Key Performance Indicators for Rowing

Andrew J Murphy, PhD
Anthony MJ Bull
Alison H McGregor

Imperial College London
Department of Bioengineering
Division of Surgery

Imperial College London

uk sport

British Rowing

Setting the scene

- Biomechanics
- Kinematics
- External forces

Structure

- History – rowing, research, and Imperial
- My work – rationale, systems, scope
- Results
- Discussion and implications

Rowing, research, and Imperial

- Early imaging studies

- Spinal motion
  - Lumbar
  - Pelvic

- Lab based motion analysis
  - Two-dimensional
  - Stroke profile

Rationale, systems, scope

Rationale for my work

- Development of existing system
  - 3D movement
- Description
  - Intensity
  - Training
- Performance
- Injury?

Andrew J Murphy
andrew.j.murphy@strath.ac.uk

Measurement system

- Real time biofeedback
- Handle force and motion
- Flock of Birds motion capture
- Seat force and COP

Experimental method

- □ Stretch
- □ Warm up
- □ Attach markers

- □ Ergometer rowing
  - Incremental 6 stage Step test
  - Individualised using 2k PB

Measurements

- □ Trajectory and rotation of:
  - LSJ,HJC,KJC,AJC,FJC

Sagittal plane

LSJ flexion

Lumbar spine

Pelvis

LSJ extension

Lumbar spine

Pelvis

Measurements

- □ Trajectory and rotation of:
  - LSJ,HJC,KJC,AJC,FJC

- □ Stroke profile
  - Handle force
  - Handle motion
  - Seat force
  - Seat COP
  - Suspension
  - Length, Work, Power

c:\data\test\a-rower-1

-104.8   STOP

Three-dimensional (3D) kinematic reconstruction and modelling

Additional testing

- □ Muscle function
- □ Cybex
- □ Trunk
  - Extensors
  - Flexors
  - Strength
  - Power

Andrew J Murphy
andrew.j.murphy@strath.ac.uk

Scope

- Members of GB Rowing squad
- Many months
- Comprehensive database of biomechanical data

Results

Data analysis

- Descriptive
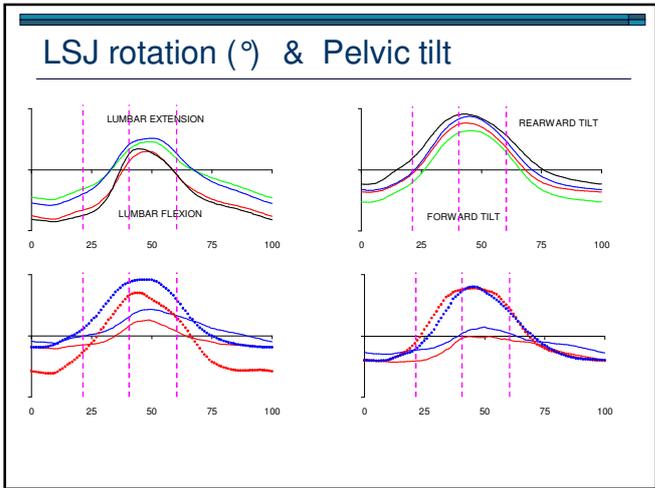- Intensity
- Longitudinal
- Performance
- Injury

External forces

Force (N)

COP (mm)

3D kinematics

Joint trajectories (mm)

Horizontal axes: 0-100% stroke cycle   Step 6 – race pace efforts

Joint rotations (°)

Horizontal axes: 0-100% stroke cycle   Step 6 – race pace efforts

LSJ rotation (°)   & Pelvic tilt

"…the knee bone's connected to the thigh bone…"
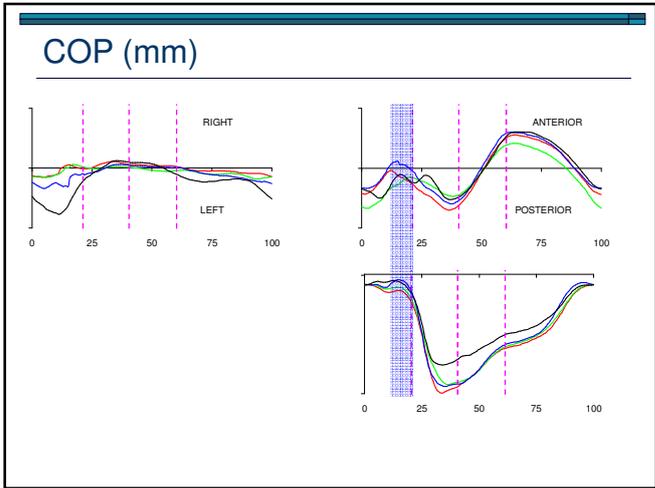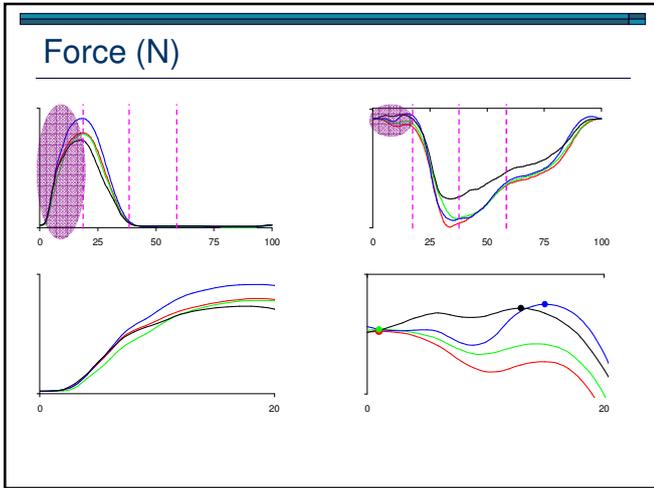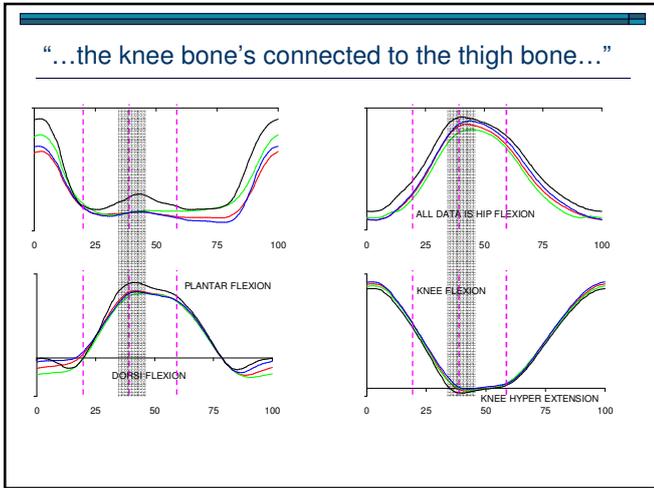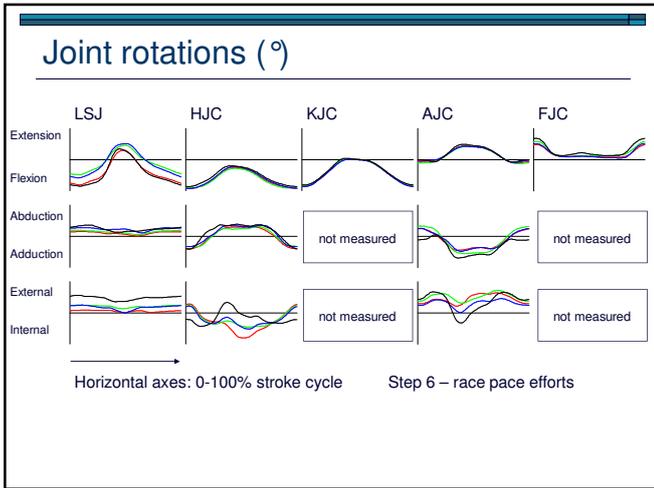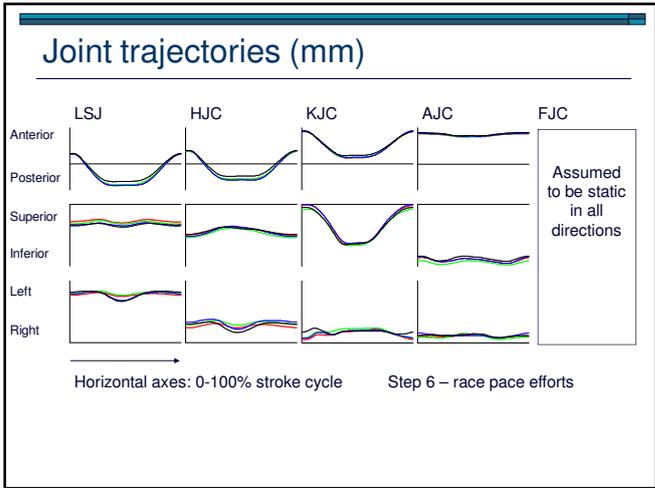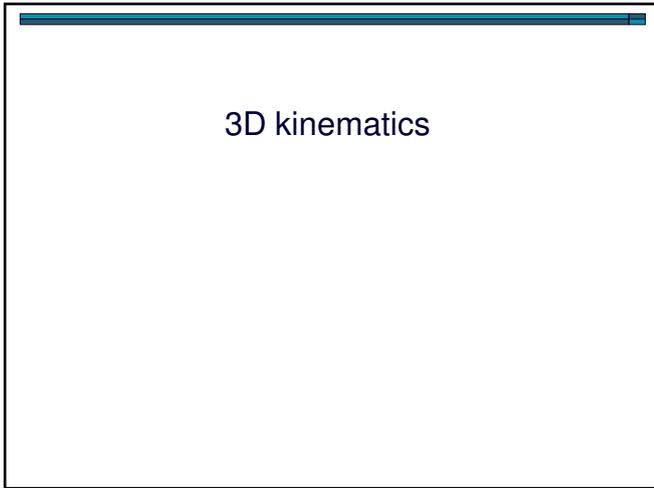
Descriptive

- ☐ Some differences noted between athlete groups
- ☐ Variability of motion
- ☐ High correlation
  - ■ Max, Min – Catch, Finish

- ☐ Does the pelvis and back influence the limbs, or is it the opposite?

Andrew J Murphy
andrew.j.murphy@strath.ac.uk

Discussion and implications

Exercise intensity - Summary

- □ Stroke profile
  - As expected
- □ Kinematics
  - Race pace sig different from lower intensity
  - Possibly less controlled
  - Less postural control
    - □ Less time to perform same action
    - □ 18 strokes/min ≈ 3.3 s   32 stroke/min ≈ 1.9 s

Longitudinal – Summary

- □ Stroke profile
  - As expected
- □ Stronger, more upright posture
- □ Lower LSJ alpha at catch and mid drive
- □ Coaching, training and assessment are effective in managing stroke profile and kinematic technique

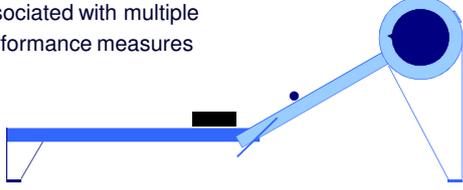## Performance

Performance - Measurement

- □ Predicting performance
  - Timing of the stroke
  - Rate of force production
  - Stroke length
  - Power output
  - Seat force & COP
- □ Statistics
  - Principal component analysis
  - Correlation analyses
  - Multivariate regression

Performance - Kinematics

- □ Majority of kinematic variables influenced at least one performance measure
- □ Recommendations based on association with multiple performance measures

Performance - Kinematics

- Flex/Ext or displacement in sagittal plane is more important than medial lateral
 - All general recommendations associated with multiple performance measures

Performance - Power - Kinematics

- Majority of kinematic variables influential to power output described motion of the legs
  - Majority of power output should come from the legs
  - Low back & pelvis main role is transmitting power
  - Driving legs down quickly
  - Heels up at catch and down at finish

Cybex – Trunk muscles – LSJ delta

- Literature suggests
  - 130-160% bias in favour of extensors

- Correlation analysis
  - Stroke events have different optimal muscle bias
  - General recommendation is in line with literature
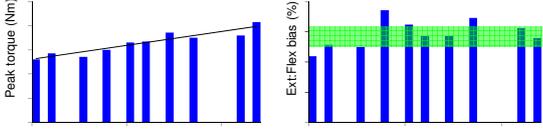
Performance - Stroke Profile

- Rate force production ↑
- Suspension
  - Maximise during initial drive
  - Reduce during late drive
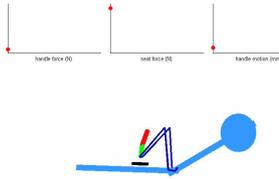- COP deviation left/right ↓

What does this mean?

- Action of the legs
- Postural control
- Rate and magnitude of force production
- Importance of suspension

Energy transfer

Training implications – Kinematics

- LSJ alignment
- LSJ delta during drive
- Heel timing
  - Catch
  - Mid-drive
  - Finish

Andrew J Murphy
andrew.j.murphy@strath.ac.uk

Training implications – Kinematics

- Biomechanical measurement
  - High level analysis for discrete joint behaviour
  - Video playback to observe gross segment motion
  - Visual inspection of relative rate of motion of:
    - Blade/handle vs knees
    - Shoulders vs hips
    - ...
  - Boat setup/rigging, insoles, orthotics

Training implications – Muscle

- Awareness of muscle group activation and sequencing
- Flexibility
- Role of specific muscle groups
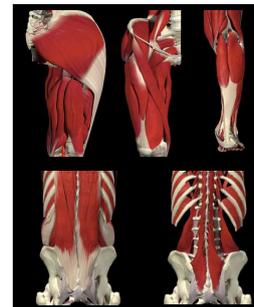
Training implications – Stroke profile

- Suspension may be a surrogate for measuring good energy transfer from the primary movers
- With COP deviations to observe stability, control, smoothness, efficiency of force delivery

- Stroke events
  - Catch
  - Peak force
  - Finish
- Better at Catch = better at Finish
- For measurement, recall:
  - Max, Min Catch, Finish

Predicting performance

- As with consideration of kinematics feedback
  - Sport in general
- Specific and Individual
  - Athlete
  - Performance parameter

Spinal injury

- Influence on performance
  - Lost training days
  - Crew disruption

- Dependent variable
  - Informed by the literature

  - Change in LSJ alpha
  - Rate of change LSJ alpha
  - Magnitude of loading

- Statistics
  - Principal component analysis
  - Correlation analyses
  - Multivariate regression

Spinal injury

- Did not test injured athletes
  - Discursive
- Potentially injurious LSJ kinematics are associated with lower limb motion
- Catch highly associated with finish
  - Safer at one = safer at other
  - Catch is more important than finish
    - Kyphosis leads to rapid lumbar extension during the drive
- Greater risk at higher intensity
- Greater risk with high rates of external force production
- Greater risk with increased late drive suspension

Andrew J Murphy
andrew.j.murphy@strath.ac.uk

Summary

- Explicit description is possible and useful
- Intensity is influential
- Kinematics can be trained
- Motion does influence performance
- Technique is probably closely linked with injury risk
- Motion of lower limbs, pelvis and lower back are intimately connected
- Suspension
- Feedback must be accurate precise and individualised

Key performance indicators for rowing

- Traditional
  - Power
  - Peak forces
  - Length
  - Split
  - ...
- (re)Fresh
  - Timing and sequencing of body segments motion
  - Postural control
  - Suspension
  - Efficiency and smoothness of motion in optimal directions

Thank you for your attention

andrew.j.murphy@strath.ac.uk

- Explicit description is possible and useful
- Motion does influence performance
- Technique probably linked with injury risk
- Lower limbs, pelvis and lower back connected
- Kinematics can be trained
- Intensity is influential
- Suspension
- Quality of feedback

Imperial College London   **uk sport**   British Rowing

Anthony Bull • Alison McGregor • Samson Chee

• Athletes •

Paul Thompson • Robin Williams • Miles Forbes Thomas • Darren Whiter • John Keogh David Tanner
Rosie Mayglothling • Nikolai Boehlke • Scott Drawer