EPTRI

THE CHILDREN'S MEMORIAL HEALTH INSTITUTE

EPTRI General Assembly and Scientific Meeting
Warsaw, 28-29 July, 2026

OptiTrack Feasibility for Paediatric Gait Assessment in Achondroplasia: A Rare Disease Laboratory Use Case

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Achondroplasia: the clinical challenge

1 in 25,000
live births
skeletal dysplasia

–6.0 SD
final adult height, both genders

110–130 cm
typical final adult height range

- Disproportionate limb segments, joint laxity and macrocephaly → demanding gait pattern
- Standard adult-based or full-body clinical gait models not appropriate
- Movement assessment→ implementation strategies tailored to condition-specific anatomy
- Need of adaptable tools to generate evidence

Why gait analysis matters

A

Objective detection

Walking pattern → quantifiable kinematic, kinetic and temporal data

B

Diagnostic support

Disease-specific gait deviations vs typical developmental variation

C

Treatment planning & monitoring

Surgical, orthotic and therapeutic decisions guidance

Effect tracking over time

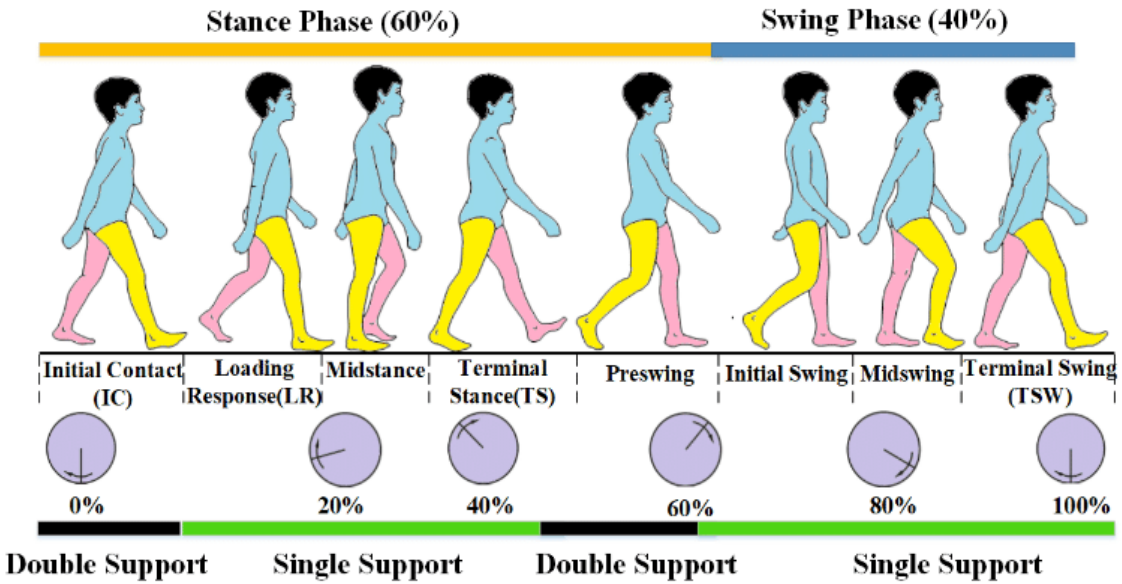
D

Research capacity for rare diseases

Evidence base for translational research

Gait analysis is essential for supporting children's healthy development and improving quality of life, enabling early detection of abnormalities, guiding targeted interventions

Wren T et al., (2020) Clinical efficacy of instrumented gait analysis: Systematic review. *Gait Posture*



Gait analysis

1

Kinematics

- joint angles
- segment motion through the gait cycle

2

Kinetics

- ground reaction forces
- joint moments/powers (force plates, inverse dynamics)

3

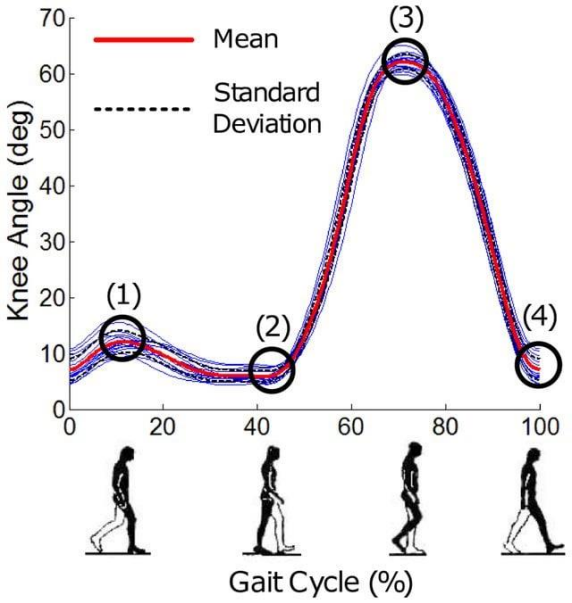
Electromyography

muscle activation

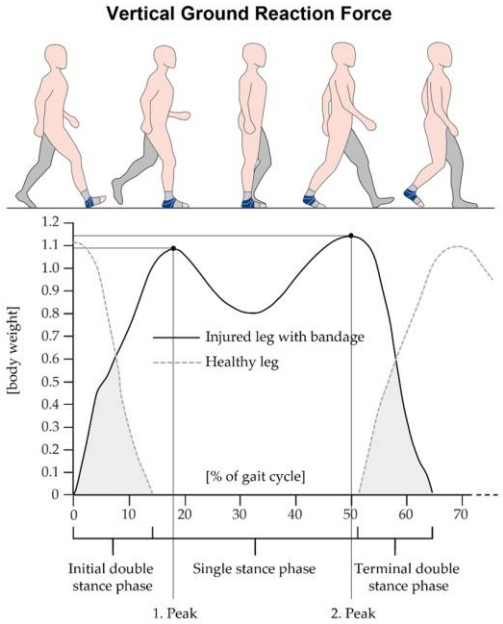
4

Energy cost

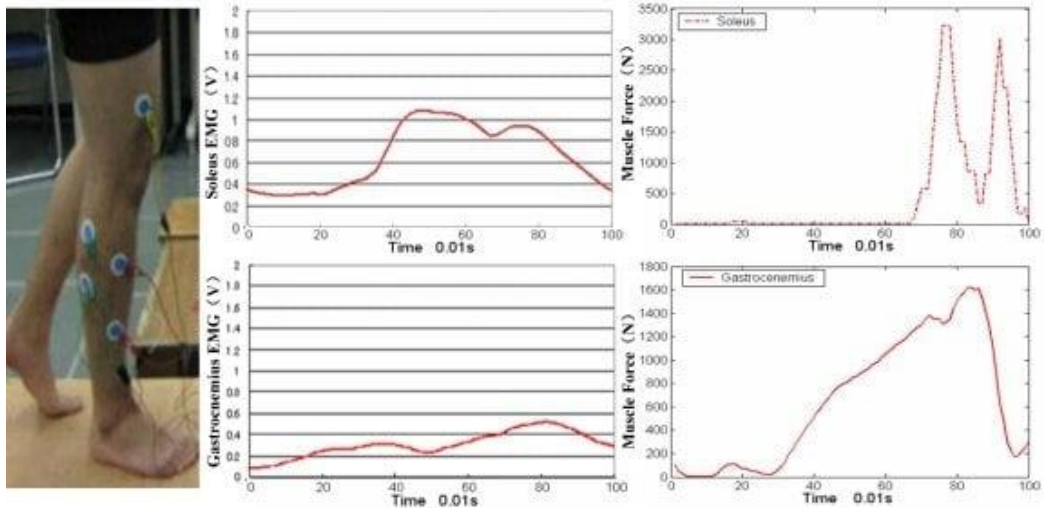
metabolic efficiency of walking



Ahn J, Hogan N (2012) Walking Is Not Like Reaching: Evidence from Periodic Mechanical Perturbations. PLoS ONE



Heß T, et al (2024). Immediate Effects of Wearing an Ankle Bandage on Fine Coordination, Proprioception, Balance and Gait in the Subacute Phase of Ankle Sprains. *Life (Basel)*.



Tao W et al (2012). Gait analysis using wearable sensors. Sensors

Gait analysis

1

Clinical exam & observation

Baseline physical exam + qualitative / video observation of walking pattern

→

2

Marker or sensor placement

Reflective markers,
active LEDs,
wearable IMUs
(applied to anatomical landmarks)

→

3

Synchronised capture

Multi-camera optical tracking,
force plates
EMG

→

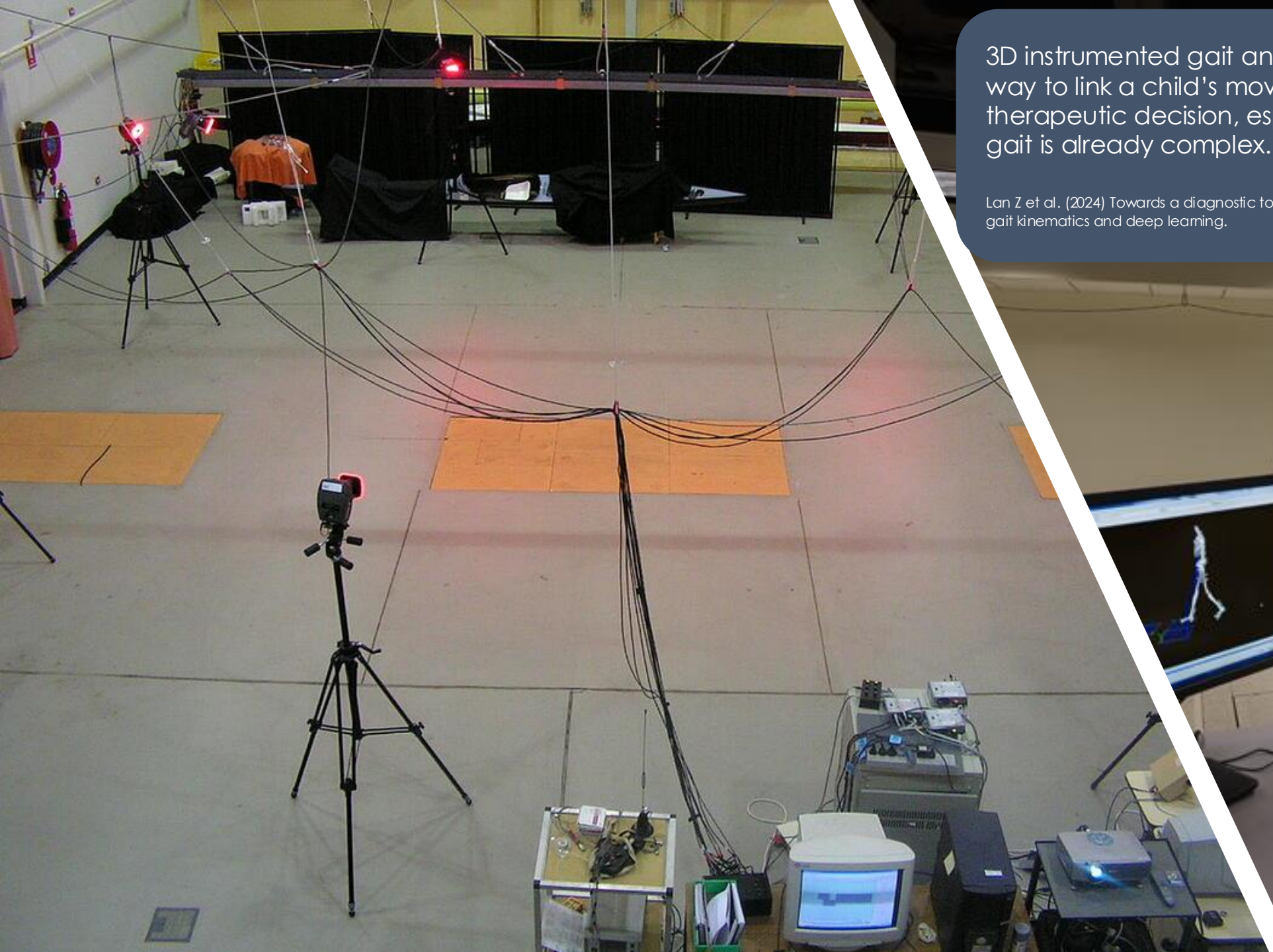
4

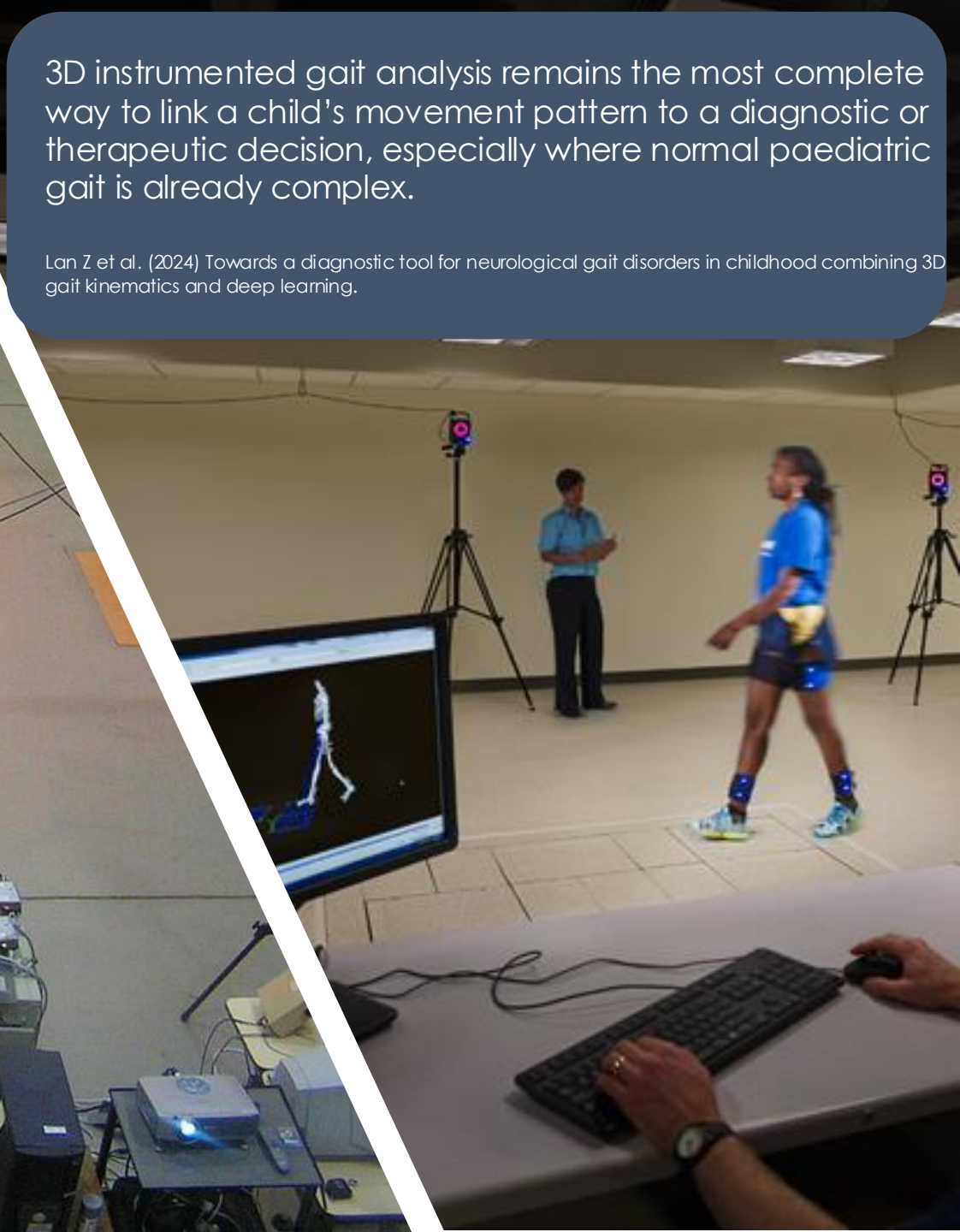
Modelling & parameter extraction

3D reconstruction
joint kinematics,
kinetics,
muscle activation
gait-cycle metrics

3D instrumented gait analysis remains the most complete way to link a child's movement pattern to a diagnostic or therapeutic decision, especially where normal paediatric gait is already complex.

Lan Z et al. (2024) Towards a diagnostic tool for neurological gait disorders in childhood combining 3D gait kinematics and deep learning.





Motion-capture system categories

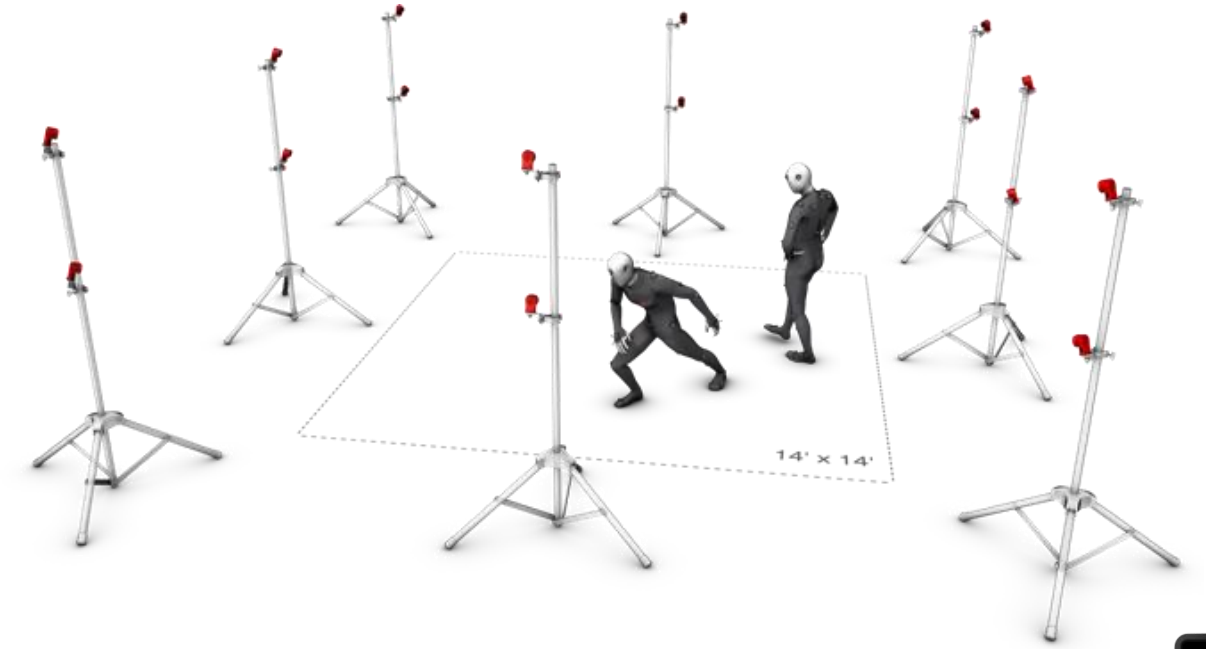
System type	Systems	Accuracy	Set-up burden	Portability
Marker-based optical	Vicon, Qualisys, **OptiTrack**	Sub-mm	High: Marker application + calibration	Fixed laboratory volume
Markerless optical / video	Theia, pose-estimation systems	Good and improving; still below marker-based	Low: no markers, faster set-up	Flexible — lab or field-capable
Inertial (IMU) / wearable	Xsens Other sensor suits	Moderate; drift over longer recordings	Low–moderate	High — portable, community-based

Nagymáté & Kiss (2018), Motion capture system validation with surveying techniques
Schroeder et al., (2022) Accuracy measurement of different marker based motion analysis systems

The "right choice" depends on required accuracy, participant burden, and setting.

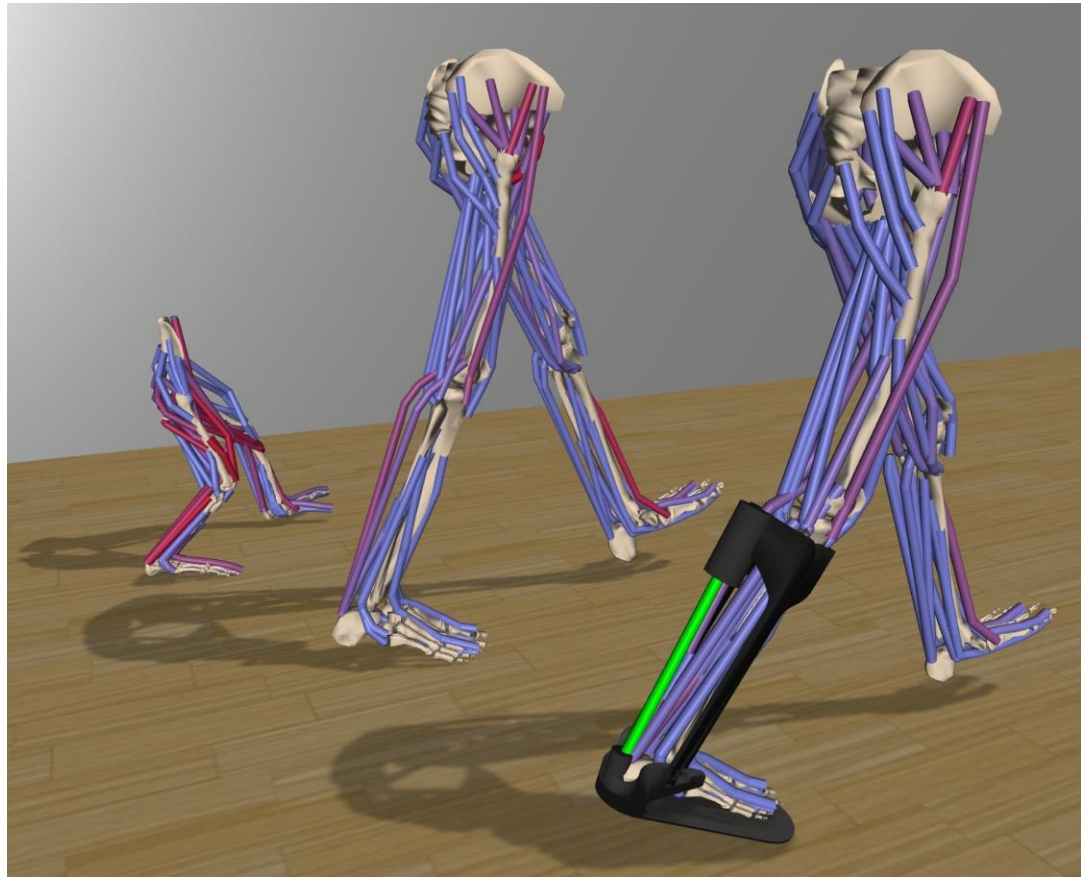
OptiTrack

- Infra-red optical motion-capture system
- Multiple synchronised IR cameras track passive retro-reflective or active LED markers
- Sub-millimetre marker-tracking accuracy achievable under controlled laboratory conditions
- Predefined & custom models
- Marker auto-generate a **3D avatar** / skeleton in real time
- Interoperable with external biomechanics platforms (**OpenSim**) → inverse dynamics and joint force/moment calculation



Exploring OptiTrack vs traditional 3D systems in paediatrics

Usability dimension	Traditional clinical 3D systems	OptiTrack
Marker model	Fixed, adult-oriented clinical templates	**Flexible** — predefined or fully custom models
Set-up time (this case)	Often lengthy in the achondroplasia literature	10 minutes, program-guided placement
Fit for disproportionate anatomy	Limited — built for typical proportions	Adaptable to short stature and altered landmarks
Modelling / analysis integration	Frequently closed, proprietary pipelines	Open coordinate export; integrates with **OpenSim**
Accessibility	High cost, specialised infrastructure	Comparatively more accessible for exploratory use



Seth et al. (2018) OpenSim: Simulating musculoskeletal dynamics and neuromuscular control to study human and animal movement. *PLoS Comput Biol*

Feasibility study in a girl with achondroplasia

Objective

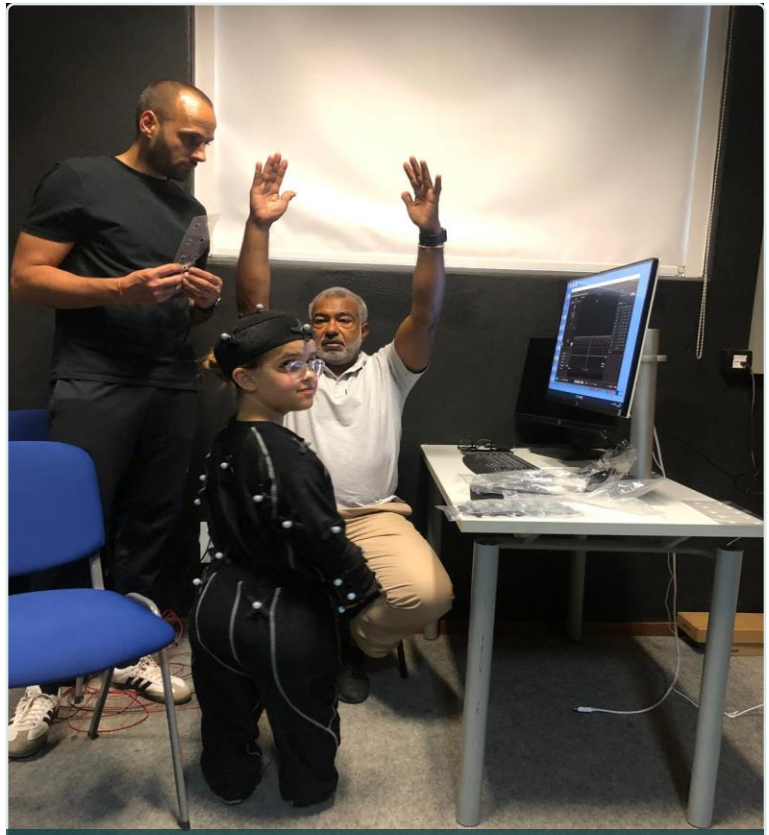
- Assess the usability of OptiTrack for paediatric gait recording
- Compare against traditional 3D gait-analysis systems previously used in achondroplasia research.

Kiernan (2021) → CODA

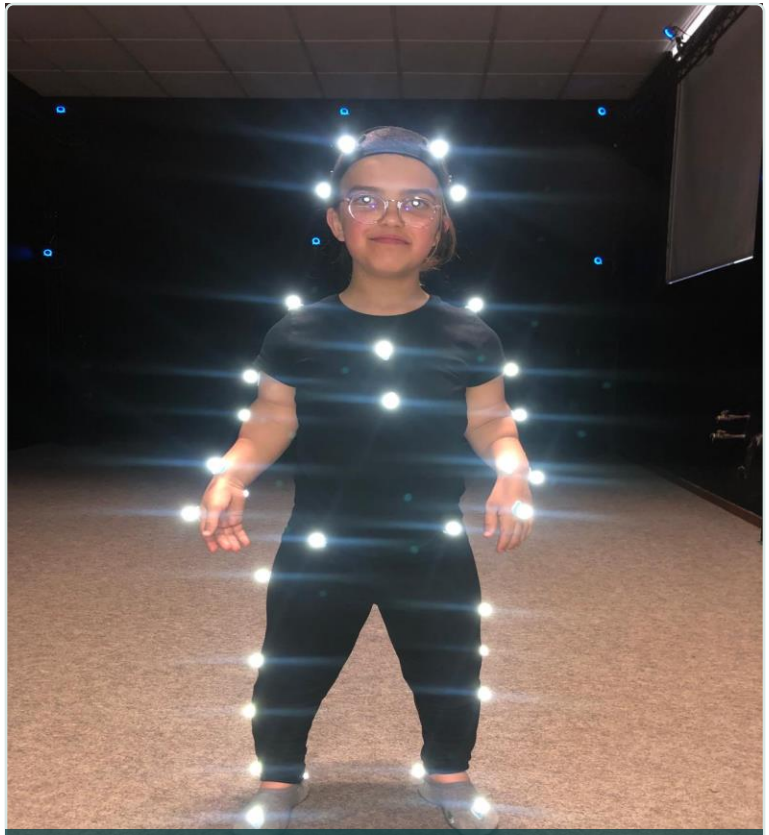
Broström at al. (2022) → Vicon

12 yrs	120 cm	40 kg	41 points
age	height	weight	marker model

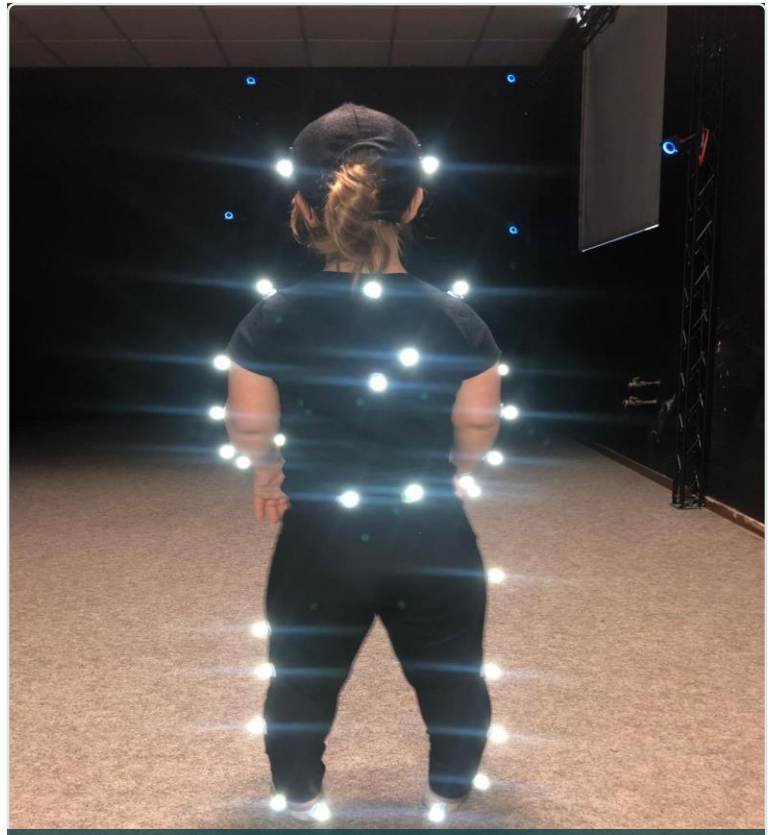
Marker placement in practice



Lower-limb marker application



41-point model, full-body view



Positioning for calibrated capture

Data collection protocol

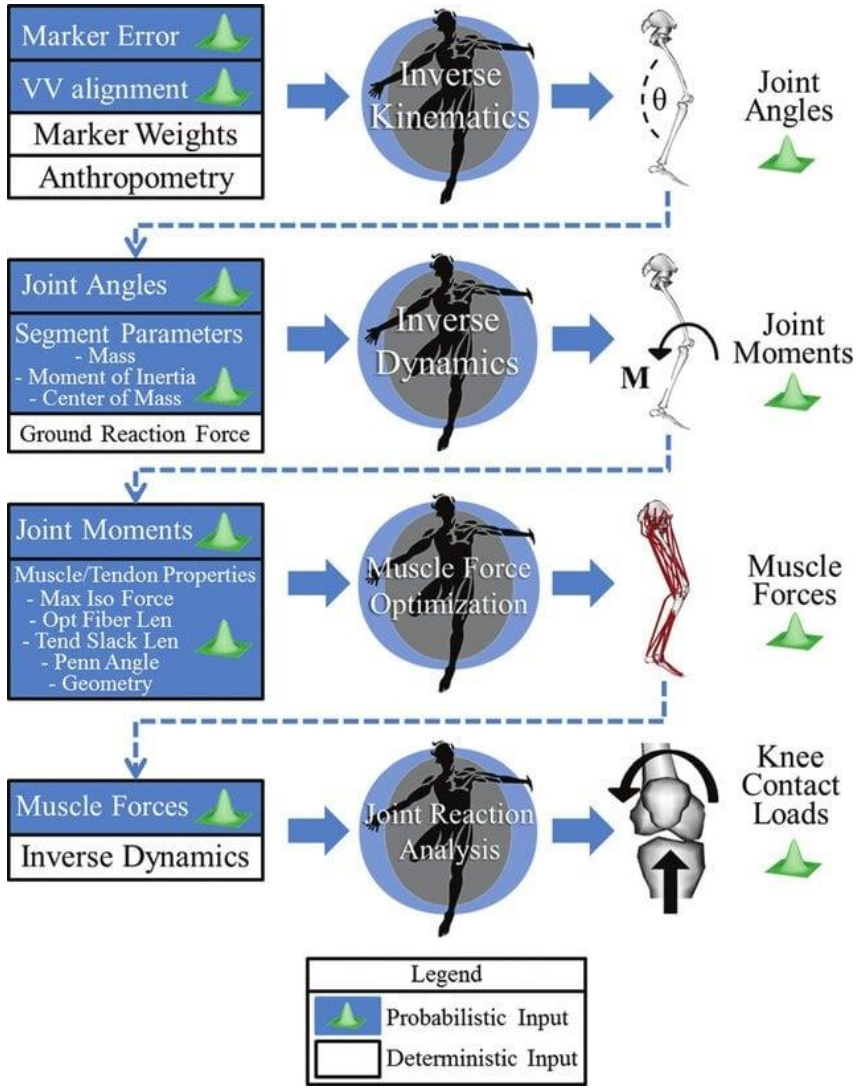
Complementary tools

OptiTrack
Primary optical tracking
3D marker trajectories

OpenSim
Inverse dynamics — joint forces & moments

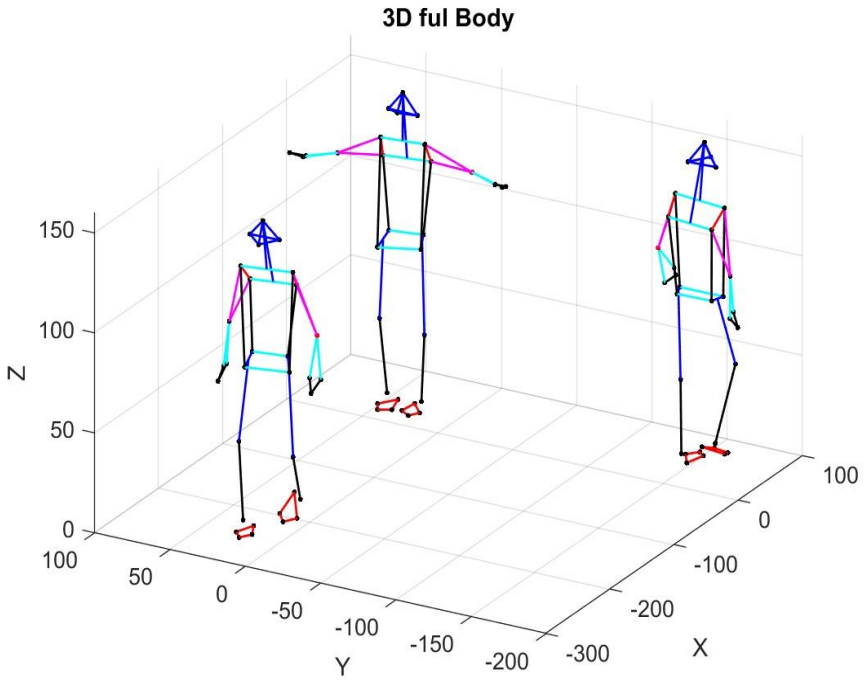
+ IMU sensors

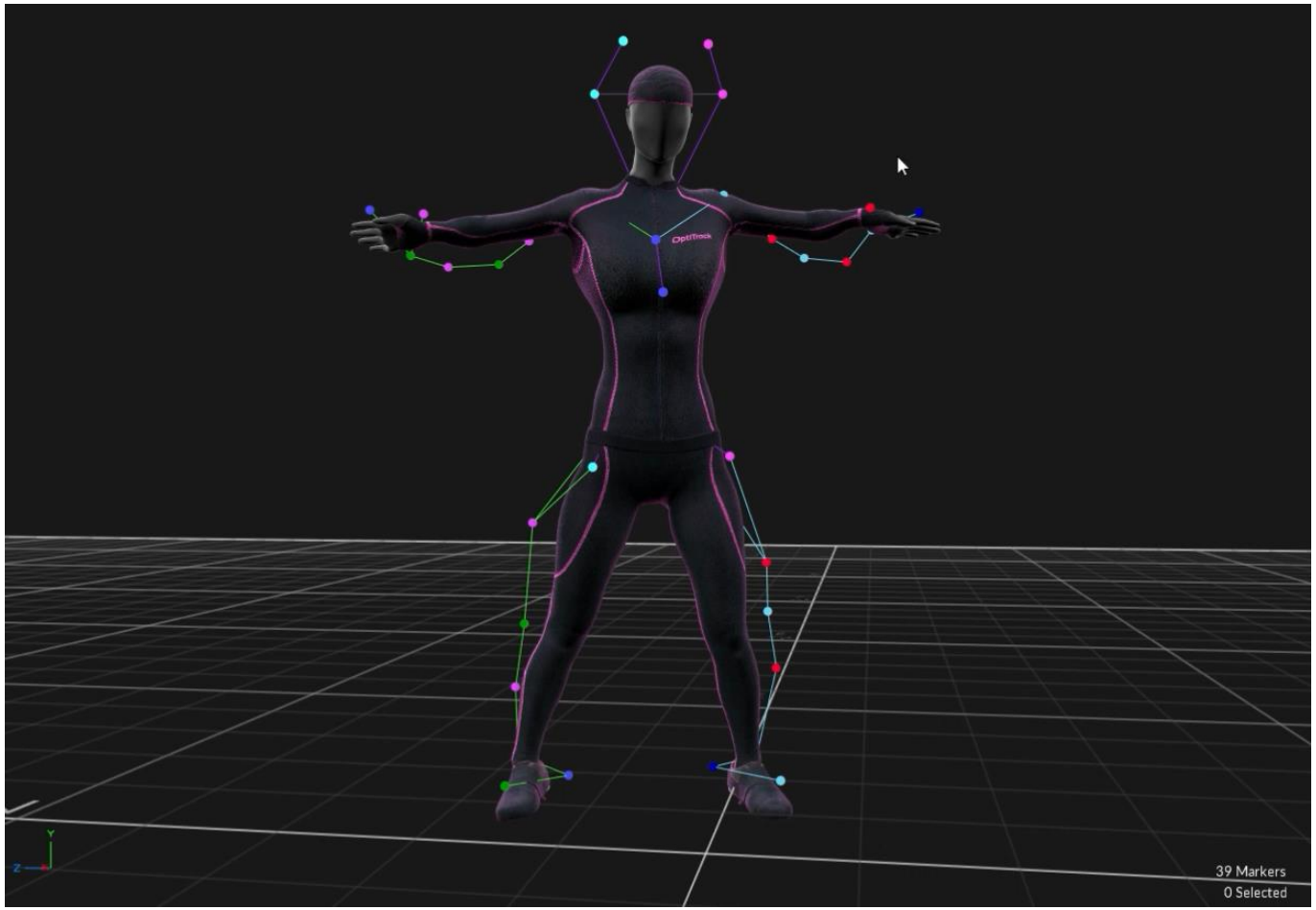
Conventional parameters
nonlinear gait dynamics



Navacchia et al. (2016) Prediction of In Vivo Knee Joint Loads Using a Global Probabilistic Analysis. J Biomech Eng..

3D capture & reconstruction





Synchronised IR camera array

Real-time avatar reconstruction

Feasibility outcomes

Flexible modelling

Practical protocol

Open interoperability

Scalable for other conditions in pediatrics

What remains a challenge

- Anatomical landmark identification remains complicated by severe short stature, body disproportionality and frequent coexisting obesity
- Condition-specific paediatric marker and biomechanical models are still needed

Thank you

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