**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
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 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

\[ \text{Moment} = \text{Force} \times \text{Distance} \]

\[ M_1 > M_2 \quad \text{if} \quad d < D \]

\[ M_1 = M_2 \quad \text{if} \quad d = D \]
Muscles or their associated tendons across joints at some distance away from the joint center

\[ \text{Moment} = \text{Force} \times \text{Distance} \]

\[ \text{[N} \times \text{m}] \]

**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 \textcolor{red}{\rightarrow} Internal Moments = External Moments

THE BODY PROCURES \textcolor{red}{\rightarrow} INTERNAL MOMENTS
IN RESPONSE TO \textcolor{red}{\rightarrow} \textcolor{red}{\rightarrow} \textcolor{red}{\rightarrow} EXTERNAL LOADS
THAT PRODUCE \textcolor{red}{\rightarrow} \textcolor{red}{\rightarrow} \textcolor{red}{\rightarrow} EXTERNAL MOMENTS

Force of gravity
\[ F = m \times g \]
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

\[ Power = \text{Moment} \times \text{Angular Velocity} \]

\[ Power = \text{Force} \times \text{Distance} \times \text{Angular Velocity} \]

[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)
The muscle power production depends on

- Gross sectional area
- Length/tension ratio
- Degree of fatigue
- Fiber type
KINETICS:
NORMATIVE DATA
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

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SAGITTAL PLANE: KNEE JOINT

PART A
Flexion
Extensor moment
Absorbed power

Eccentric contraction of extensor muscles

PART B
Flexion
Flexor moment

Eccentric contraction of gastrocnemius

PART C
Extension
Flexor moment
Absorbed power

Eccentric contraction of flexor muscles

SAGITTAL PLANE: HIP JOINT
PART A
Extension
Extensor moment
Generated power

PART B
Extension
Flexor moment
Absorbed power

PART C
Flexion
Flexor moment
Generated power

PART D
Flexion
Extensor moment

Concentric contraction of extensor muscles

Extensor muscles are not working \(\rightarrow\) gravity

Concentric contraction iliopectoas (rectus femoris)

Concentric contraction of extensor muscles
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

KNEE-FLEXOR MOMENT PATTERN

Eccentric contraction
of plantarflexors
Concentric contraction of
plantarflexors

Plantarflexion spasticity
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

Eccentric contraction of flexors
KNEE-EXTENSOR MOMENT PATTERN

KINEMATICS
High flexion in stance → CROUCH
Low ROM

MOMENT
Extensor moment in stance

POWER
Variable (it depends on ROM)
No high peaks

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

Conclusioni

DINAMICA

Tracciati soggetti sani

Tracciati patologici

Qual è il ruolo del tronco e degli arti superiori?

Informazioni EMG
PIANO FRONTALE: ANCA

DOUBLE SUPPORT
Momento ridotto

SINGLE SUPPORT
PRIMA PARTE
Anca addotta
Momento abduttorio
Potenza assorbita

SECONDA PARTE
Anca addotta
Momento abduttorio
Potenza generata

PIANO FRONTALE: GINOCCHIO

DOUBLE SUPPORT
Posizione neutra ginocchio
Ridotto momento

SINGLE SUPPORT
Posizione neutra ginocchio
Momento abduttorio
Potenza nulla
PIANO FRONTEALE

ANCA

- Adduction (30)
- Hip Angle (10 degrees)
- Abduction
- Abductor
- Hip Moment (N-m/kg)
- Adductor
- External Rotation
- Hip Power (Watts/kg)
- Absorption

% Gait Cycle

GINOCCHIO

- Double Support
- Single Support
- Double Support
- Varus
- Knee Angle (degrees)
- Valgus
- Abductor
- Knee Moment (N-m/kg)
- Adductor
- Internal Hip Abductor Moment

HIP-ABDUCTOR AVOIDANCE PATTERN

PHOTOGRAPHS OF A CHILD WALKING
HIP-ABDUCTOR AVOIDANCE PATTERN

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

MOMENTO
Ridotto momento abduttorio in stance

POTENZA
Ridotta potenza

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

- Garantire l’equilibrio

- Azionare i segmenti corporei

CONTRAZIONE ECCENTRICA

Plantaflessori durante il midstance
CONTRAZIONE CONCENTRICA

Plantaflessione in terminal stance