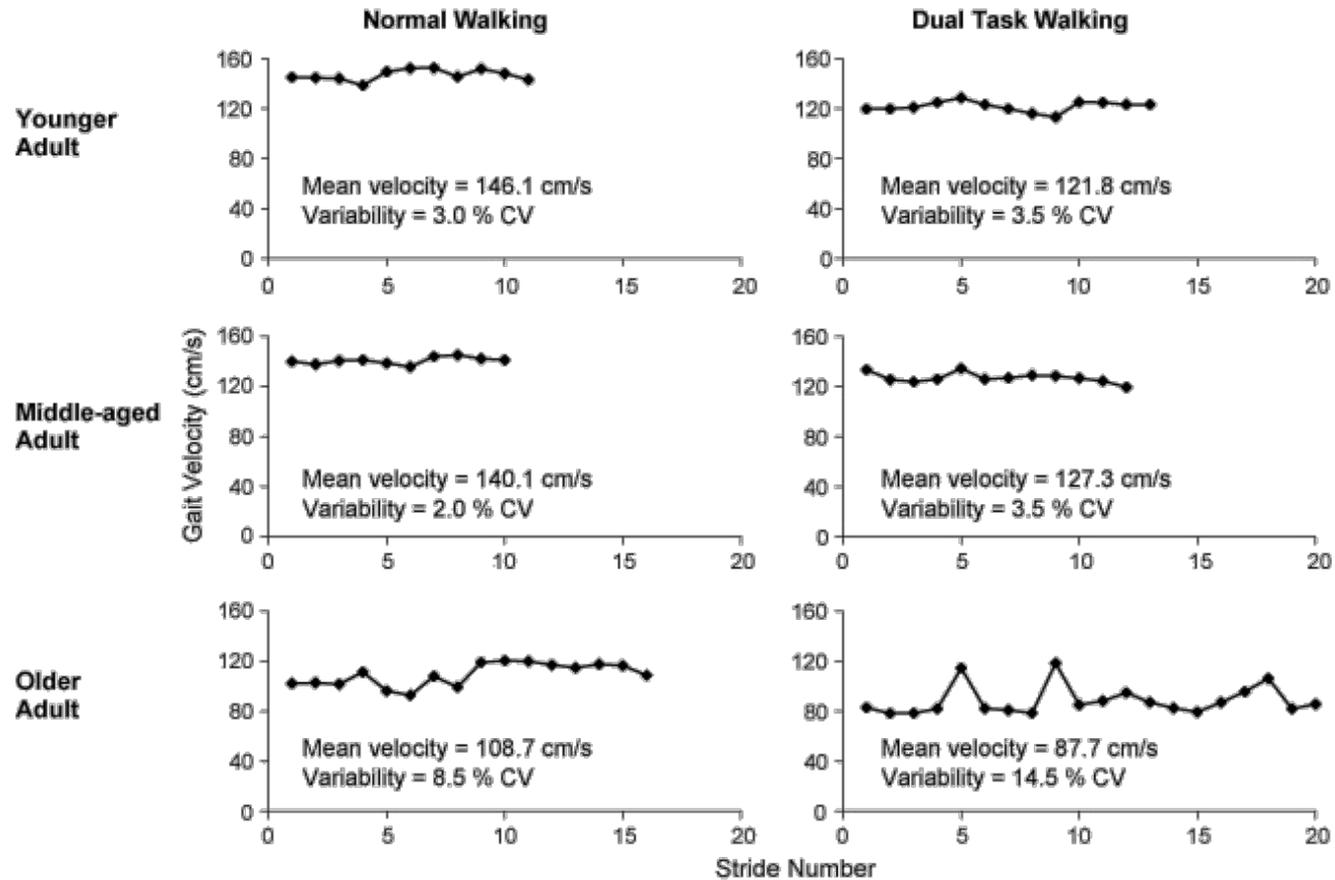
**Filtro digital de segundo orden *Butterworth*, con frecuencia de 4 Hz.**

# VELOCIDAD



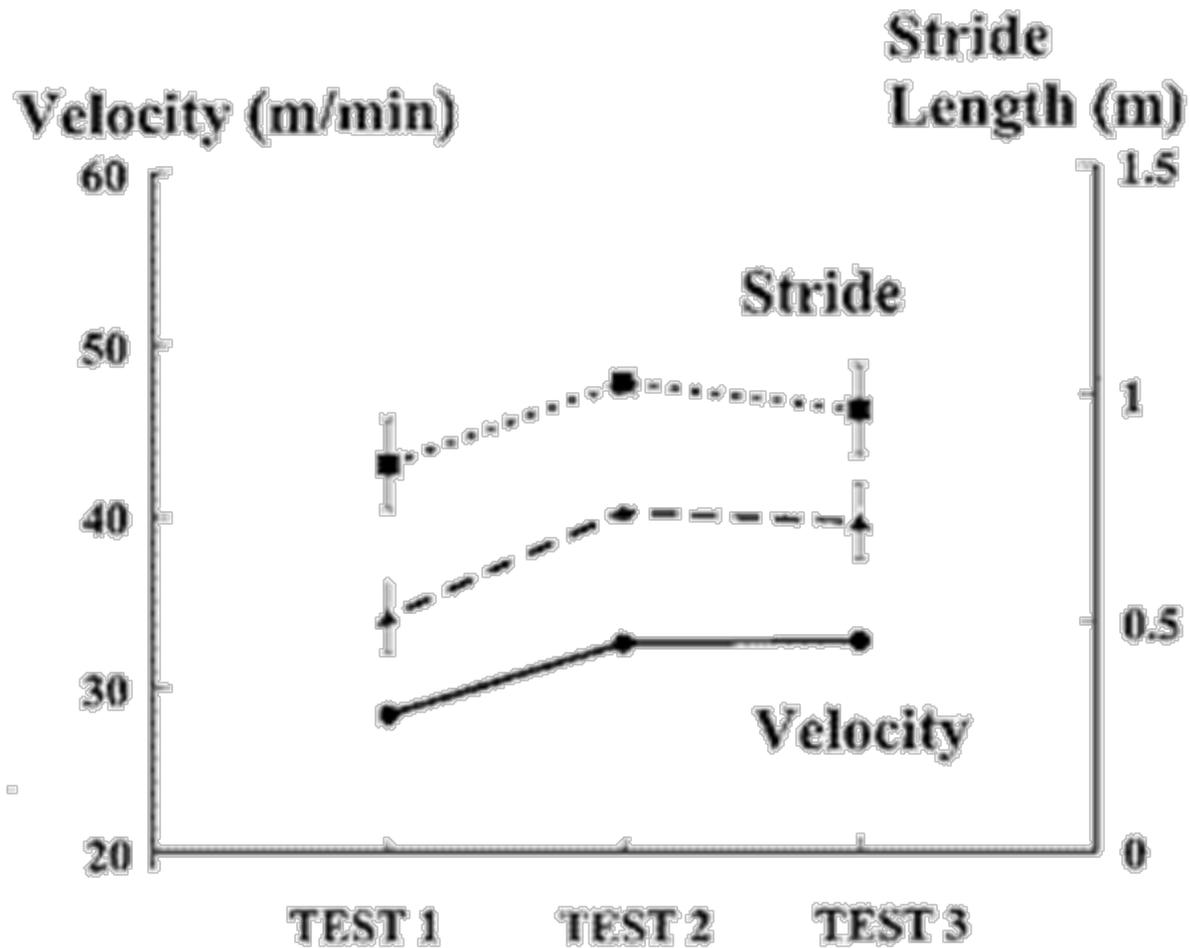
*Montero-Odasso M et. al. BMC Neurology, 2009.*

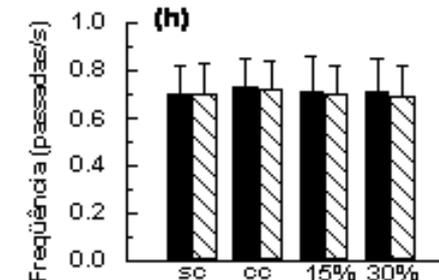
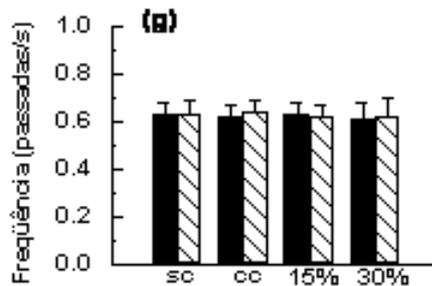
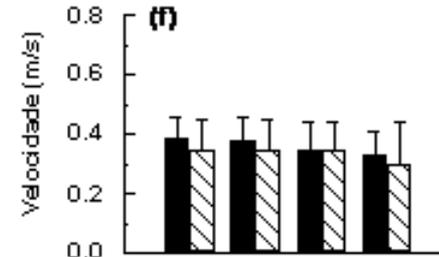
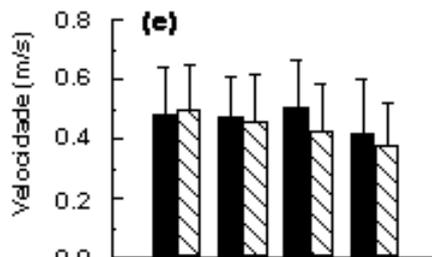
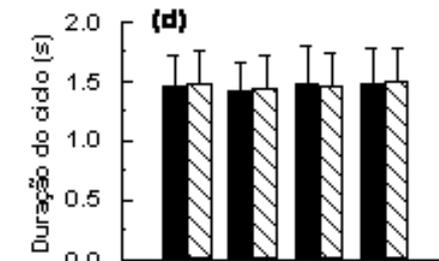
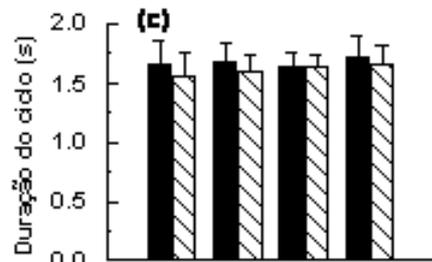
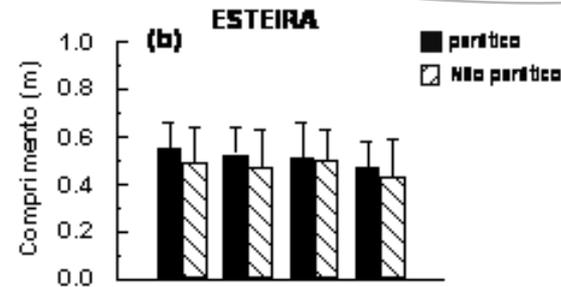
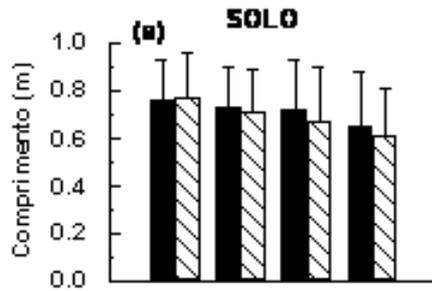
# VELOCIDAD



*Hollman JH et. al. Gait and posture, 2007.*

# VELOCIDAD

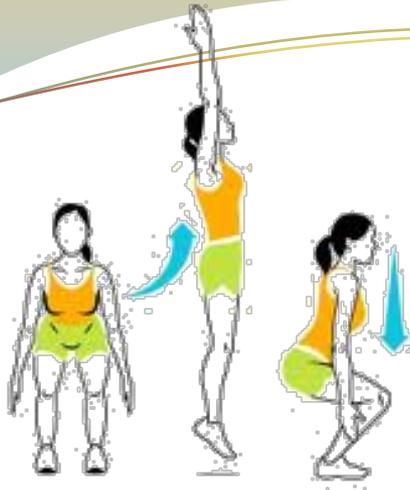




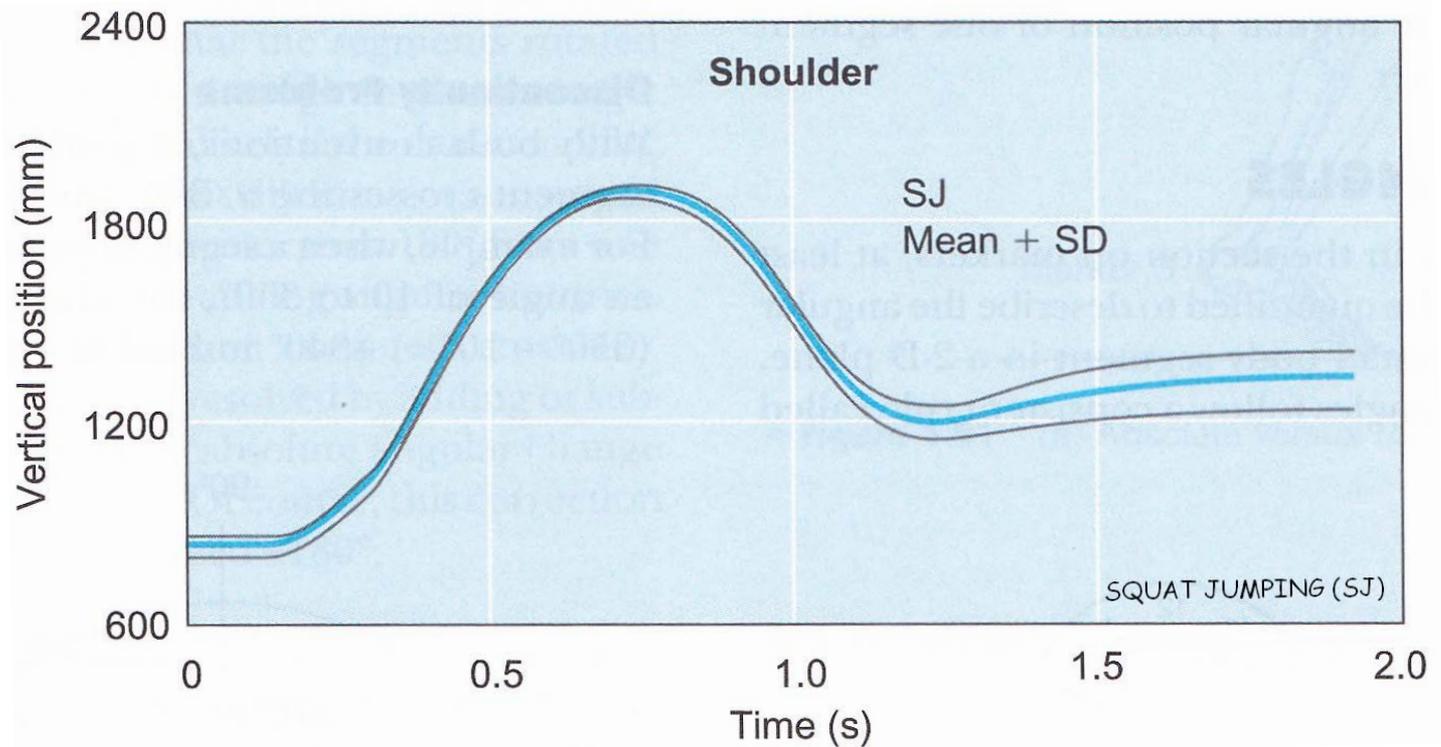
Condições

Condições

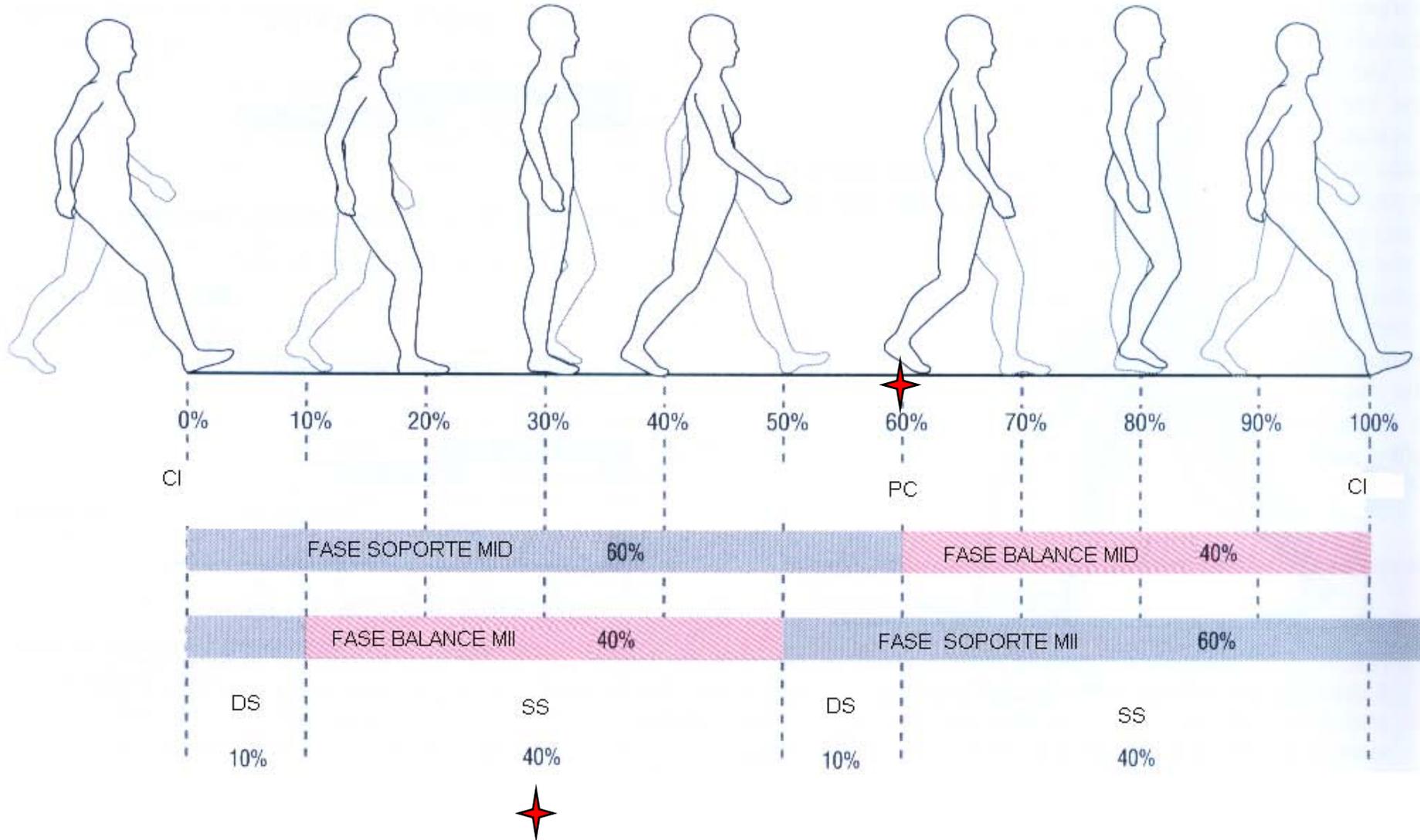
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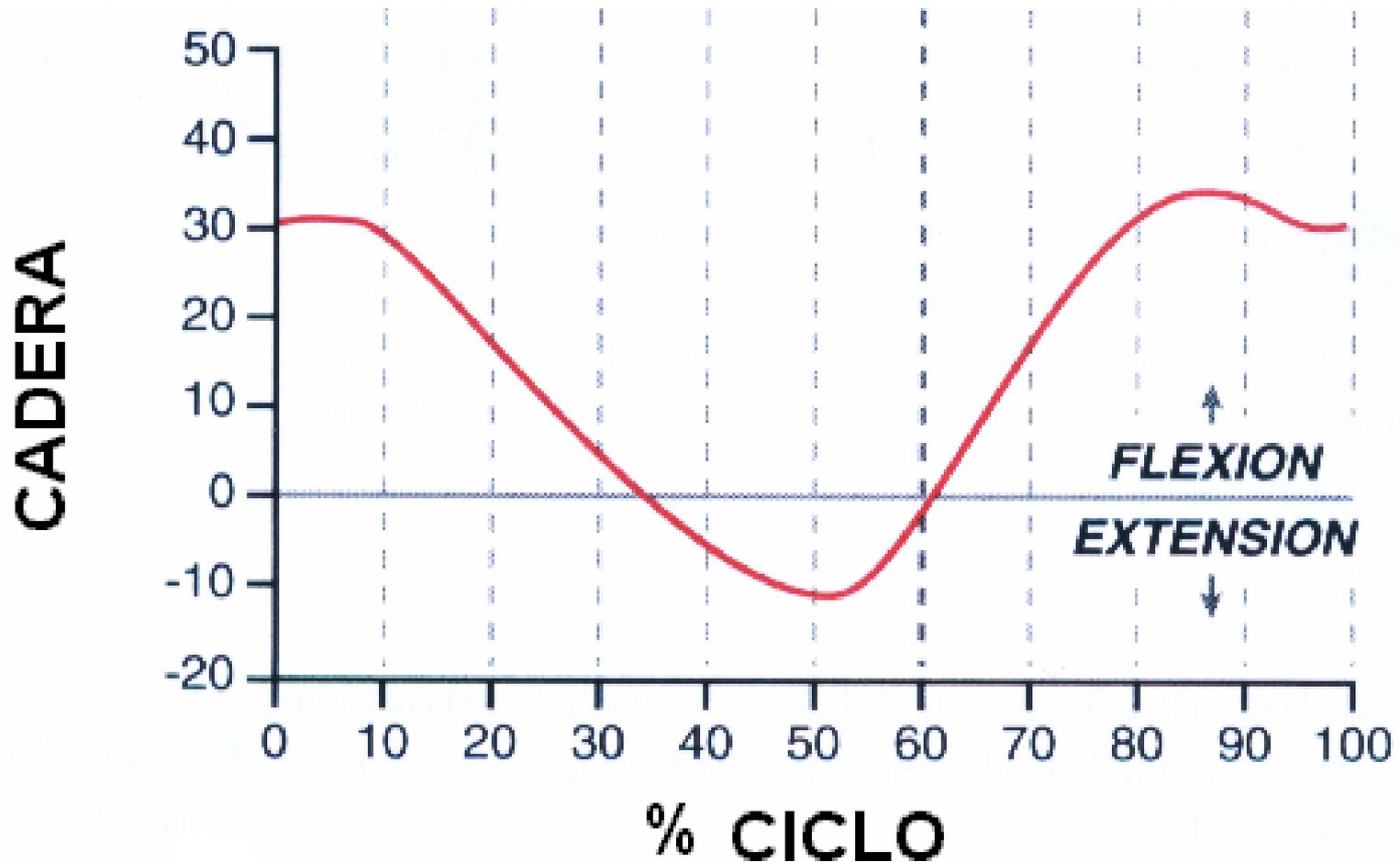
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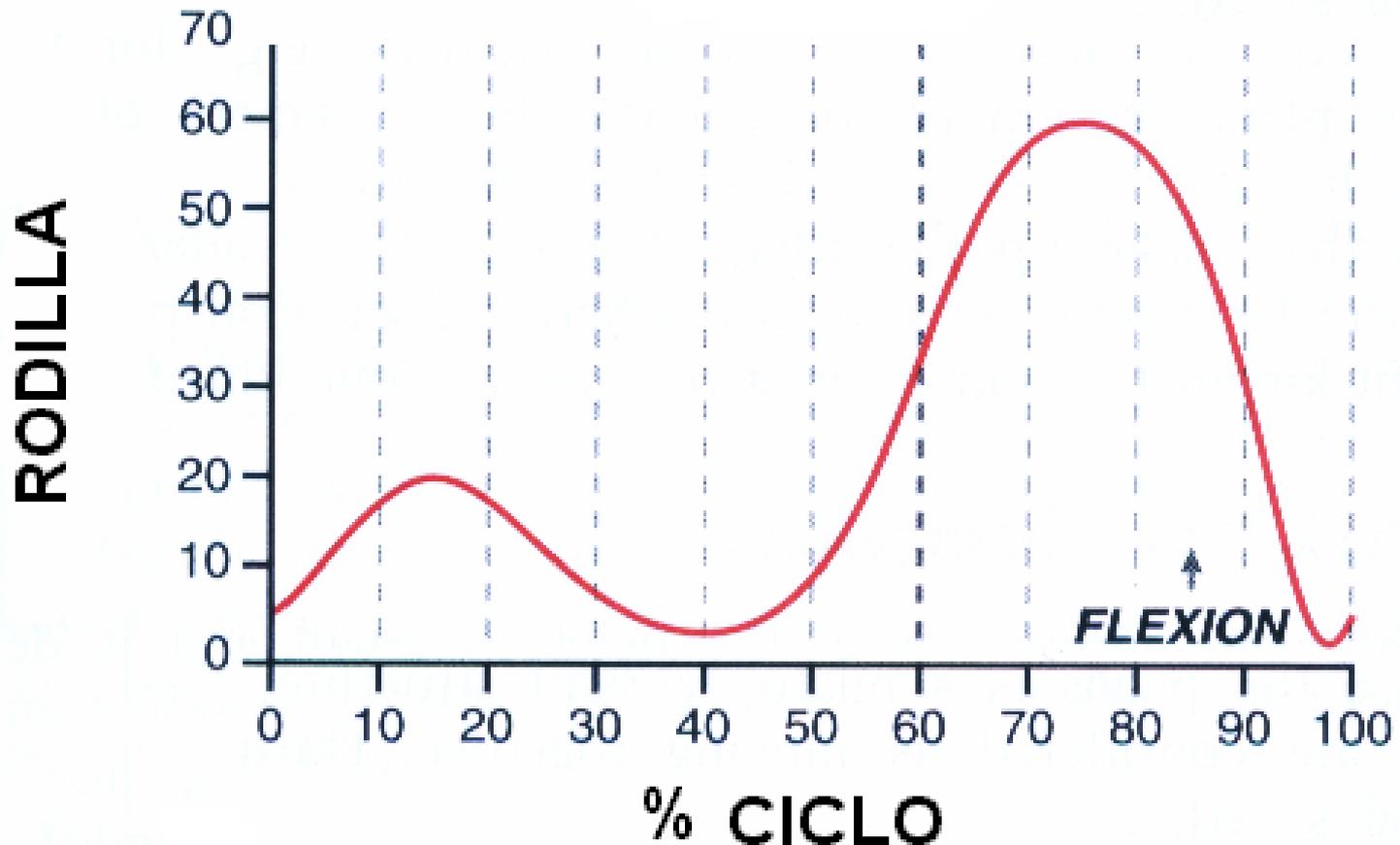
# VARIABLES TEMPORALES



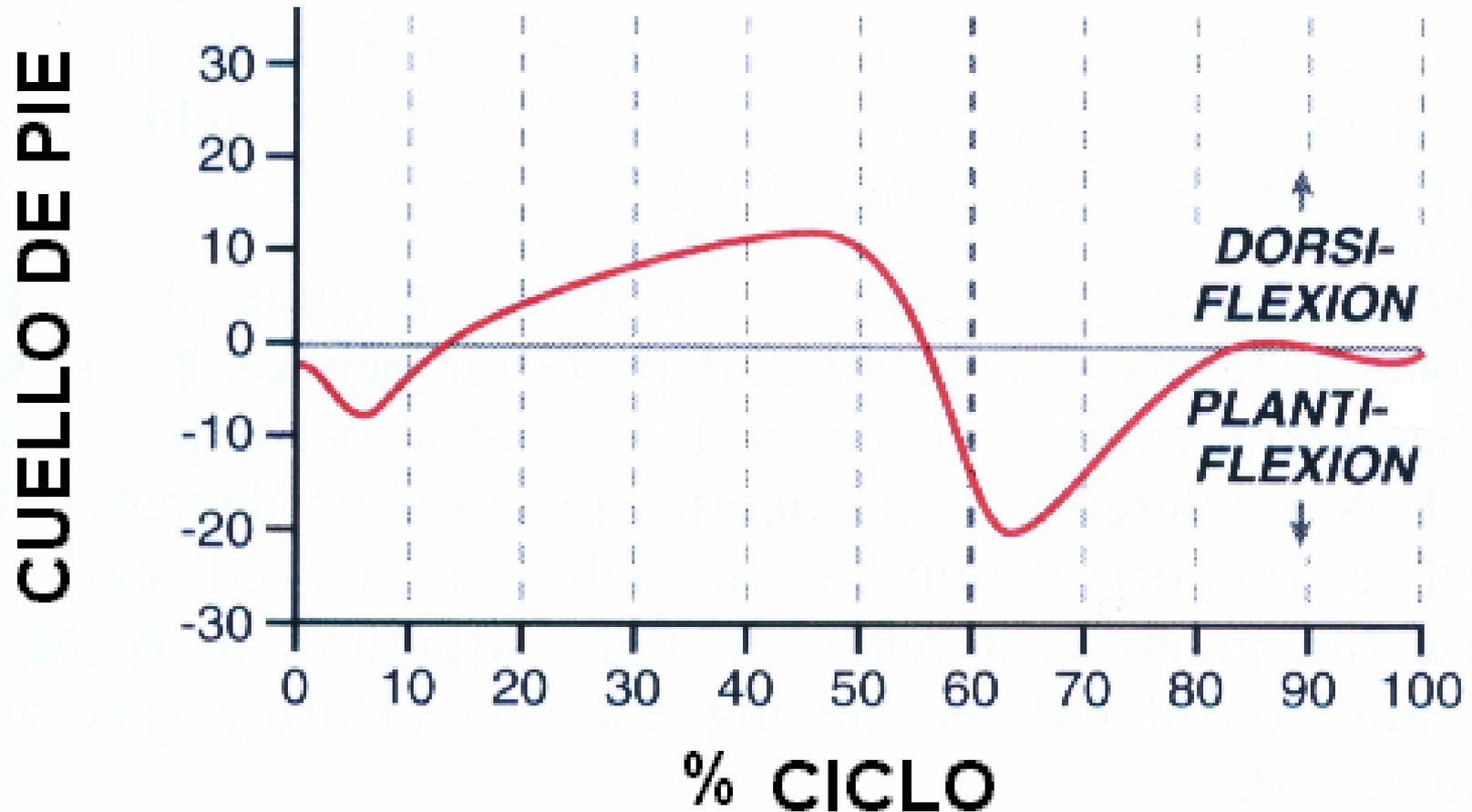
# ÁNGULOS ARTICULARES



# ÁNGULOS ARTICULARES



# ÁNGULOS ARTICULARES



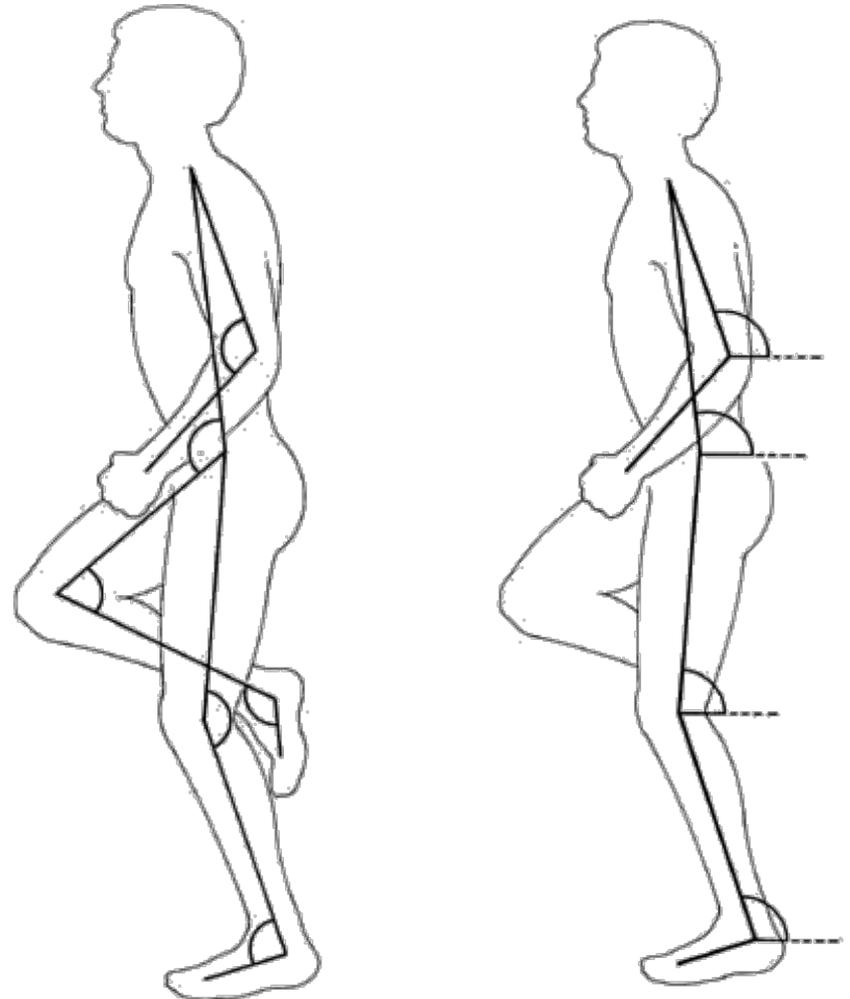
# ÁNGULOS ARTICULARES

## Relativos:

- Referencia anatómica.

## Absolutos:

- Referencia horizontal



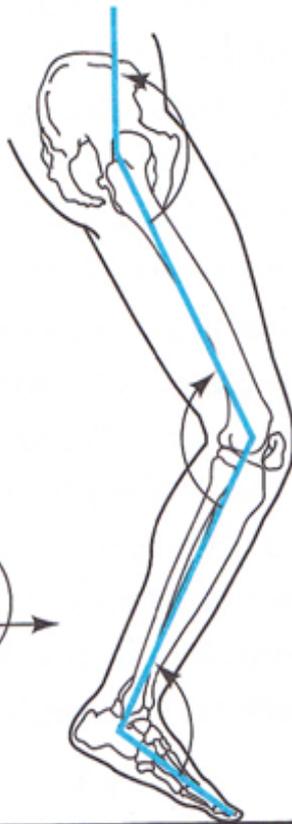
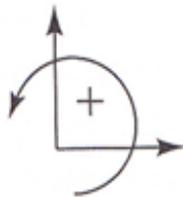
# ÁNGULOS ARTICULARES

Biomecánica

$160^\circ$

$-135^\circ$

$95^\circ$



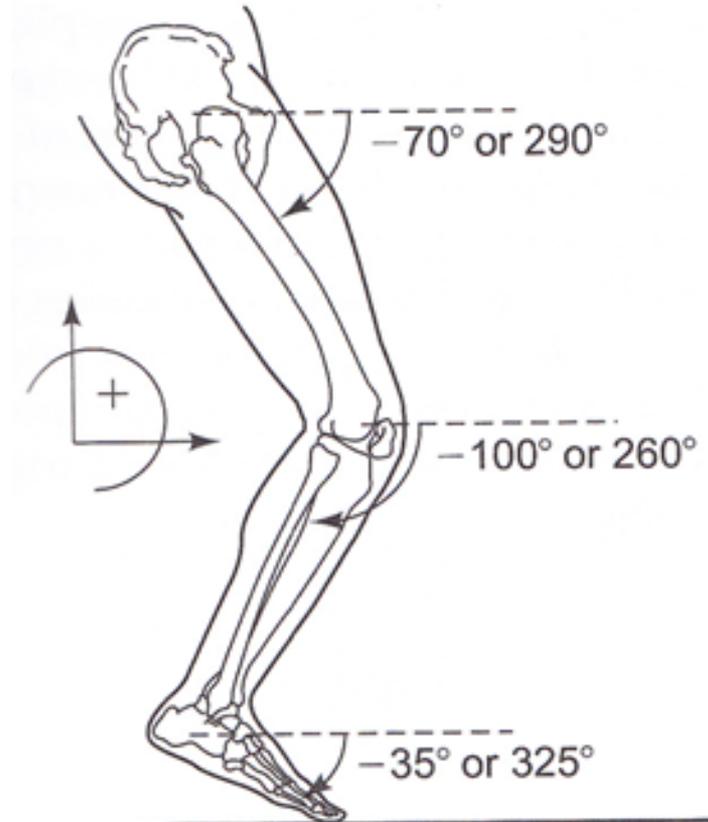
ángulos relativos

Goniometría

$20^\circ$  flexion

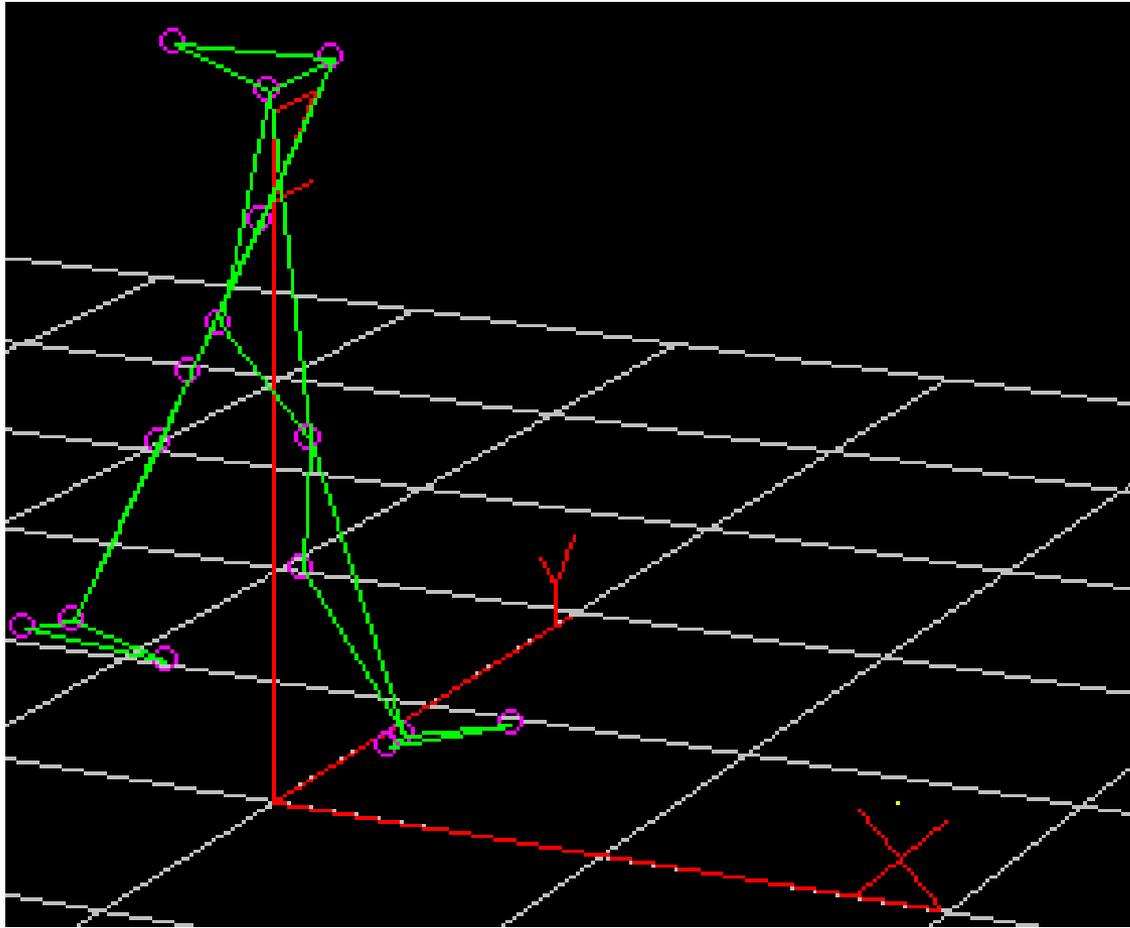
$45^\circ$  flexion

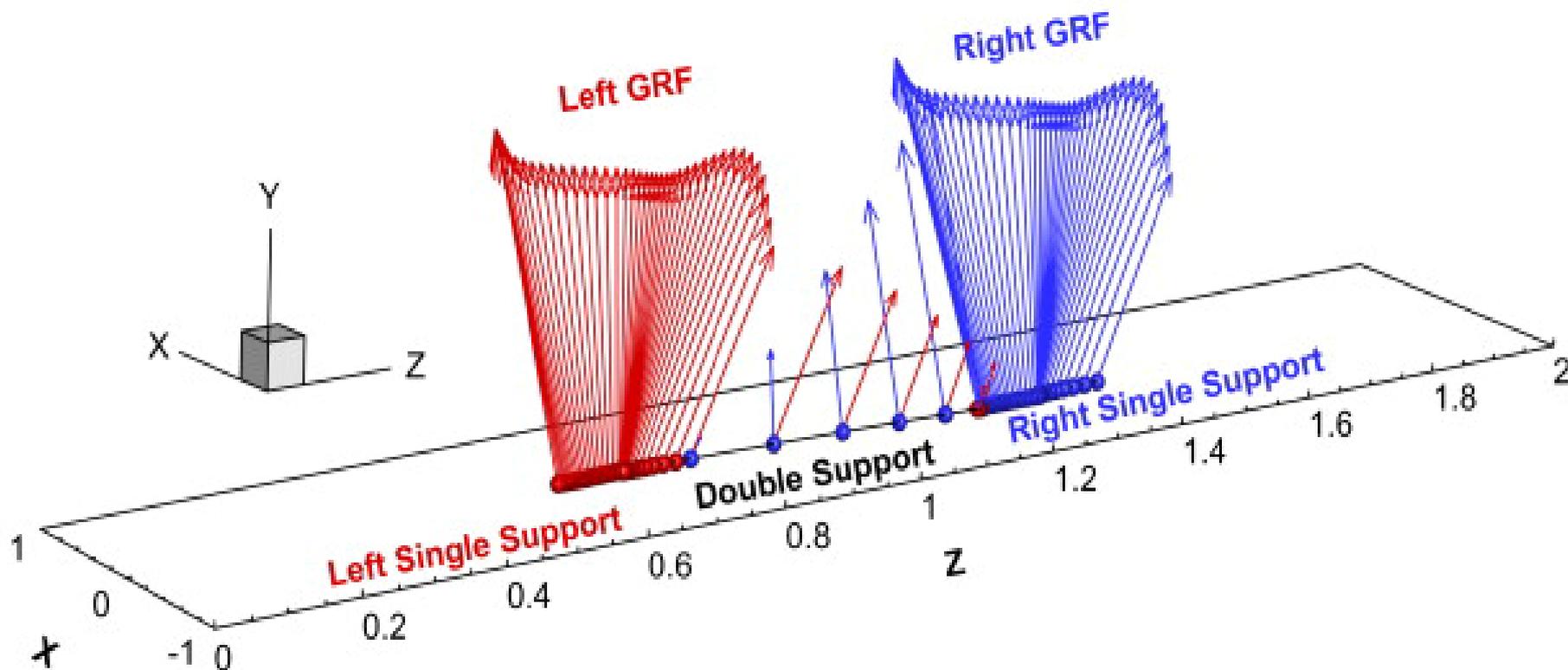
$5^\circ$  flexion plantar

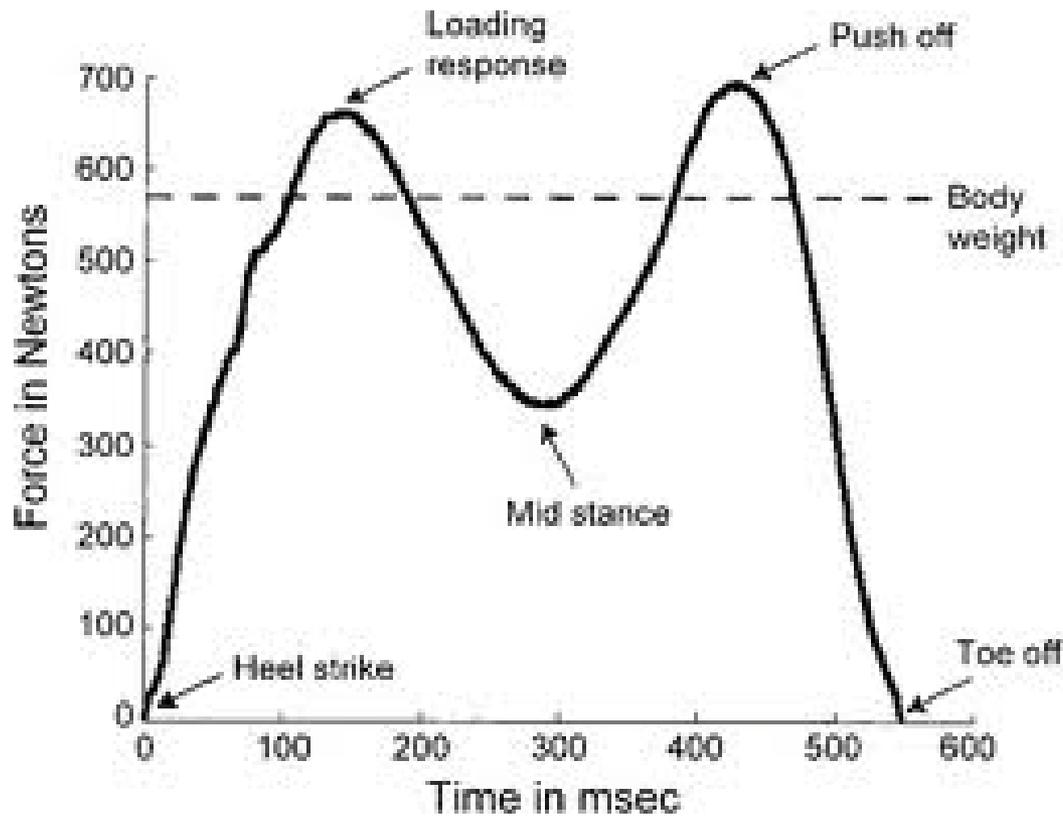


ángulos absolutos

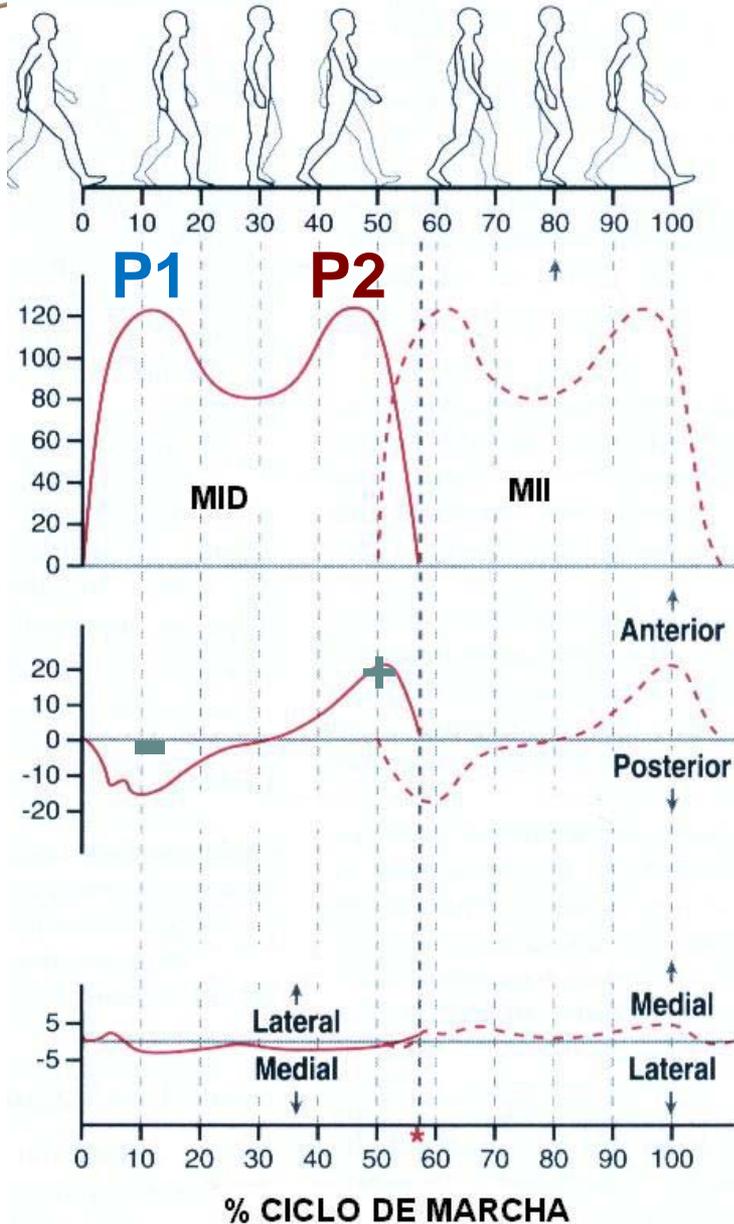
# CINÉTICA







**Filtro digital  
Butterworth, de cuarto  
orden, con frecuencia  
de corte de 6Hz.**



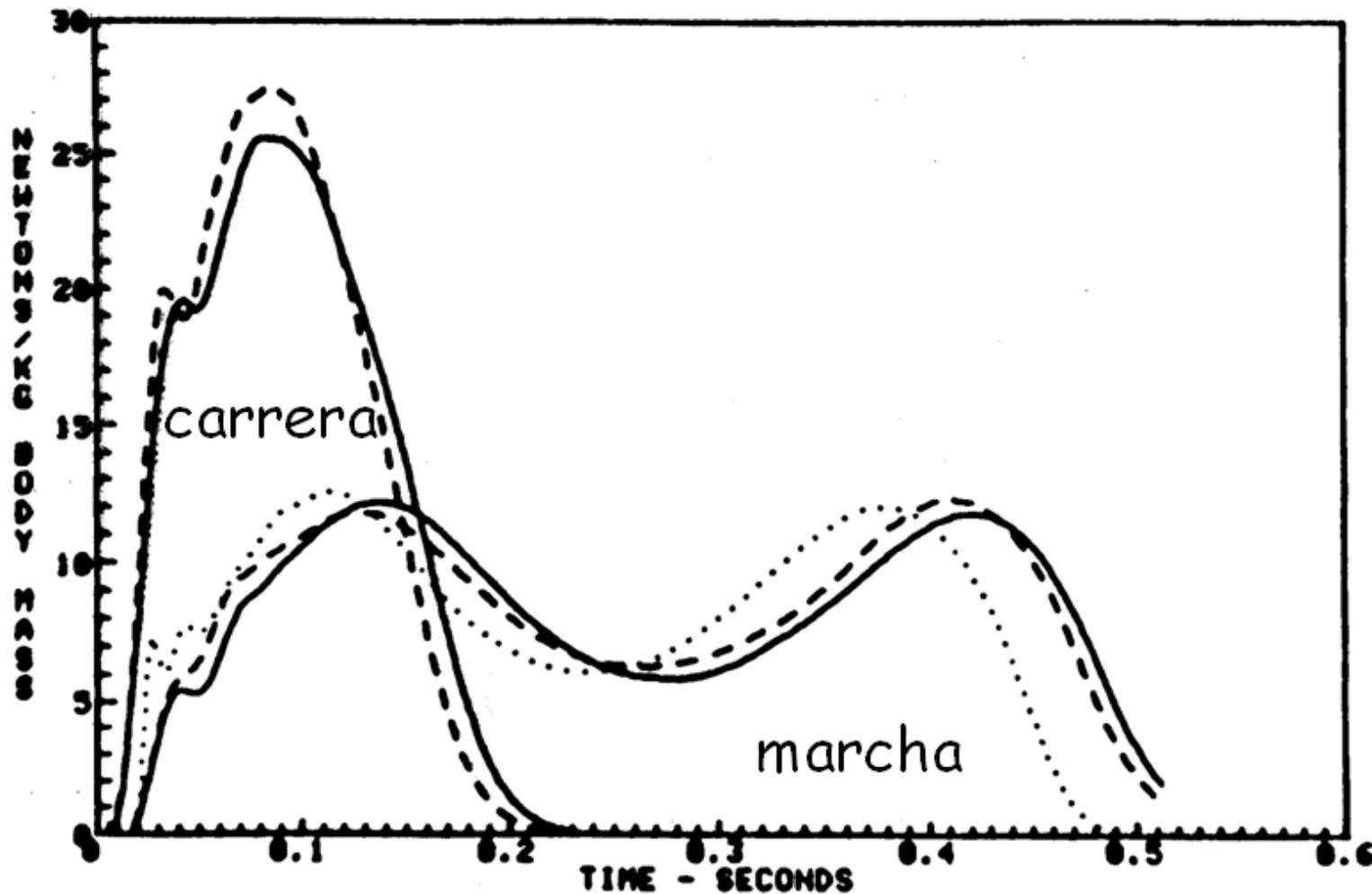
**P1= pasivo, producto de la aceleración.**

**P2= activo, producto de la propulsión.**

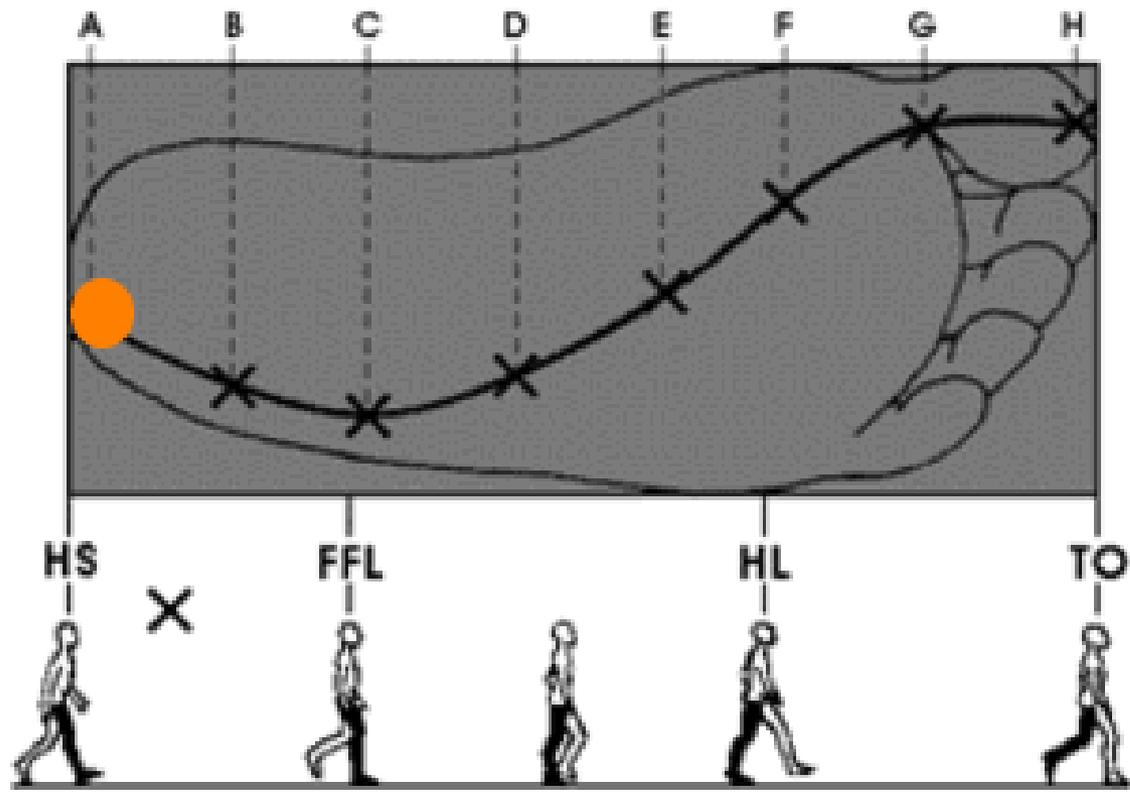
- va hacia anterior.
- + para propulsar va atrás.

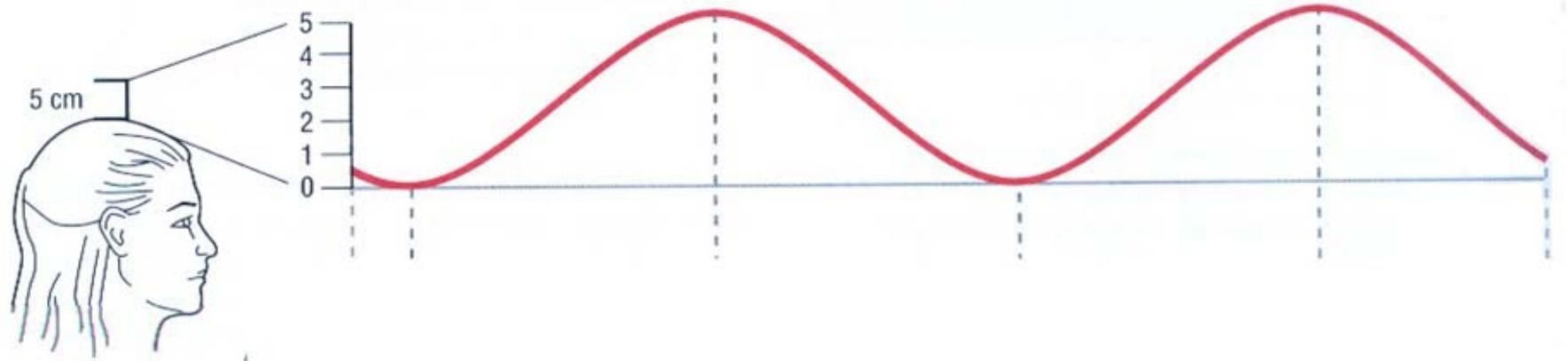
# FUERZA DE REACCIÓN DEL SUELO

# DIFERENCIAS EN FRS

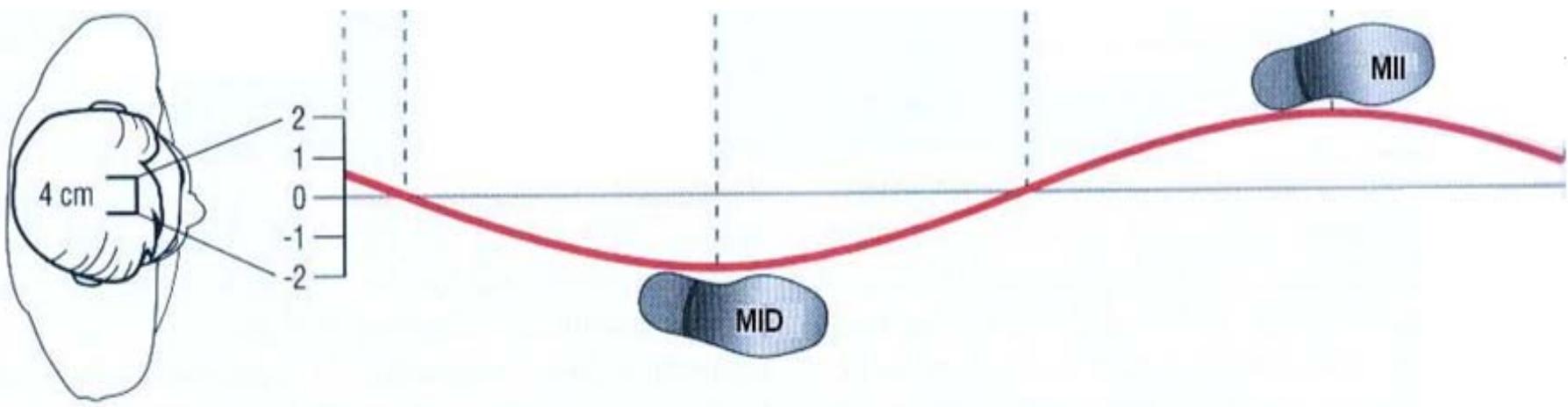


# CENTRO DE PRESIÓN



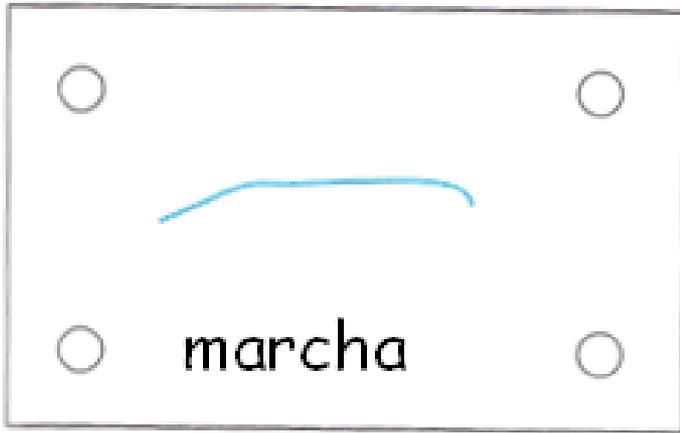


# DESPLAZAMIENTO VERTICAL CoM

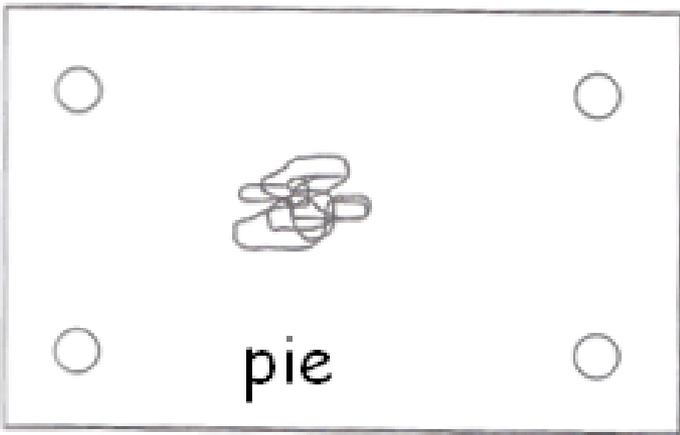


# DESPLAZAMIENTO LATERAL CoM

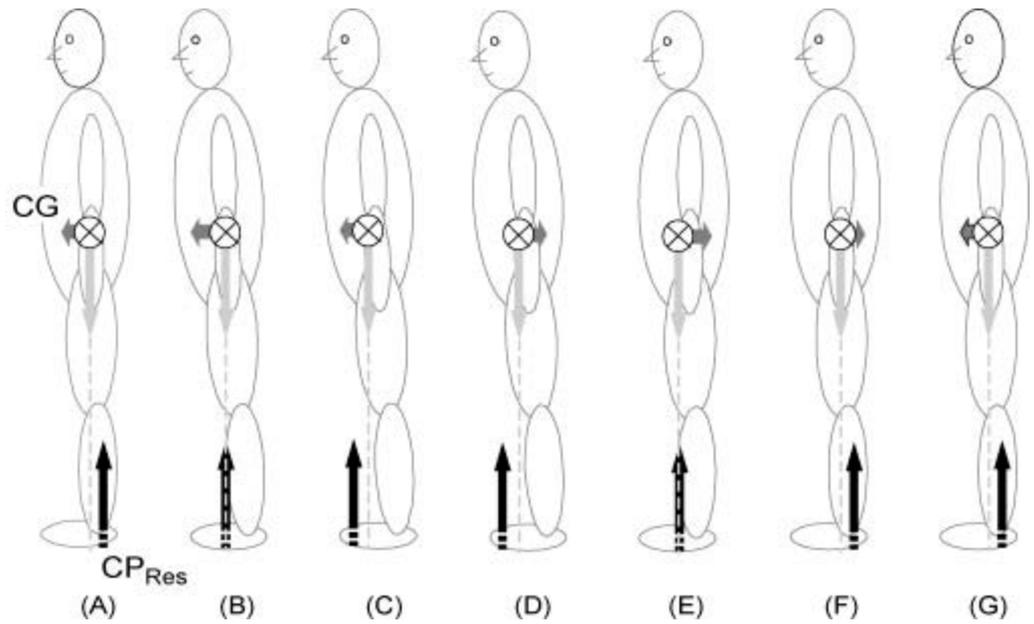
# CENTRO DE PRESIÓN



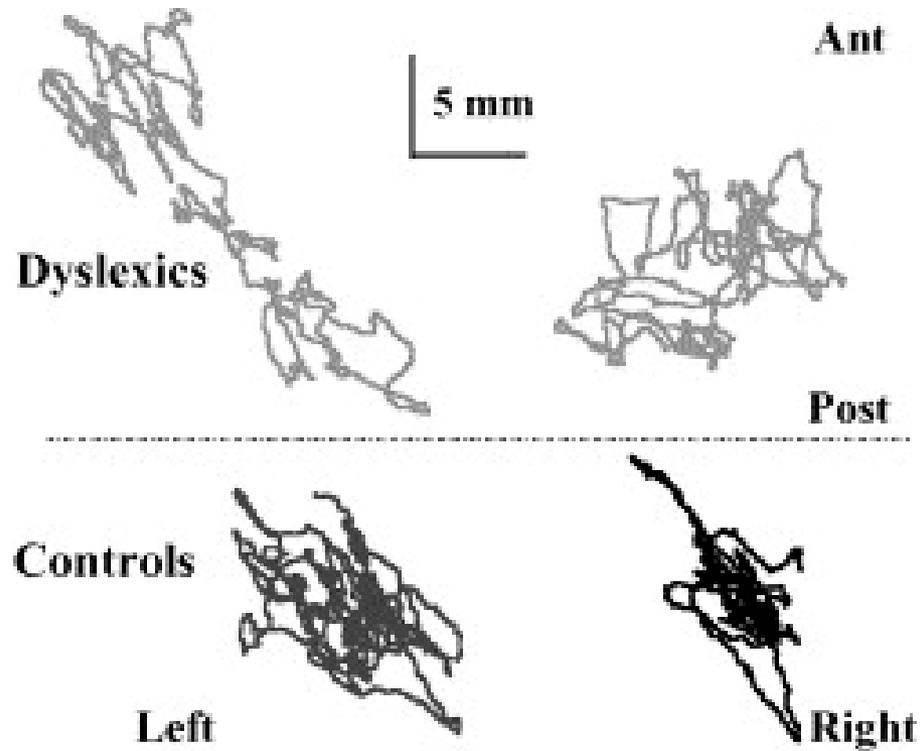
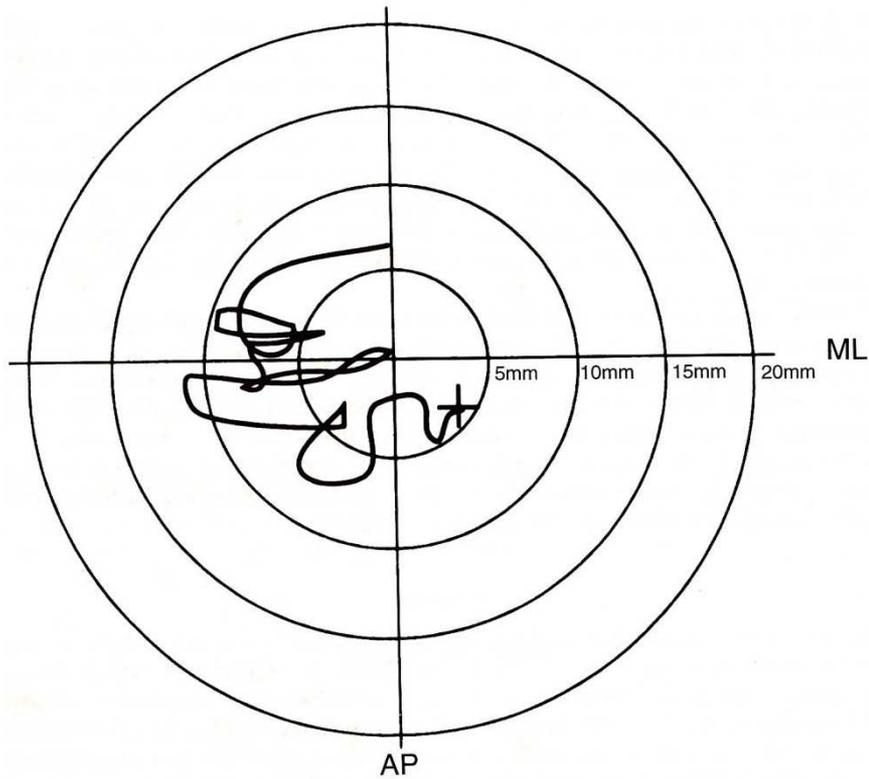
a

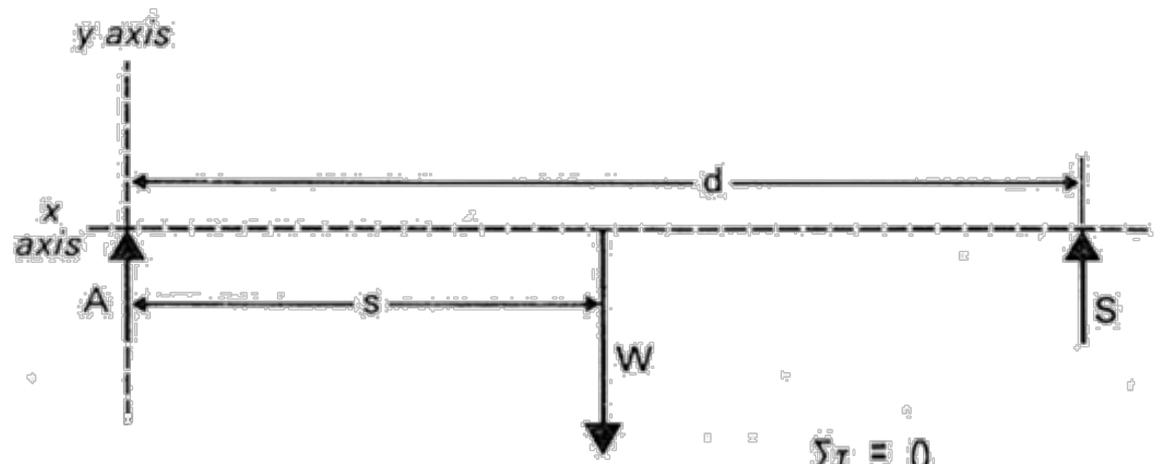
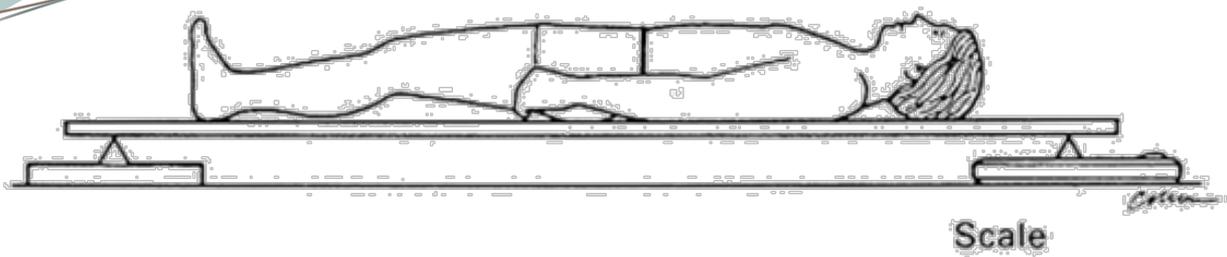


b



# CENTRO DE PRESIÓN

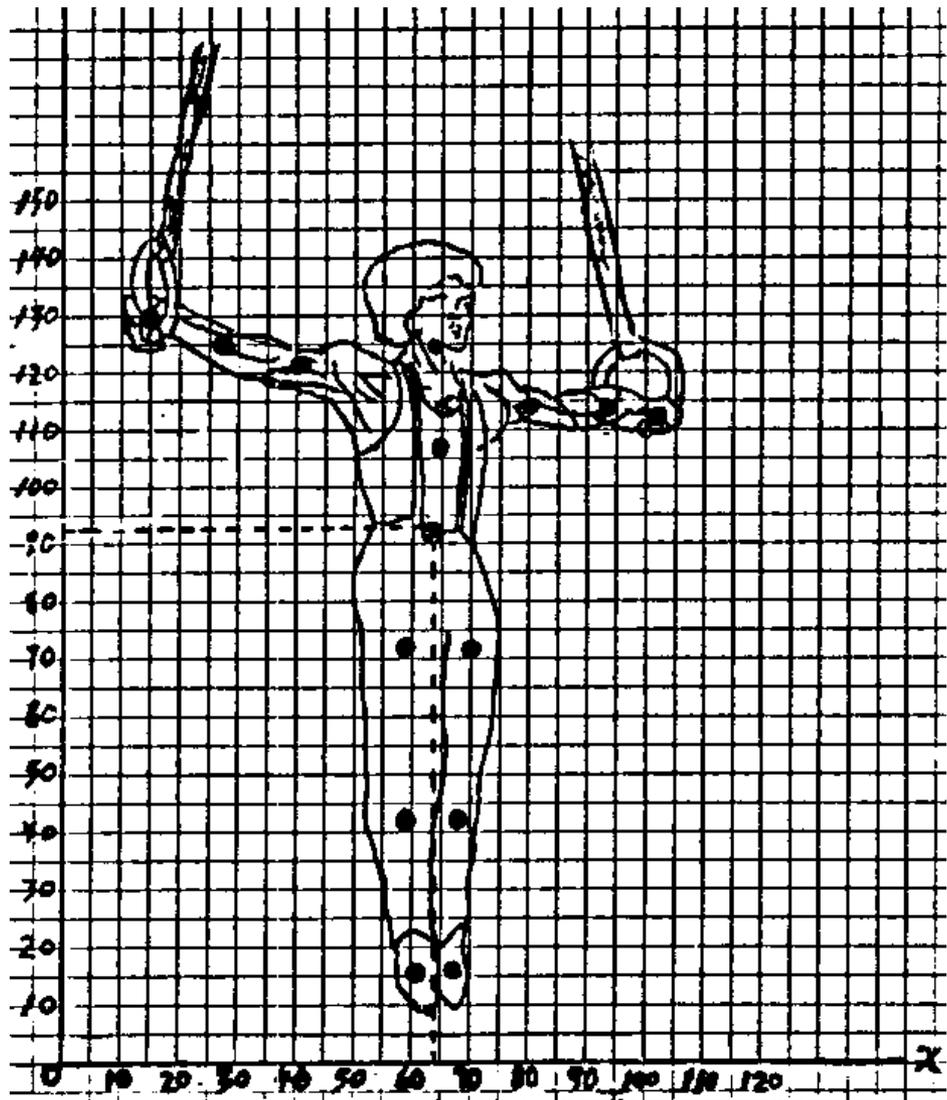




# CG CORPORAL TOTAL

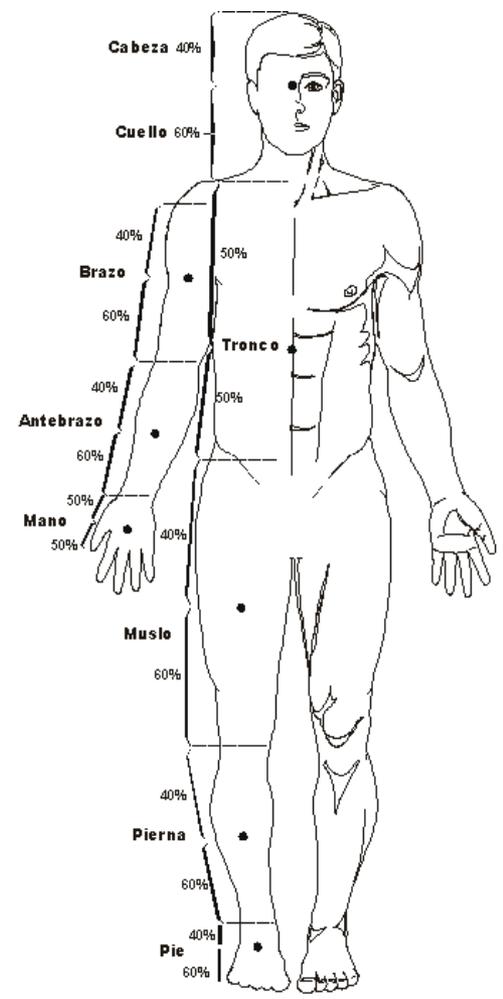
- A = axis
- W = body weight (150 lbs.)
- S = scale reading (80 lbs.)
- d = distance between supports (76 in.)
- s = distance of center of gravity from axis

$$\begin{aligned} \sum \tau &= 0 \\ +Ws - Sd &= 0 \\ s &= \frac{Sd}{W} \\ s &= \frac{80 \text{ lbs.} \times 76 \text{ in.}}{150 \text{ lbs.}} \\ s &= 40.5 \text{ in.} \end{aligned}$$



**LOCALIZANDO EL CENTRO DE GRAVEDAD**

**CG**



**LOCALIZACIÓN DEL CENTRO DE GRAVEDAD PARA CADA SEGMENTO DEL CUERPO**

Adaptado de: Kinesiology: *Scientific Basis of Human Motion*. 7ma. Ed.; (p. 400), por K. Lutgens & K. F. Wells, 1982, Philadelphia: Saunders College Publishing  
 Copyright 1982 por: Saunders College Publishing

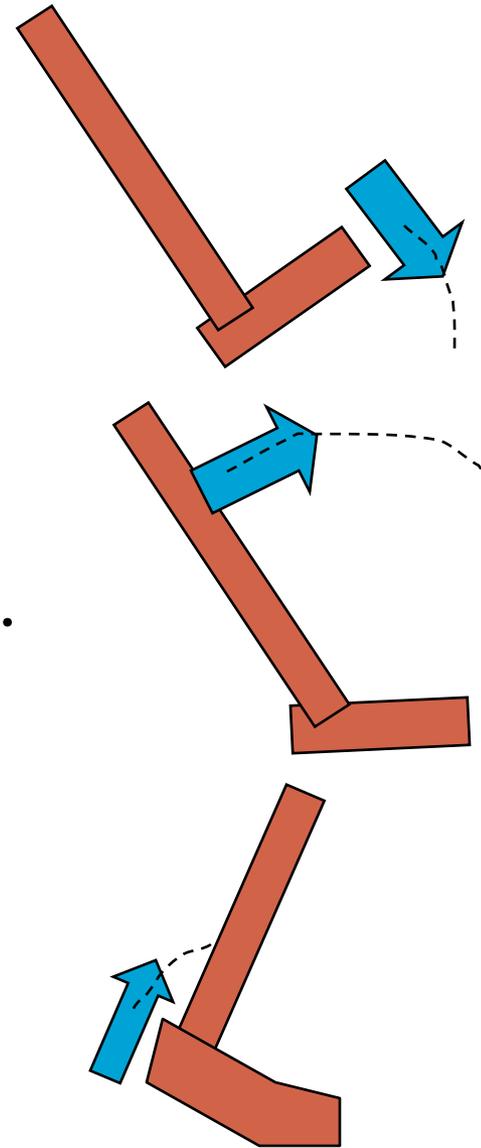
# INTERPRETACIÓN CG

## Condiciones de estabilidad:

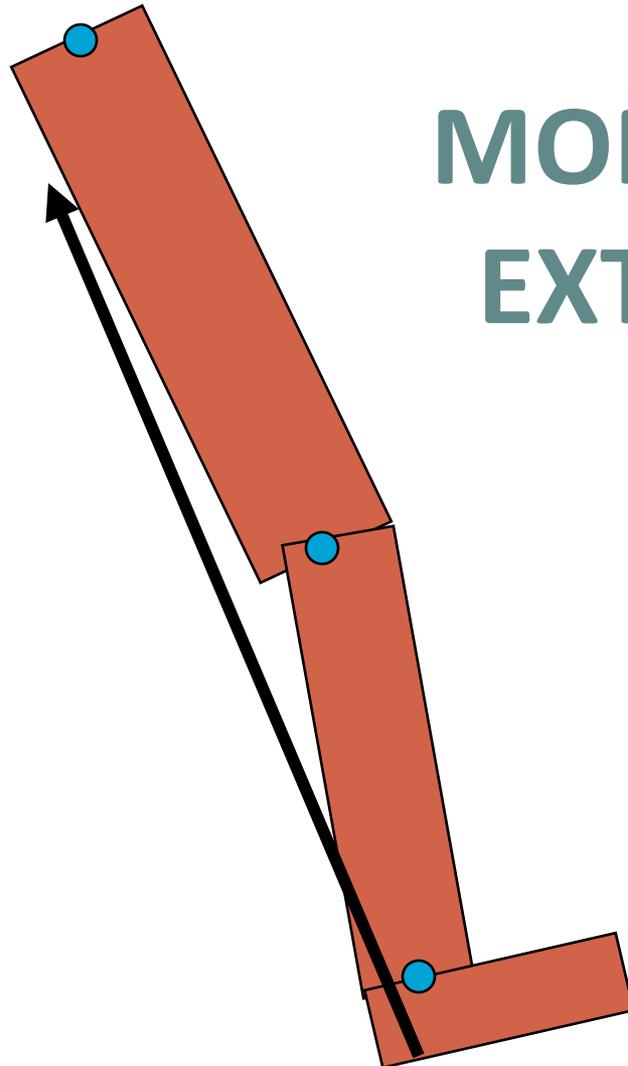
- El cg es mas bajo y cercano a la BS.
- El cg se proyecta cerca al centro de la BS.
- Se incrementan cuando se amplía la BS.
- Oscilación dentro de límites fisiológicos.
- Se reconocen los límites de estabilidad.

# Movimientos del tobillo (rockers)

- Primero: plantiflexión.
- Segundo: dorsiflexión mecánica.
- Tercero: dorsiflexión, despega el talón y apoyo de metatarsianos.

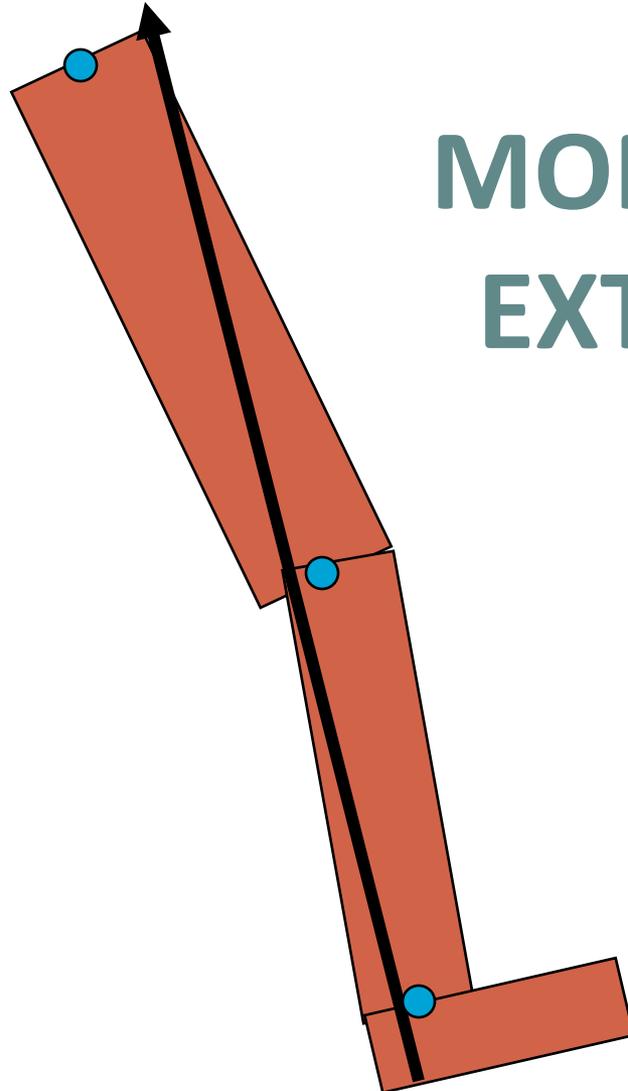


- Cadera
- Rodilla
- Tobillo



**MOMENTOS  
EXTERNOS**

- Cadera
- Rodilla
- Tobillo

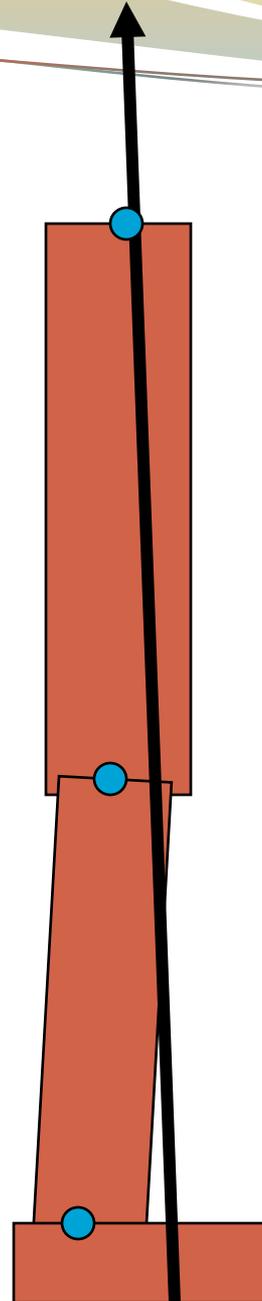


## MOMENTOS EXTERNOS

- Cadera

- Rodilla

- Tobillo

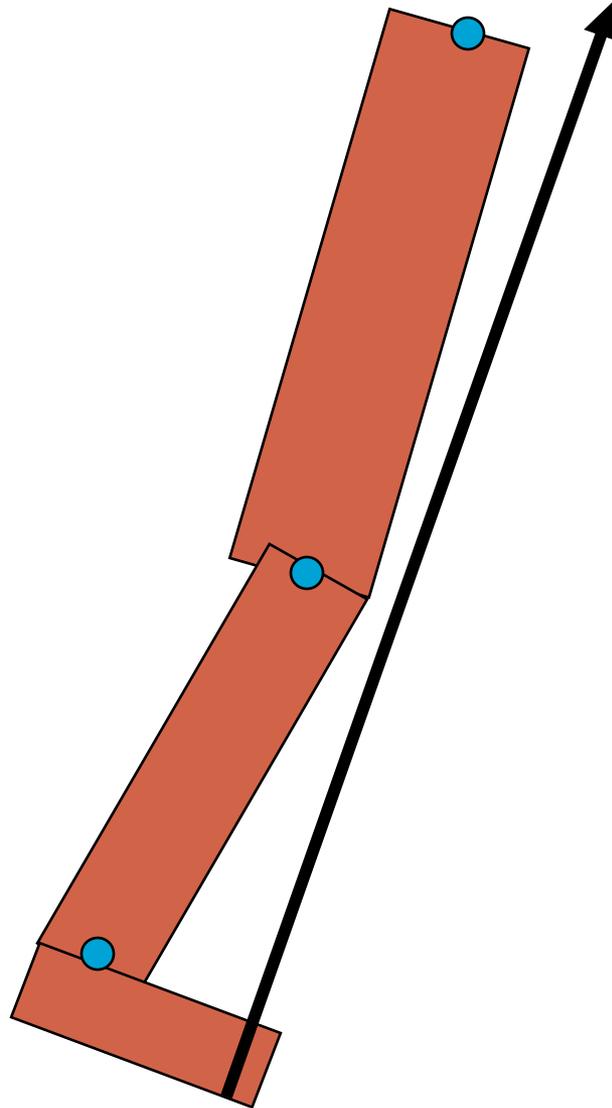


**MOMENTOS  
EXTERNOS**

- Cadera

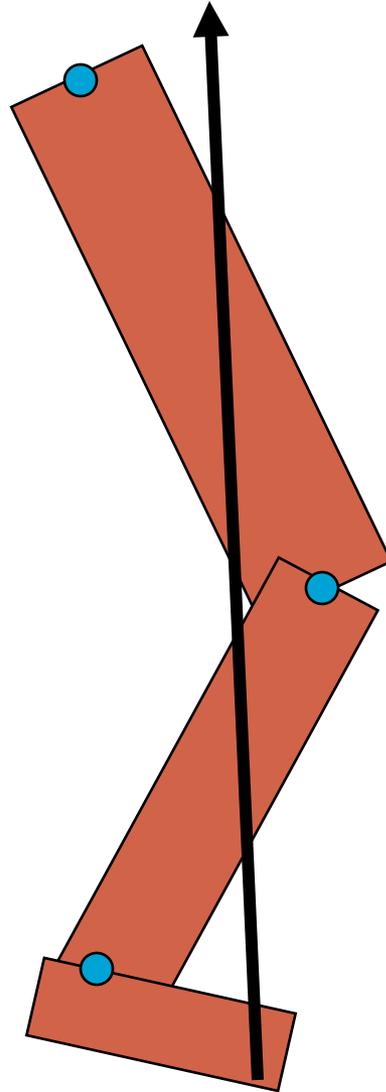
- Rodilla

- Tobillo

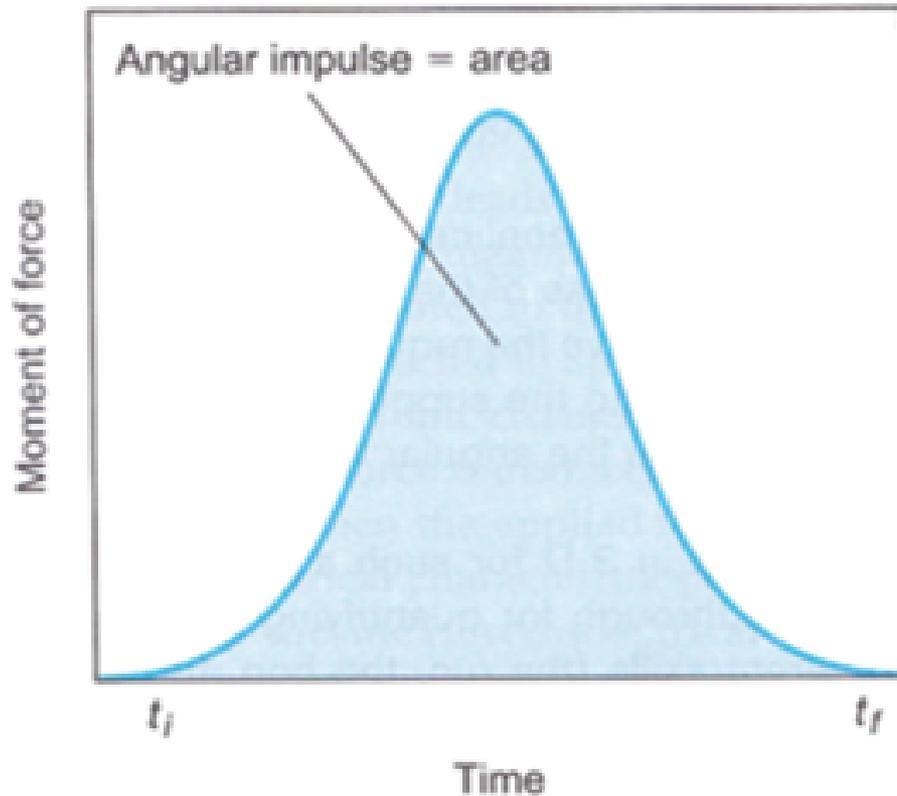


**MOMENTOS  
EXTERNOS**

- Cadera
- Rodilla
- Tobillo



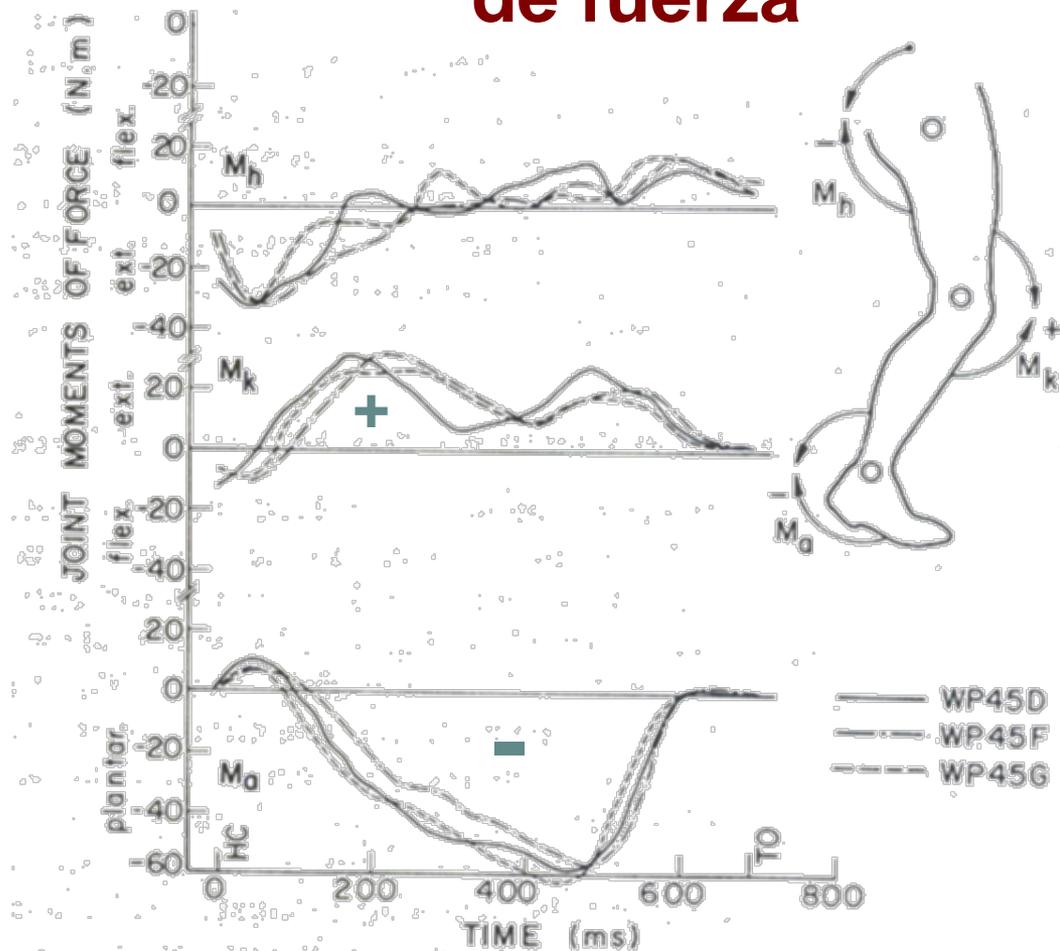
**MOMENTOS  
EXTERNOS**



# MOMENTOS EXTERNOS

El torque articular es la representación funcional de la acción muscular sobre la articulación, que permiten regular el movimiento.

# Momento articular de fuerza

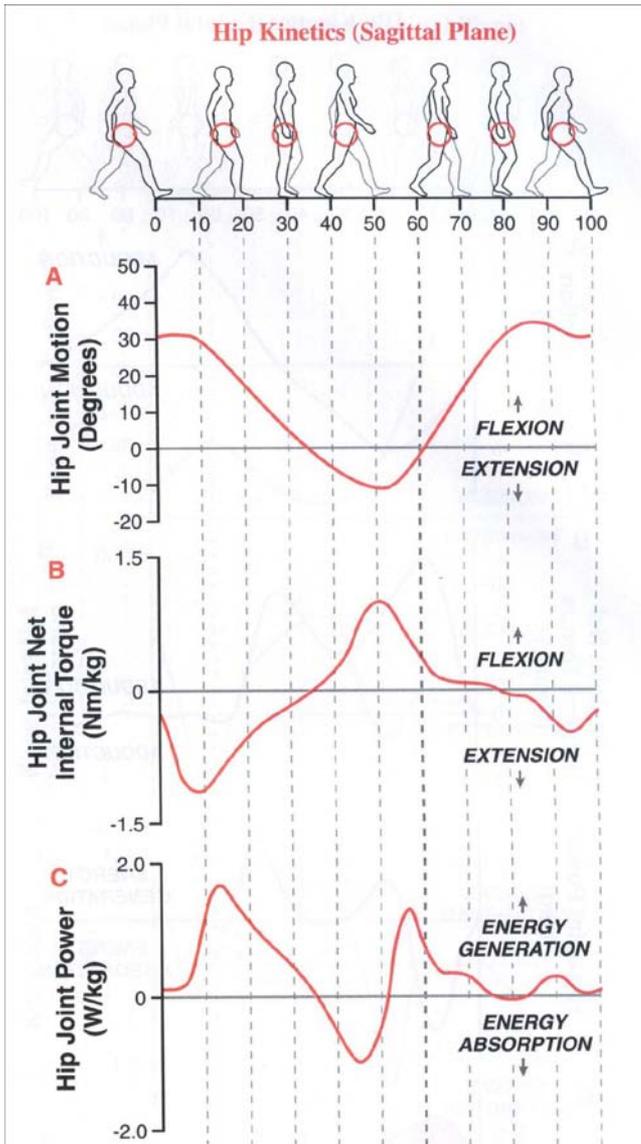


Torque ext, generado en ext es (+).

Torque ext, generado en flex es (-).

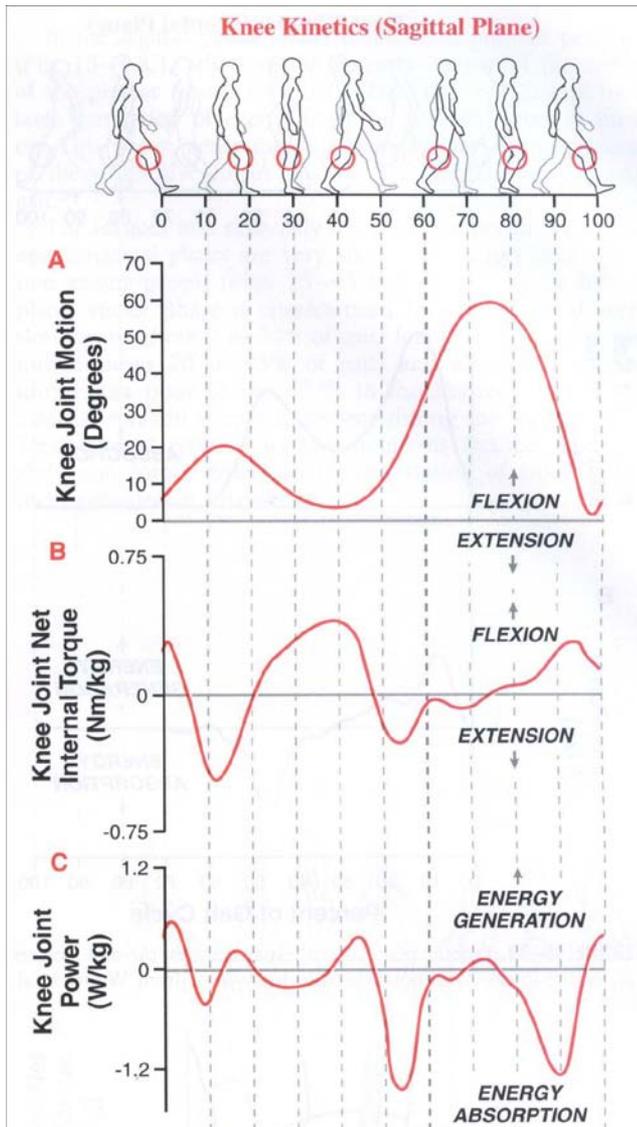
4.13 Joint moment-of-force profiles from three repeat trials of a patient fit total hip replacement.

Winter D, 1990



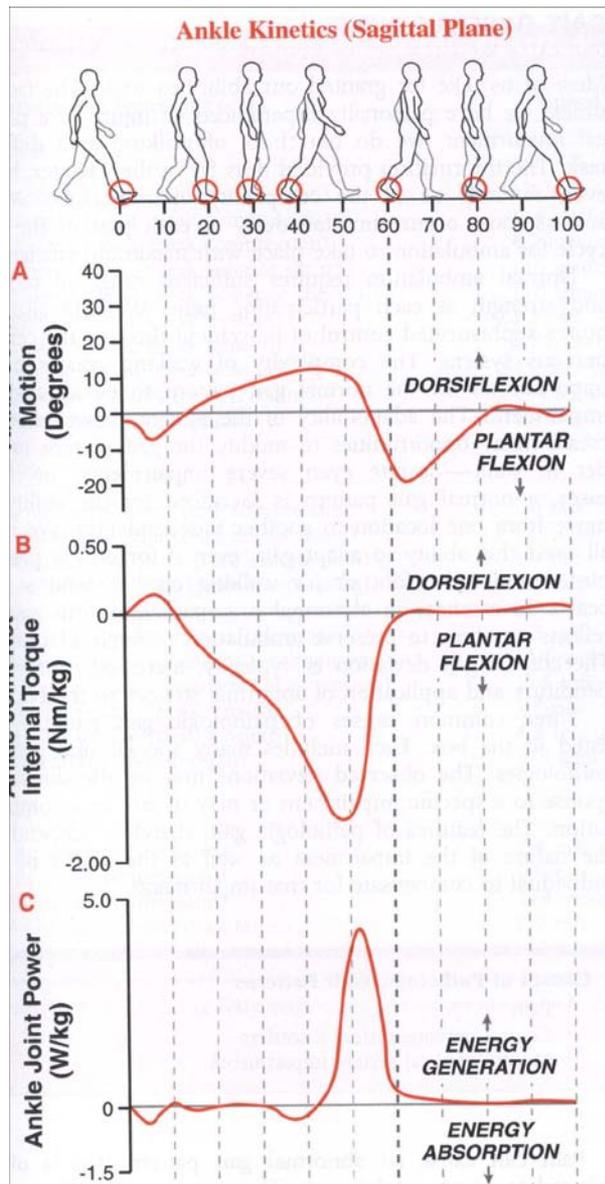
## MOMENTO ARTICULAR

- ✓ Los músculos de cadera ayudan al cuadriceps en el control de la semiflexión de rodilla.
- ✓ Los extensores de cadera controlan el desplazamiento anterior del cg.



## MOMENTO ARTICULAR

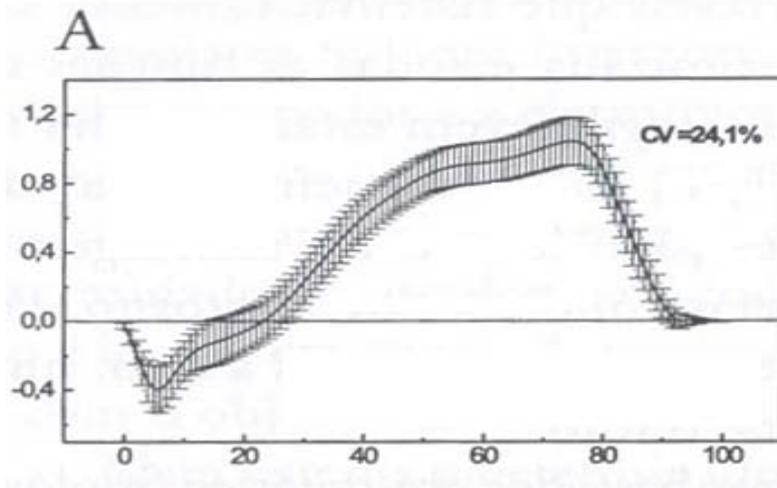
- ✓ El cuadriceps genera un momento extensor, controlando la semiflexión de rodilla durante el apoyo medio.
- ✓ Durante la propulsión, el cuadriceps actúa excéntricamente.



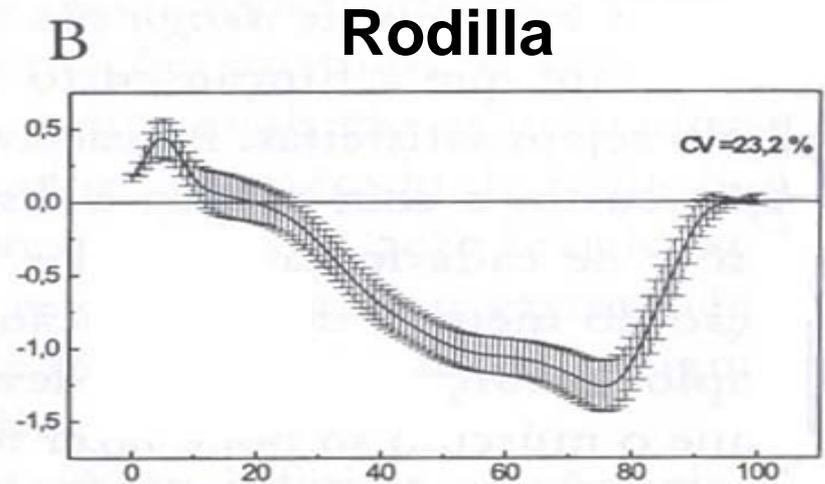
## MOMENTO ARTICULAR

- ✓ Los dorsiflexores generan un momento positivo, actuando excéntricamente en el apoyo plantar.
- ✓ Los plantiflexores actúan concéntricamente durante la propulsión.

# Momento articular de fuerza



**Tobillo**



Muestra variabilidad intrínseca durante la marcha (CV).

# POTENCIA MUSCULAR

- Potencia muscular es el producto de la velocidad por la fuerza.
- Es directamente proporcional a la fuerza o la velocidad.

$$P = \frac{T}{\Delta t}$$

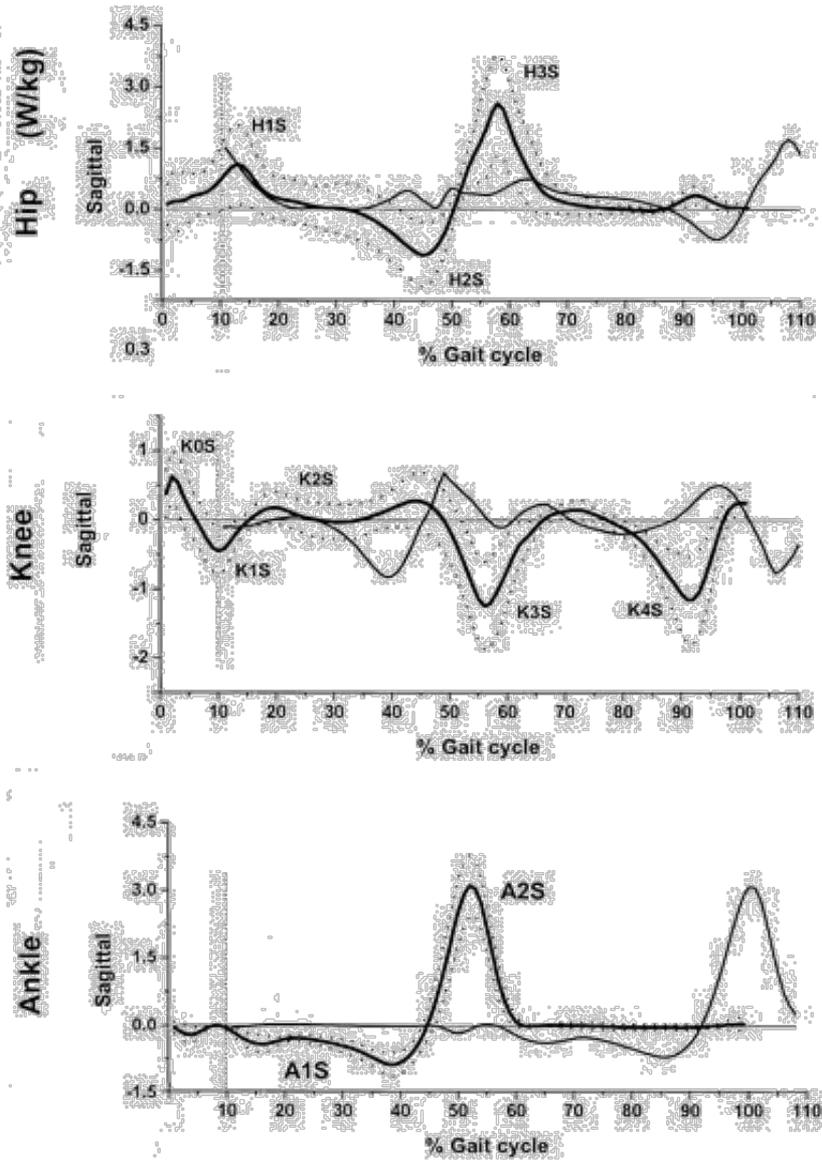
$$P = \frac{F \times D}{\Delta t}$$

$$P = F \times v$$

( 1W= 1J/s)

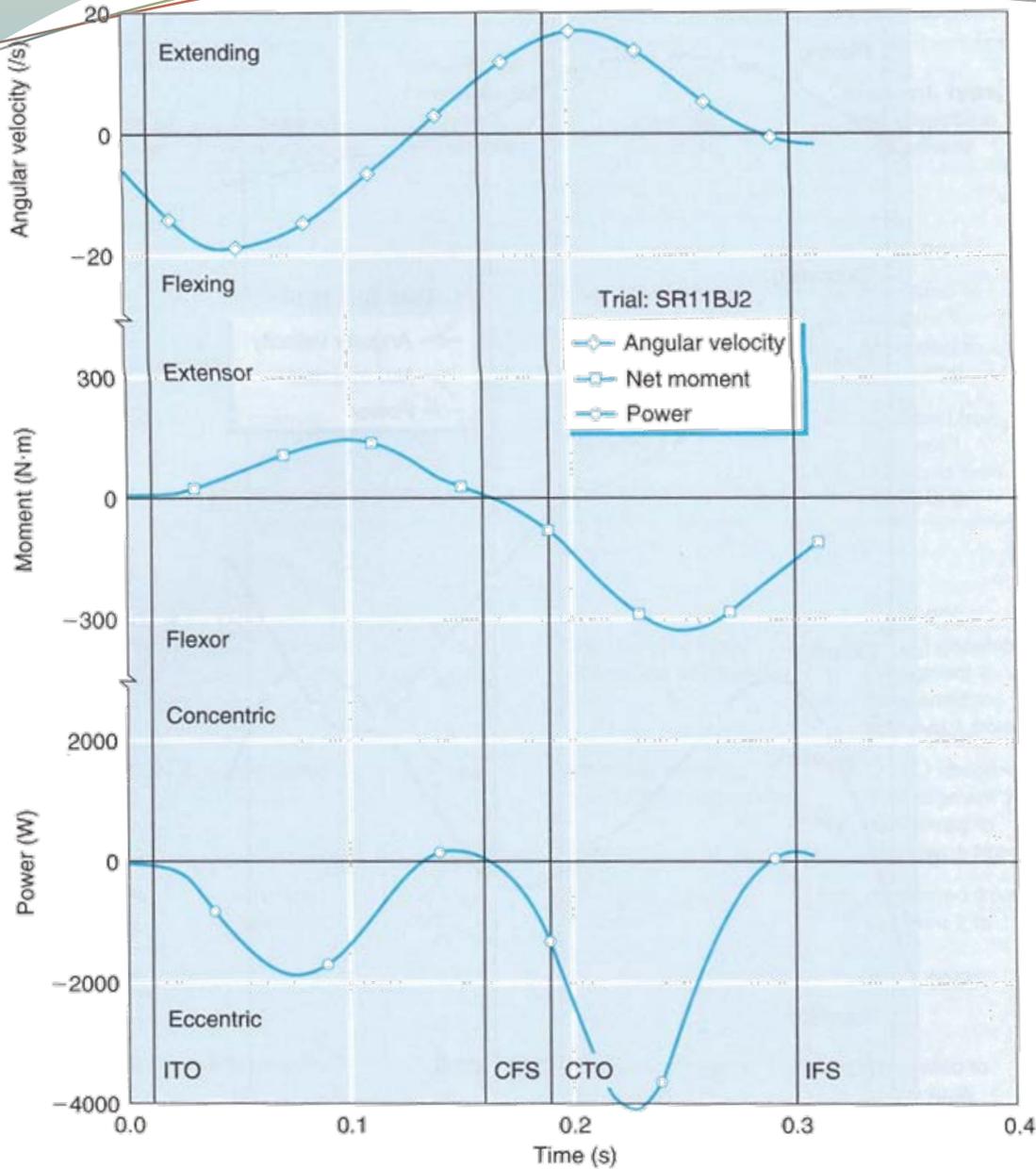
# POTENCIA MUSCULAR (marcha)

(+) Genera E  
 (-) Absorbe E



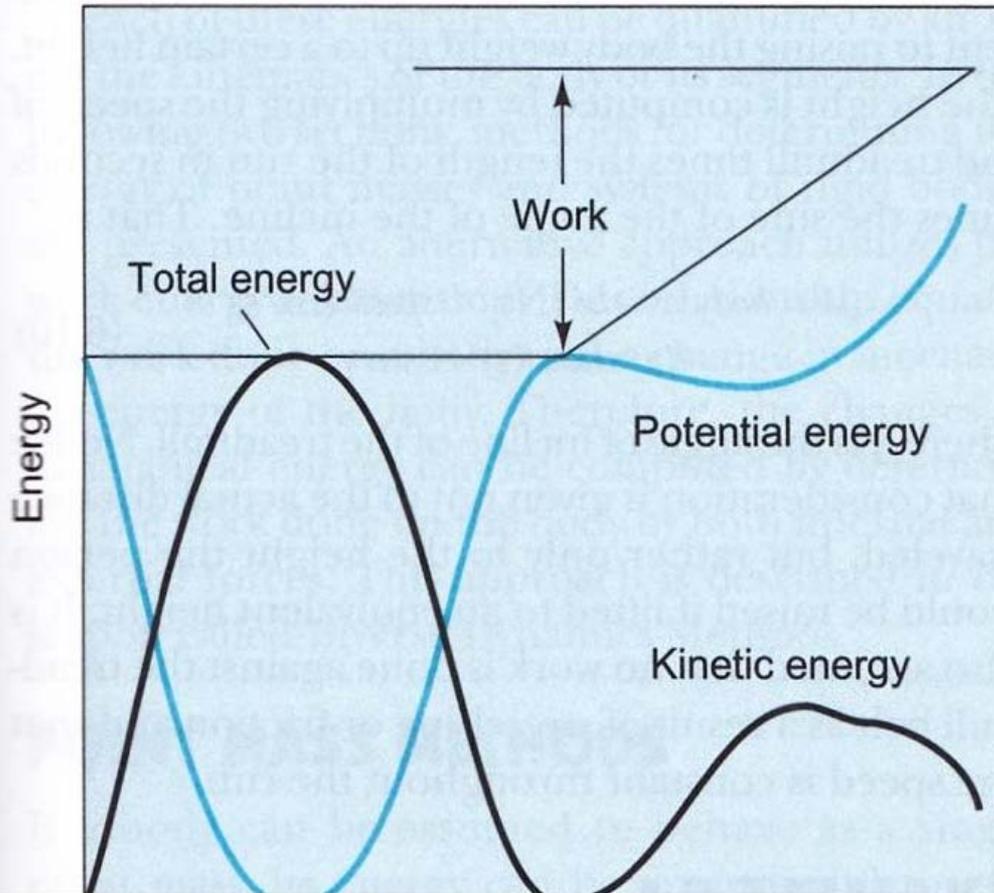
— MID  
 — MII  
 - - - DE

Knee angular velocity, moment, and power



# VELOCIDAD ANGULAR, MOMENTO Y POTENCIA (rodilla)

# ENERGÍA



- Energía es la capacidad de realizar un trabajo.
- Energía mecánica (J): cinética y potencial.

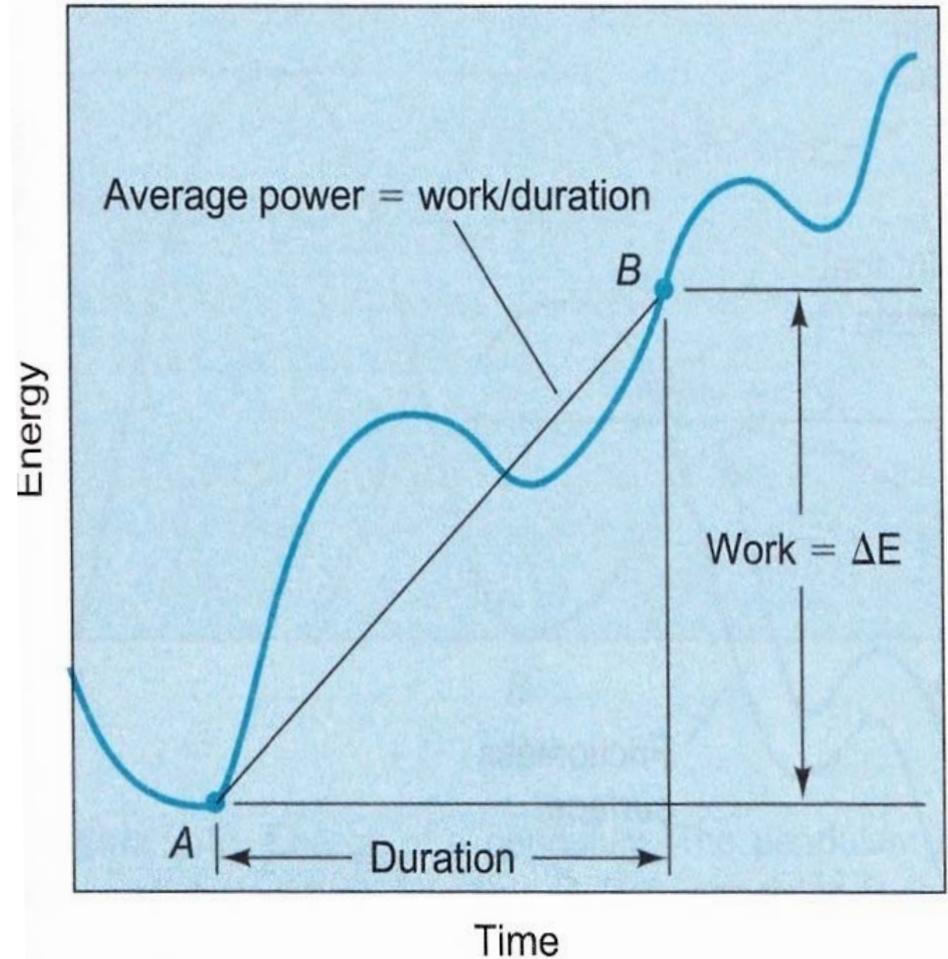
# ENERGÍA

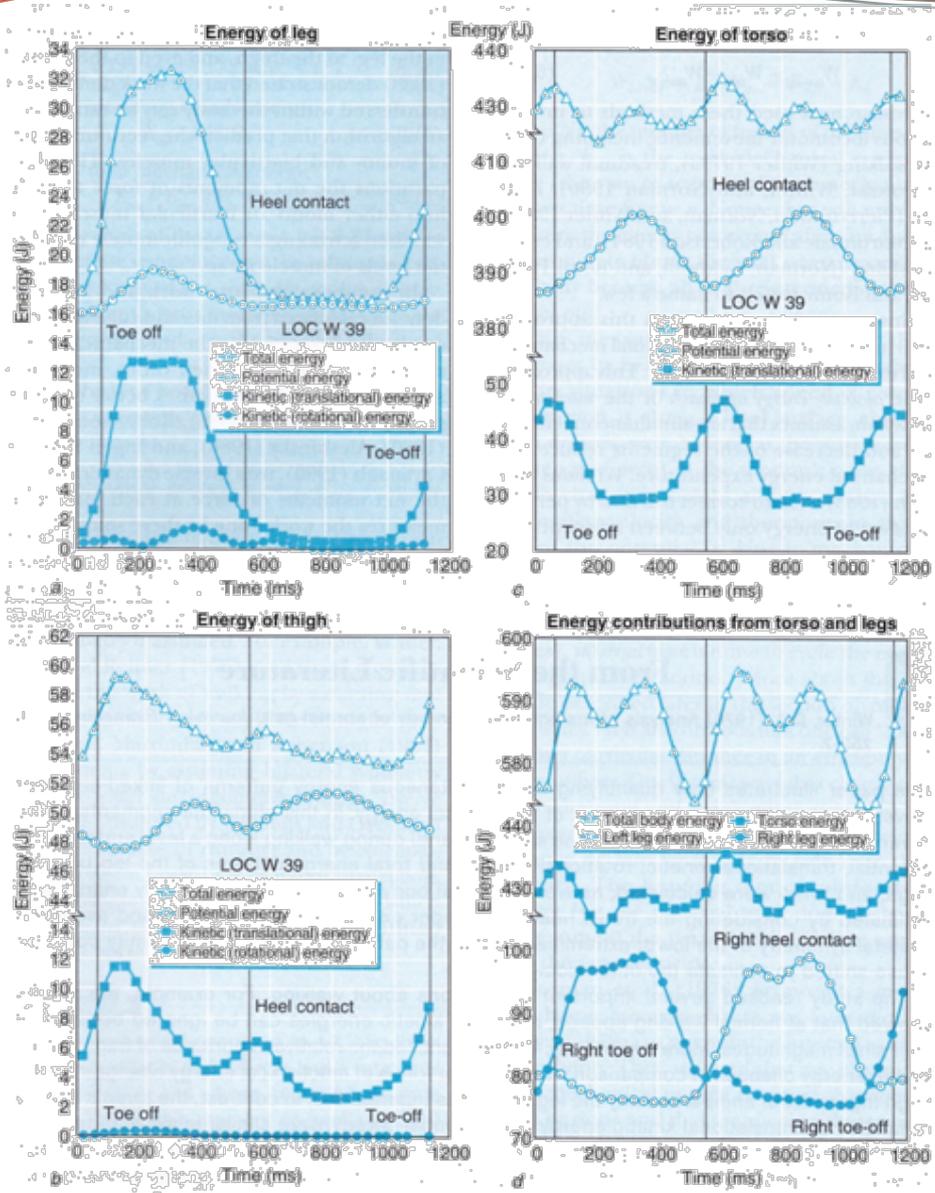
- **Energía cinética:**  
resulta del movimiento.

$$EC = \frac{1}{2} mv^2$$

- **Energía potencial:**  
almacenada.

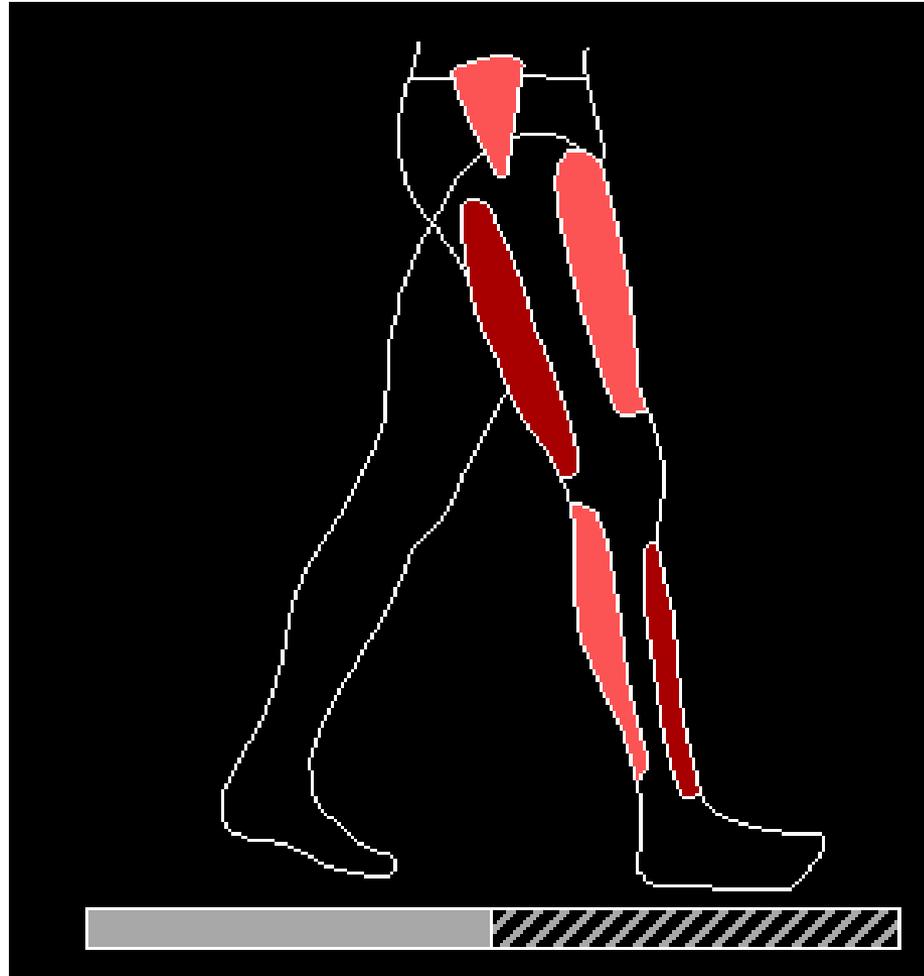
$$EP = m \cdot g \cdot h$$



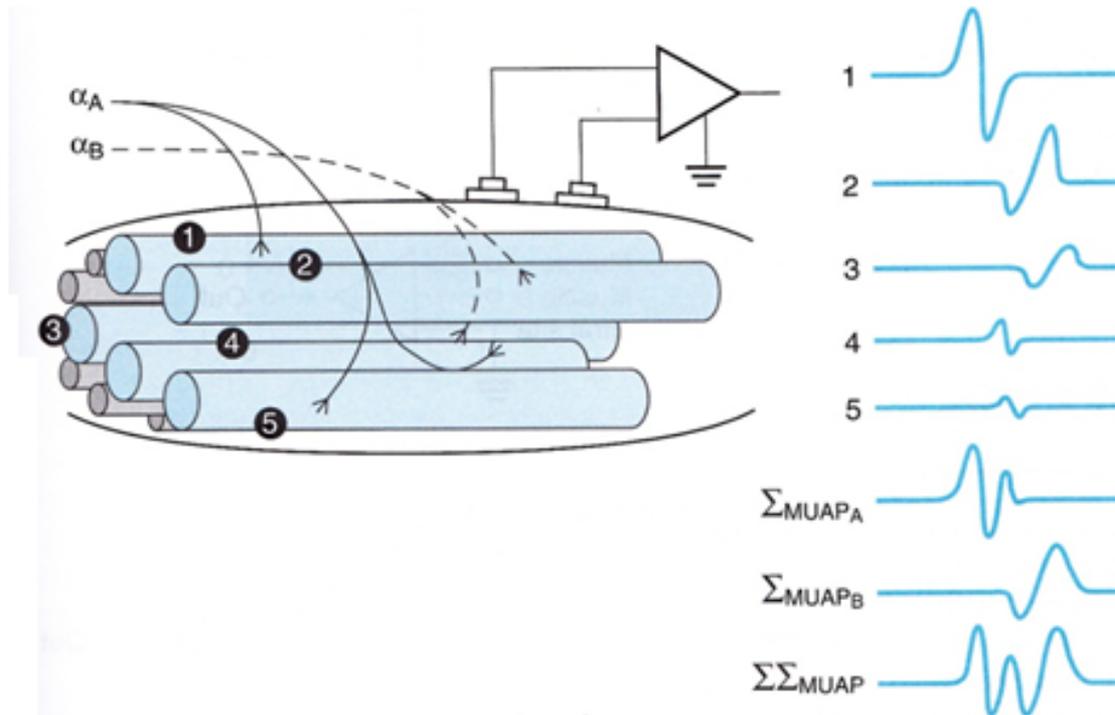


# ENERGÍA (marcha)

# ELECTROMIOGRAFÍA

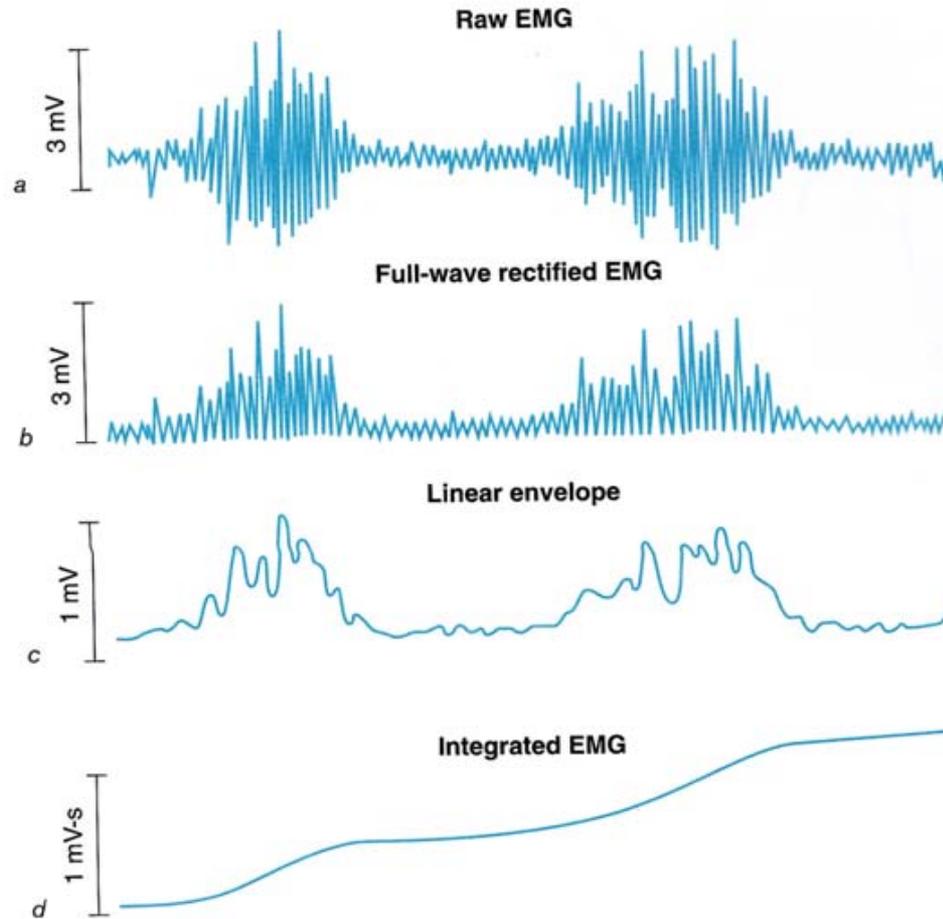


# REGISTRO SEÑAL



• **Figure 8.2** The contribution that each fiber's AP makes to the EMG signal depends in large part on the depth of the fiber; note that fiber 5 contributes a smaller AP than fiber 1. The temporal characteristics of the signal also depend on the electrode-motor endplate distance, as well as the terminal lengths and diameters of the motoneurons. Two motor units are shown here, with the amplitude of each motor unit represented as the algebraic sum of the individual muscle fiber APs ( $\Sigma_{MUAP}$ ). The overall signal is the algebraic sum of all motor units ( $\Sigma\Sigma_{MUAP}$ ).

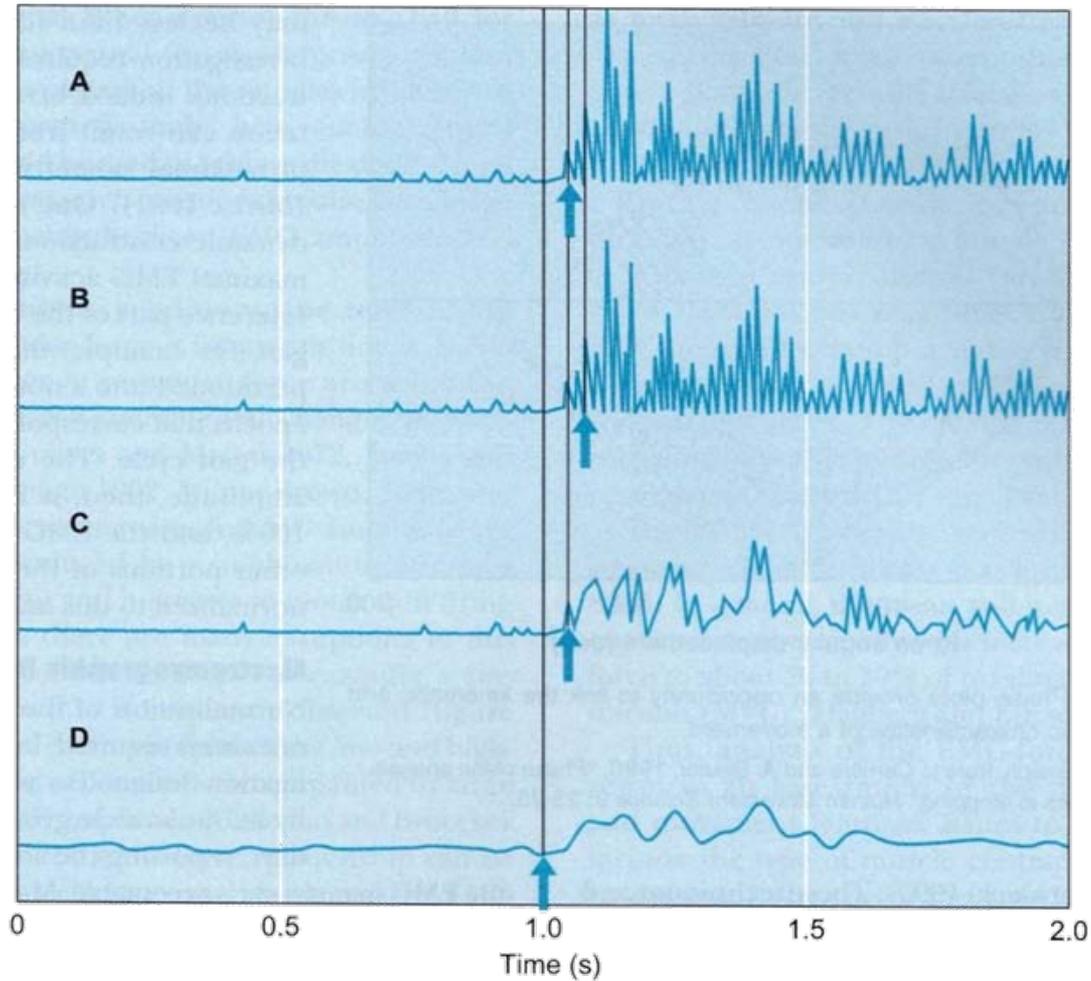
# PROCESAMIENTO SEÑAL



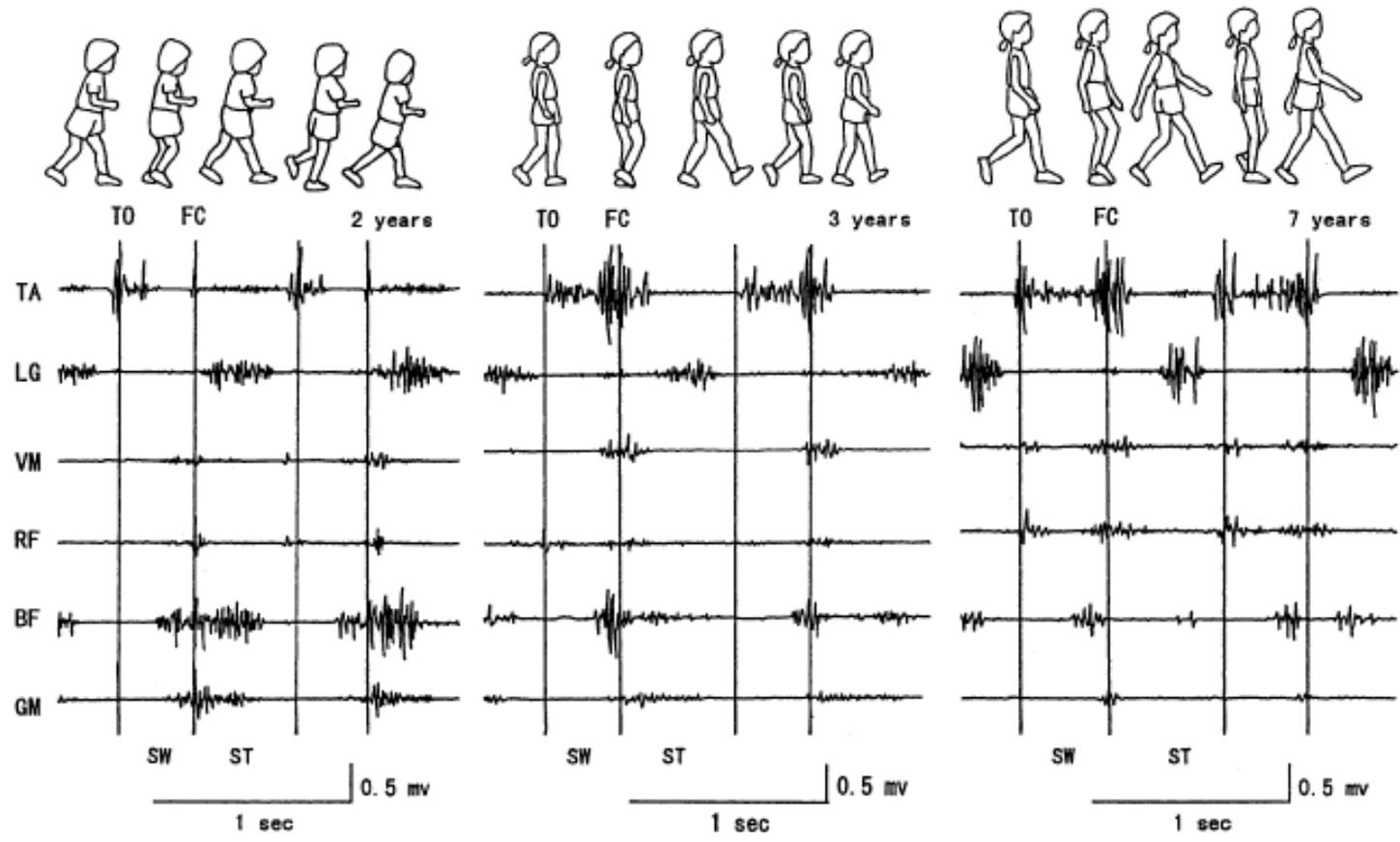
• **Figure 8.7** (a) Raw EMG. (b) Average rectified signal. (c) Linear envelope. (d) Integrated EMG.

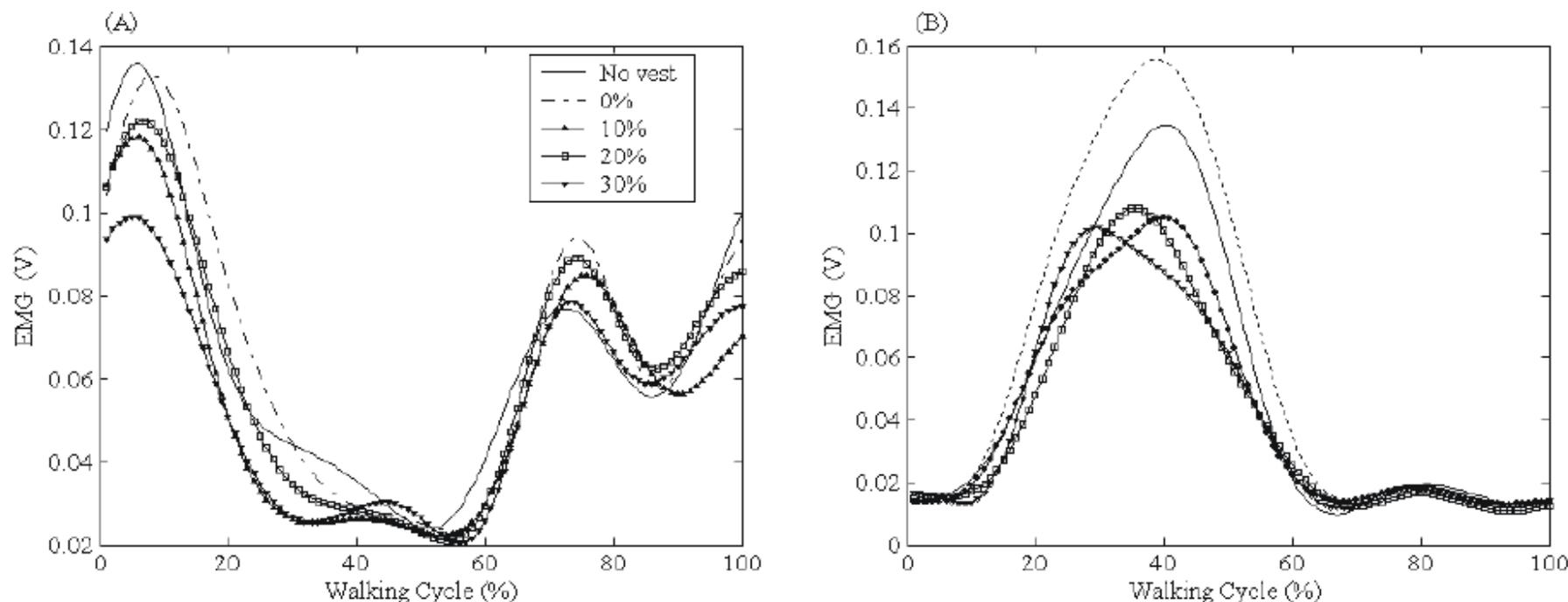
8.7a Reprinted, by permission, from G.F. Harris and J.J. Wertsch, 1994, "Procedures for gait analysis," *Archives of Physical Medicine and Rehabilitation* 75: 216-225.

# FILTRO SEÑAL



• **Figure 8.9** Low-pass filtering can have a considerable impact on the identification of EMG onset time. (a) Full-wave rectified raw EMG. Note that the onset identification becomes increasingly inaccurate as the signal is increasingly smoothed using low-pass filters from (b) 500 Hz to (c) 50 Hz and finally to (d) 10 Hz.





**Figure 3.** Mean trajectories of electromyographic (EMG) activity from tibialis anterior (A) and gastrocnemius medialis (B) muscles during the walking cycle, under the five experimental conditions.

**Filtro digital Butterworth de cuarta orden, pasa-alta con frecuencia de corte de 30Hz y pasa-bajo con frecuencia de corte de 3Hz.**

*Patiño MS et al. 2007*

