Key Performance Indicators for Rowing

Andrew J Murphy, PhD
Anthony MJ Bull
Alison H McGregor
Imperial College London
Department of Bioengineering
Division of Surgery

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 for my work

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

- Real time biofeedback
- Flock of Birds motion capture
- Handle force and motion
- 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
  - Pelvis
  - Lumbar spine
  - Pelvis

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

Measurements

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

- Stroke profile
  - Handle force
  - Handle motion
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  - Seat COP
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Additional testing

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

Three-dimensional (3D) kinematic reconstruction and modelling
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)
FISA World Rowing Coaches Conference

20-23 January 2011

3D kinematics

Joint rotations (°)

Joint trajectories (mm)

LSJ rotation (°) & Pelvic tilt

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?
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 strokes/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

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

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

Training implications – Kinematics
- LSJ alignment
- LSJ delta during drive
- Heel timing
  - Catch
  - Mid-drive
  - Finish
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
## 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

<table>
<thead>
<tr>
<th>Traditional</th>
<th>(re)Fresh</th>
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<tbody>
<tr>
<td>Power</td>
<td>Timing and sequencing of body segments motion</td>
</tr>
<tr>
<td>Peak forces</td>
<td>Postural control</td>
</tr>
<tr>
<td>Length</td>
<td>Suspension</td>
</tr>
<tr>
<td>Split</td>
<td>Efficiency and smoothness of motion in optimal directions</td>
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<td>...</td>
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</tbody>
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Thank you for your attention

andrew.j.murphy@strath.ac.uk

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- Motion does influence performance
- Lower limbs, pelvis and lower back connected
- Kinematics can be trained
- Intensity is influential
- Suspension
- Quality of feedback

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Anthony Bull • Alison McGregor • Samson Choe

Paul Thompson • Robin Williams • Max Forbes Thomas • Darren Whiter • John Keogh • David Tanner
Roisin Maygbverting • Nikolai Boshike • Scott Drawer

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