Clinical Gait Analysis

Potential Advantages of WSN Technology Over Passive Optical Measurement

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Overview

- What is gait analysis?
  - The gait cycle
- Measurement of gait
  - Kinematics
  - Kinetics
  - Three-dimensional gait analysis
  - Passive optical measurement
  - Pathological gait
  - Data output and interpretation
- Advantages of WSN technology
- Further applications

What is gait analysis?

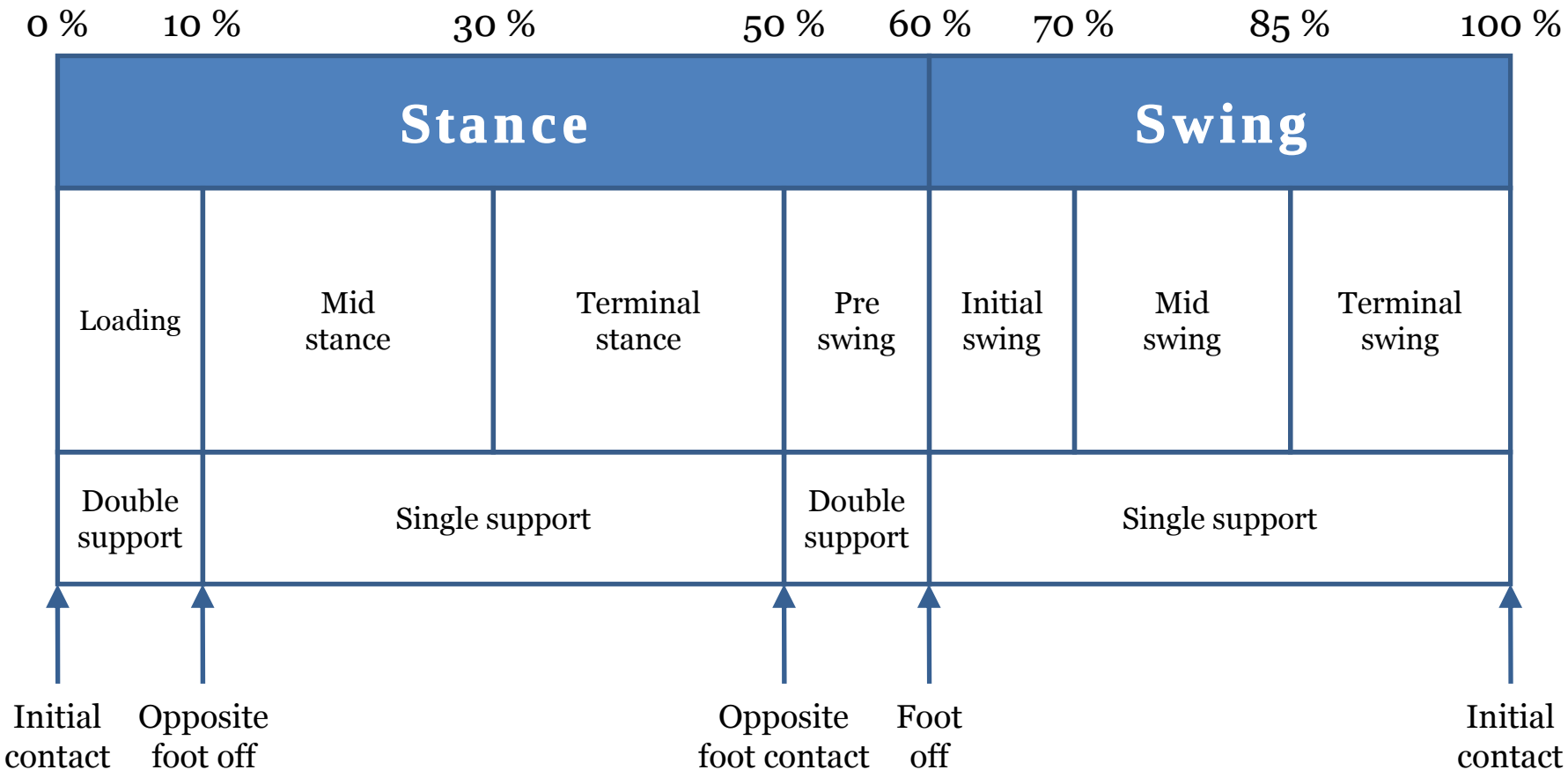
- Brief observation to sophisticated measurement
- Various approaches and paradigms
  - Podiatry
  - Physiotherapy
  - Prosthetics
  - Cerebral palsy
- Objective theoretical principles
- Data collection
- Subjective interpretations

What is gait analysis?

- *If thou examinest a man having a smash of his skull, … while his eye is askew because of it, on the side of him having that injury which is in his skull [and] he walks shuffling with his sole … with his sole dragging, so that it is not easy for him to walk, when it [the sole] is feeble and turned over, while the toes are contracted to the ball of his sole, and they [the toes] walk fumbling the ground*

Edwin Smith Surgical Papyrus ~ 2000 BC

The gait cycle



Measurement of kinematics

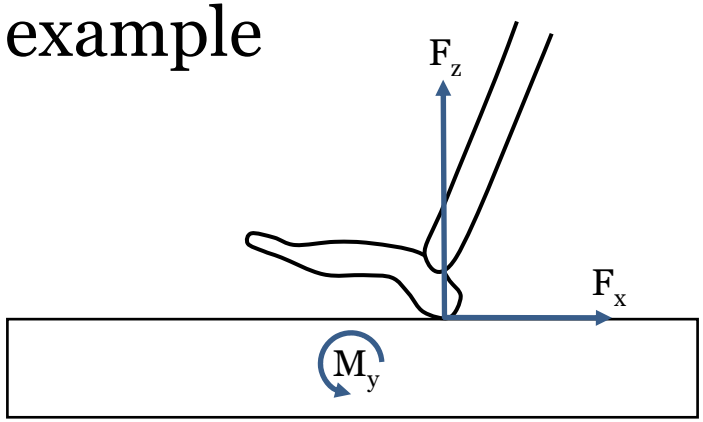
- Description of gait in terms of angles, displacements, velocities and accelerations
- Measurement techniques
  - Video
    - Subjective scoring methods
  - Electrogoniometer (potentiometer, strain gauge)
    - Rely on accurate alignment
    - 2D (sagittal plane) measurement
    - Relative motion between adjacent body segments

Measurement of kinematics

- Absolute measurement techniques
  - Optical
    - Vicon Motion Systems, CODA
  - Electromagnetic
    - FasTrak, MotionStar Wireless
  - Ultrasonic
    - Zebris
  - Inertial
    - xSense, Specknet?

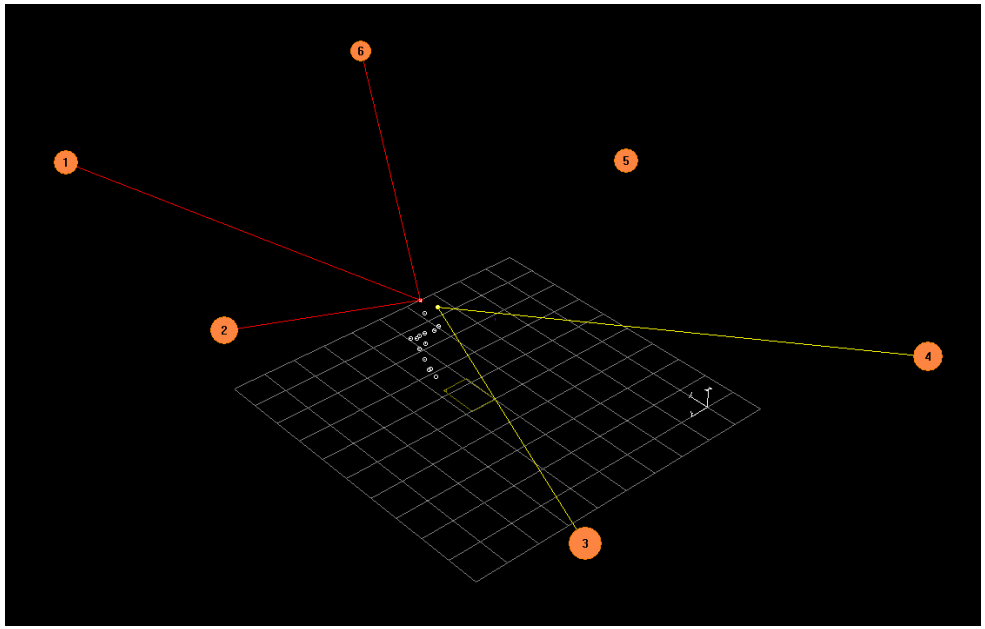
Measurement of kinetics

- Ground reaction force
- Centre of pressure
  - Force plate
  - Three components of GRF (F_x, F_y, F_z)
  - Three moments about force plate centre (M_x, M_y, M_z)
- Sagittal plane example



Three-dimensional gait analysis

- Track images from two or more cameras
- Points used to reconstruct original 3D trajectories



Three-dimensional gait analysis

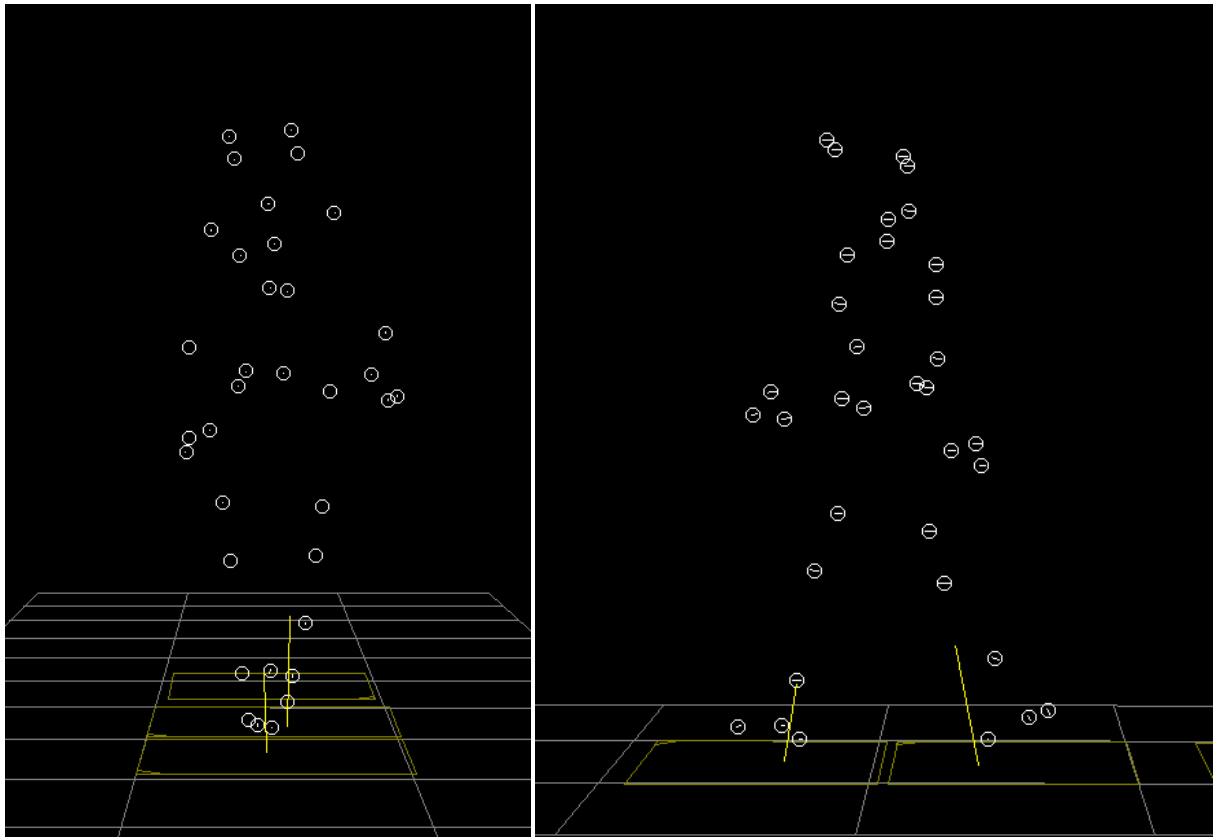
- Track images from two or more cameras
- Points used to reconstruct original 3D trajectories
- Volume calibration
- Typical accuracy ± 0.1 % of capture volume
- Anderson gait analysis laboratory
  - 6 IR cameras (12.5 mm lens)
  - 100 Hz, 1.3 million pixel resolution, 64 analogue
  - £50k

Gait analysis models

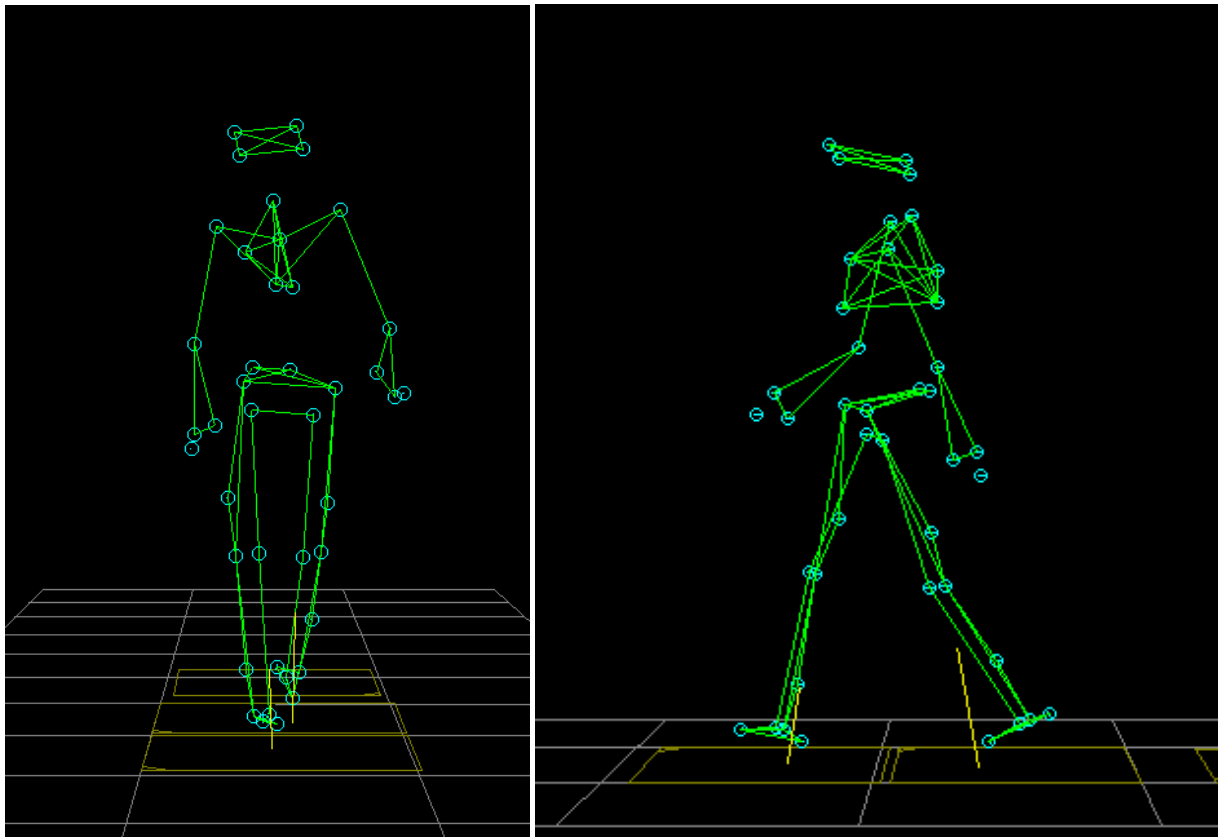
- Three markers per body segment
  - Markers on joints define two adjacent segments
- Vicon Clinical Manager (VCM) model
  - 3D axis system for each segment
    - Flexion/extension (sagittal plane angles)
    - Abduction/adduction (coronal plane angles)
    - Internal/external rotation (transverse plane angles)
  - Euler angle sequence
    - y, x, z (Davis *et al.* 1991)
    - Different sequences usually clinically insignificant

Passive optical measurement

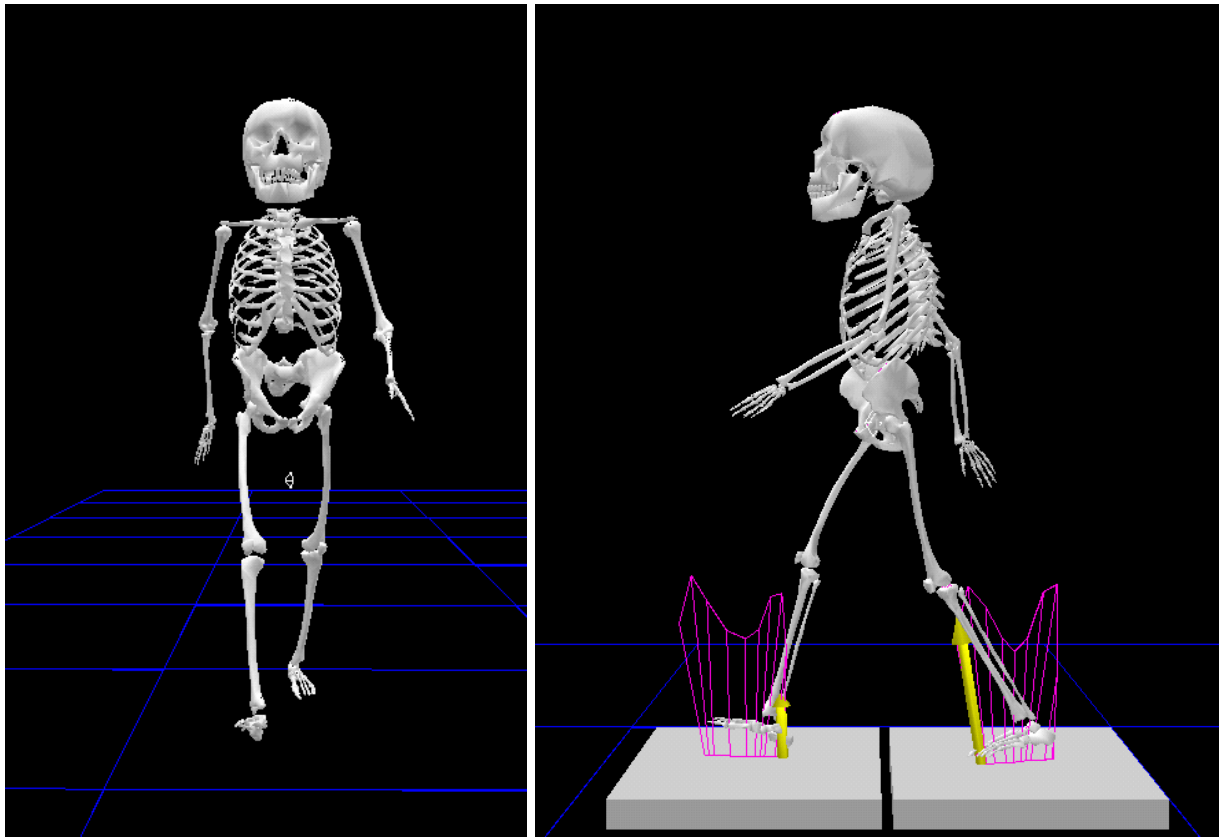
Passive optical measurement



Passive optical measurement

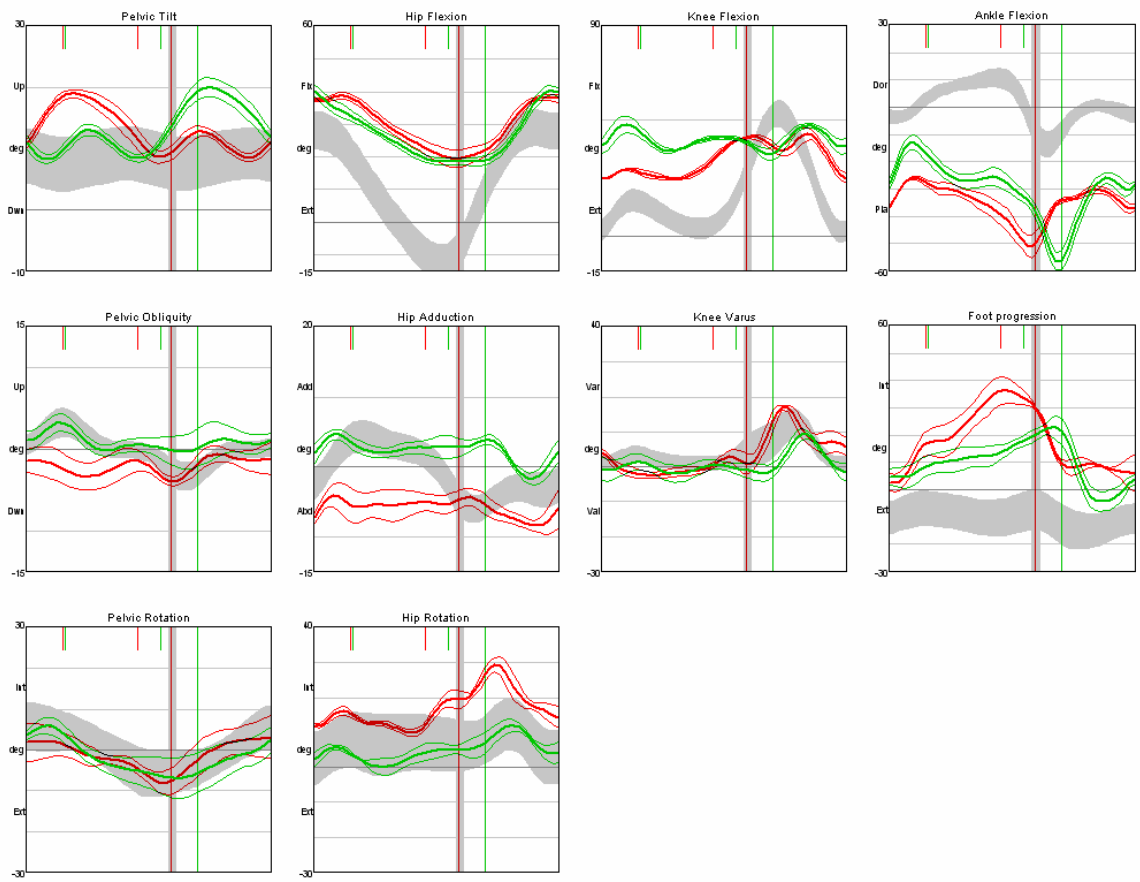


Passive optical measurement



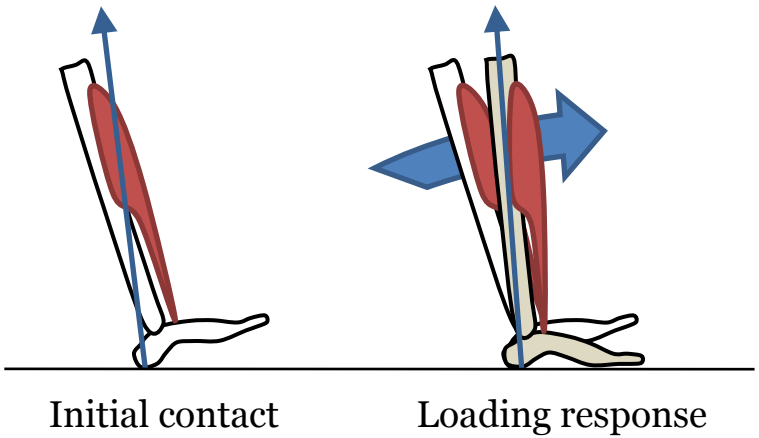
Pathological gait

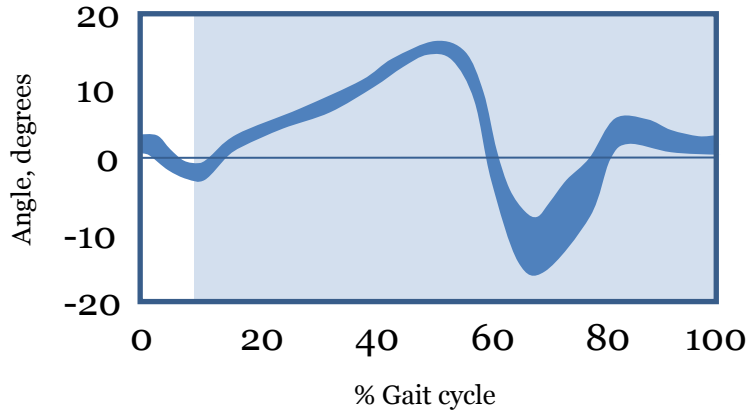
Data output and interpretation

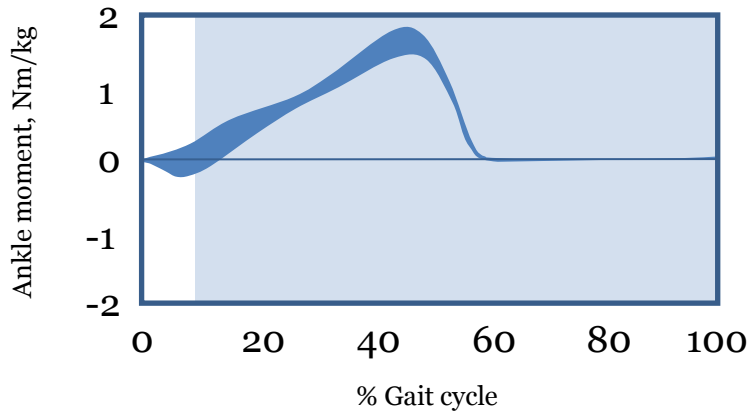


Data output and interpretation

- Initial contact & loading response
- 0 – 10 % gait cycle
- Ankle plantar flexion
- Heel rocker







Advantages of WSN technology

- Not confined to laboratory
  - Capture ‘normal’ walking
  - Different ground surfaces
  - Ramps, stairs etc
  - Remote motion capture
- Less invasive
  - Capture ‘normal’ walking
  - Tolerate for extended periods
- No crossover
  - Improved measurement of foot kinematics
- Lower cost
  - Screening tool

Further applications

Further applications

Questions?