

"The past, present and future of gait analysis,


why there are still plenty of unanswered questions and what shall we do about them?"

R E Major

### Early Education & Experience

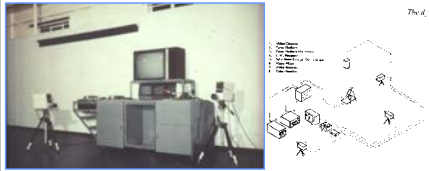
- Trained and worked in the motor industry.
- Taught Motor Vehicle Studies in Further Education.
- Saw advert. for orthotic G.A. post ---

### My early days in GA (1978 ...)



- Mr G K Rose FRCS
- One of the 'old school'
- Black could be white!
- A great leader
- Founder of Orthotic Research and Locomotor Assessment Unit (ORLAU)

### Original ORLAU Lab.



MAJOR, RE., STALLARD, J. and ROSE, GK. (1981). The dynamics of walking using the Hip Guidance Orthosis (Hgo) with crutches. Prosthetics & Orthotics International, 5(1), 19-22

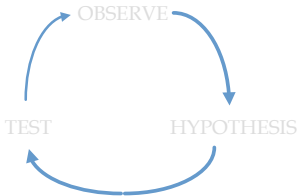
### 3D labs did exist, but

- Accepted clinical marker sets had not been developed.
- Data processing took several days.
- Useful for research.
- Not judged to be a clinical tool.

### The First UK Clinical Lab ?

- Established at ORLAU in 1980
- Working methodology:
  - Clinical examination
  - Gait recording (with Video Vector)
  - Analysis (with the patient present)


### ANALYSIS with patient



THINKING  
is  
MORE IMPORTANT  
than  
INSTRUMENTATION

### Patient Mix

- Spina Bifida
- Muscular Dystrophy
- Traumatic paraplegia
- Other orthopaedic conditions
- CP



- In many cases it is not possible to restore 'normal' gait.
- Therefore seek the best compromise.
- Optimise orthotic intervention through surgery.

### Problem

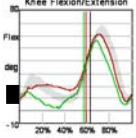
- Why do we expect surgery on children with cerebral palsy to succeed?
  - We know they have a control deficit
  - Deformity and muscle imbalance have developed in light of the deficit
  - We compare their walking with expectation
  - Why should surgery succeed since the control deficit is still present?
  - Does this need more research?

### Quality Control

All contribute to the final success or failure.

- Gait Assessment
- Proposed Intervention (Surgery?)
- Intervention
- Rehabilitation therapy
- Re-assessment

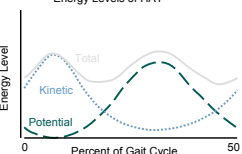
Is it worth putting a large resource into QA in the Gait Laboratory if other components are less well controlled?



- Why consider the 'normal' range?
- Is it to give you confidence in the measurements?
- Does it help plan an intervention?
- What about understanding 'normal' gait?



### Energy Levels of HAT




### Recent studies examining determinants of gait.

- Gard SA, Childress DS. The effect of pelvic list on the vertical displacement of the trunk during normal walking. *Gait Posture* 1997;5 :233-8.
- Gard SA, Childress DS. The influence of stance-phase knee flexion on the vertical displacement of the trunk during normal walking. *Arch Phys Med Rehabil* 1999;80:26-32
- Kerrigan DC et al., A refined view of the determinants of gait: significance of heel rise. *Arch Phys Med Rehabil* 2000;81:1077-1080

### Questions:

- 1) Why do we walk the way we do?
- 2) Why does changing a treadmill gradient influence metabolic cost?
- 3) Why do we allow our prime sensory organs to be perturbed during walking?
  - Textbooks explain the exchanges between potential and kinetic energy.
  - Why not walk at constant velocity and constant height?



### Some answers: Level Walking

- Gravity is our main problem.
- Minimising moments, and therefore moment arms, is essential for low energy walking.
- In general accelerations in the plane of progression are mandatory for low energy ambulation.
- Vertical excursions are invoked for energy exchange purposes despite the data management costs.

### Some answers: Level Walking References

- ALEXANDER RMcN. The Human Machine, Columbia University Press, ISBN 0-231-08066-2, 1992.
- MAJOR RE, BUTLER PB. A new description of gait determinants (Abstr 93), European Federation for Research and Rehabilitation, Abstracts. Clin. Rehab. 1992; 6(Suppl), 52.
- PAUL JP. Fundamental concepts in gait analysis. Abstracts. VIII meeting of the society of biomechanics, Rome, 1992: 11-12.

### Some answers: Uphill Treadmill Walking

- Gravity is still our main problem.
- Minimising moment arms is still essential for low energy walking.
- We can no longer optimise our geometry with the ground reaction force.
- Metabolic costs rise even without external work increases.

### Speculation: Downhill Walking

- Gravity is still our main problem.
- Minimising moment arms is still essential for low energy walking.
- We can no longer optimise our geometry with the ground reaction force.
- Metabolic costs may rise even though we are gaining potential energy.
- The need to **CONTROL** our descent may be the governing factor.

### Knee Moment

Radem & DiPaola: Biomechanics of Descending Ramps, Gait and Posture 6 (1997) 118-125

### Push Off

- Power
  - Difference between scientific definition and clinical use to mean the ability of muscle to generate force.
  - Misuse of the scientific measurement. Power is a scalar quantity.

### Push Off

The Great Propulsion Heresy.

The major bursts for propulsion are generated by the ankle plantarflexors (A2) .....  
(85% attributed to Winter (1987).

Gage JR. Gait Analysis in Cerebral Palsy, 1991

### Push Off

GRF data from D A Winter

### But .....

..... from the work of Collins and Ruina at Cornell.