



**POLITECNICO**  
MILANO 1863

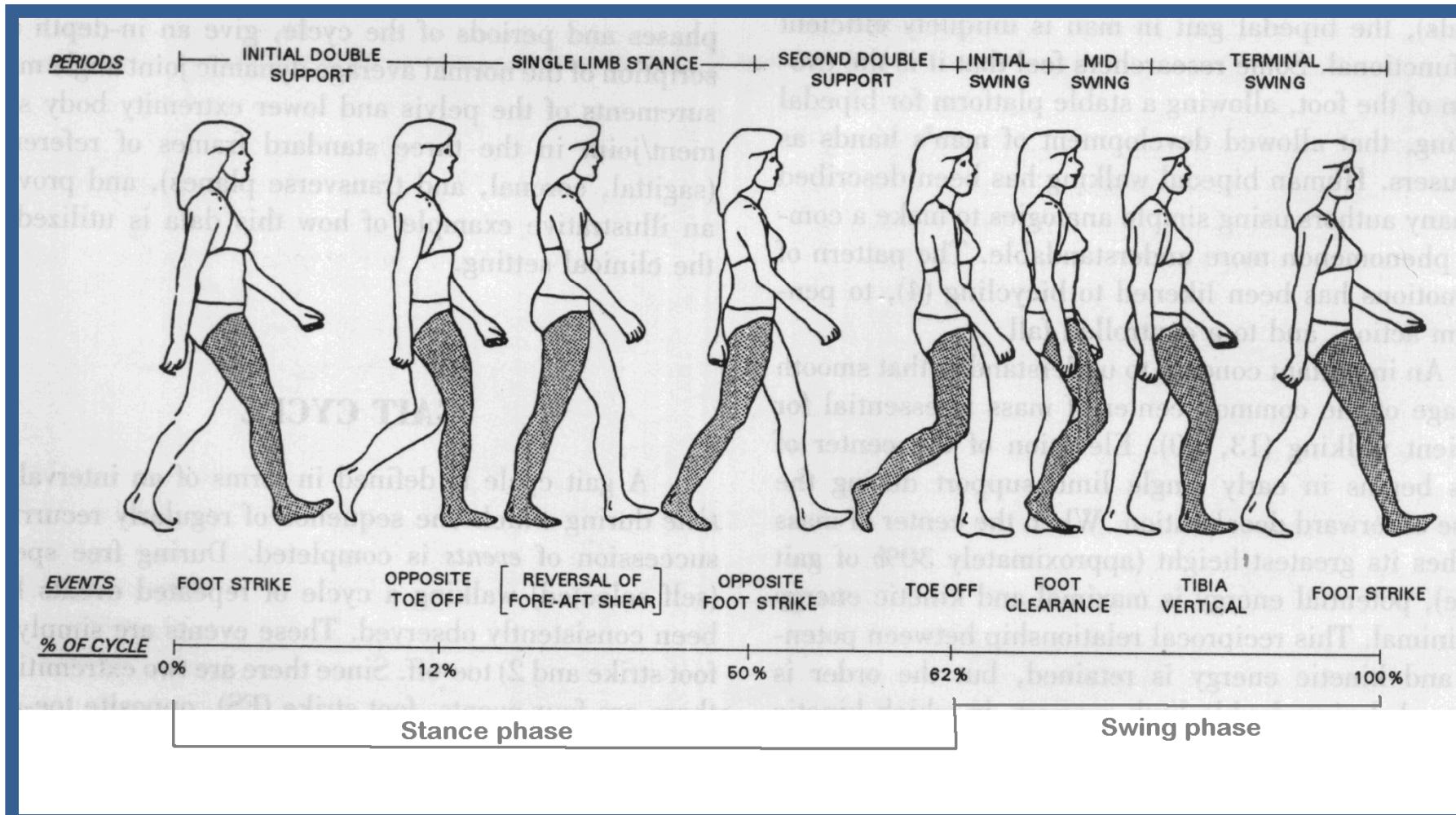
**BIOINGEGNERIA DEL SISTEMA  
MOTORIO  
Sezione: M-Z  
Fenomenologia della locomozione**

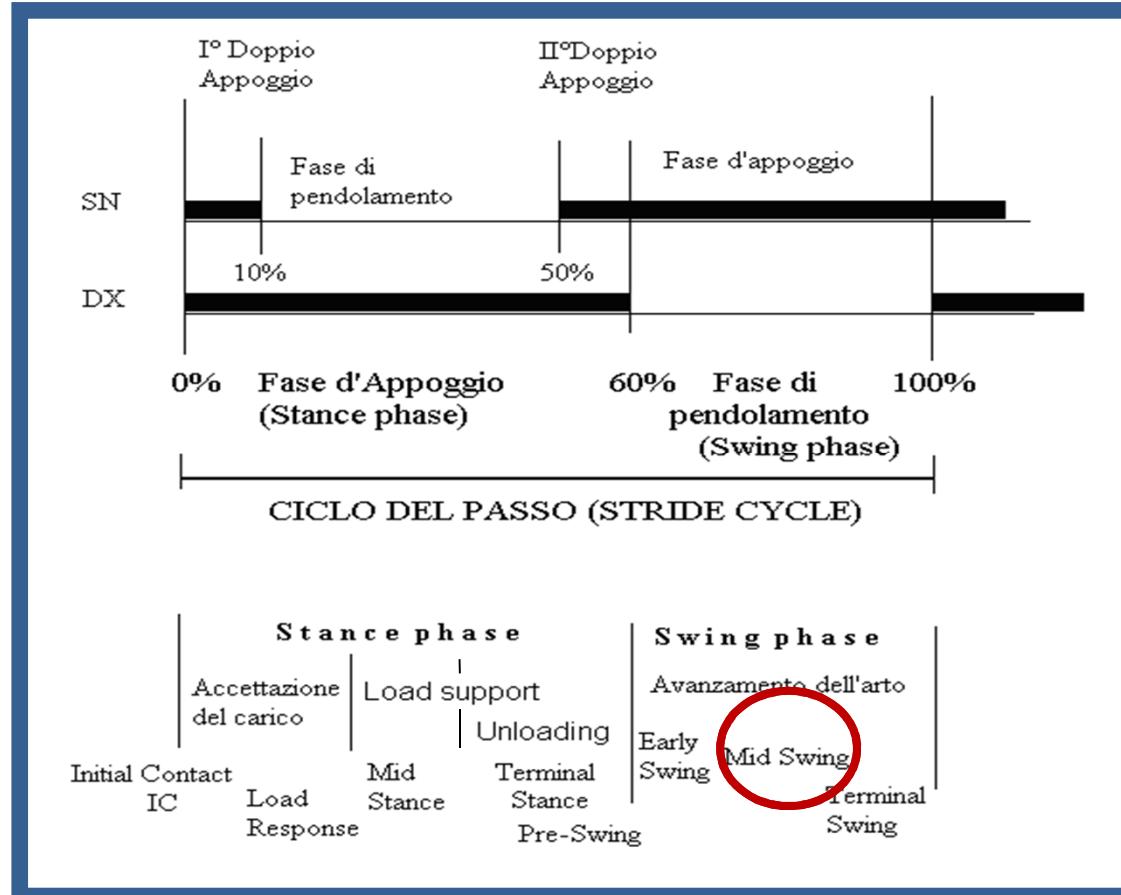
# Analisi biomeccanica della locomozione



# Fasi del Gait stride

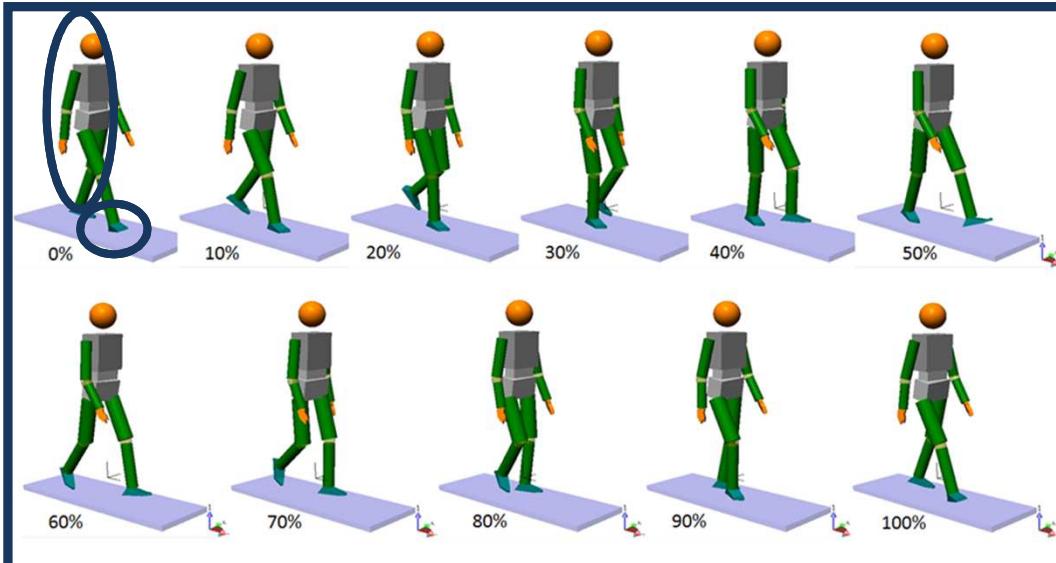
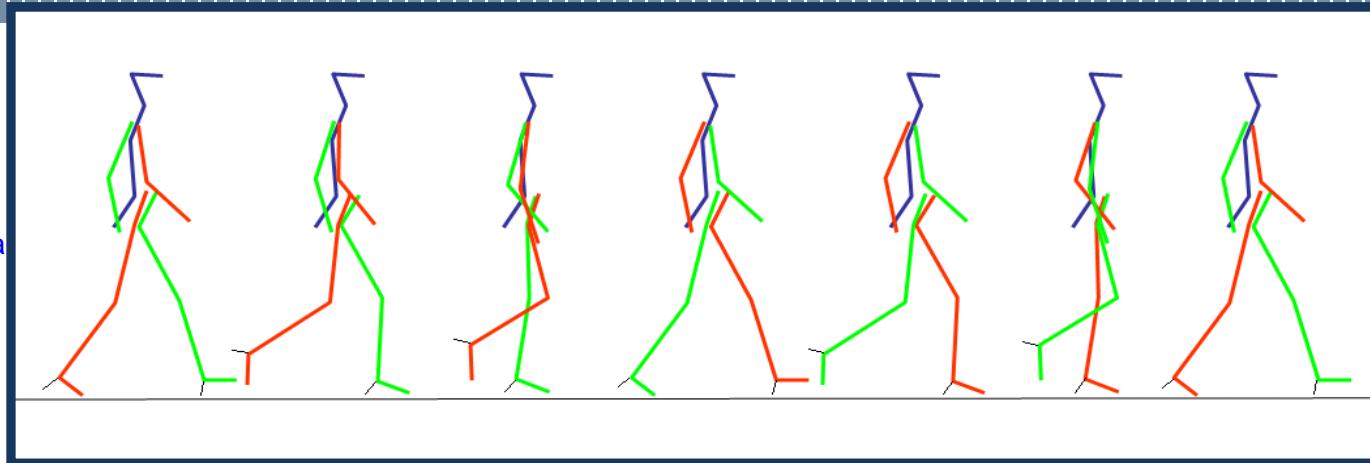
evoluzione filogenetica (della specie) e ontogenetica (dell'individuo)



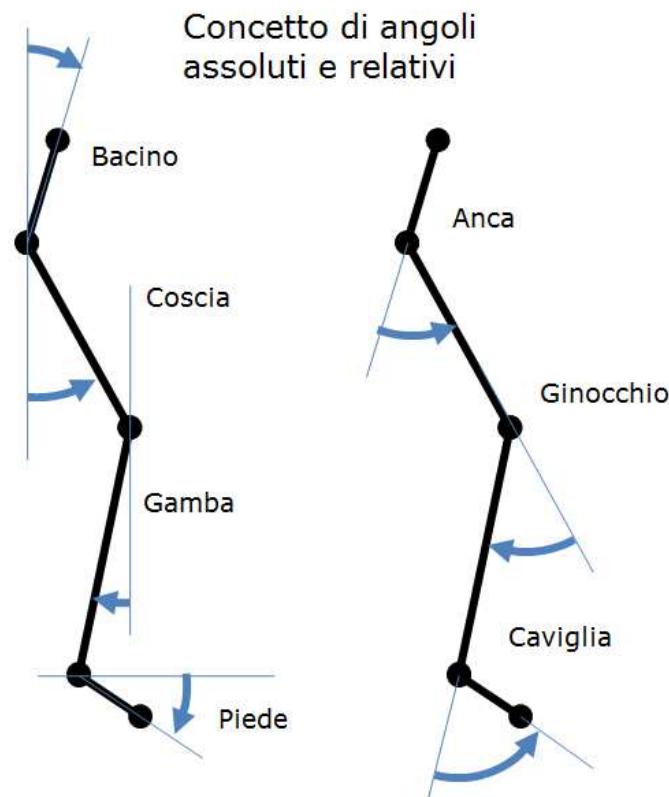
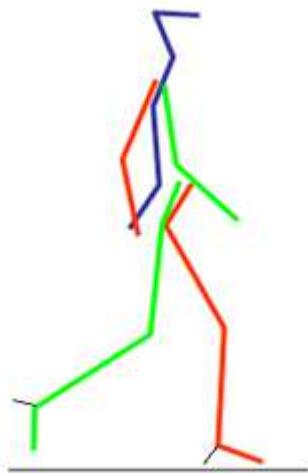


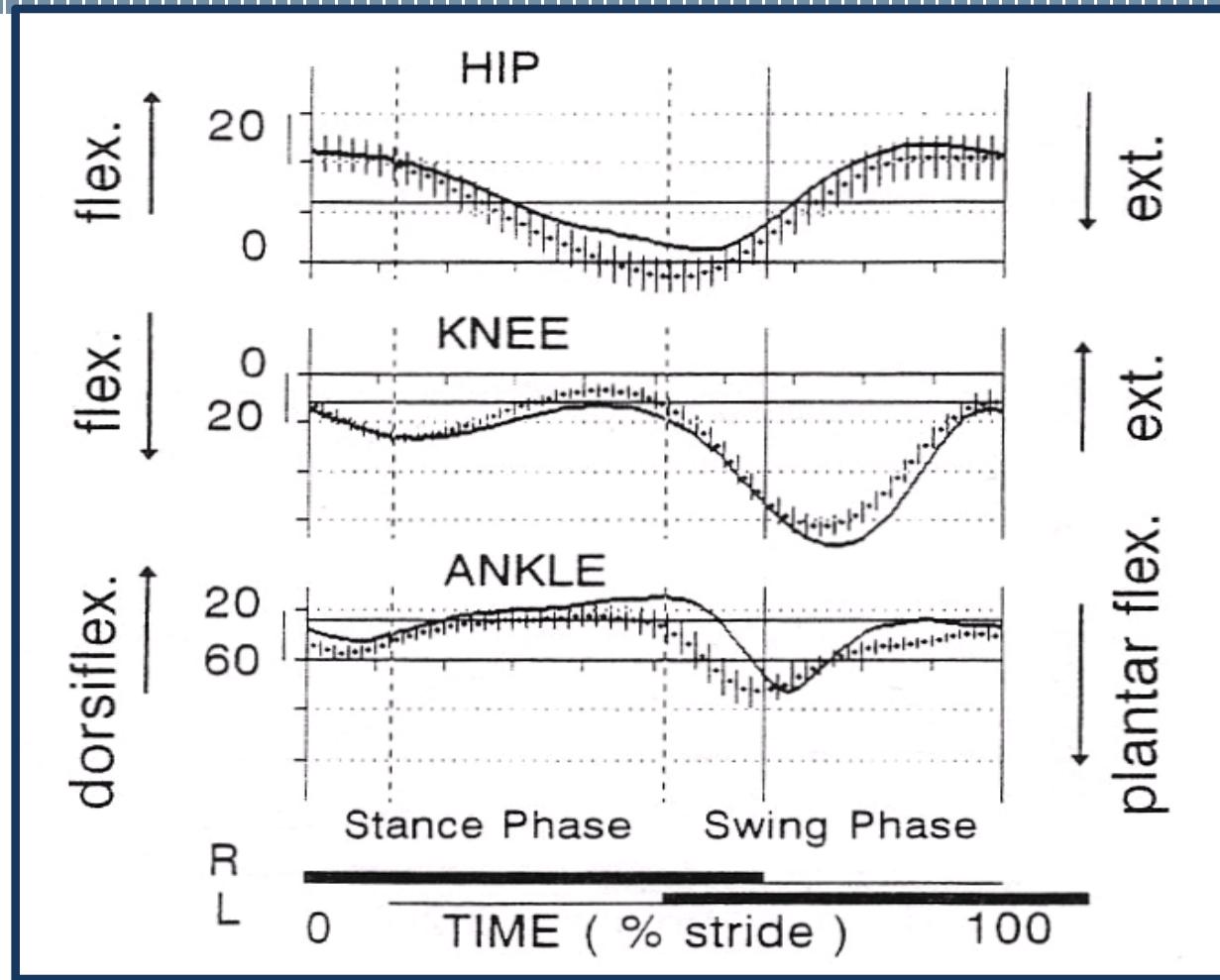
# Movimenti sincroni delle varie parti del corpo

si può notare come gli arti superiori ed inferiori siano in controfase. Evidente in un soggetto SANO, ma viene a mancare in patologie come parkinson e paralisi cerebrale infantile. Questo porta per forza ad una torsione della colonna vertebrale.

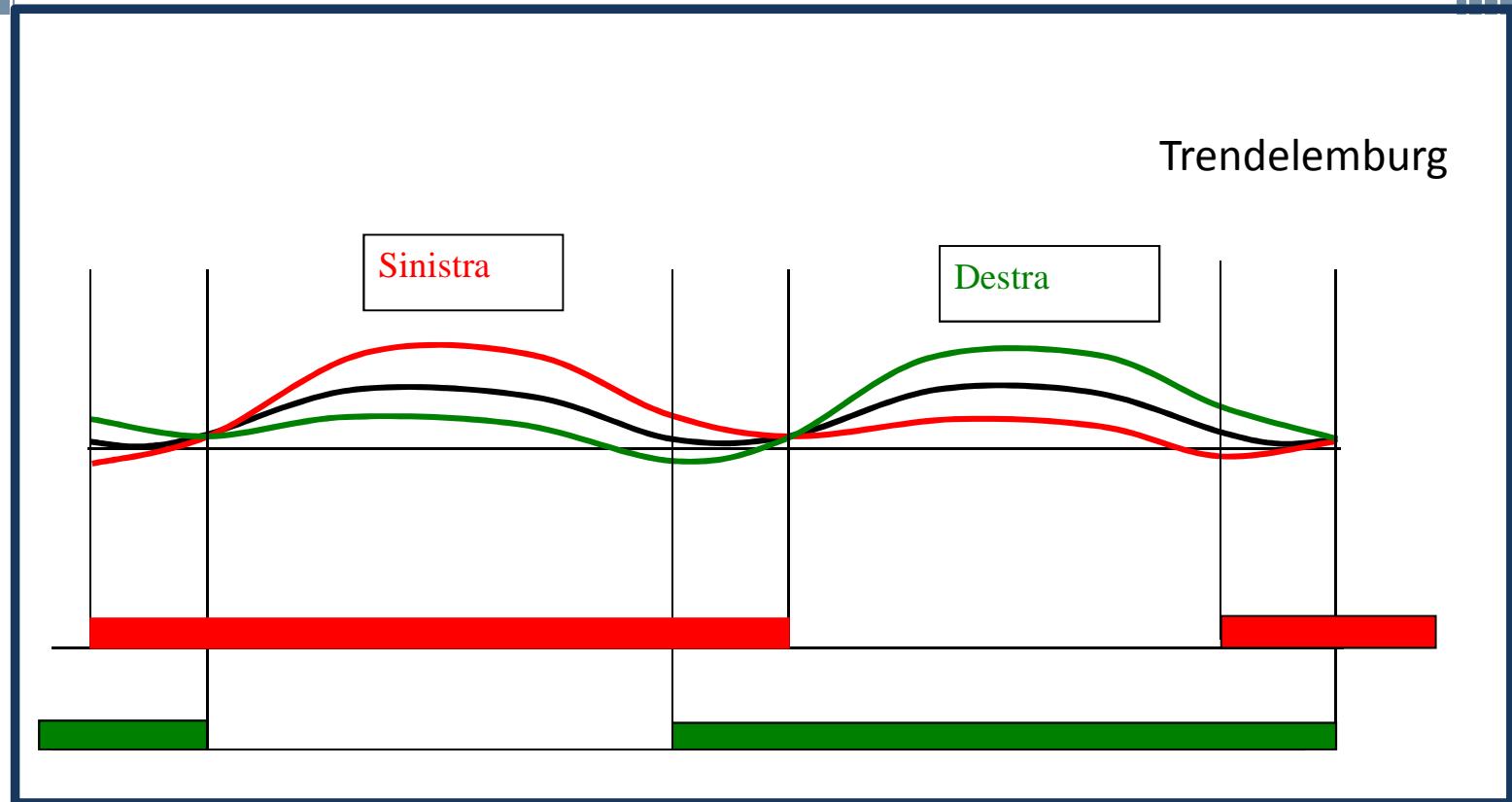


# Angoli assoluti e angoli relativi

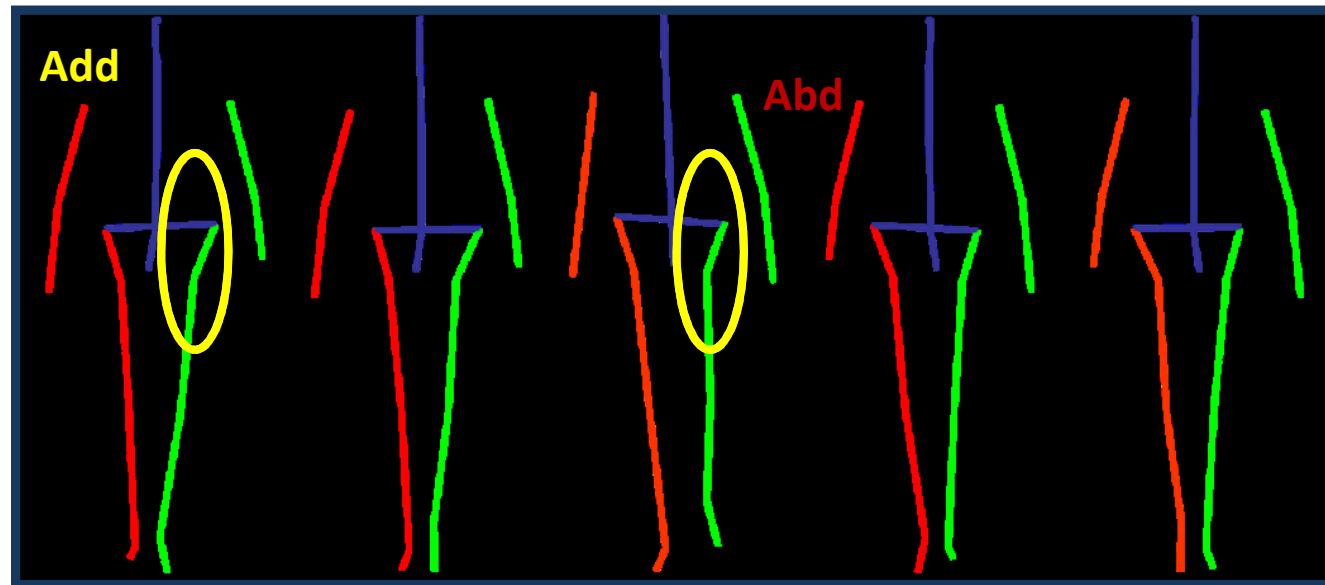




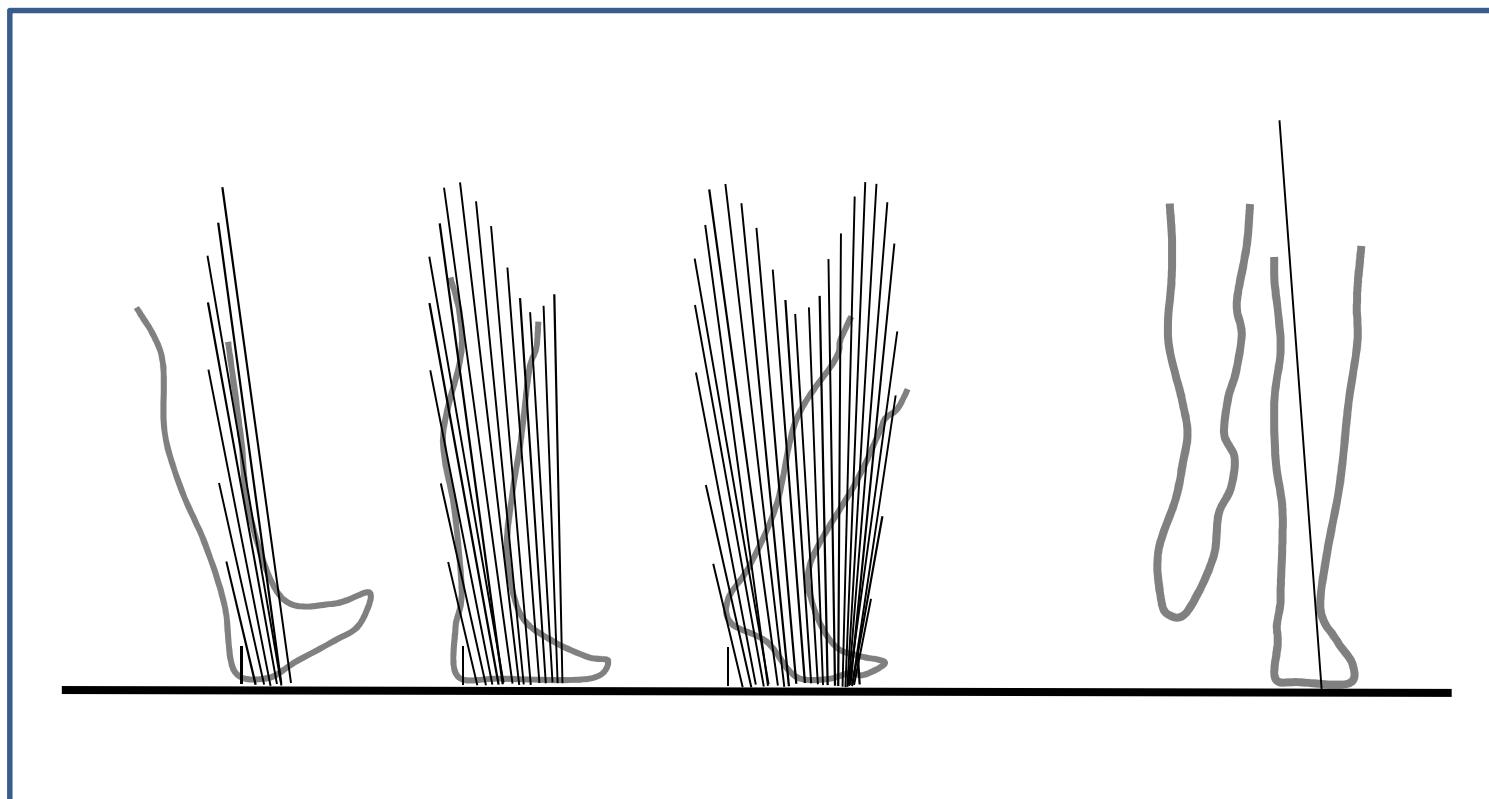
# Spostamenti verticali delle sommità delle creste iliache

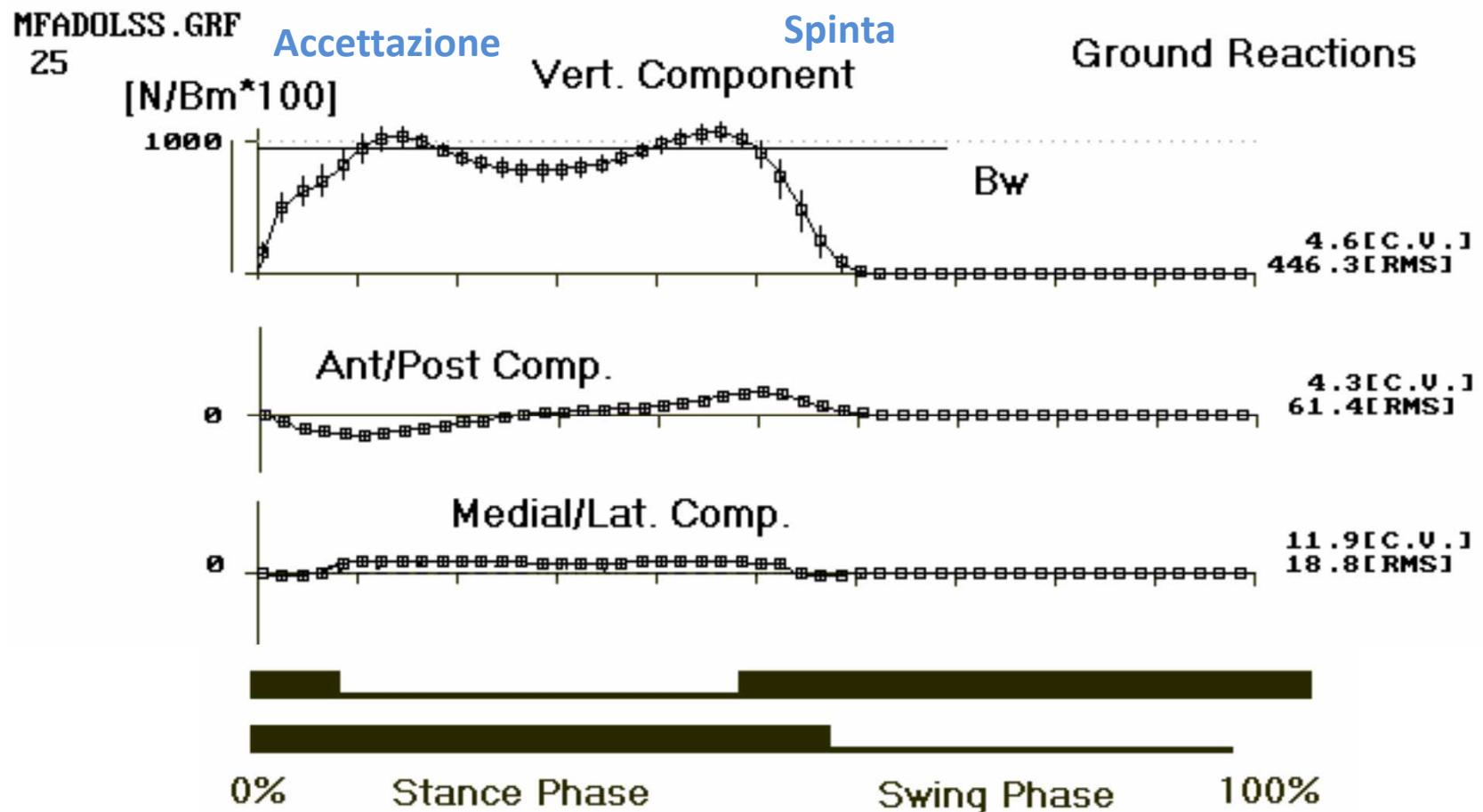


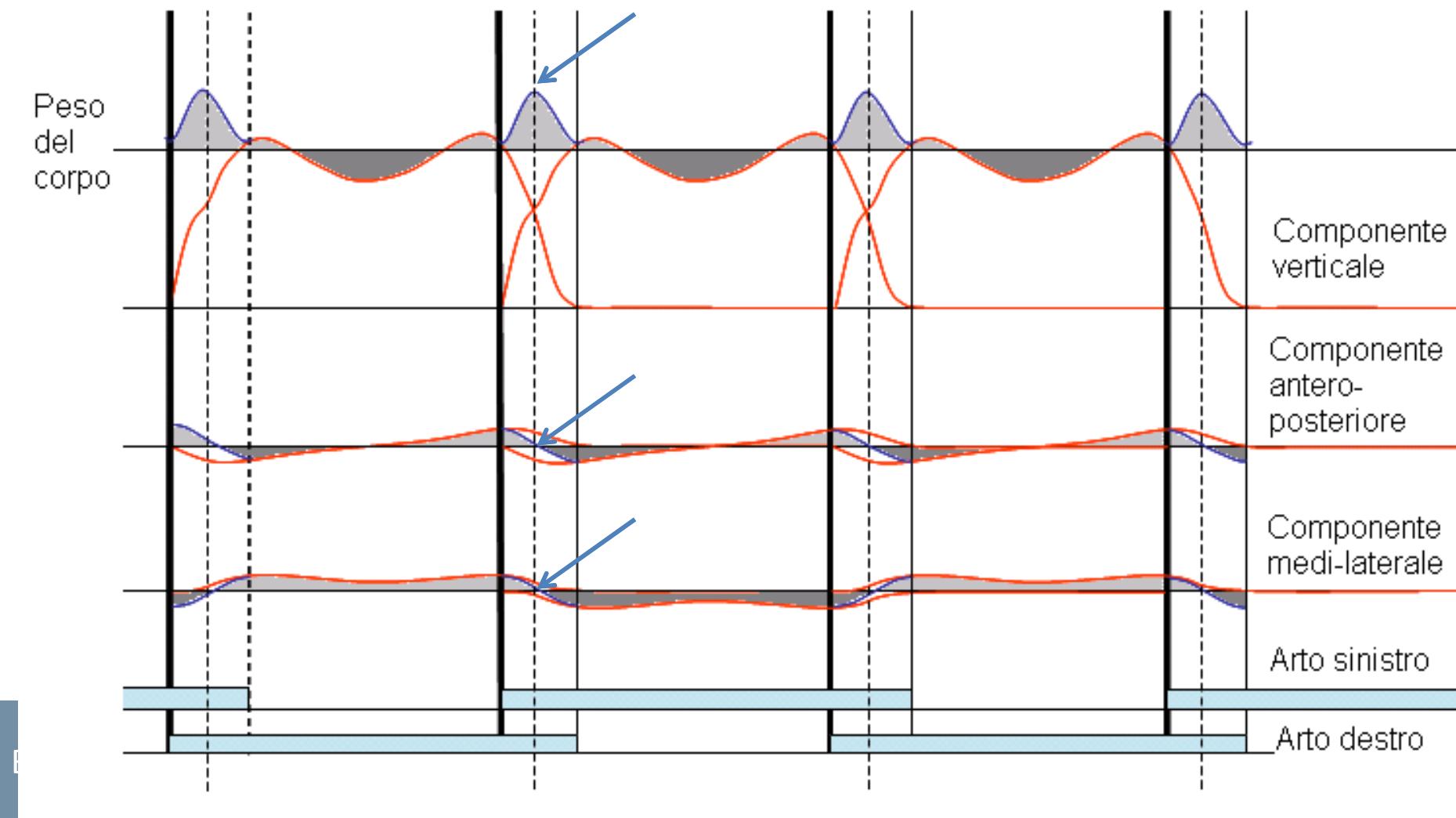
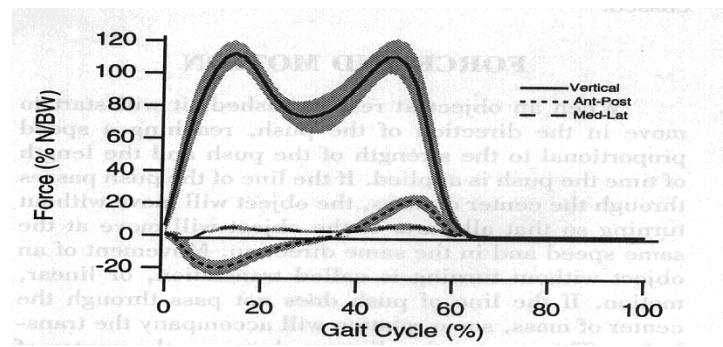
# Piano frontale

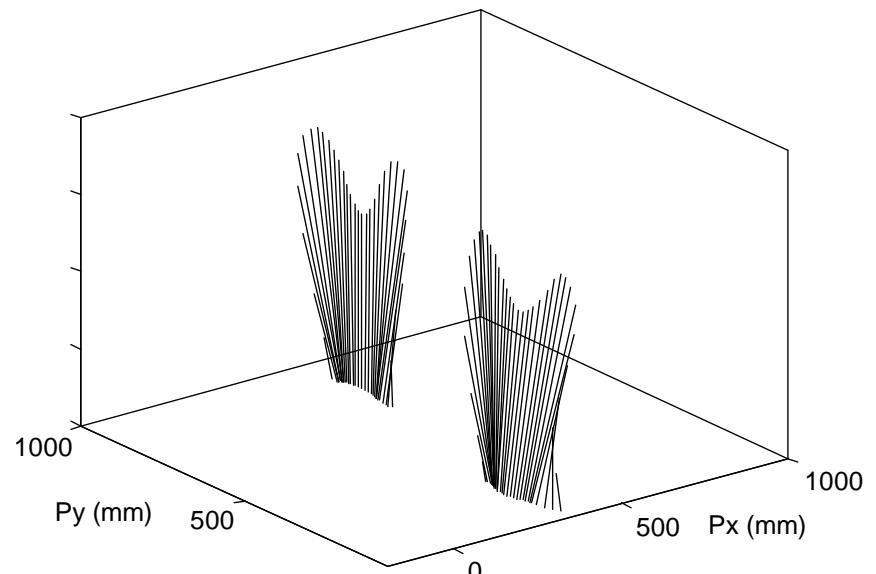
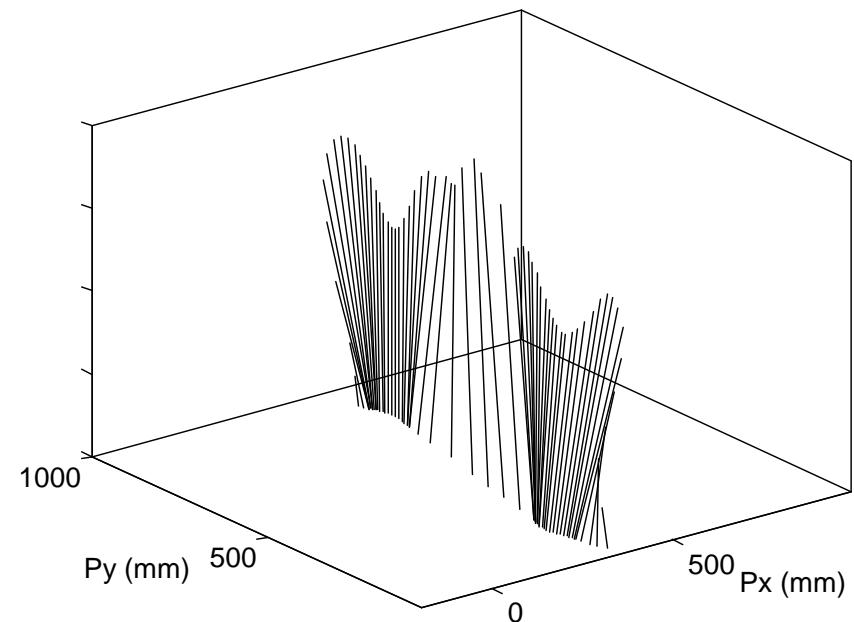
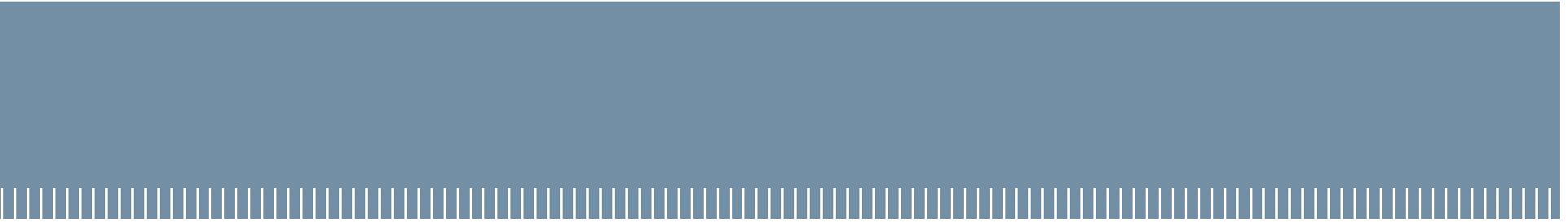


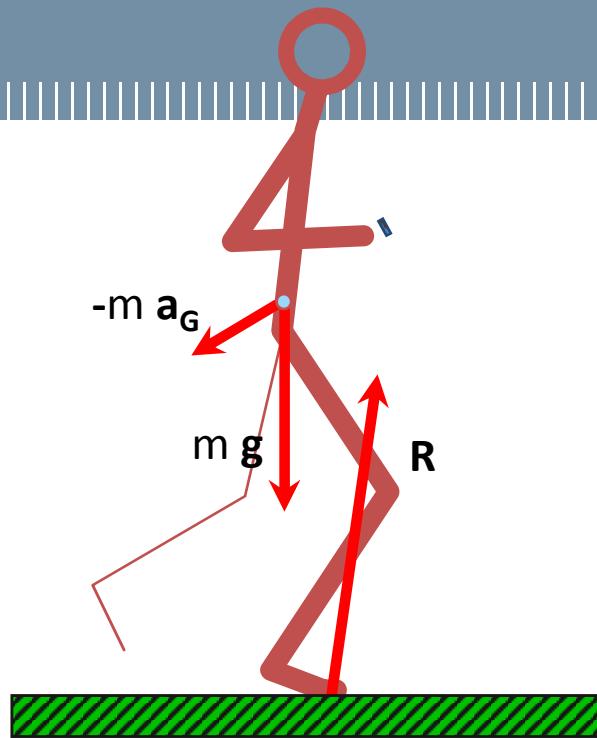
# Inclinazione vettore reazione appoggio piano sagittale e frontale





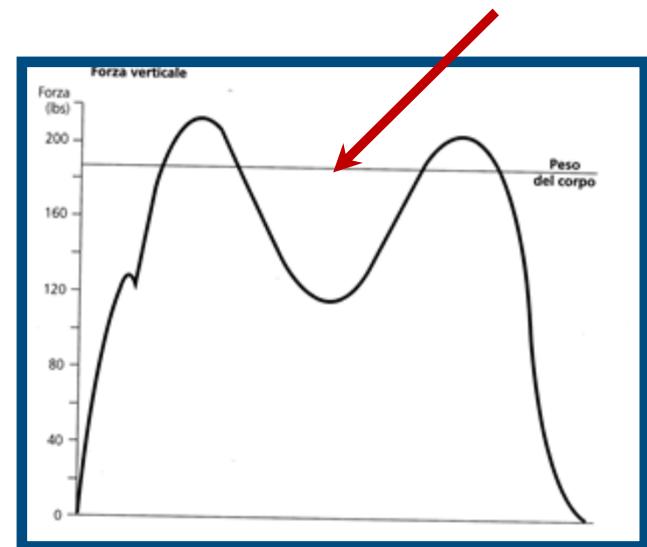






$$R - m g = m a_G$$

A meno di costanti, come il peso corporeo, la **Reazione del terreno** è proporzionale alle accelerazioni del baricentro.

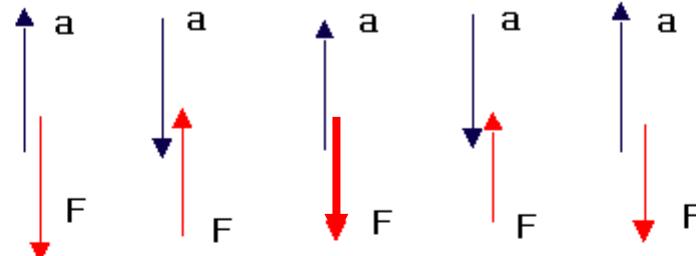


Vertical Acceleration : a

$$a = F / m$$

Inertia Force

$$F = -m a$$



$$R - P = F$$

P

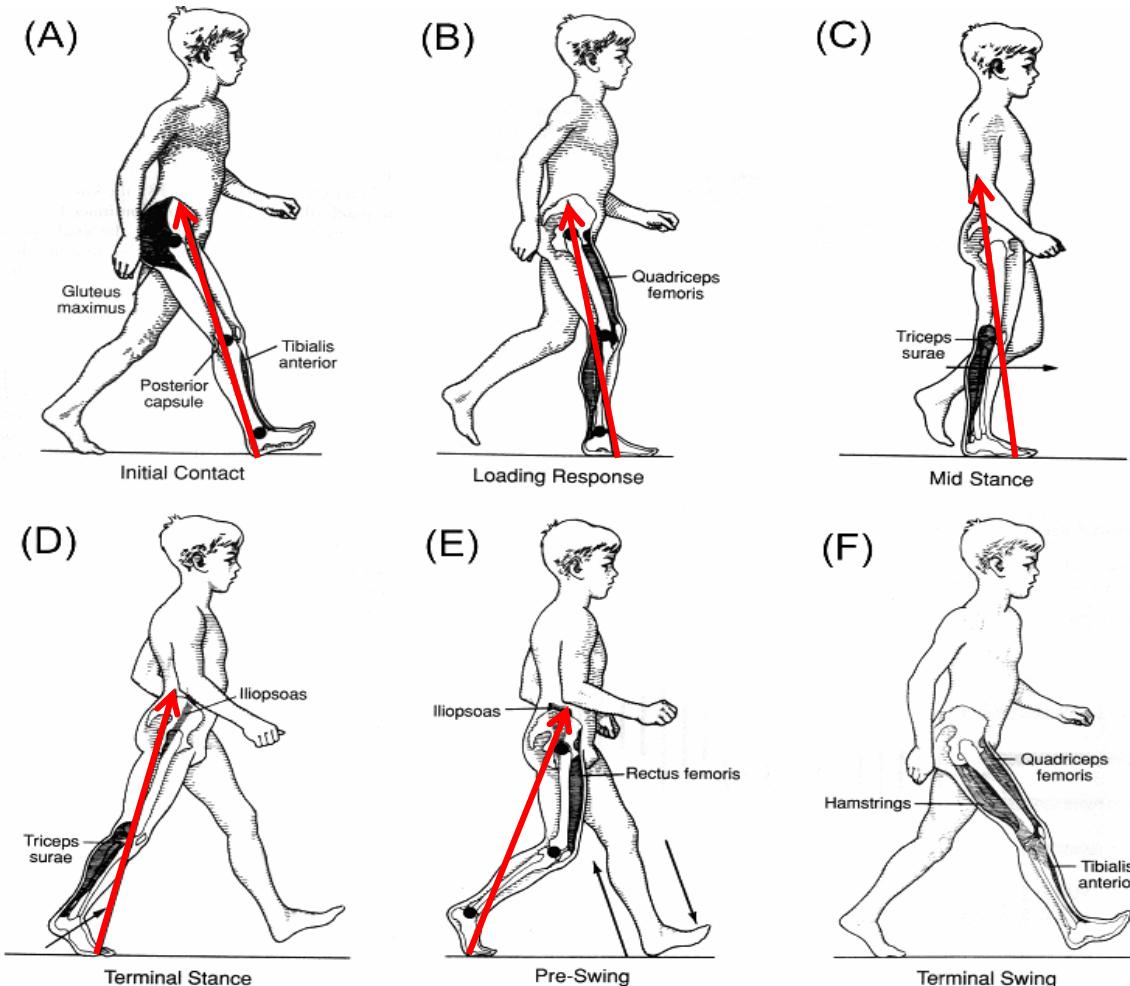
$$R = R_1 + R_2 = (P + F)$$

R1      R2

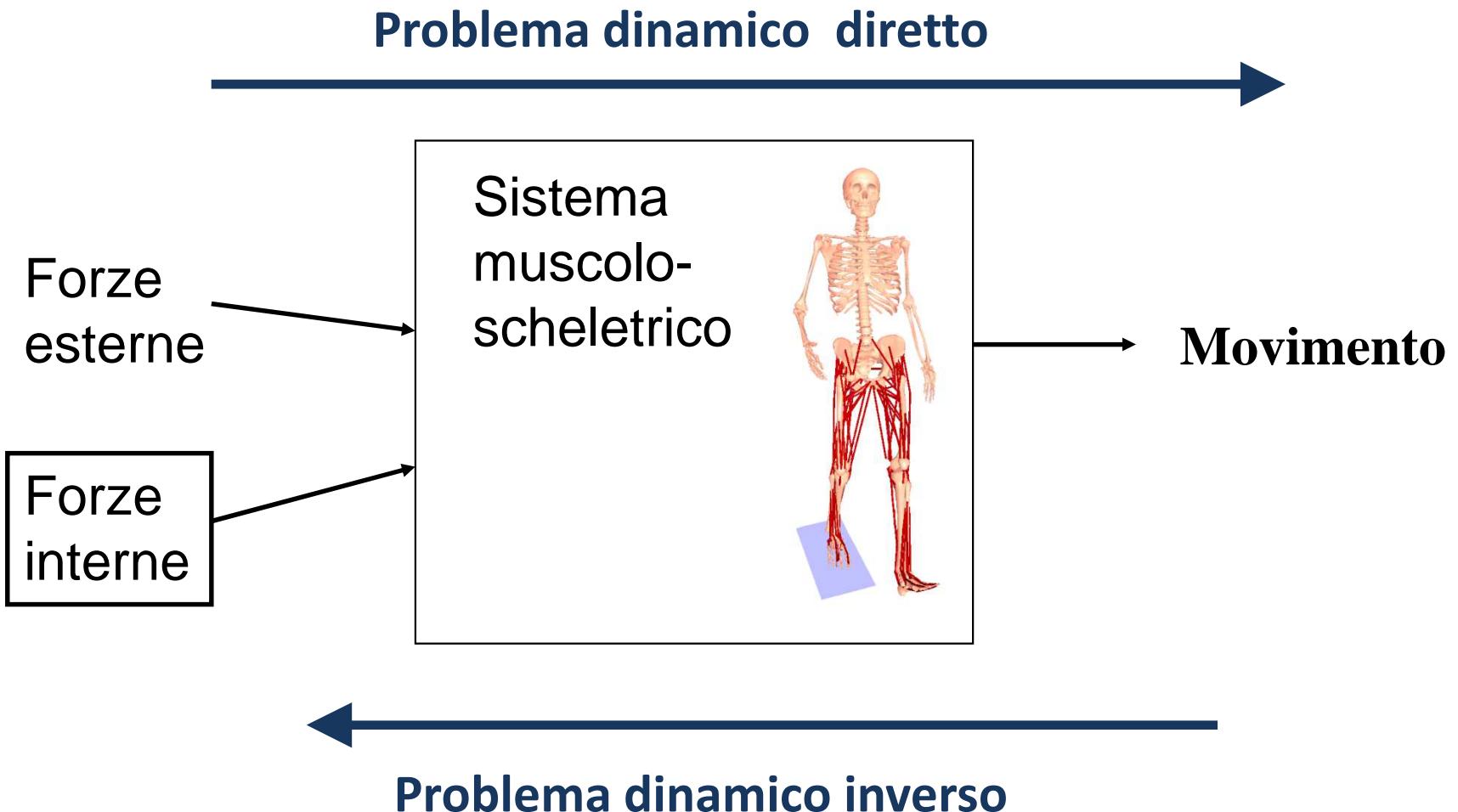
S . A . F . L o

B

# Ruolo dei principali muscoli



# Problema dinamico diretto ed inverso

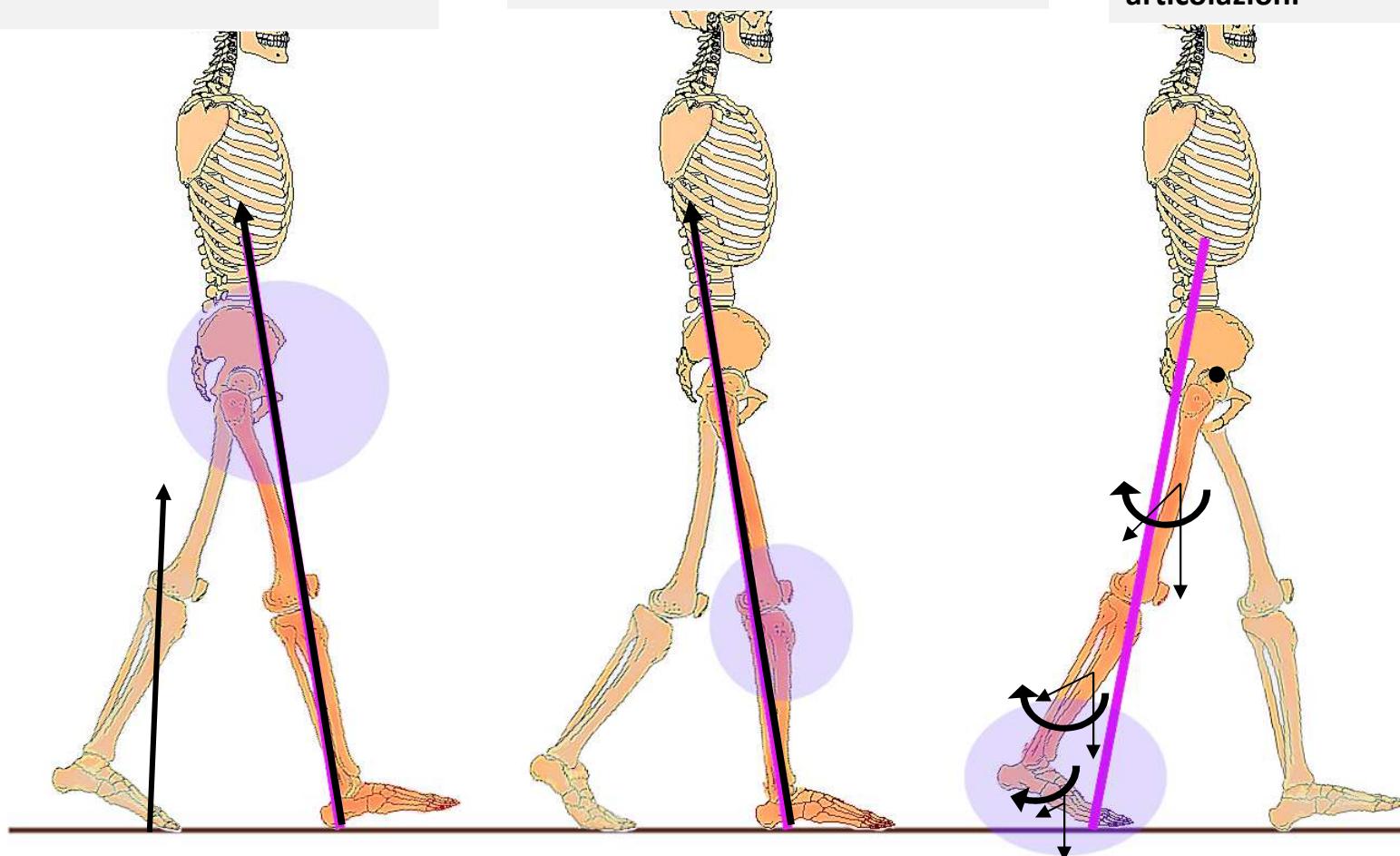


# Momenti articolari

Le REAZIONI D'APPOGGIO sono forze e momenti che si sviluppano all'interfaccia piede-terreno

Un MOMENTO è il risultato di una FORZA che agisce ad una certa DISTANZA da un punto

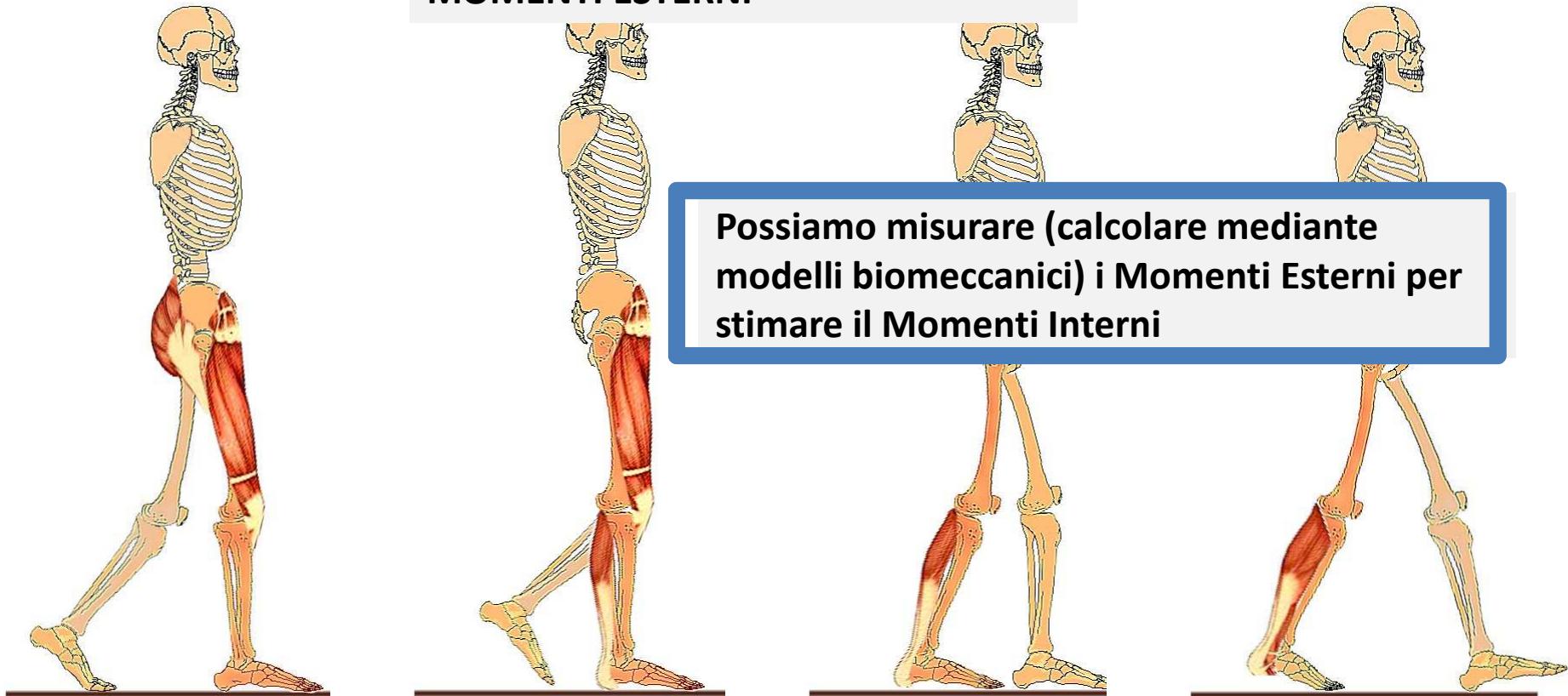
Generalmente siamo interessati ai momenti delle FORZE ESTERNE rispetto ai centri delle articolazioni

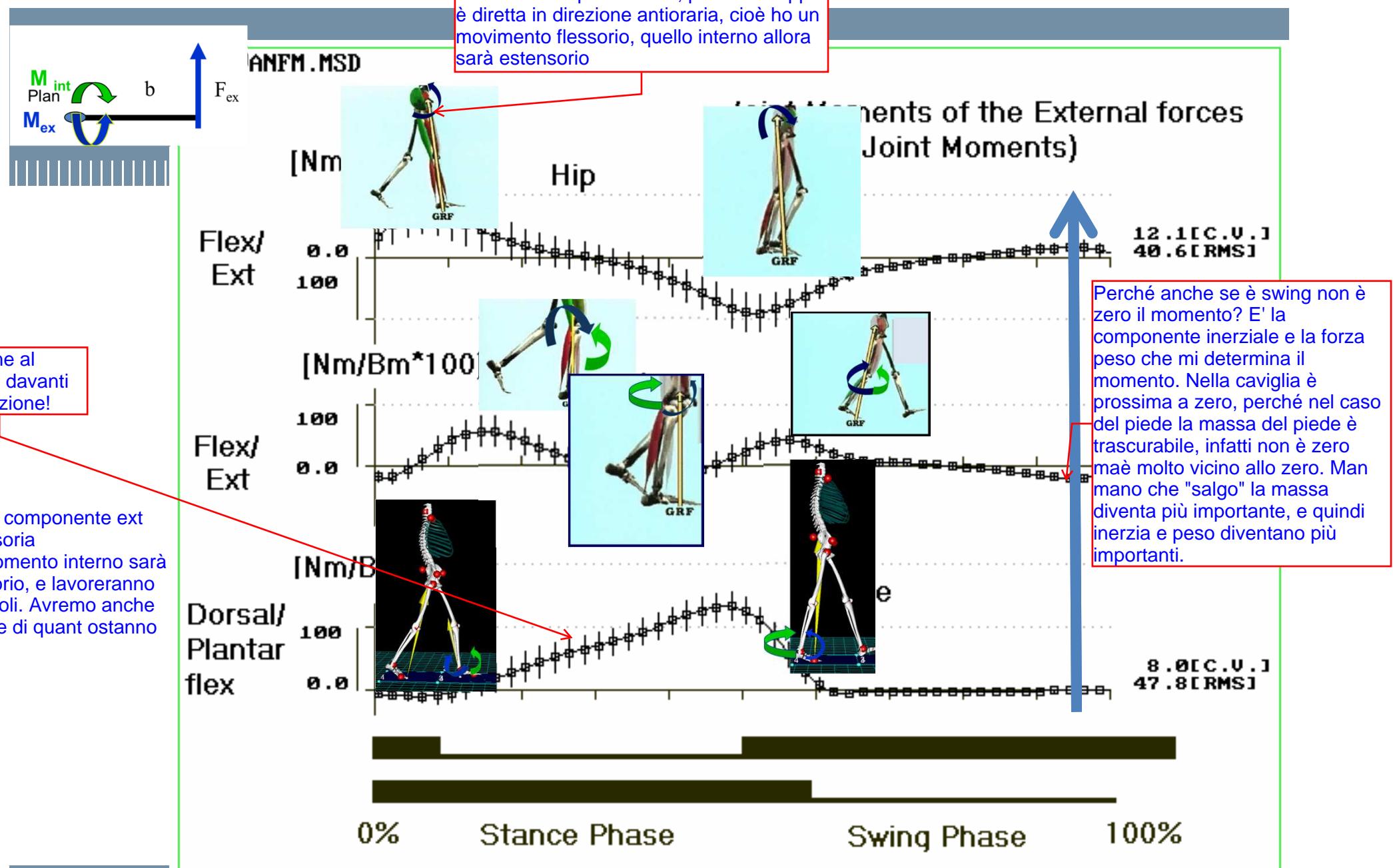


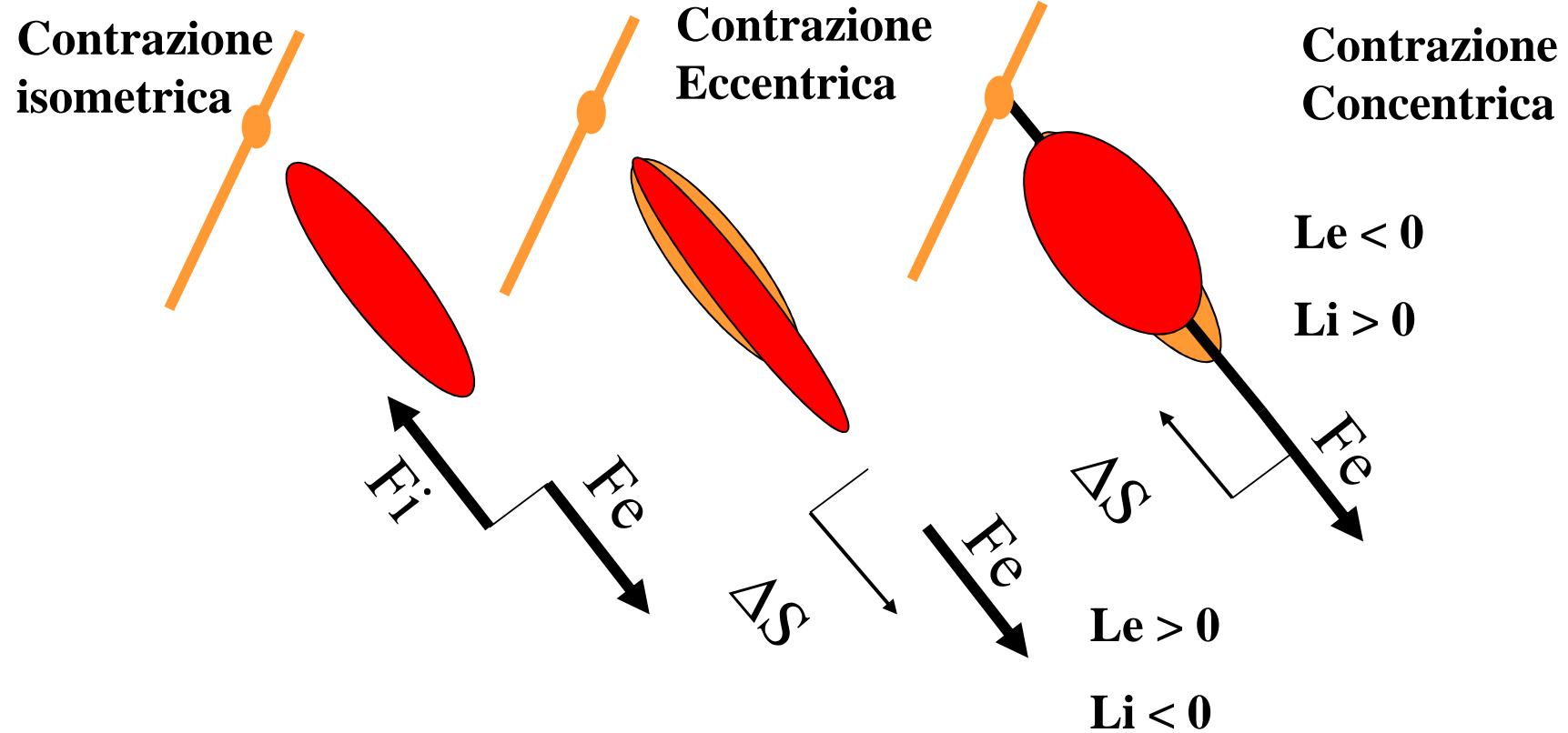
**Muscoli, legamenti e altri tessuti molli  
peri-articolari producono MOMENTI  
INTERNI**

**I Momenti Interni contro-bilanciano i  
MOMENTI ESTERNI**

**Possiamo misurare (calcolare mediante  
modelli biomeccanici) i Momenti Esterni per  
stimare il Momenti Interni**



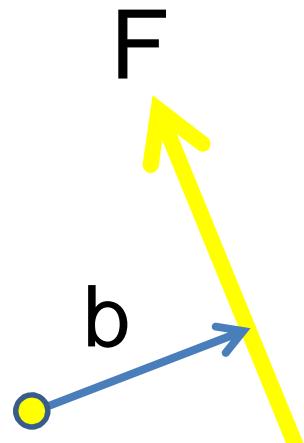




**Lavoro Meccanico:**  $L = F \times \Delta S$

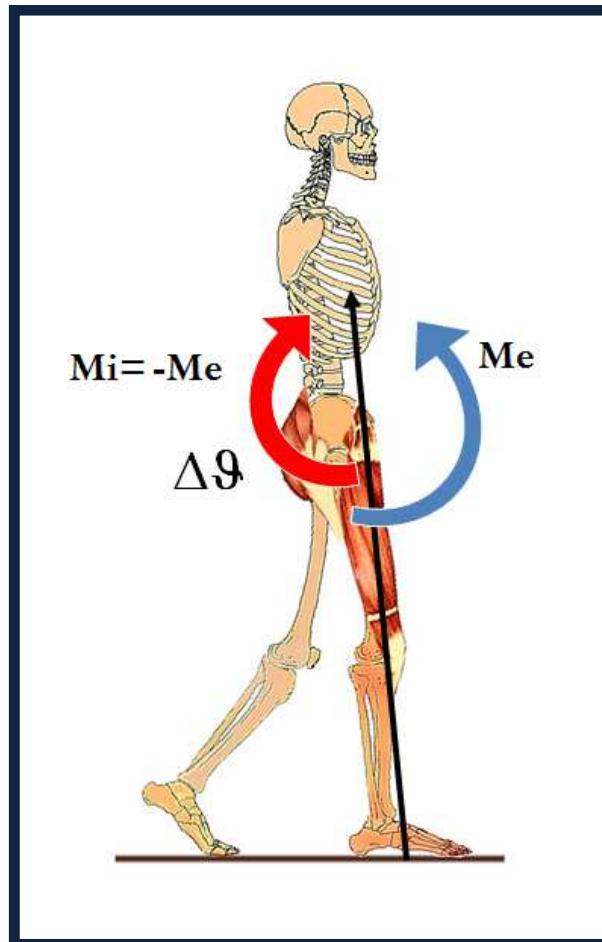
# I momenti e le potenze articolari

Momento di una forza



$$M = F \times b$$

$$Li = Mi \cdot \Delta\vartheta$$



Lavoro interno:

$$L = Mi \times \Delta\vartheta$$

Potenza prodotta:

$$P = Mi \times \Delta\vartheta / \Delta t$$

$$= Mi \times \omega$$

GIOVANFM.PSD

101

[W/Bm\*100] Hip

Joint Power

0.0  
100

16.5[C.V.]  
46.0[RMS]

[W/Bm\*100]

0.0  
100

11.9[C.V.]  
50.5[RMS]

Knee

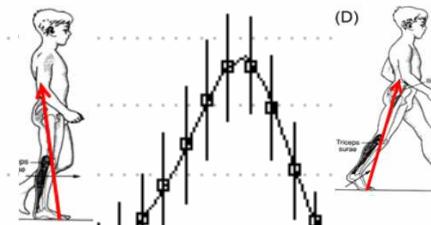
0.0  
100

[W/Bm\*100]

Ankle

0.0  
100

7.4[C.V.]  
71.3[RMS]

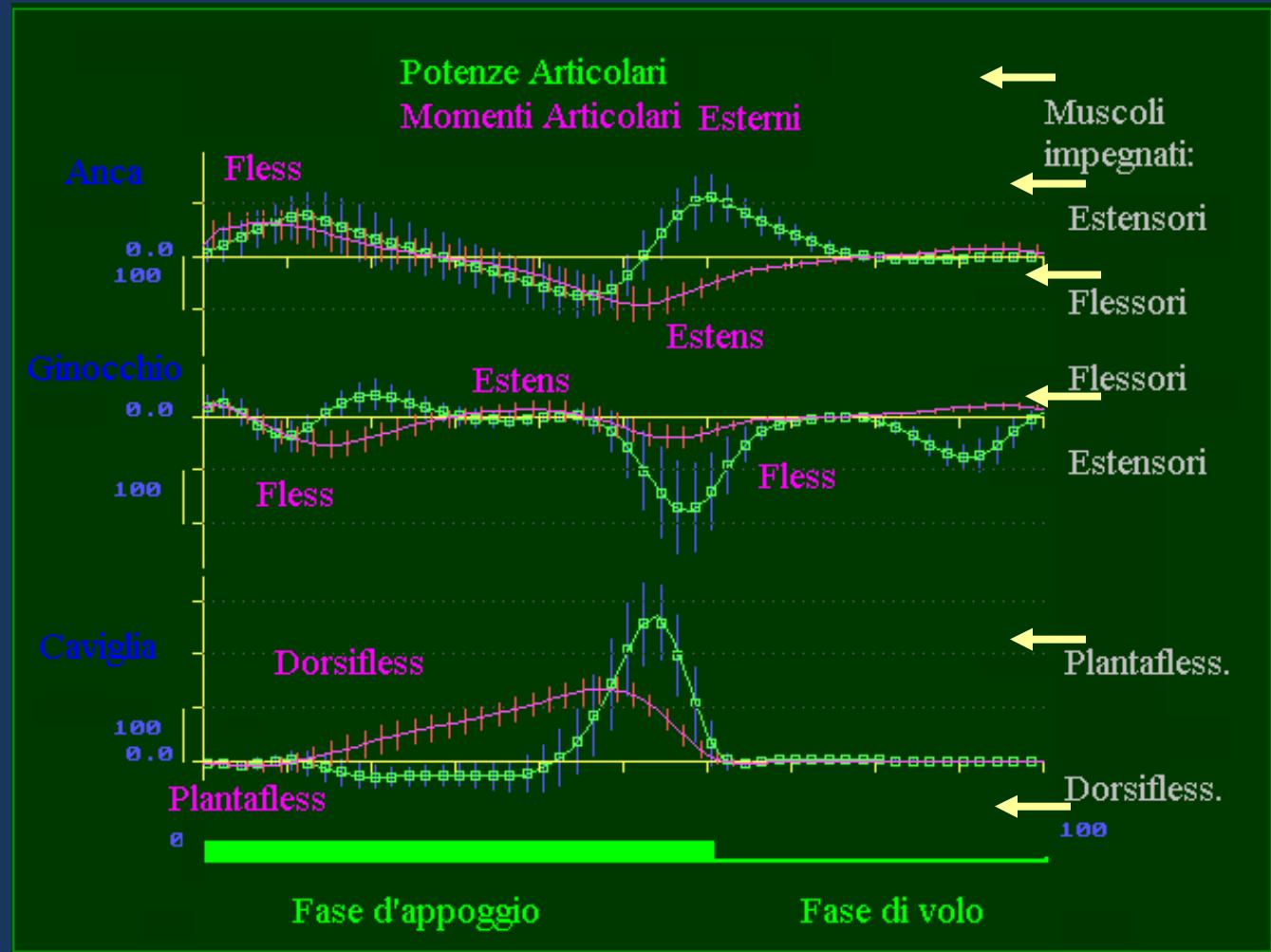


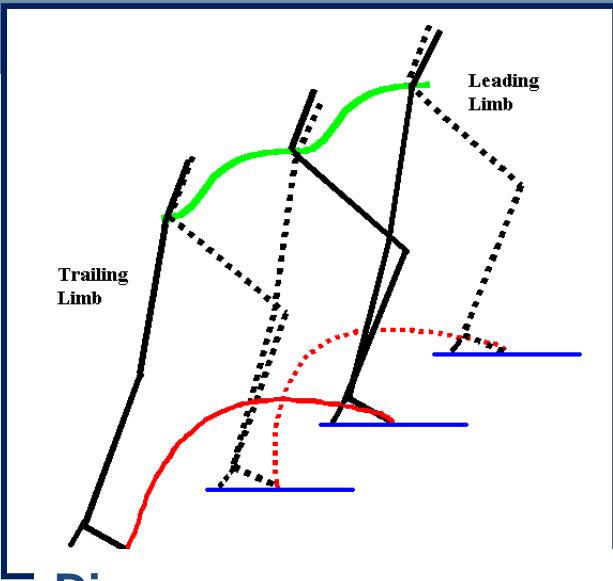
0%

STANCE PHASE

100%

SWING PHASE





## Discesa

-fase di stance:

- doppio appoggio (double support)
- continuazione in avanti (forward continuance)
- discesa controllata (controlled lowering)
- secondo doppio appoggio (double support)

-fase di swing:

- slancio iniziale (pull through)
- fase di posizionamento (foot placement)

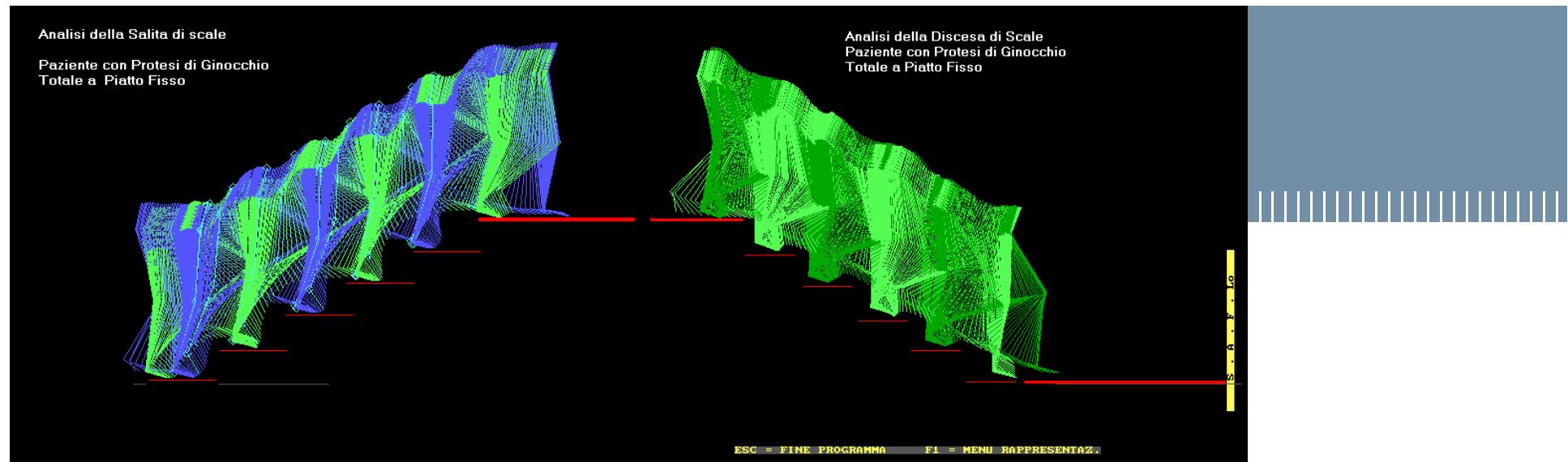
## Salita

-fase di stance:

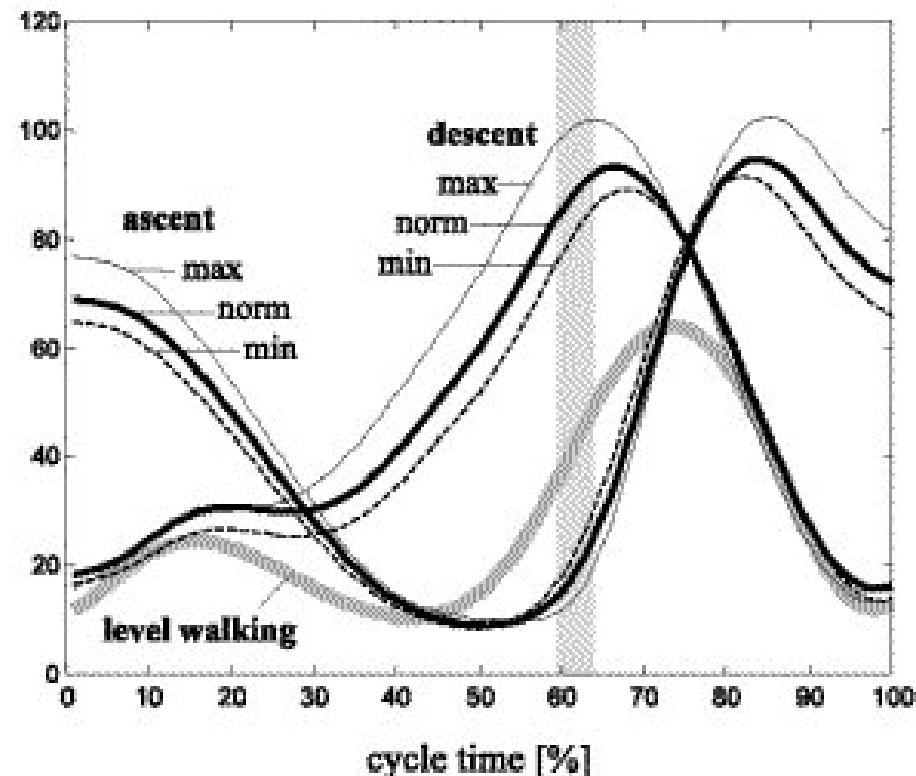
- fase di doppio appoggio (double support)
- fase di supporto singolo (single limb support)
- seconda fase di doppio appoggio (second double support)

-fase di swing:

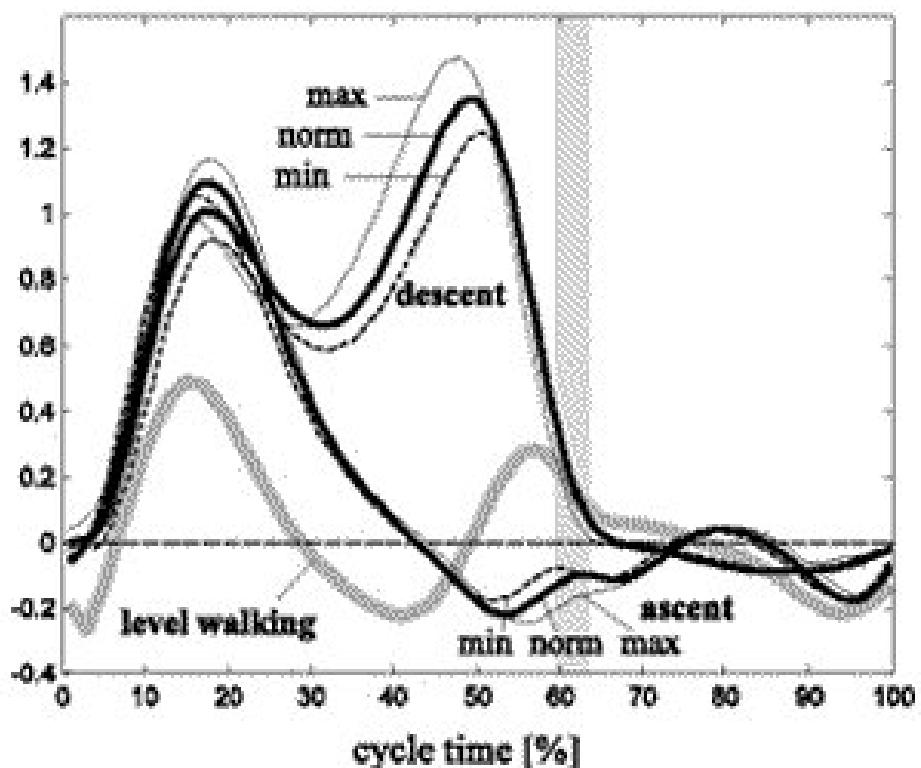
- slancio iniziale (foot clearance)
- fase di posizionamento (foot placement)

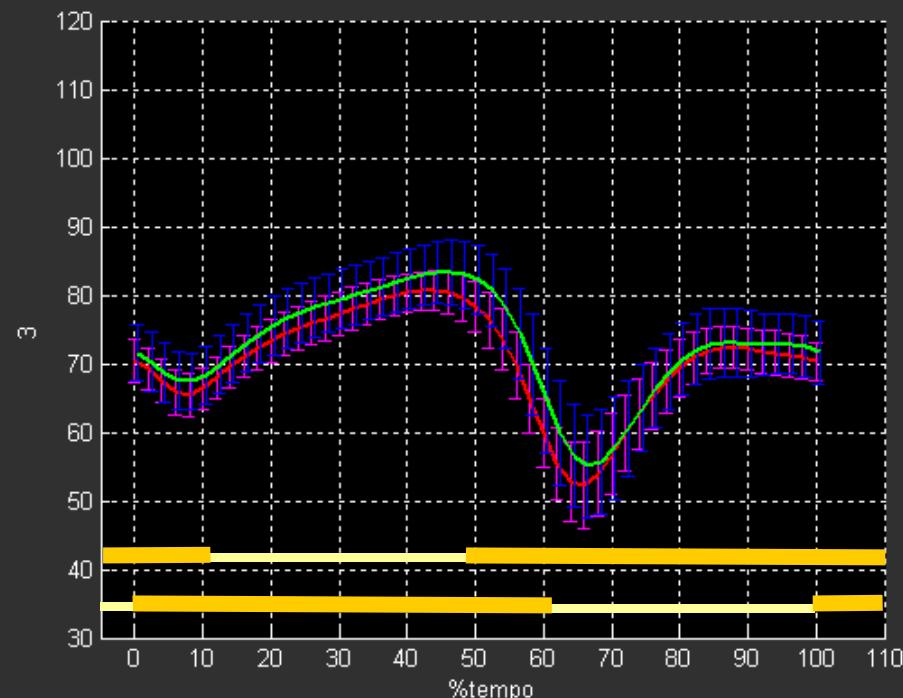
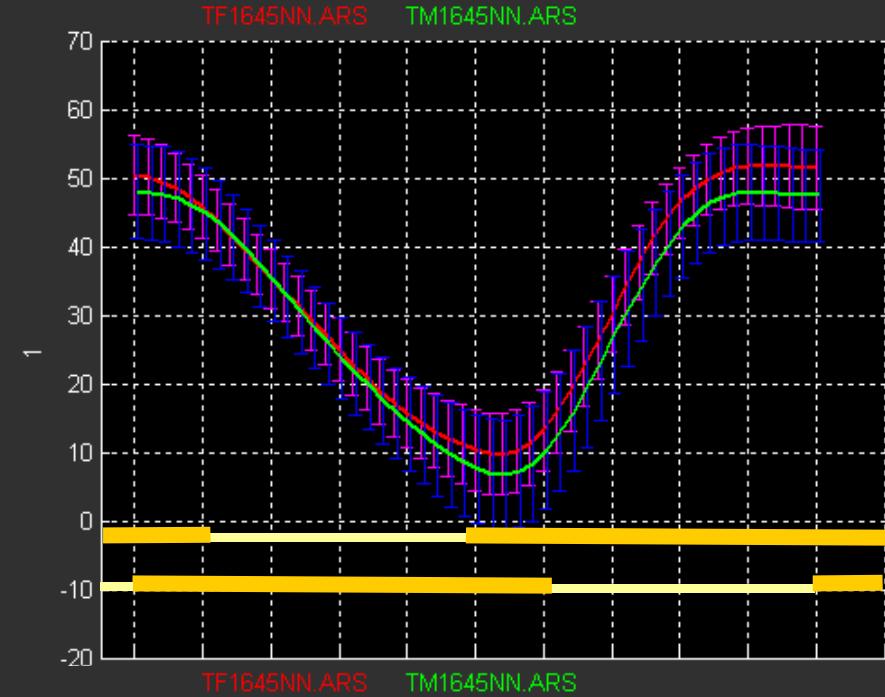


### Knee Flexion Angle

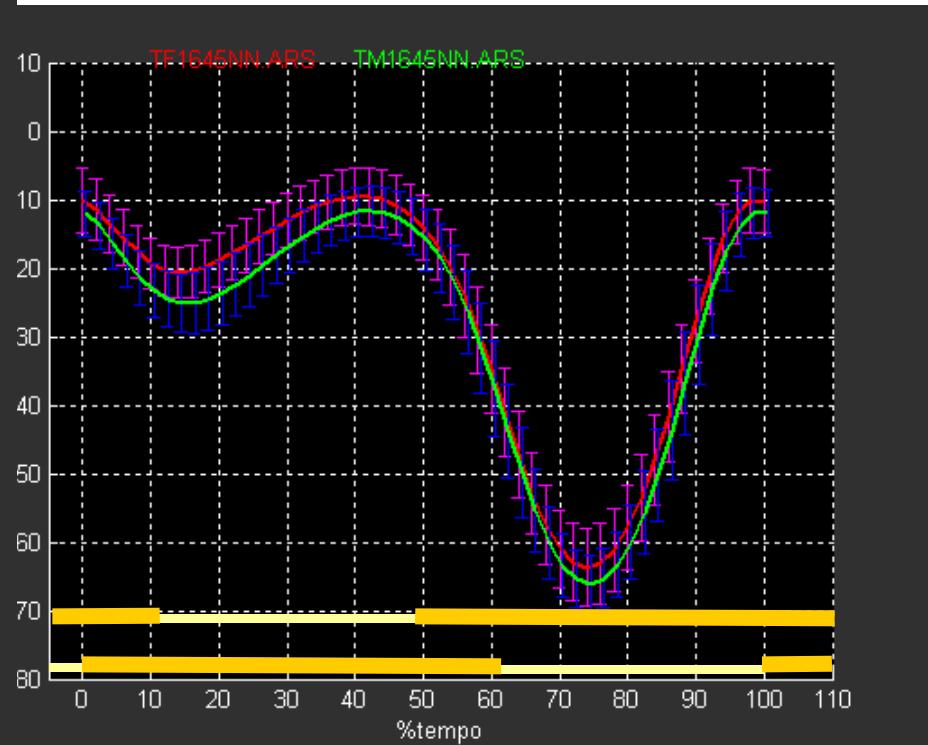


### Knee Extension Moment

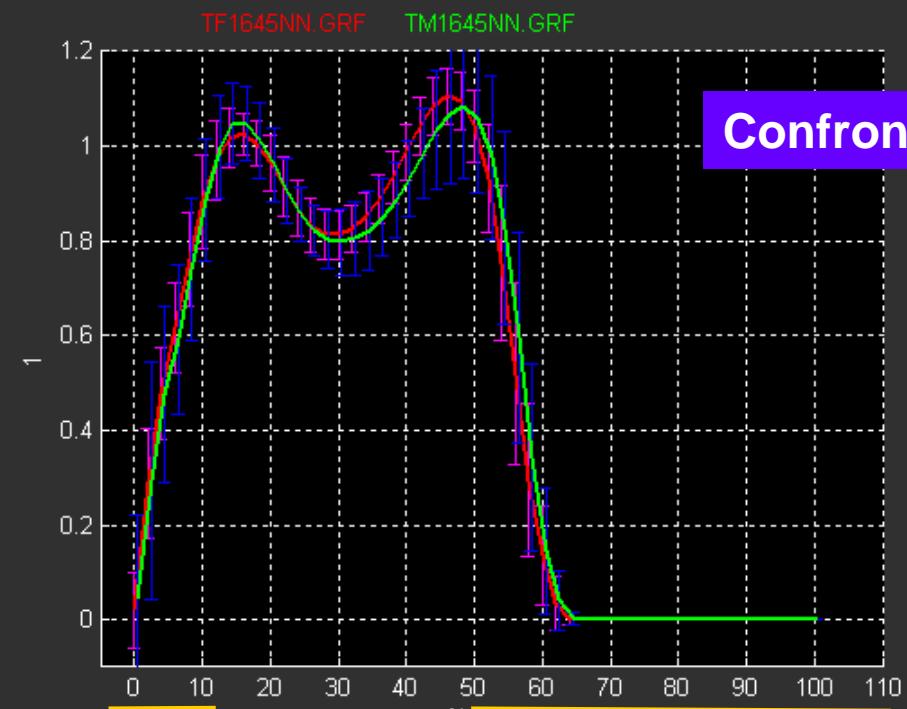




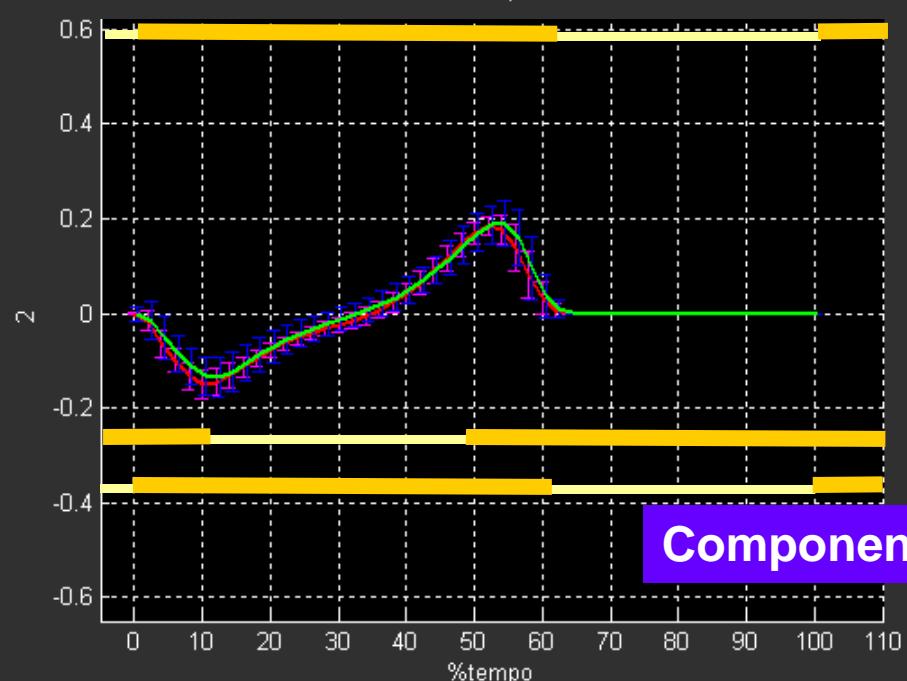
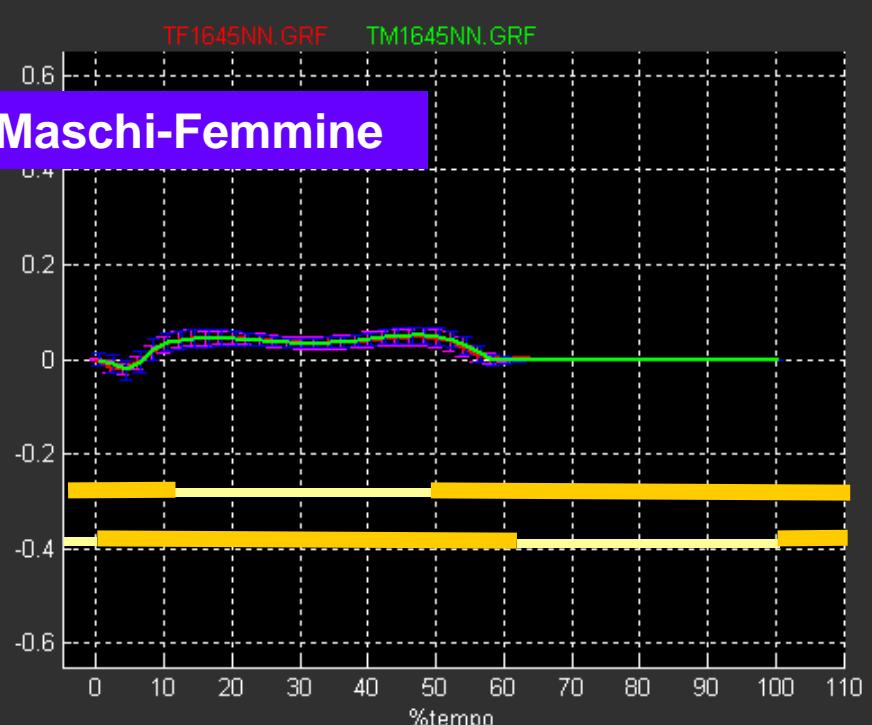
## Confronto Maschi-Femmine



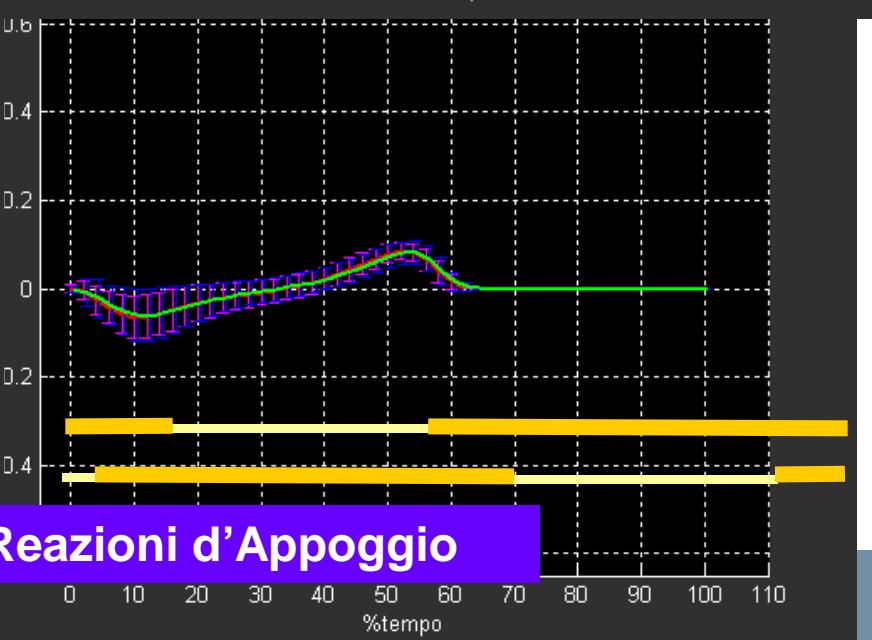
Angoli Flesso-  
Estensione

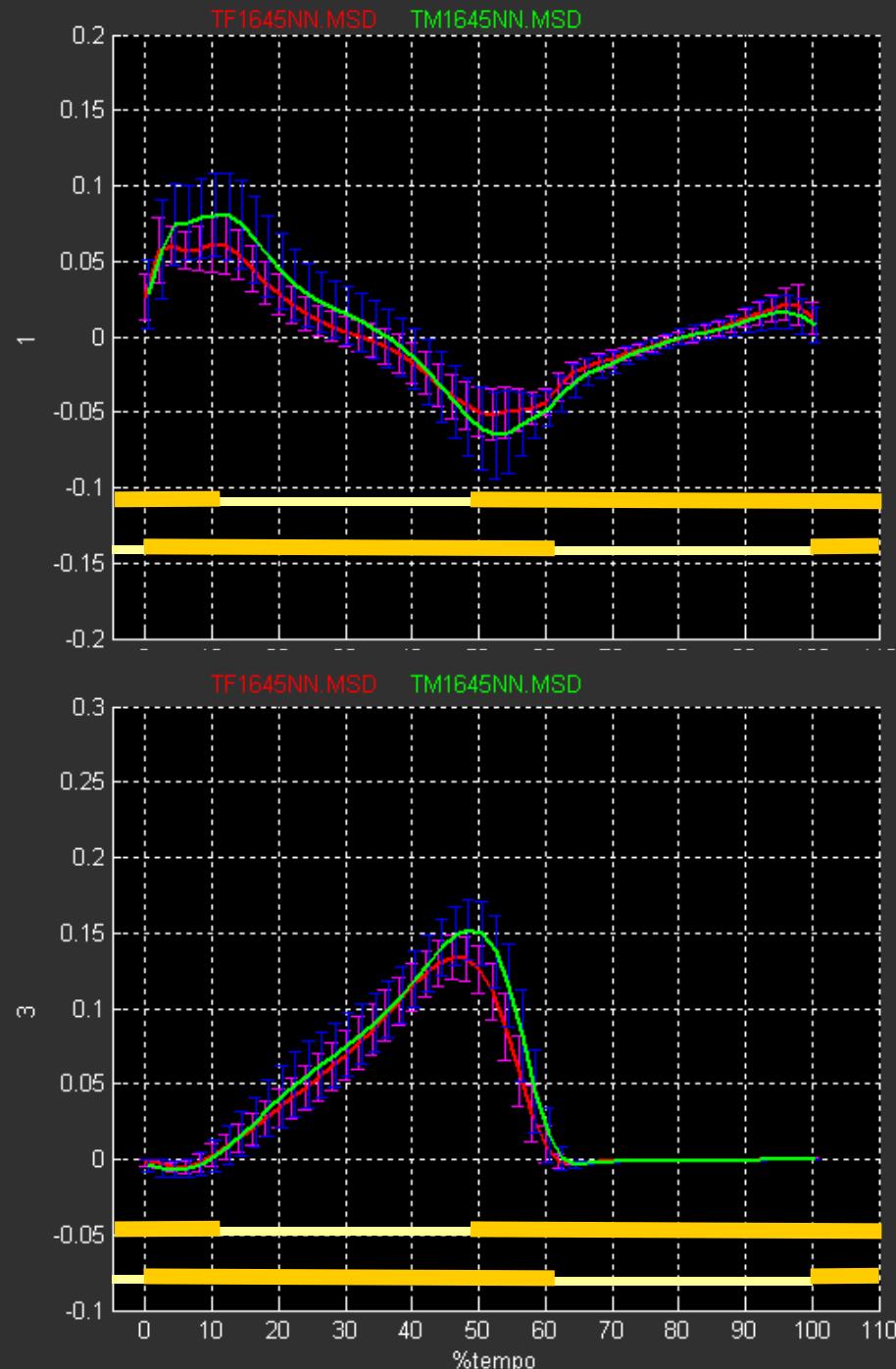


Confronto Maschi-Femmine

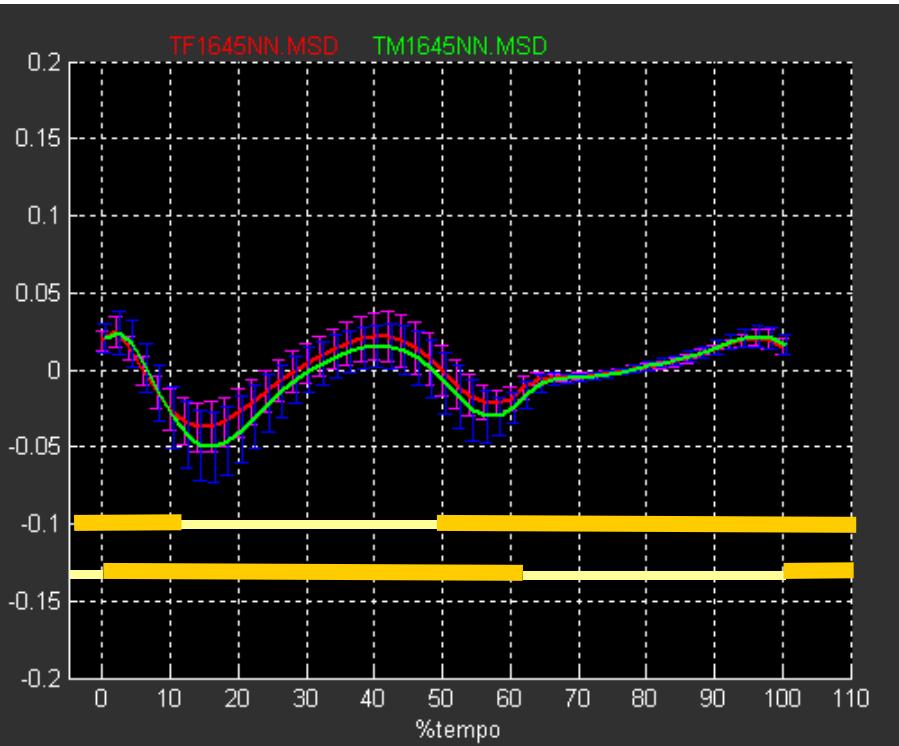


Componenti Reazioni d'Appoggio

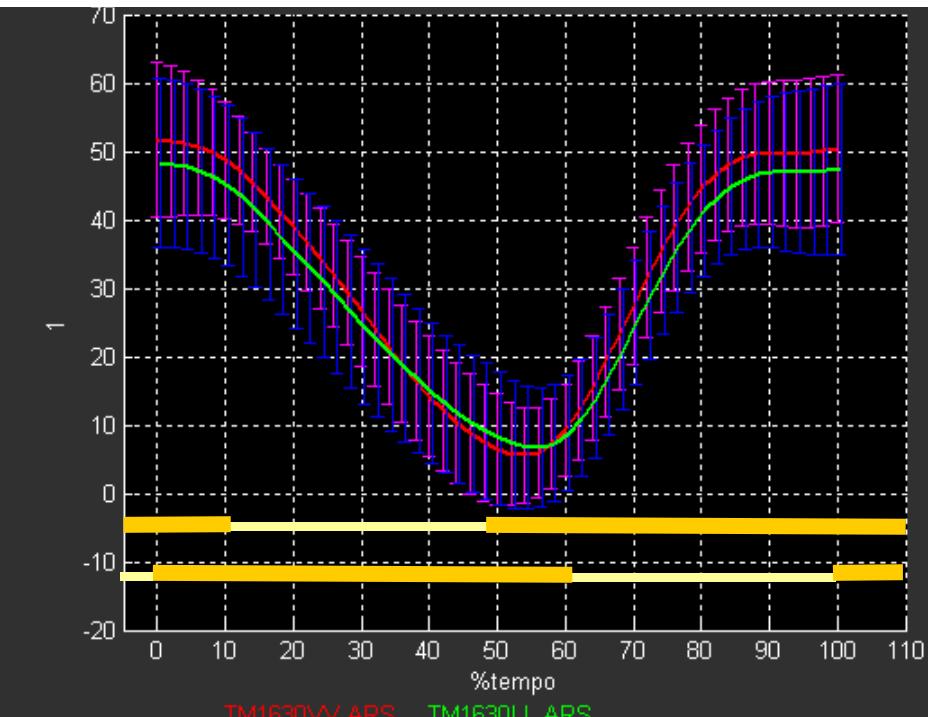




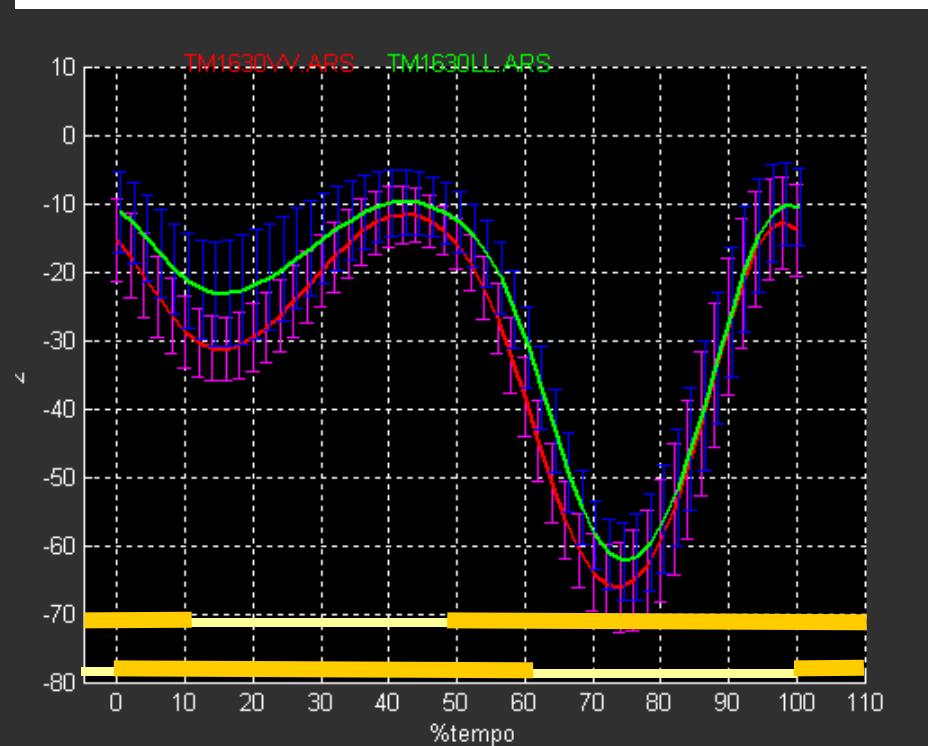
## Confronto Maschi-Femmine



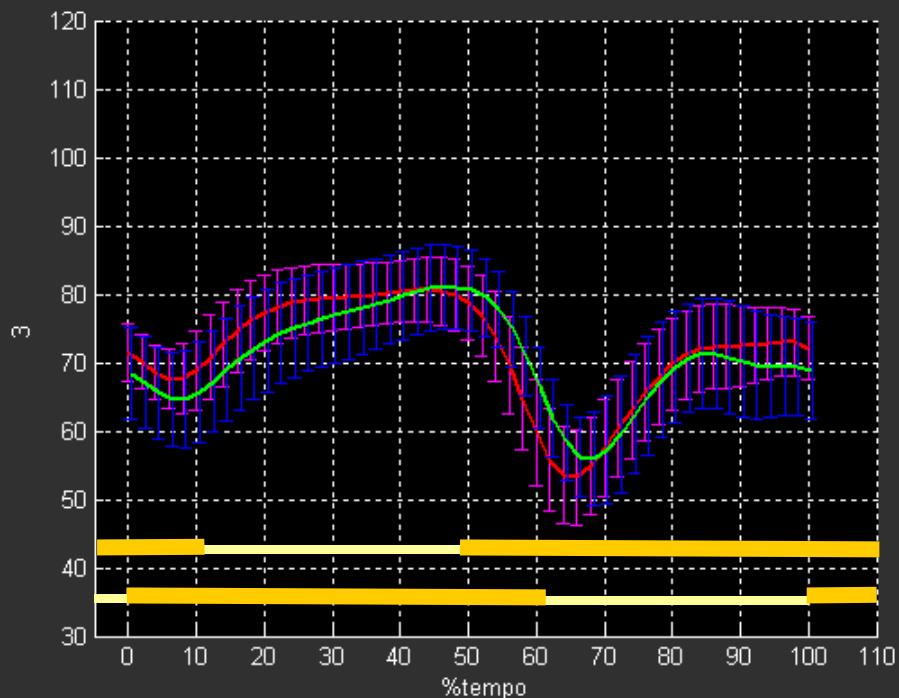
## Momenti Flesso-Estensione

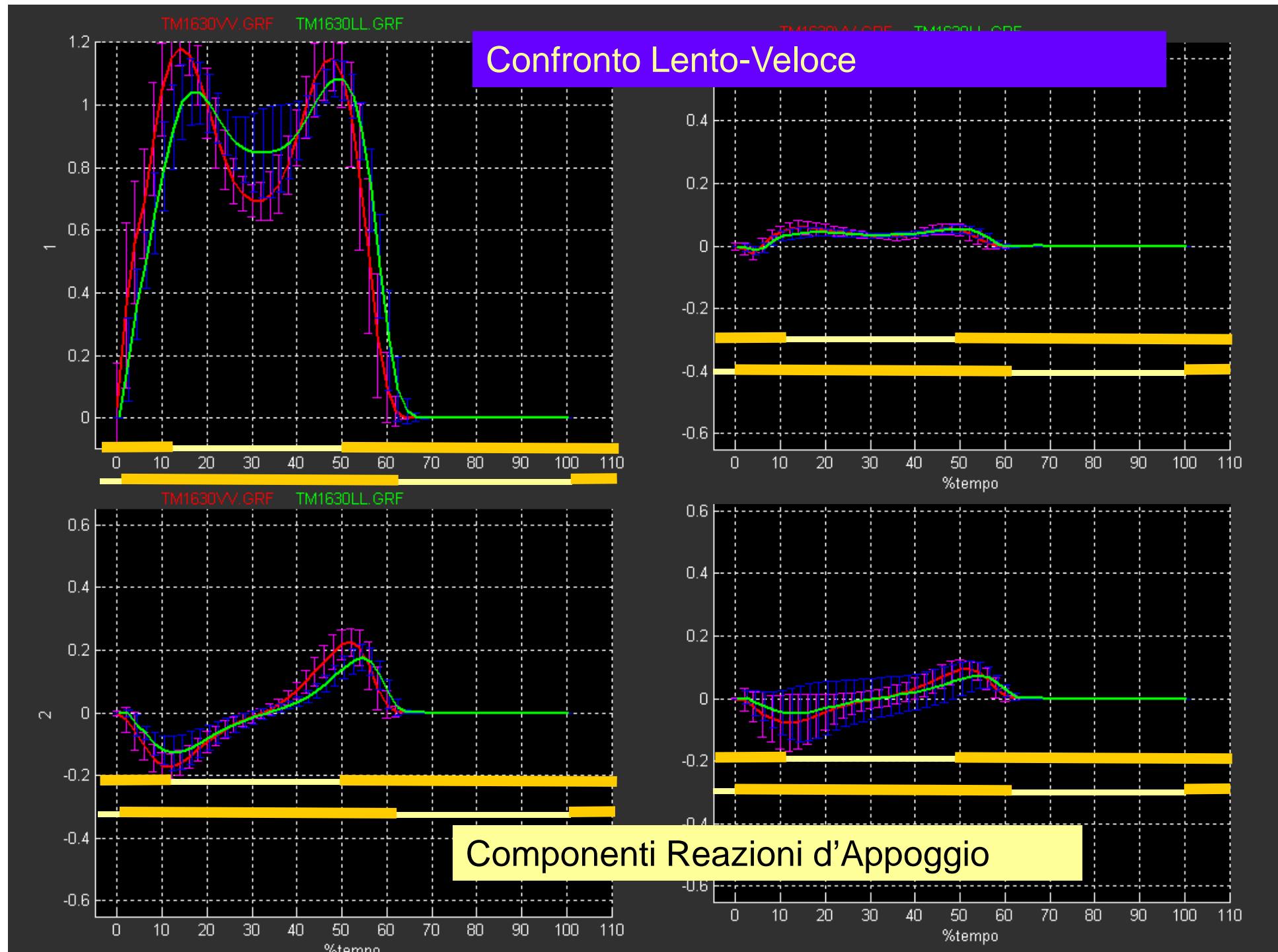


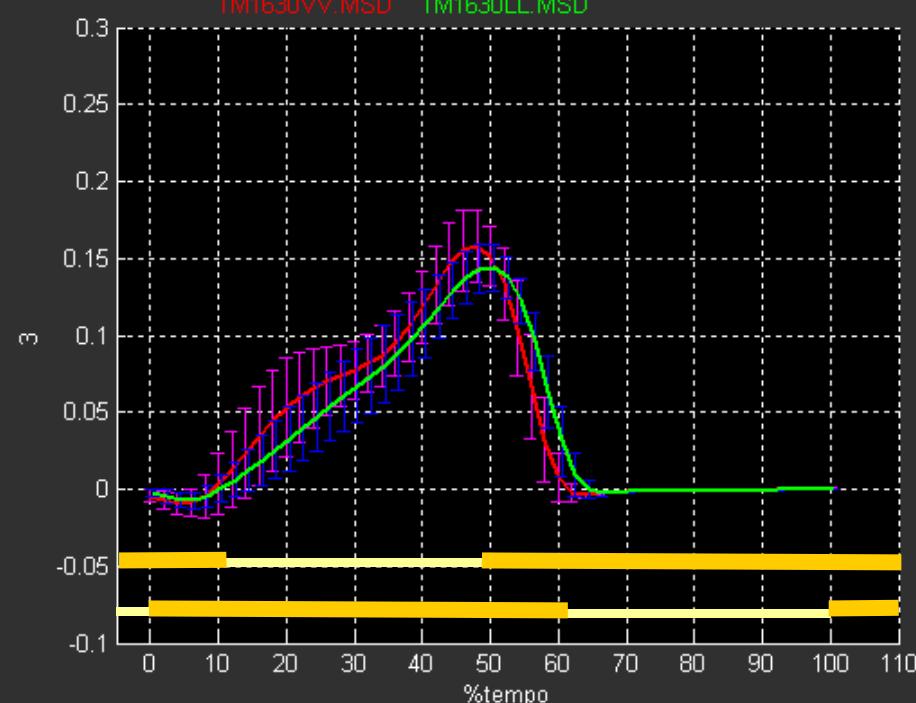
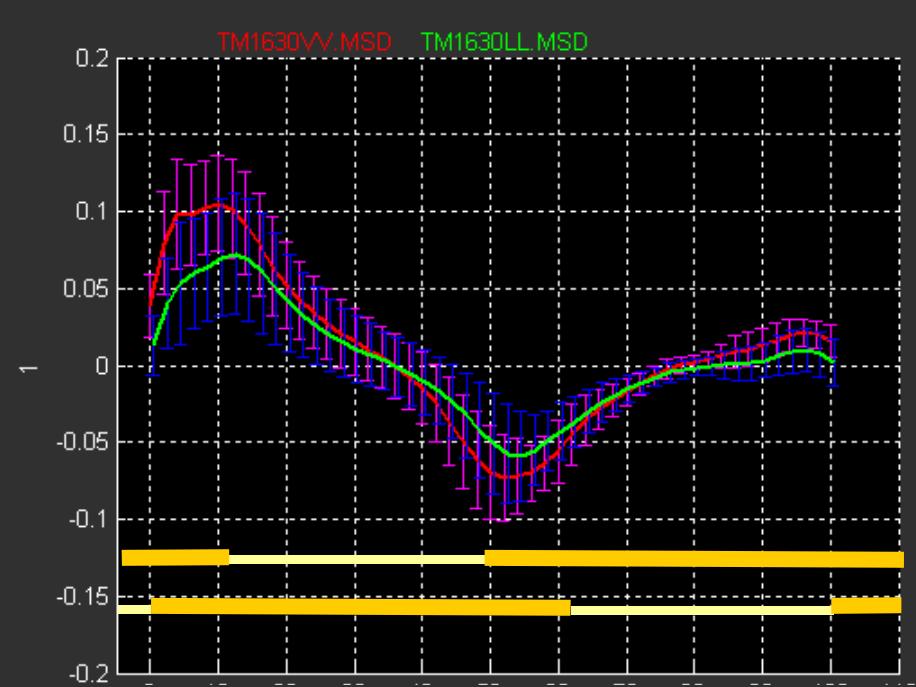
## Confronto Lento-Veloce



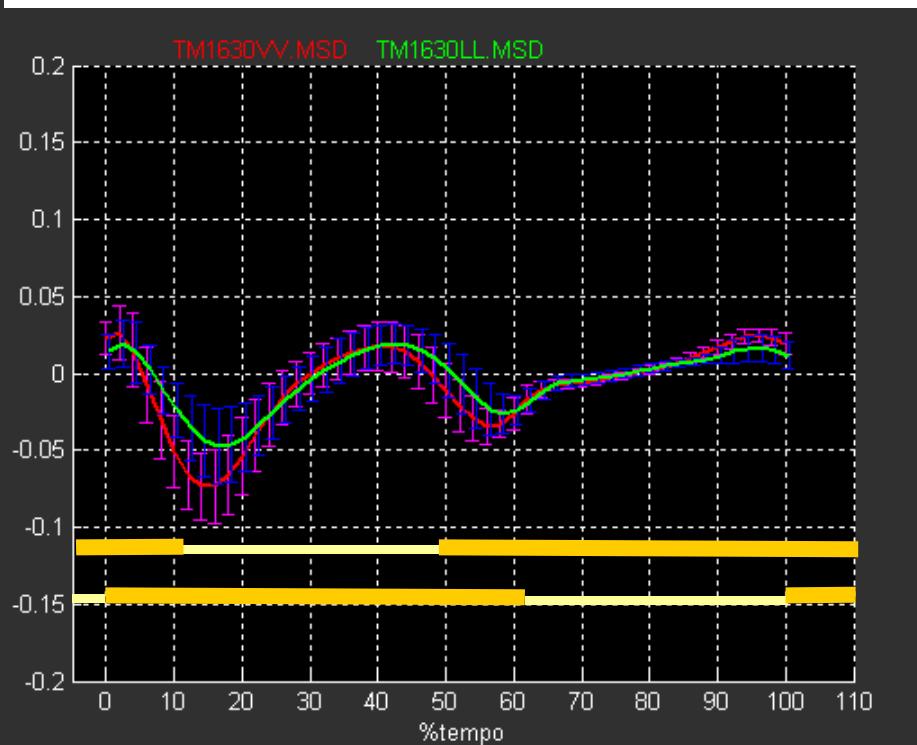
## Angoli flesso-estensione







Confronto  
Lento-Veloce



Momenti Flesso-  
Estensione

