



## Gait Analysis report: Kinetics

Practical Session of the course  
"Basics in Motion Analysis" - TRAMA Network Project  
13- 21st September 2007



### Kinetics

It studies the elements which control and produce the movement

Study of motion considering **FORCES** and **CAUSES** of movement

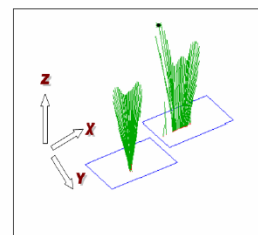
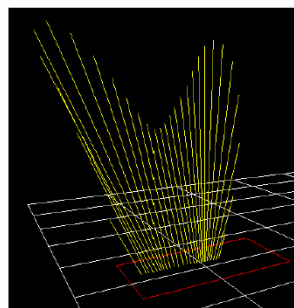




**Ground reaction forces**  
**Force of gravity**  
**Muscle and ligament forces**  
**Inertial forces**



**Ground reaction forces**









## CINETICA



### PARAMETERS WHICH DESCRIBE THE CAUSES OF THE MOVEMENT

-  GRF
-  Gravitational forces
-  Muscle/ligament forces
-  Joint moments
-  Joint powers



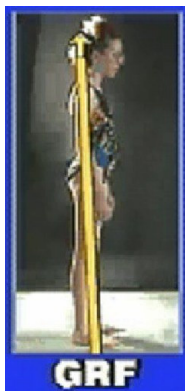
## STANDING POSITION



GRF



- Behind the hip
- In front of the knee
- In front of the ankle



**EXTERNAL FORCES**





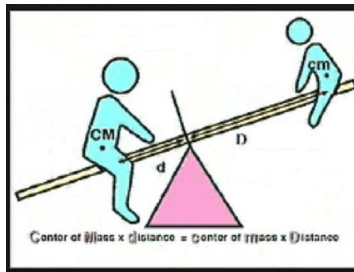
## MOMENT



### MOMENT OF FORCE

A force acting at a distance from the rotational center causing the body to rotate

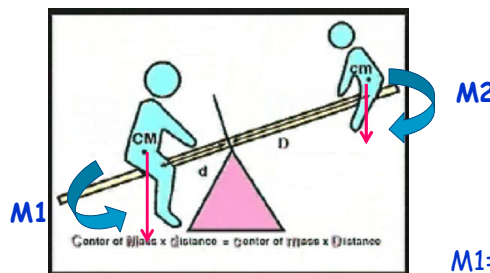
$$M = F \times D$$



## MOMENTO

Force applied at some distance away from a point of rotation produces a moment about that point



$$\text{Moment} = \text{Force} \times \text{Distance}$$




$$m_1 > m_2$$


$$M_1 = M_2 \text{ if } d < D$$

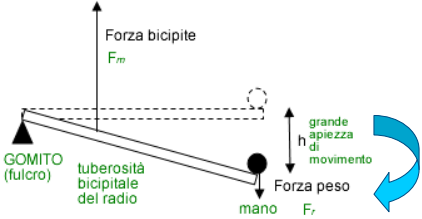




  







Muscles or their associated tendons across joints at  
 some distance away from the joint center


  
**Moment = Force X Distance**  
 [N\*m]









***Forces and moment***




***INTERNAL***

F e M produced by  
 muscles, ligaments and  
 soft tissues



***EXTERNAL***

F e M produced by ground  
 reaction forces, by  
 segments weight and  
 inertial forces





**EQUILIBRIUM → Internal Moments = External Moments**

THE BODY PRODUCES >>>> **INTERNAL MOMENTS**  
IN RESPONSE TO >>>>>>>> **EXTERNAL LOADS**  
THAT PRODUCE >>>>>>>> **EXTERNAL MOMENTS**



**Force of gravity**

$$F = m * g$$





## Inertial forces

$$F_i = -m \cdot a$$

It represents the resistance to a change in motion



## *Power*

Power indicates the rate at which a moment is rotated

$$\text{Power} = \text{Moment} \times \text{Angular Velocity}$$

$$\text{Power} = \text{Force} \times \text{Distance} \times \text{Angular Velocity}$$

[W]





## Generated power > 0

Momentum and movement are in the same direction

Flex-extension velocity increases

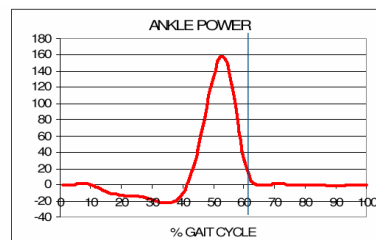
Muscle concentric contraction (the contracting muscle shortens under tension)

## Absorbed power < 0

Momentum and movement are not in the same direction

Flex-extension velocity decreases

Muscle eccentric contraction (the contracting muscle lengthens under tension)



GENERATION

ABSORPTION





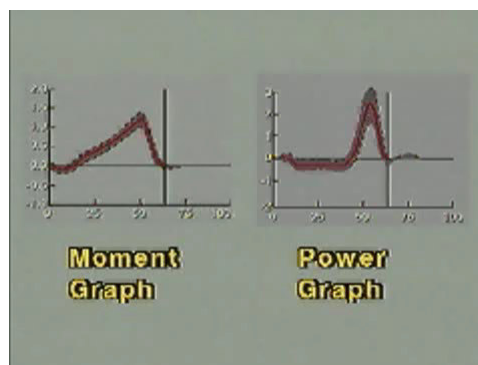


## The muscle power production depends on

- Gross sectional area
- Length/tension ratio
- Degree of fatigue
- Fiber type



## MOMENTS & POWERS





# KINETICS: NORMATIVE DATA



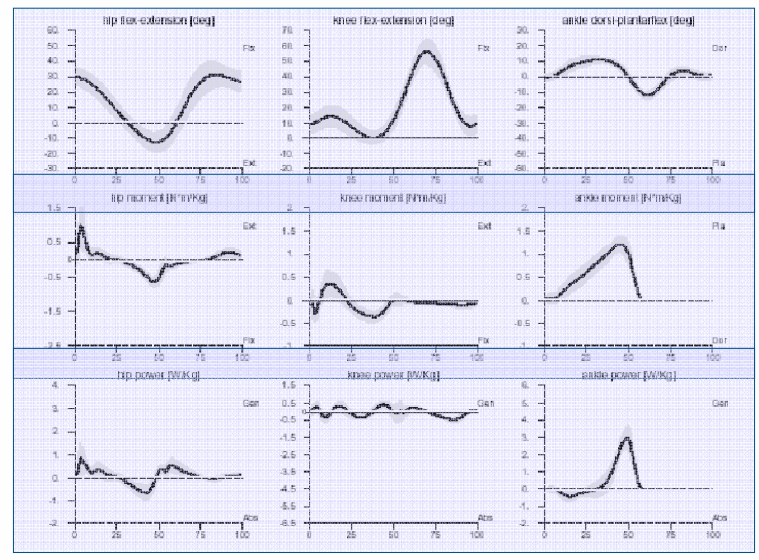
BITIS

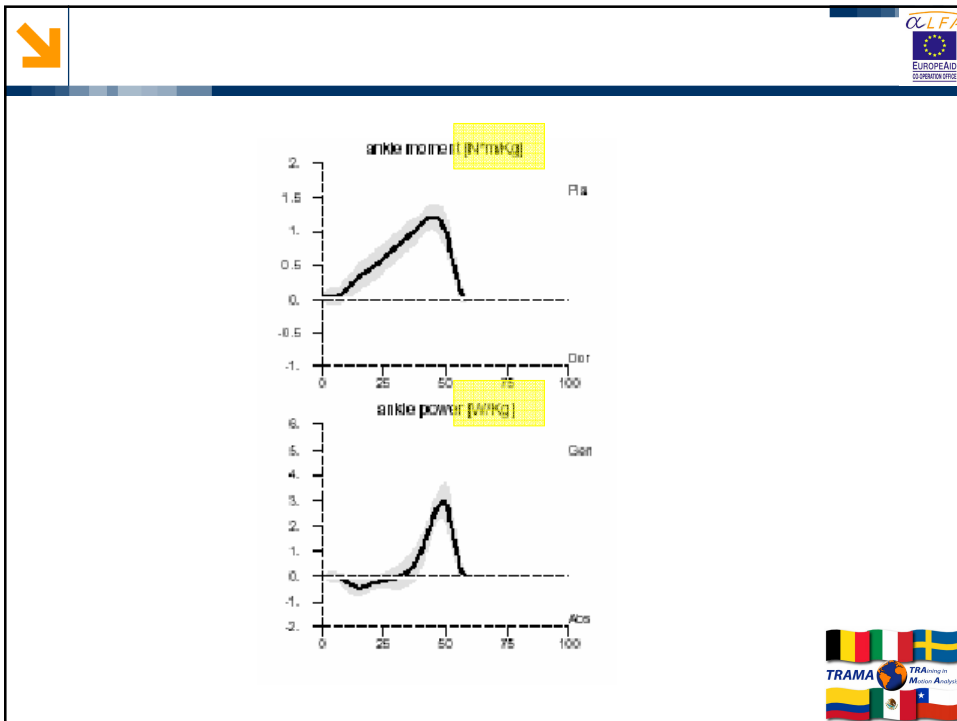
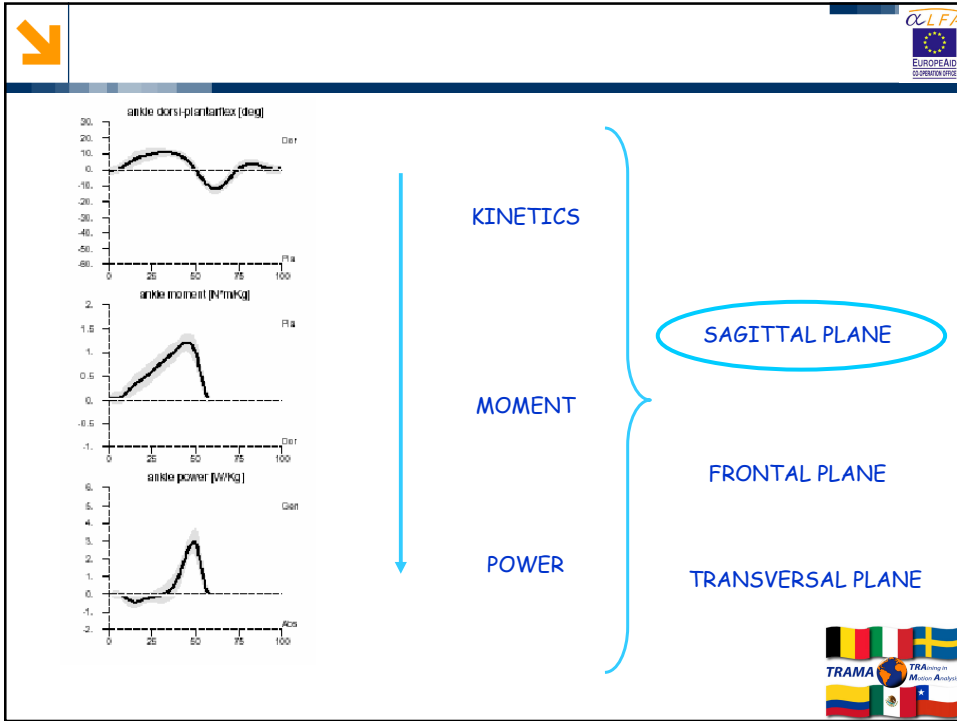
FAZIOLO, I. (2011) *Human Walking*  
Data: 30/03/2005  
Prova: 1 - Normal walking 01  
Nome del File: 15100601  
Protocollo: Anabionico

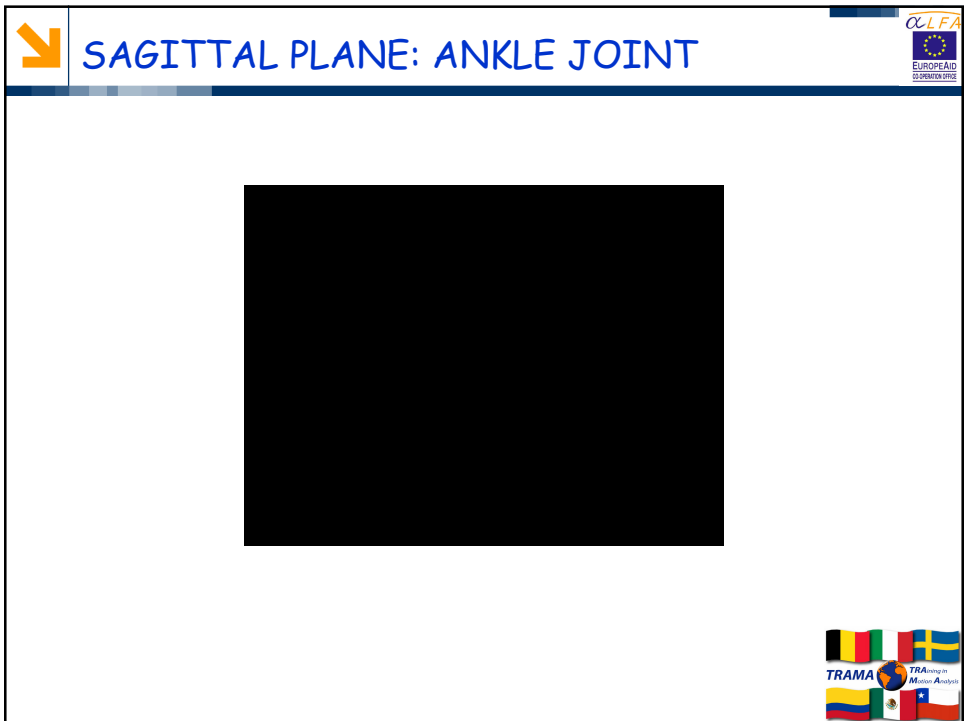
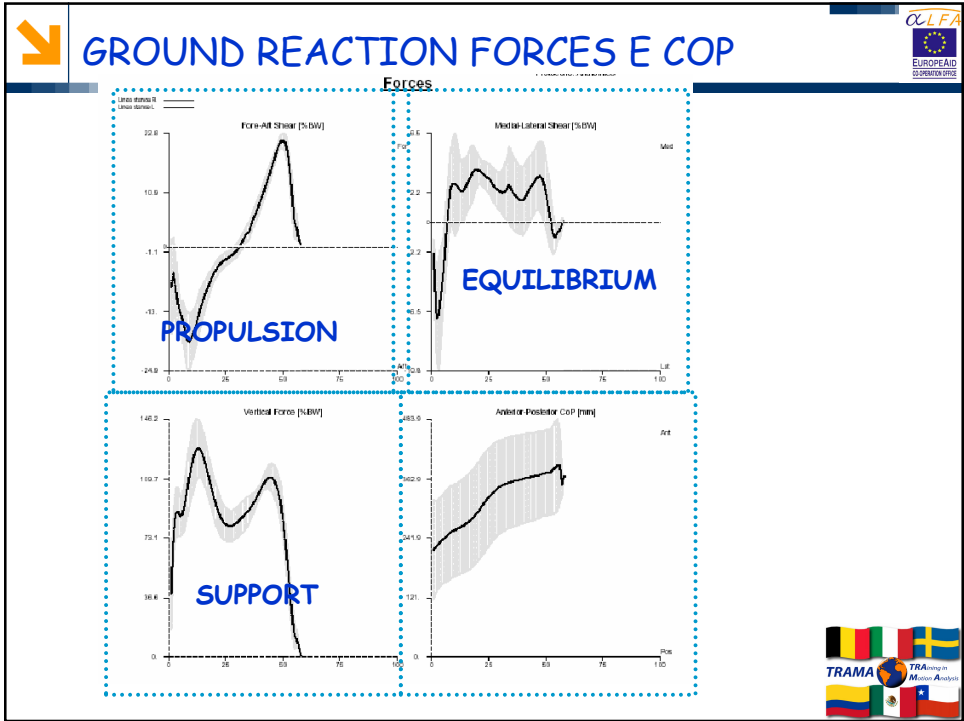


## Sagittal Kinetics

Linea rossa R  
Linea verde L









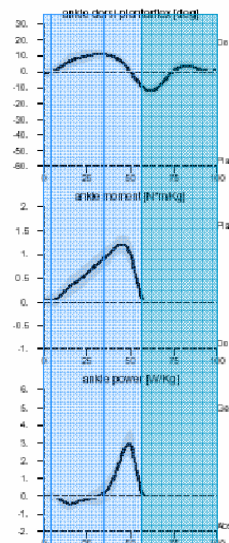
## SAGITTAL PLANE: ANKLE JOINT



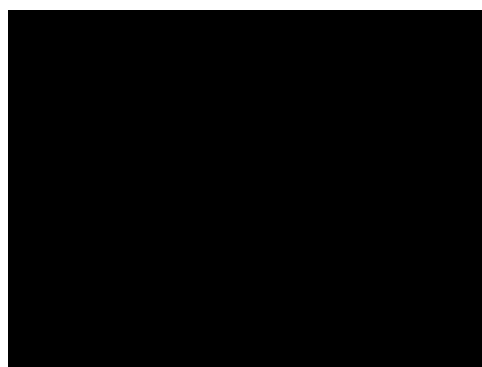
**PART A**  
Plantarflexion/Dorsiflexion  
Dorsiflexion moment  
Positive power

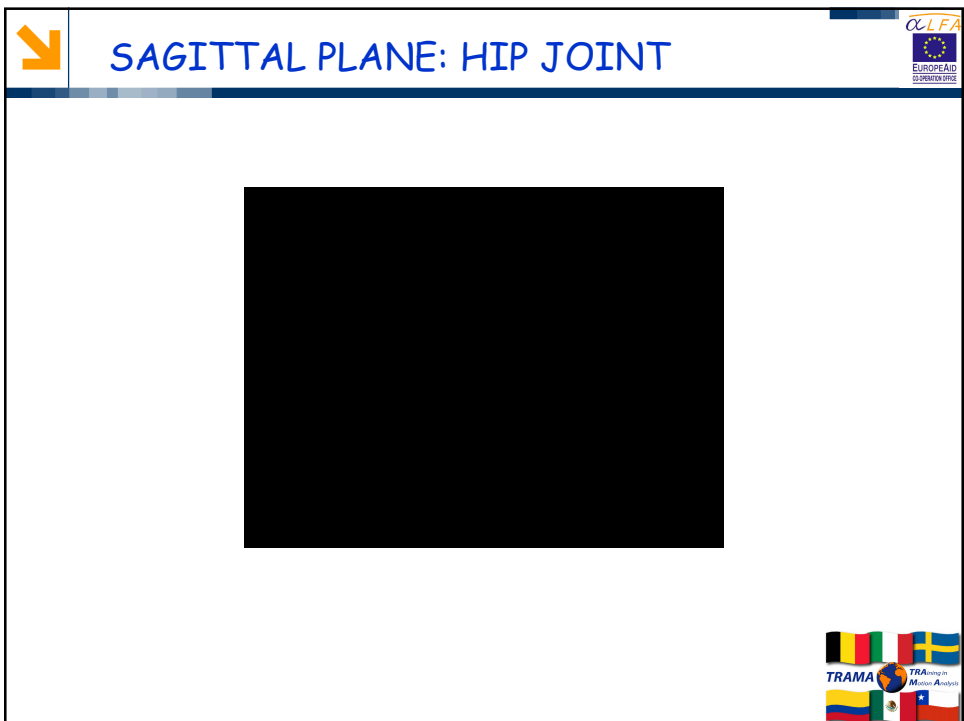
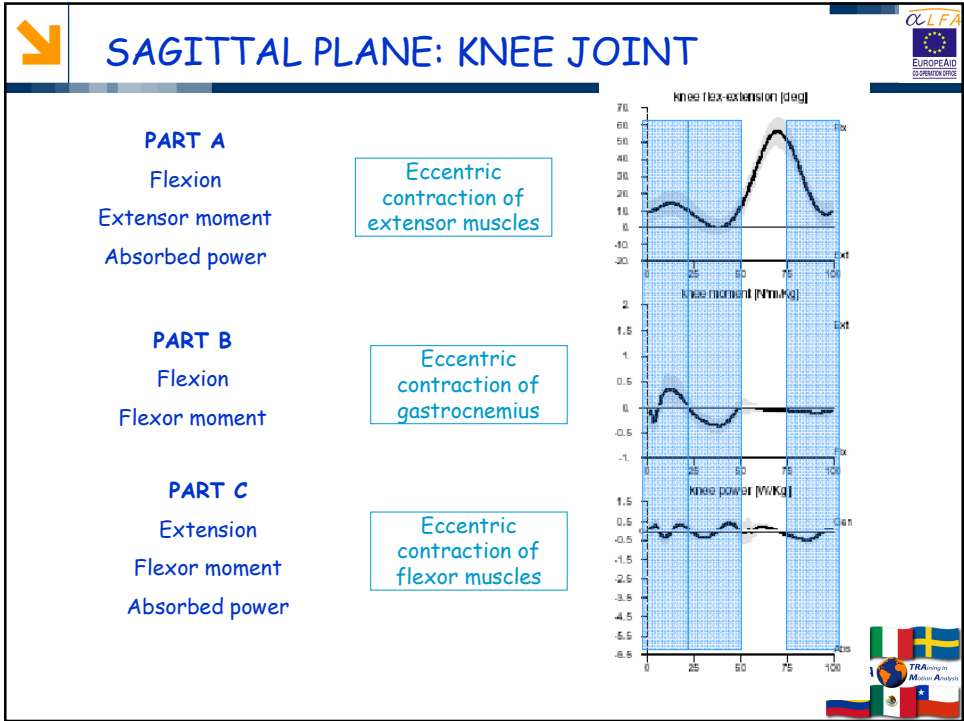
**PART B**  
Dorsiflexion  
Plantarflexion moment  
Negative power

**PART C**  
Plantarflexion  
Plantarflexion moment  
Positive power



## SAGITTAL PLANE: KNEE JOINT







# SAGITTAL PLANE: HIP JOINT



**PART A**  
 Extension  
 Extensor moment  
 Generated power

Concentric contraction of extensor muscles

**PART B**  
 Extension  
 Flexor moment  
 Absorbed power

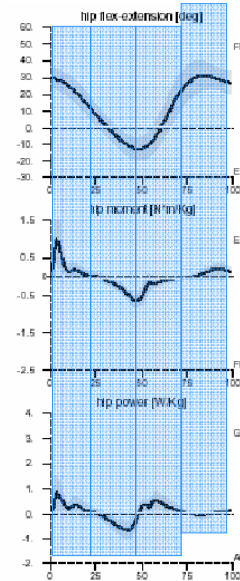
Extensor muscles are not working → gravity

**PART C**  
 Flexion  
 Flexor moment  
 Generated power

Concentric contraction iliopsoas (rectus femoris)

**PART D**  
 Flexion  
 Extensor moment

Concentric contraction of extensor muscles



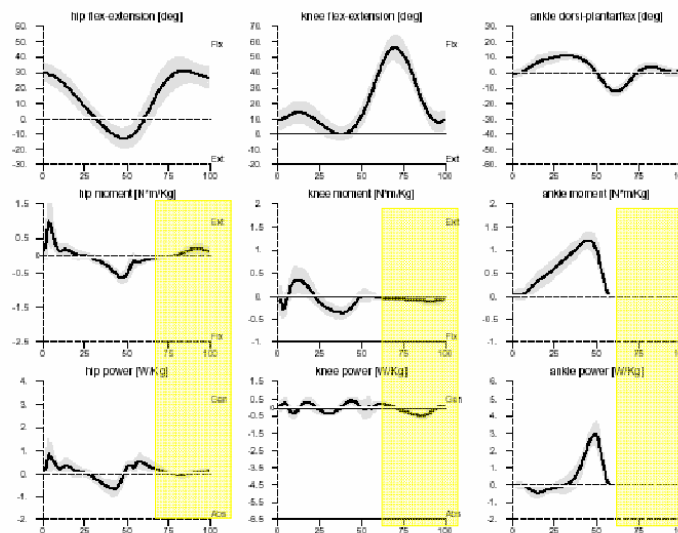
BITIS

FAZIOLO, I. (2011) *INSTRUMENTAZIONE*  
 Data: 30/03/2005  
 Proiezione: Normal walking 01  
 Nome del File: 151100201  
 Protocollo: Anal\_bianco



## Sagittal Kinetics

Linea dorsale R  
 Linea dorsale L






***KINETICS:  
MAIN DEVIATIONS FROM  
NORMATIVE DATA***





**DOUBLE-BUMP ANKLE PATTERN**







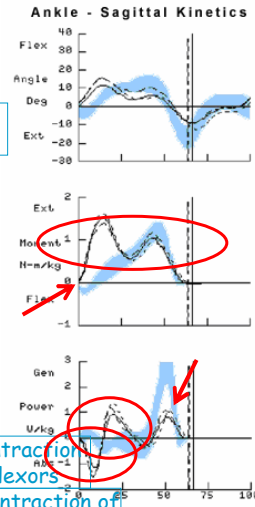
## DOUBLE-BUMP ANKLE PATTERN

**KINEMATICS**  
 High plantarflexion at IC/normal IC  
 Double bump  
 Low dorsiflexion during the third rocker

**MOMENT**  
 Early plantarflexion moment followed by double bump  
 Only plantarflexor moment during stance



**POWER**  
 Large absorbed power after IC  
 Early generated power during midstance  
 Low generated power in terminal stance




**Ankle - Sagittal Kinetics**



Plantarflexion spasticity


Eccentric contraction of plantarflexors  
 Concentric contraction of plantarflexors








## KNEE-FLEXOR MOMENT PATTERN





# KNEE-FLEXOR MOMENT PATTERN



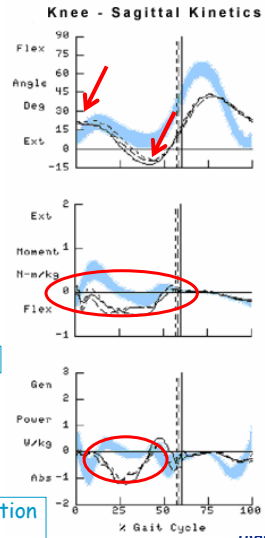
**KINETICS**  
 High flexion at IC  
 Fast extension with prolonged hyperextension

**MOMENT**  
 Flexor moment in midstance

Flexors dominance

**POWER**  
 Absorbed power in midstance

Eccentric contraction of flexors



# KNEE-EXTENSOR MOMENT PATTERN





# KNEE-EXTENSOR MOMENT PATTERN



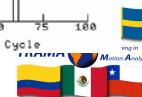
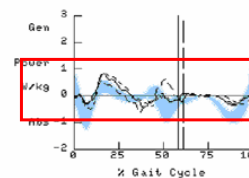
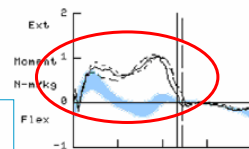
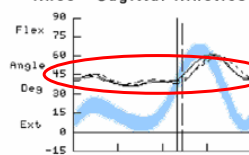
**KINEMATICS**  
 High flexion in stance → CROUCH  
 Low ROM

**MOMENT**  
 Extensor moment in stance

Attività continua  
 quadricipite

**POWER**  
 Variable (it depends on ROM)  
 No high peaks

Knee - Sagittal Kinetics



# HIP-EXTENSOR MOMENT PATTERN



**HIP-EXTENSOR MOMENT PATTERN**

**KINEMATICS**  
Shift towards flexor pattern

**MOMENT**  
Prolonged extensor moment in stance  
Low and late flexor moment at toe-off

**POWER**  
Generated power in stance  
Low and late absorbed power in terminal stance

Concentric contraction of extensors

OLFA  
EUROPEAID  
EUROPEAN COMMISSION

TRAMA  
TRAMAPRO  
Motion Analysis

**Conclusioni**

**DINAMICA**

Tracciati soggetti sani

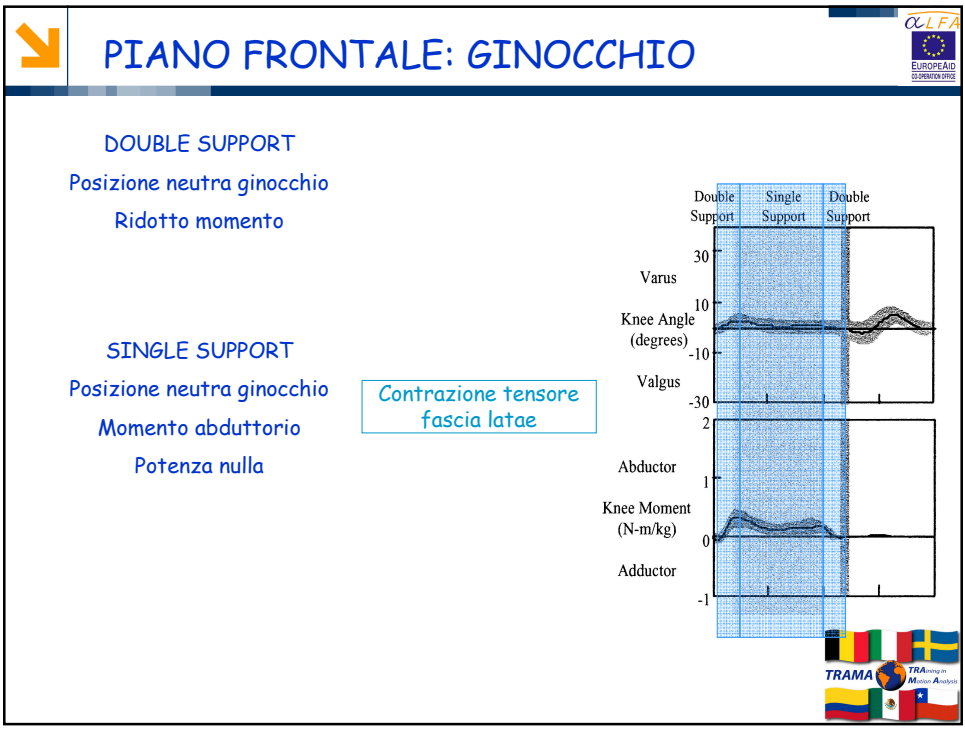
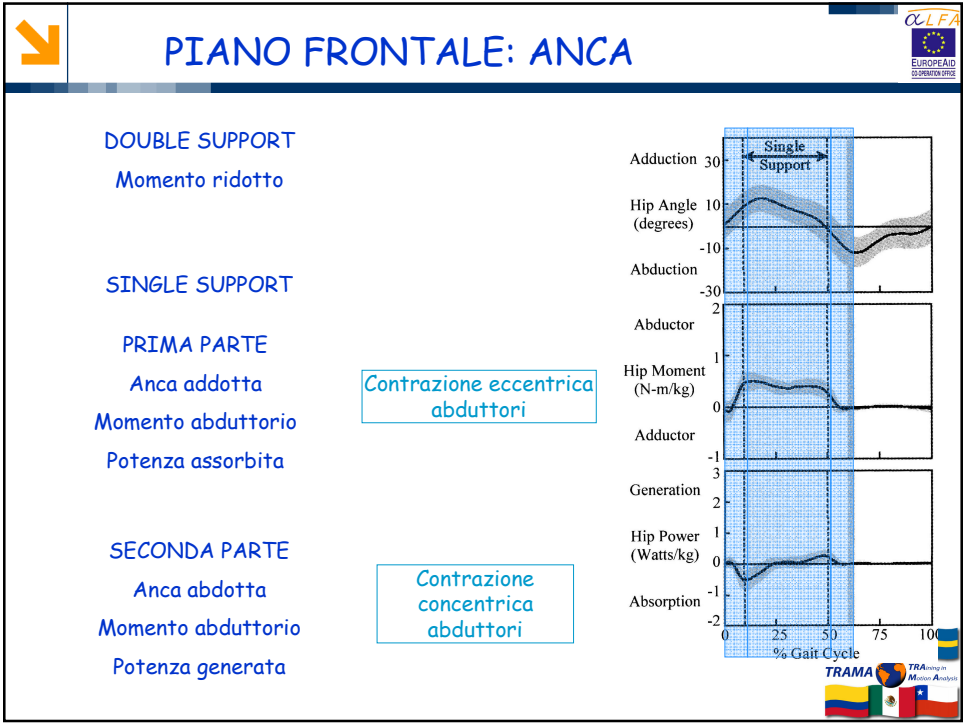
Tracciati patologici

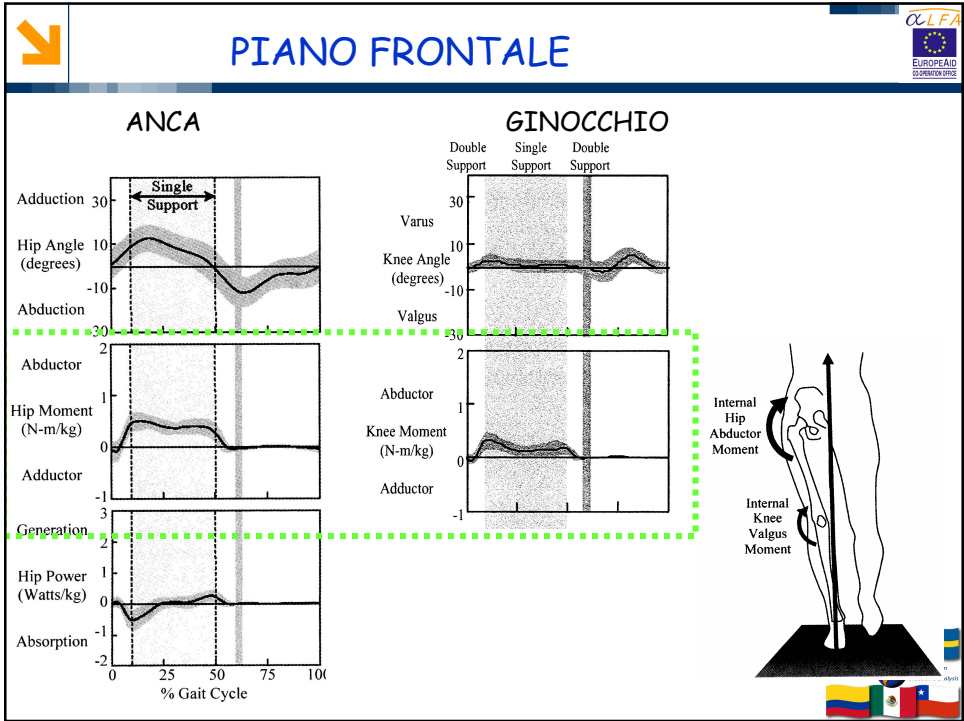
Qual è il ruolo del tronco e degli arti superiori?

Informazioni EMG

OLFA  
EUROPEAID  
EUROPEAN COMMISSION

TRAMA  
TRAMAPRO  
Motion Analysis







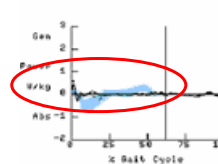
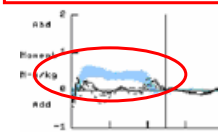
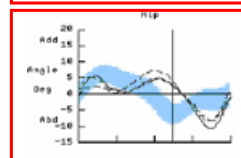
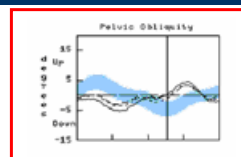
# HIP-ABDUCTOR AVOIDANCE PATTERN



**CINEMATICA**  
Pelvic obliquity down in stance con up in swing  
Anomalo movimento dell'anca in stance

**MOMENTO**  
Ridotto momento abduzionale in stance

**POTENZA**  
Ridotta potenza



*Thank you*



OLFA  
EUROPEAN UNION  
EUROPEAN COMMISSION

↓

Durante il cammino i muscoli producono delle **forze** al fine di:

- ⌘ Garantire l'equilibrio
- ⌘ Azionare i segmenti corporei

TRAMA TRAMA in Motion Analysis

↓ CONTRAZIONE EC

ABSORBER

↻

Plantaflessori durante il midstance

ankle power [W/Kg]

Gen

100s

TRAMA TRAMA in Motion Analysis



