Rowing Biomechanics & Performance Analysis

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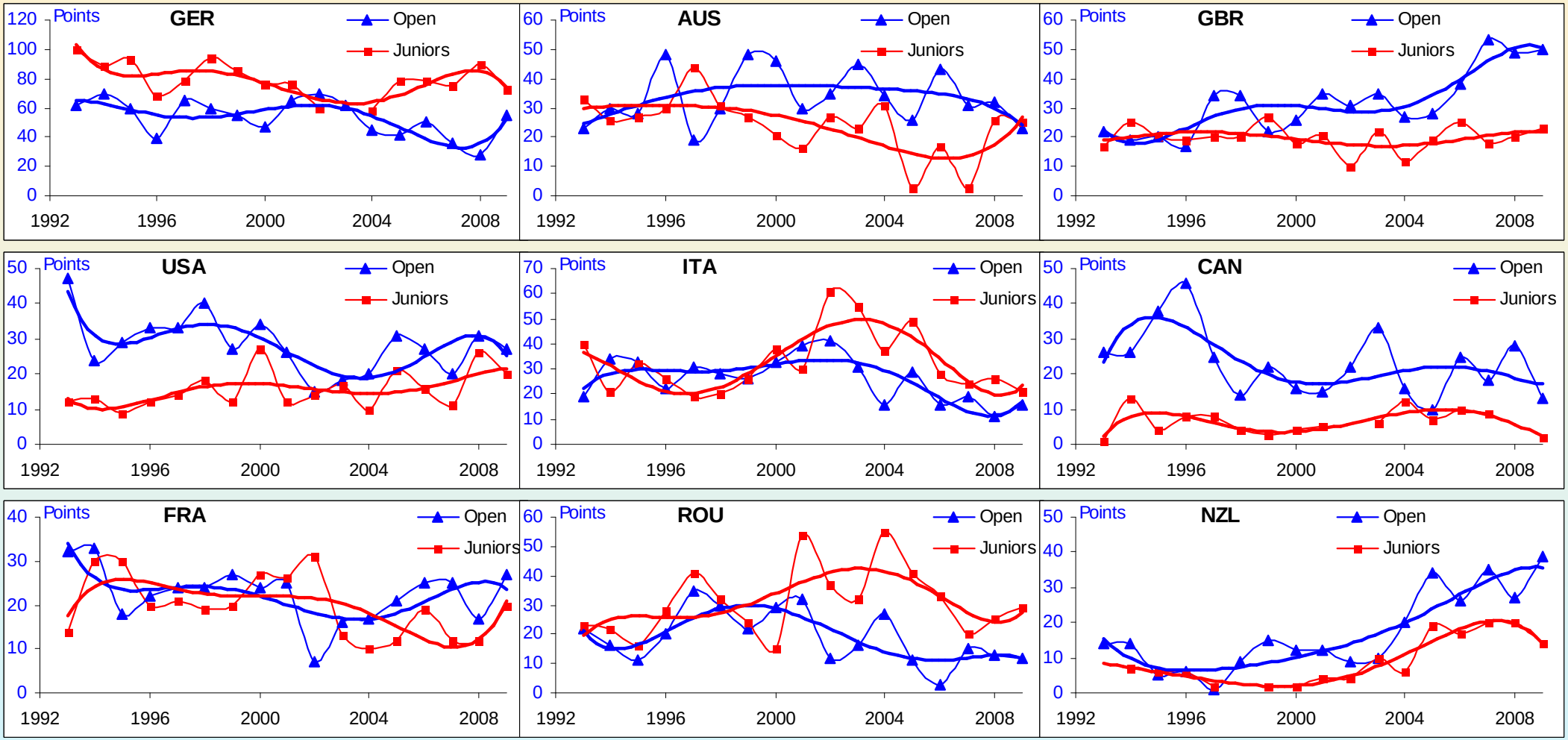
Trends of performance of nine best rowing countries in juniors and adults

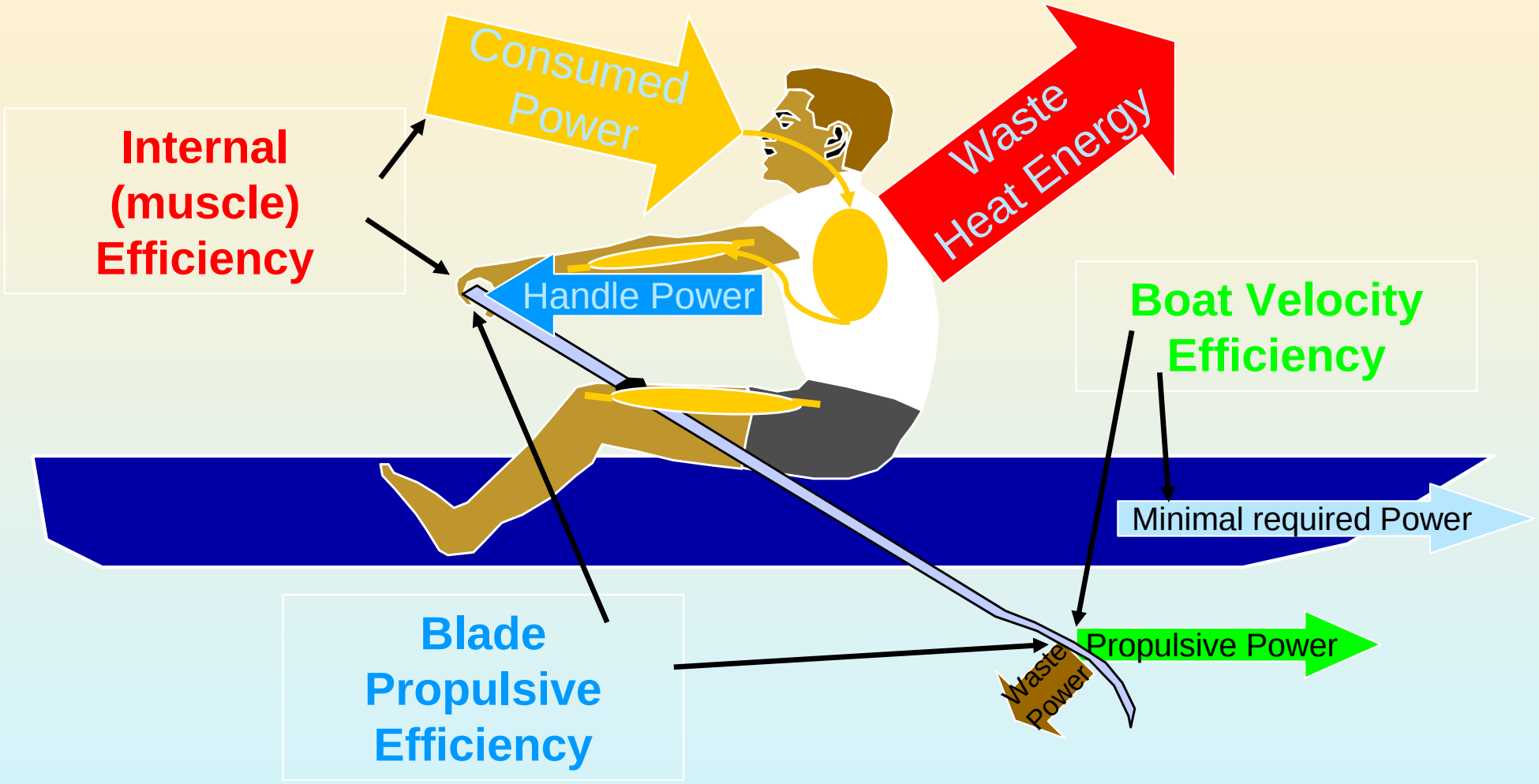


- ✓ The factors affecting performance: transition of athletes from juniors to adults, funding, organisational systems, methodology, ????

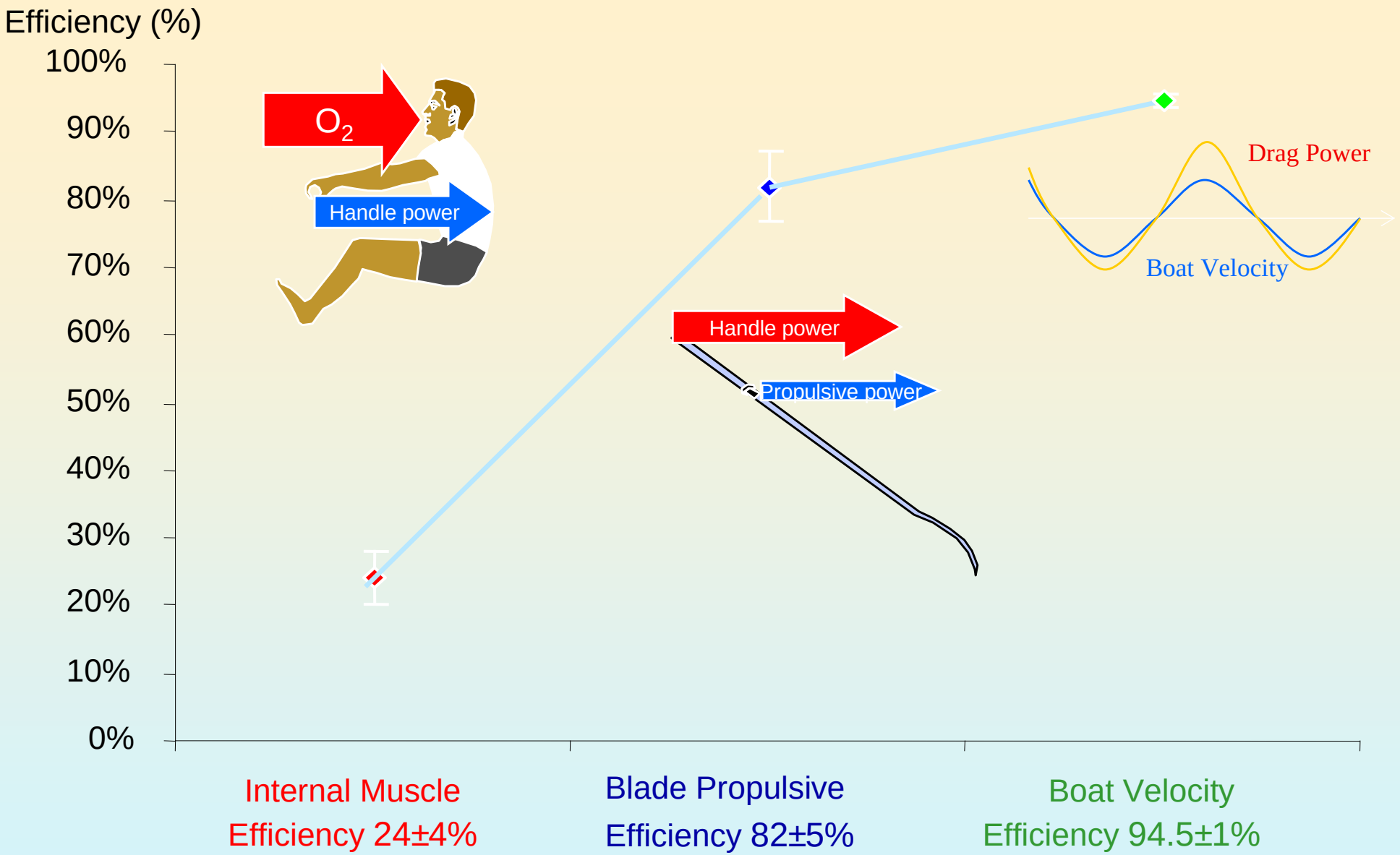
Contents of the Part 1:

- ✓ Model of rowing efficiency;
- ✓ Blade propulsive efficiency;
- ✓ Biomechanical measurements and tools;
- ✓ Biomechanical feedback;

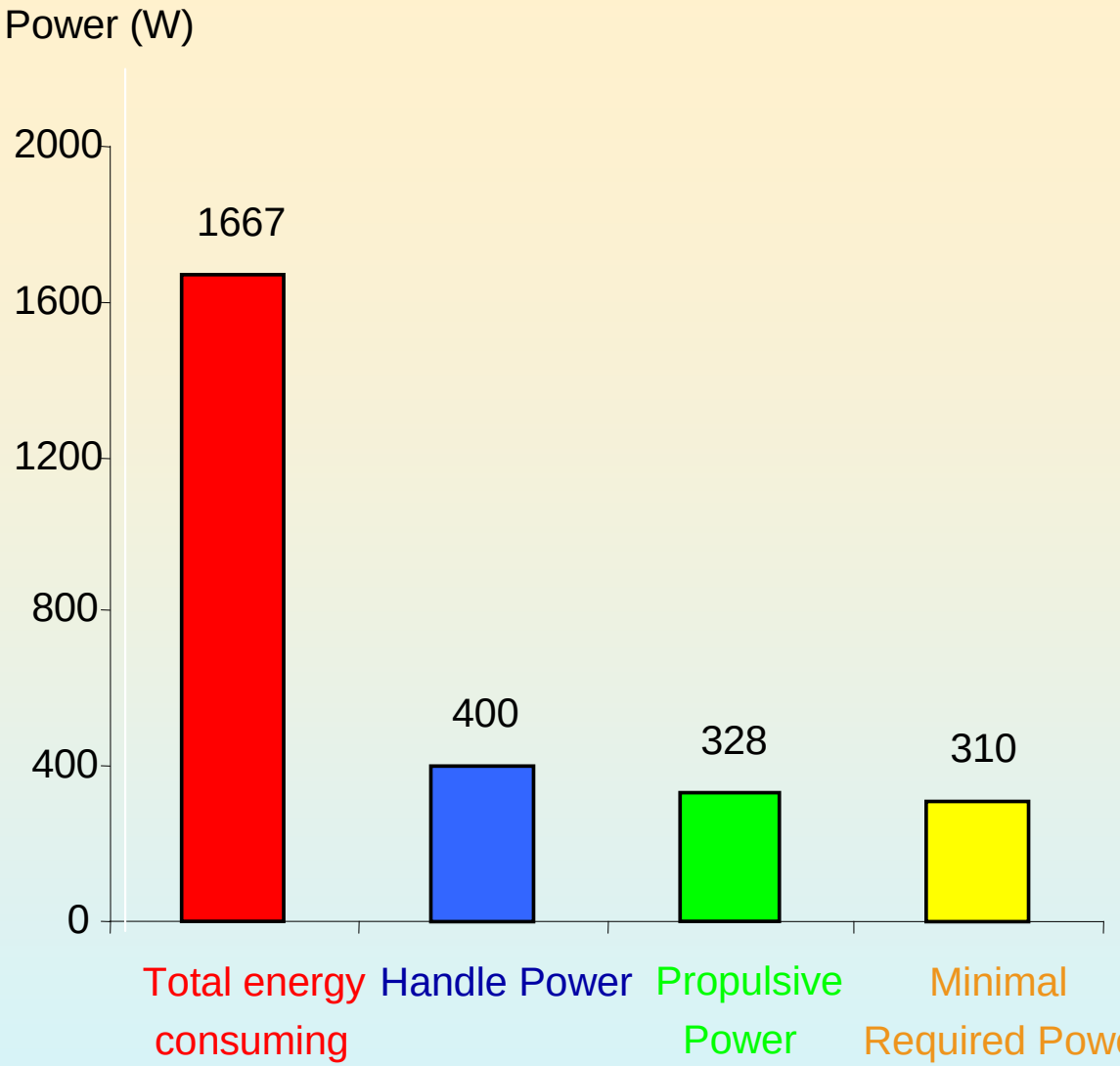
How we define rowing technique efficiency?

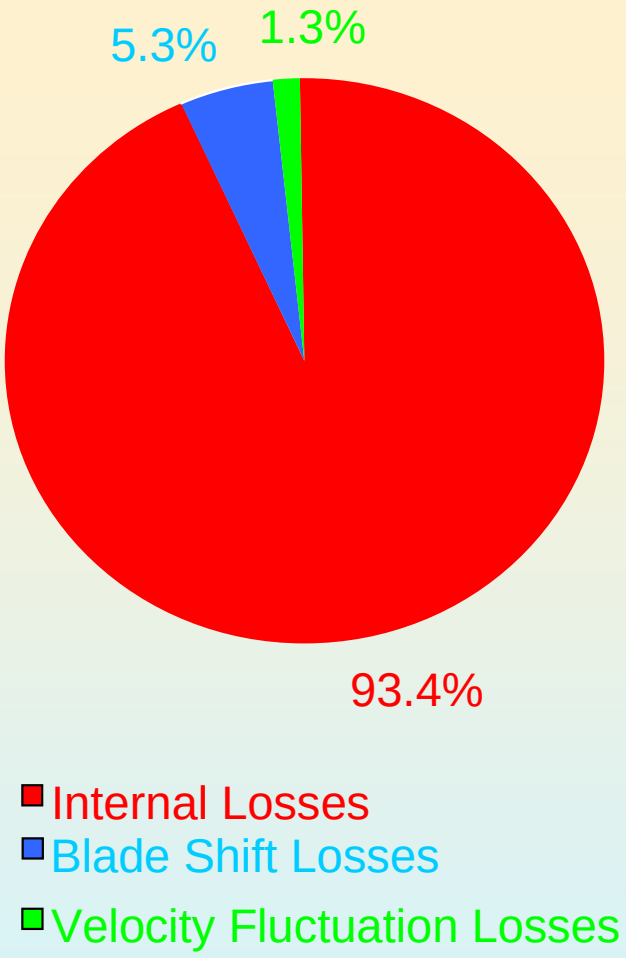


The three main parts of rowing as a process of energy transformation



Efficiencies of the components of energy transformation process during rowing



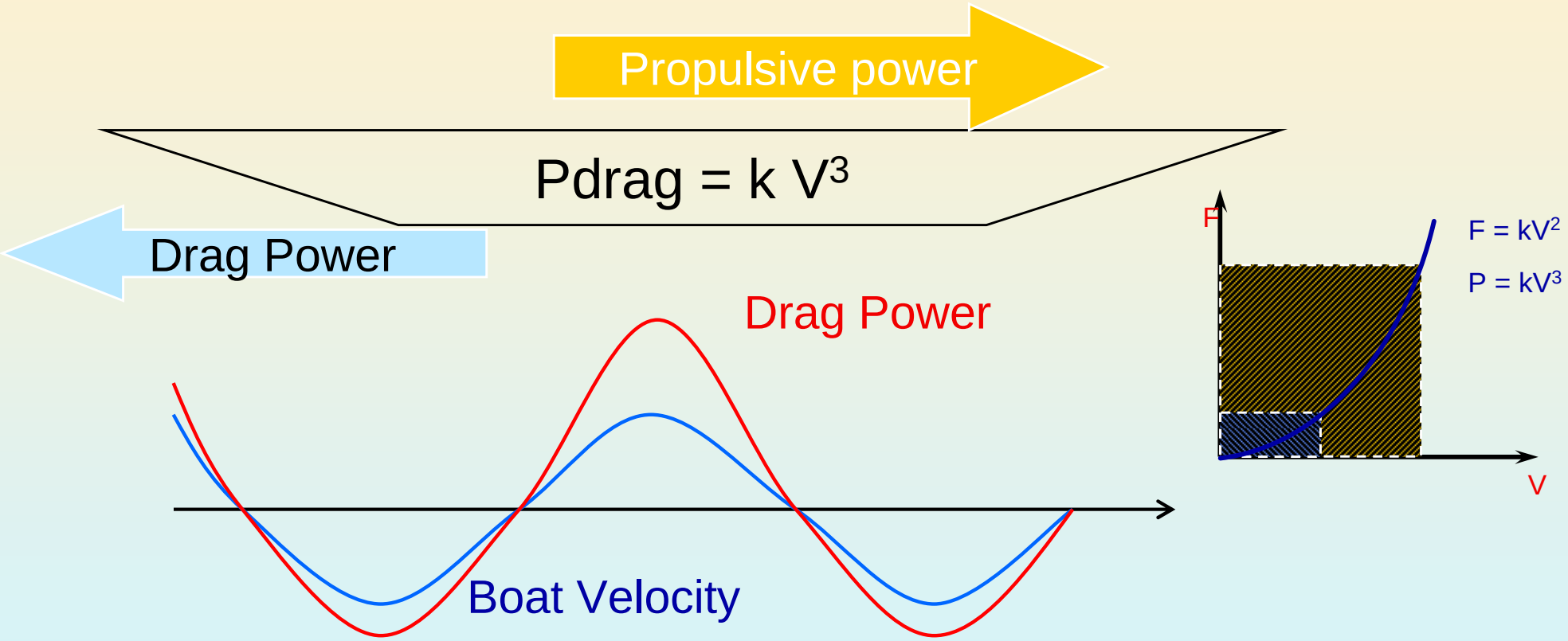


Amounts and Losses of energy during rowing (example values)

How can we increase the rower's efficiency?

- ✓ Using of the most powerful muscle groups;
- ✓ Optimisation muscles contraction velocities;
- ✓ No energy absorption, single-motion movement;
- ✓ Decreasing of muscles-antagonists activity;
- ✓ Muscles relaxation during recovery phase.

Definition of boat velocity efficiency

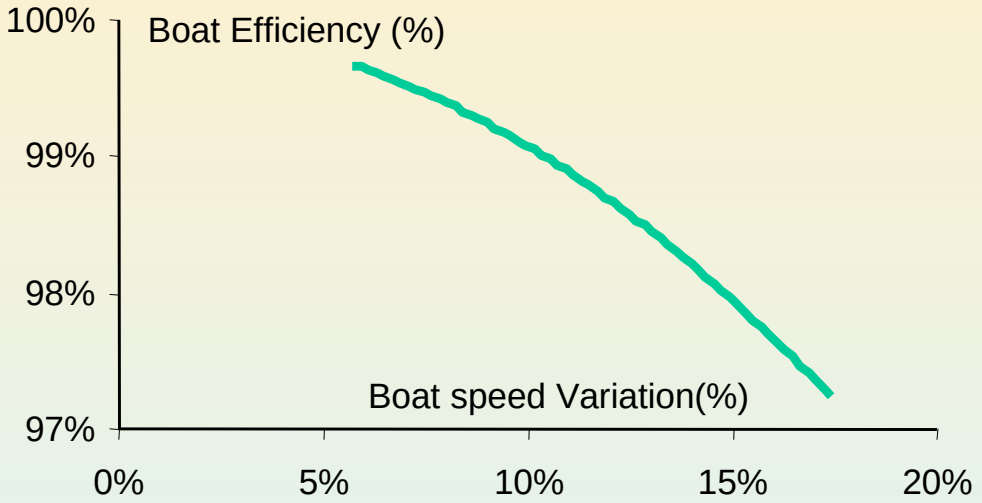


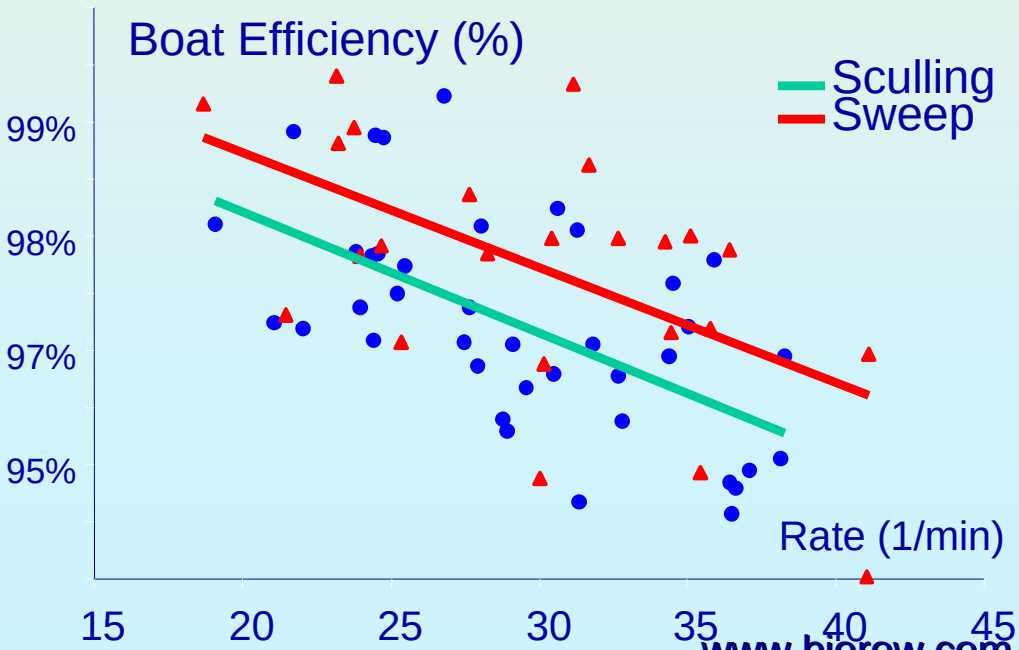
The main reasons for energy losses are:

- ✓boat velocity fluctuation;
- ✓non-linear dependence of drug power on velocity

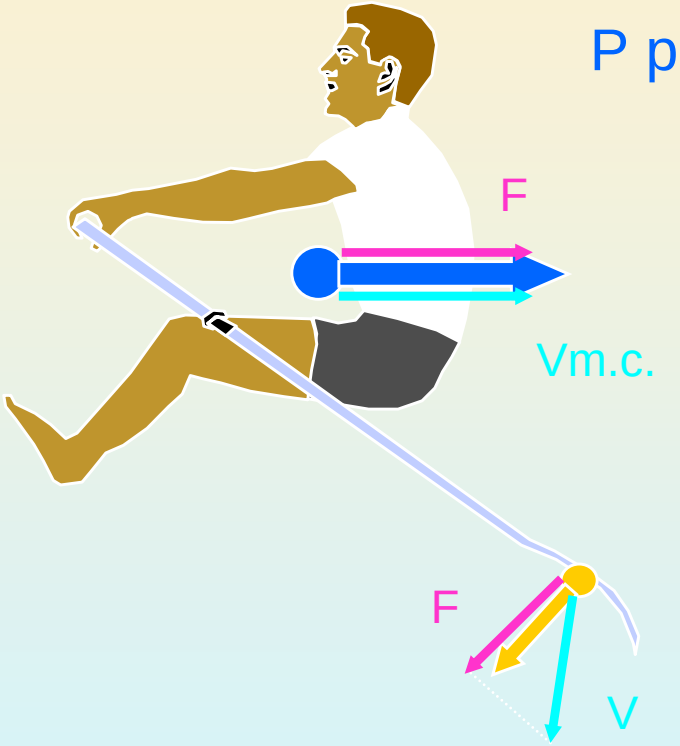
Factors affecting the boat velocity efficiency

- ✓ The boat velocity efficiency connected with variation of the boat speed;
- ✓ Both variation of the boat speed and boat velocity efficiency decreasing with increase of the stroke rate;
- ✓ At the same rate Eboat is higher in sweep boats, than in sculling;
- ✓ Even distribution of the rowers efforts during recovery is only way to increase boat efficiency (Sanderson B., Martindale W. 1986).



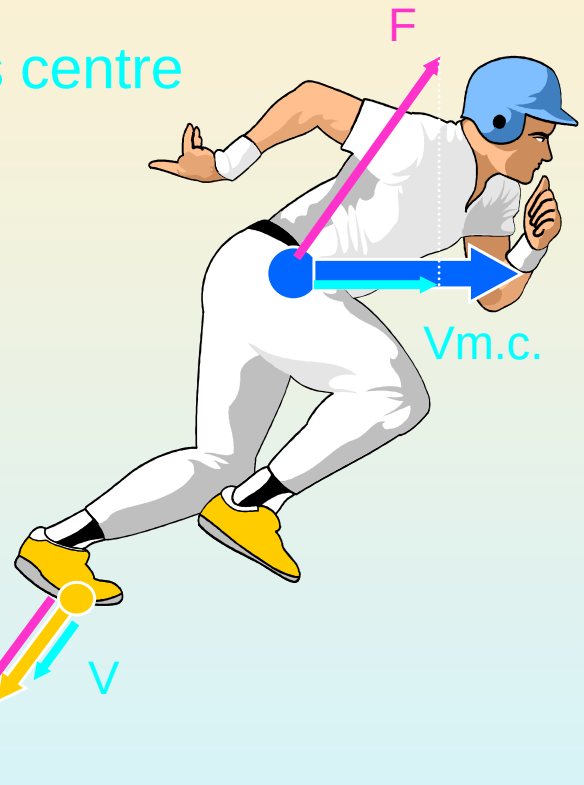


Determination of propulsive efficiency



P propulsive = $\bar{F}$ $\bar{V}$ mass centre

Propulsive Power

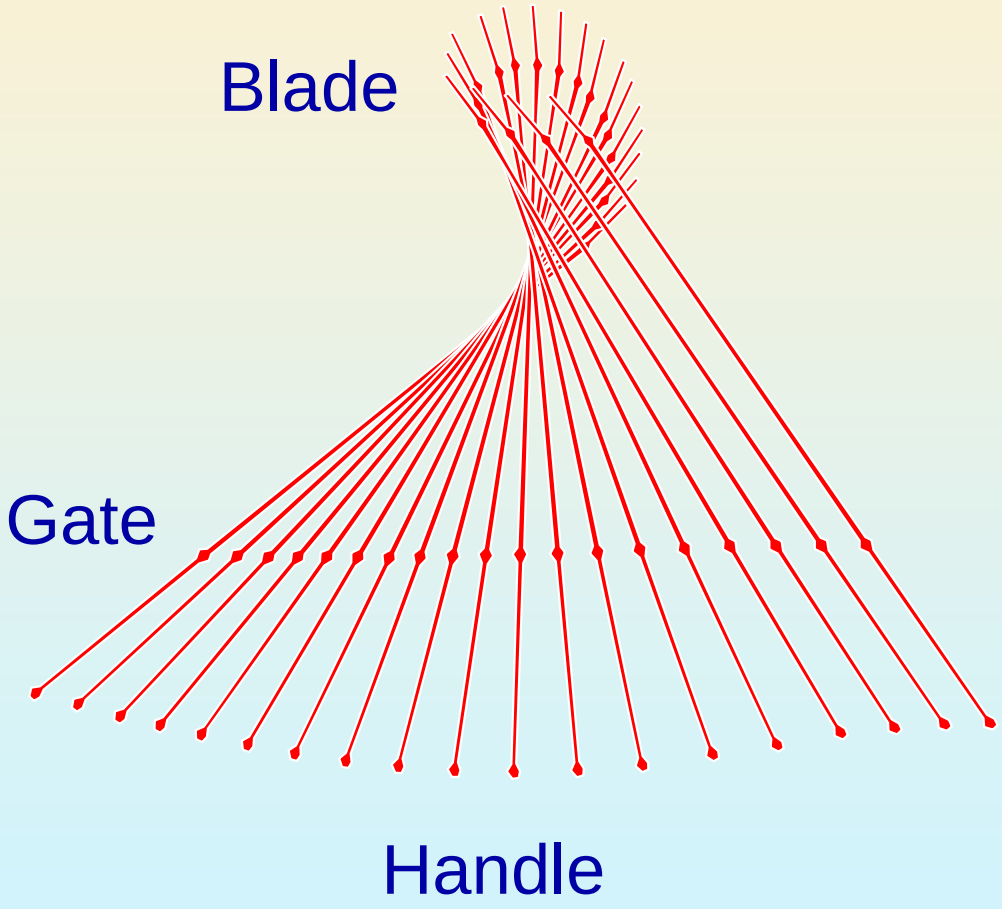


Waste Power

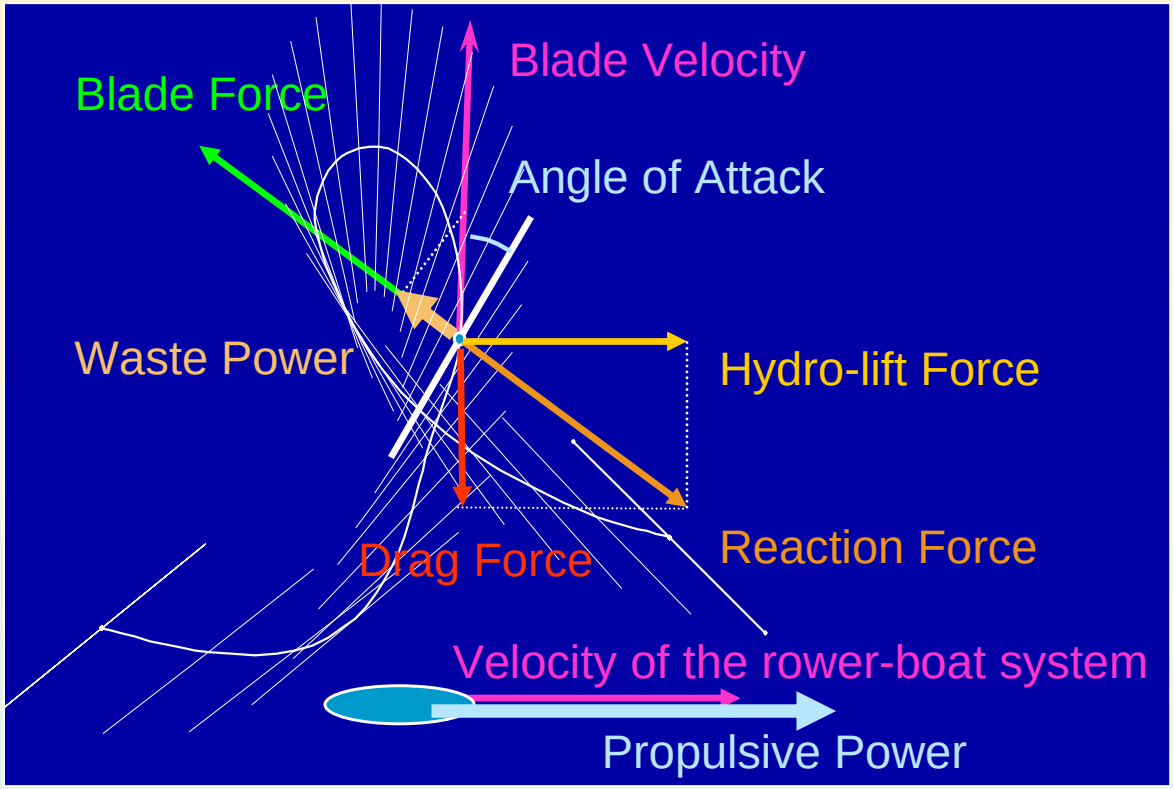
P waste = $\bar{F}$ $\bar{V}$ support point

Efficiency = P propulsive / P total = (P - P waste) / P

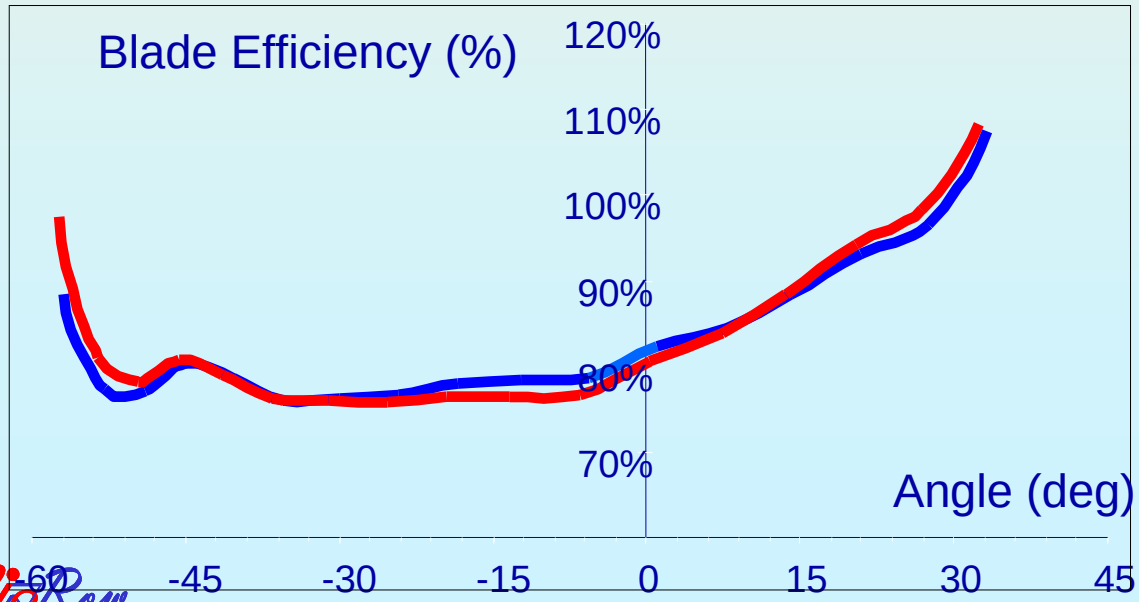
Oar Track during stroke cycle



Evaluation of rowing propulsive efficiency

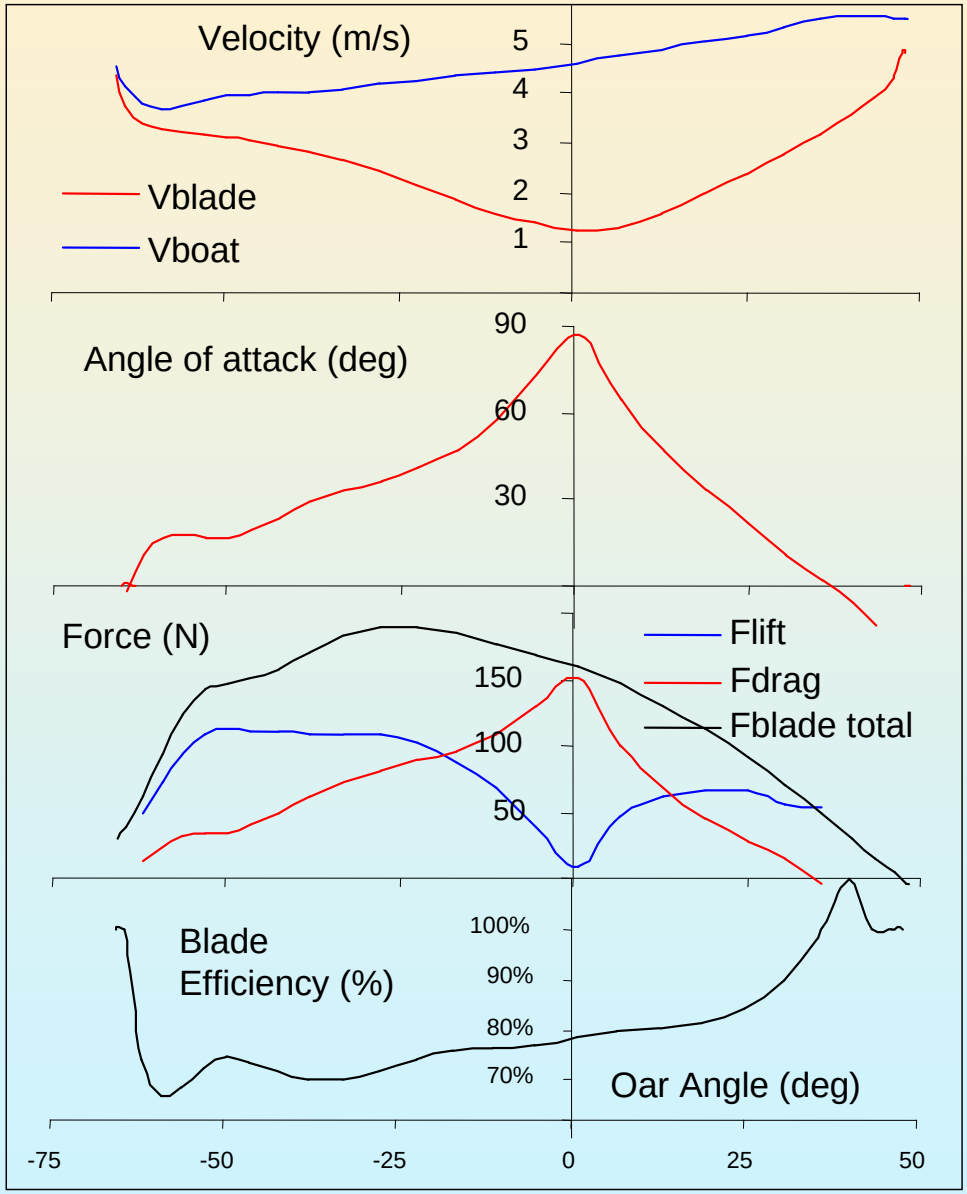


- ✓ Blade force can be defined using handle force and inboard/outboard ratio;
- ✓ Velocity of the “centre” of the blade can be defined using boat velocity and oar angle;
- ✓ Waste power is equal to dot (scalar) product of the blade force and velocity.

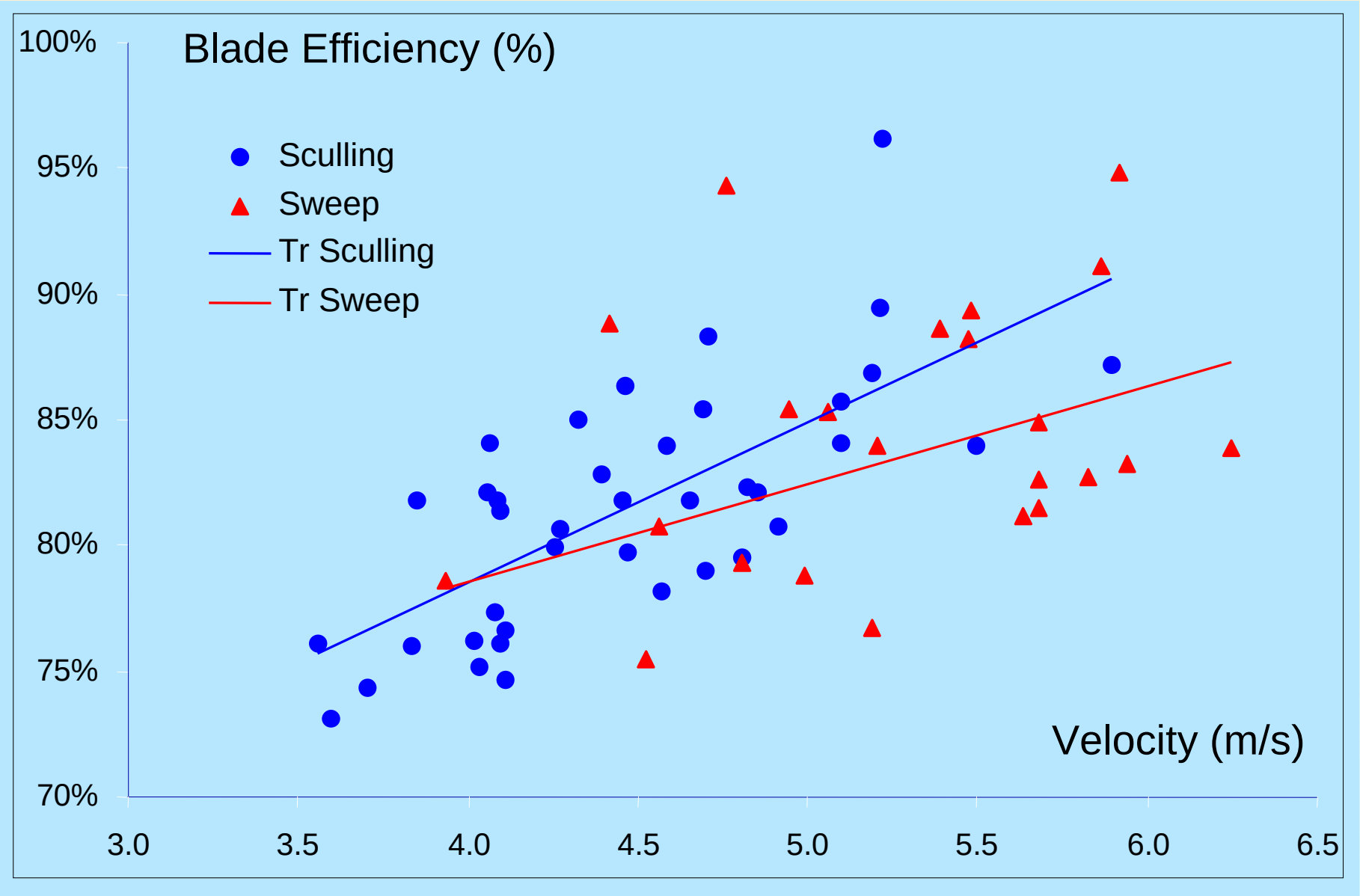


Dependence of blade efficiency on oar angle

Hydro-lift and drag forces on the blade



- ✓ Hydro-lift force works at sharp angles of attack and contributes 56% of the blade propulsive force;
- ✓ Drag force works at the middle of the drive and contributes 44% of the blade propulsive force.
- ✓ Total distance of the slippage of the blade centre is 1.7m
- ✓ Minimal slippage velocity is 1.25m/s at perpendicular position of the blade



Dependence of the blade efficiency on boat velocity

Rigging calculator

BioRow Rowing Rigging Chart (c) 2009 Dr. Valery Kleshnev

Input	
Boat Type	1x
Rower's Sex	Male
Rower's Weight Category	Open
Rower's Age Category	Open
Rower's Height (cm)	194
Rower's Weight (kg)	96
Ergo Score	5 min 50 sec

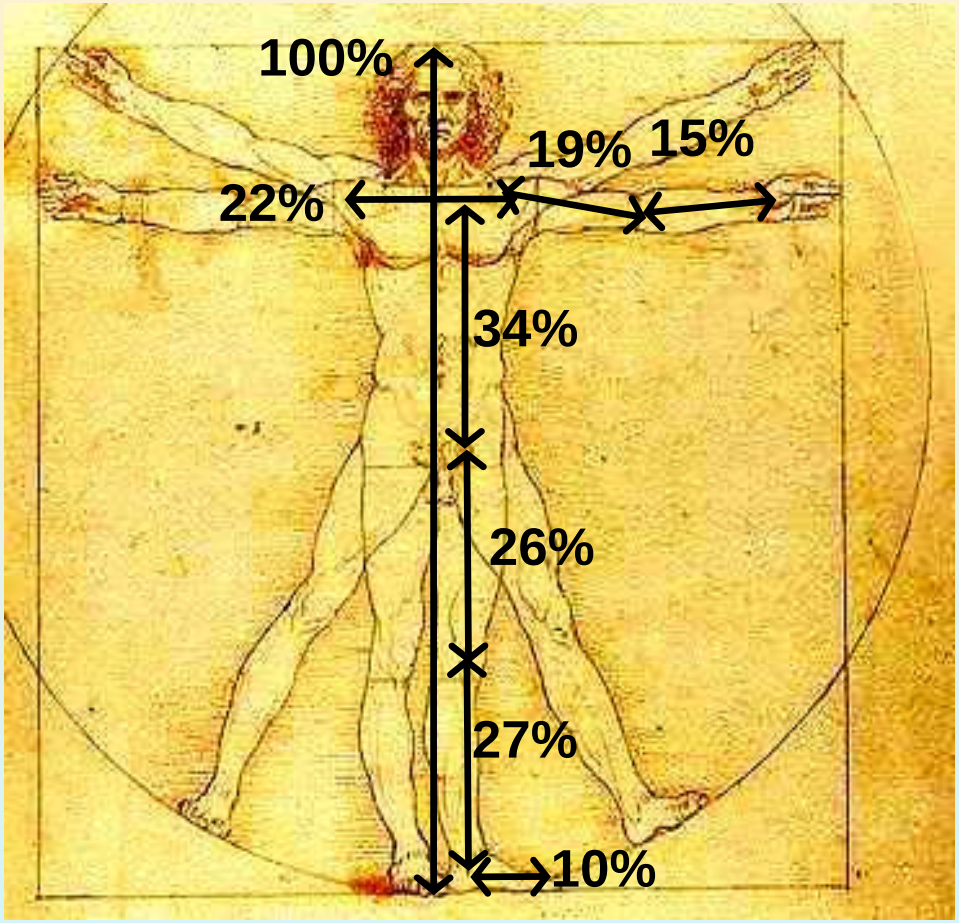
Calculate

Output	Traditional*	Innovative**
Prognostic Time over 2000m (min:sec)	0:00	
Racing Stroke Rate (str/min)	00.0	36
Recommended Inboard (cm)	00.0	00.0
Recommended Oar Length (cm)	000.0	000.0
Recommended Span/Spread (cm)	000.0	000.0

www.biorow.com/RigChart.aspx

- ✓ Traditional method is based on results of analysis of the stroke rate and boat rigging, which were conducted
- ✓ Innovative Output is based on results of biomechanical modeling:
- ✓ 1. Inboard is based on the optimal rowing angles (RBN 2009/05)
- ✓ The ratio of the arc length to the rower's height is constant = 85% (RBN 2007/03).

Boat rigging and anthropometry



The Vitruvian Man is a world-renowned drawing created by Leonardo da Vinci around 1487.

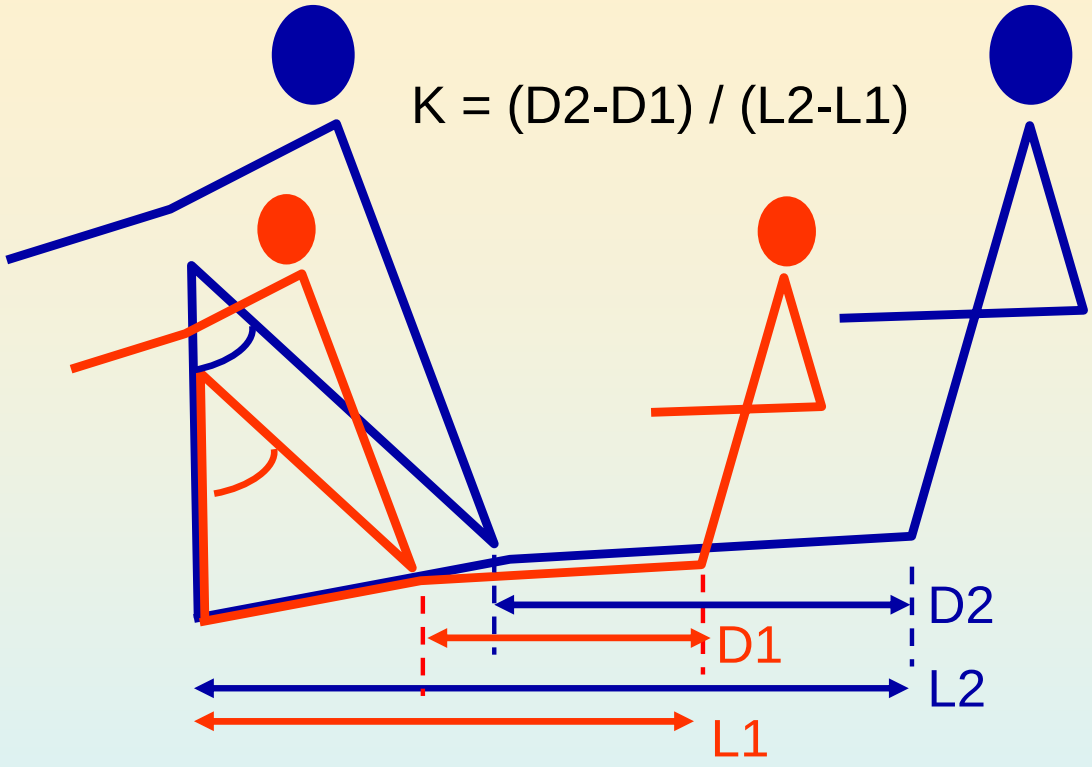
There are two factors affecting the boat rigging:

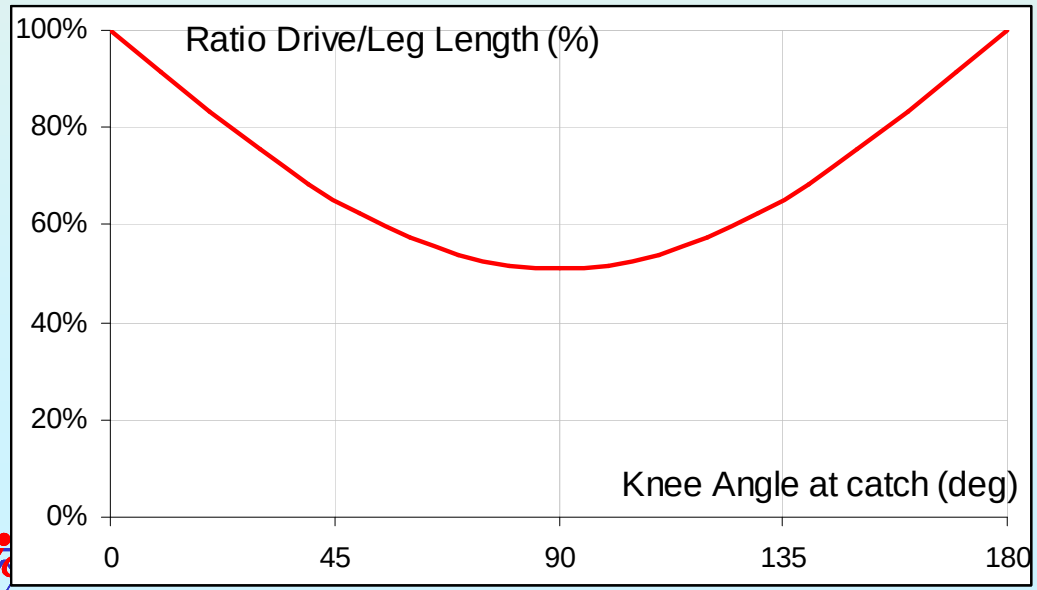
- ✓ Boat type/speed;
- ✓ Rowers anthropometry.

Length of various body segment affects the arc length differently.

Segment lengths are taken from: Kerr D., Ross W., Norton K., Hume P., Kagawa M. 2007. Olympic Lightweight and Open-Class Rowers Possess Distinctive Physical and Proportionately Characteristics. Journal of Sports Sciences 25(1):pp. 43-53.

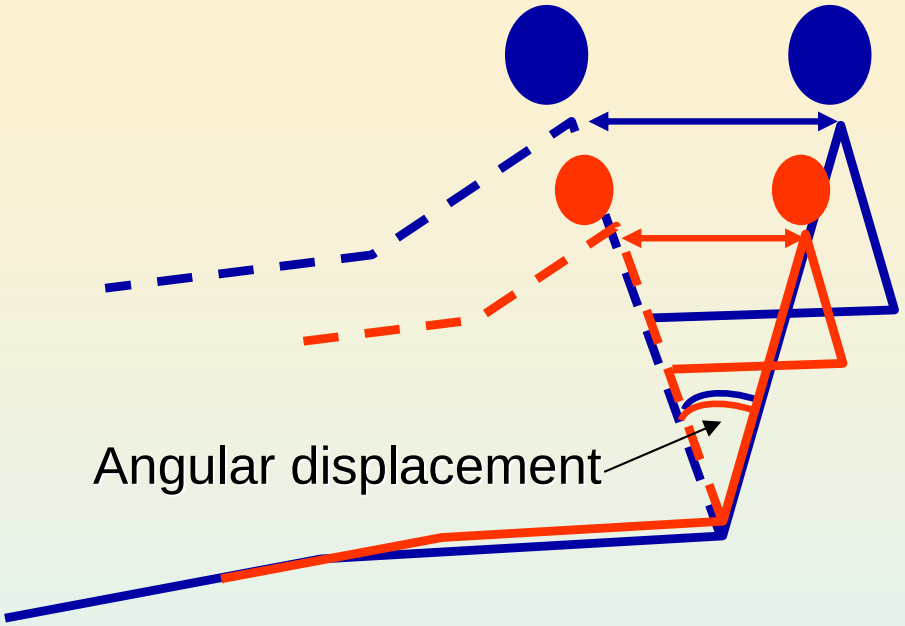
Effect of the legs length on the drive length

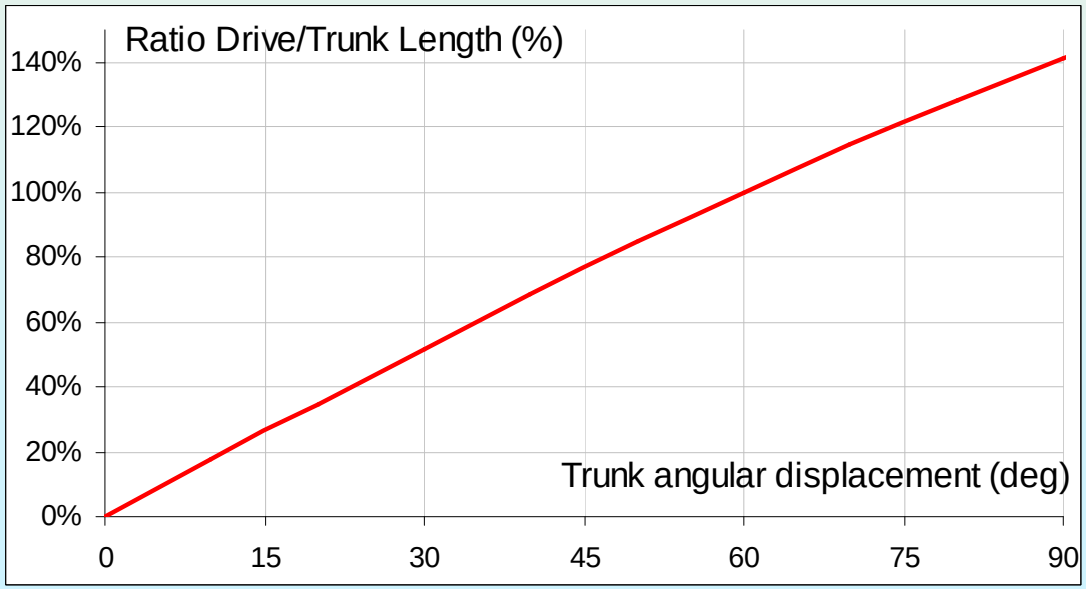




- ✓ Rowers with longer legs have longer position at the finish;
- ✓ However, at the catch longer legs allow less “compression” at the same knee angle;
- ✓ The close the knee angle at catch to 90º – the less advantage of longer legs;
- ✓ At knee angle at catch about 45º every **1cm** of extra legs length give **0.65cm** of extra drive length;

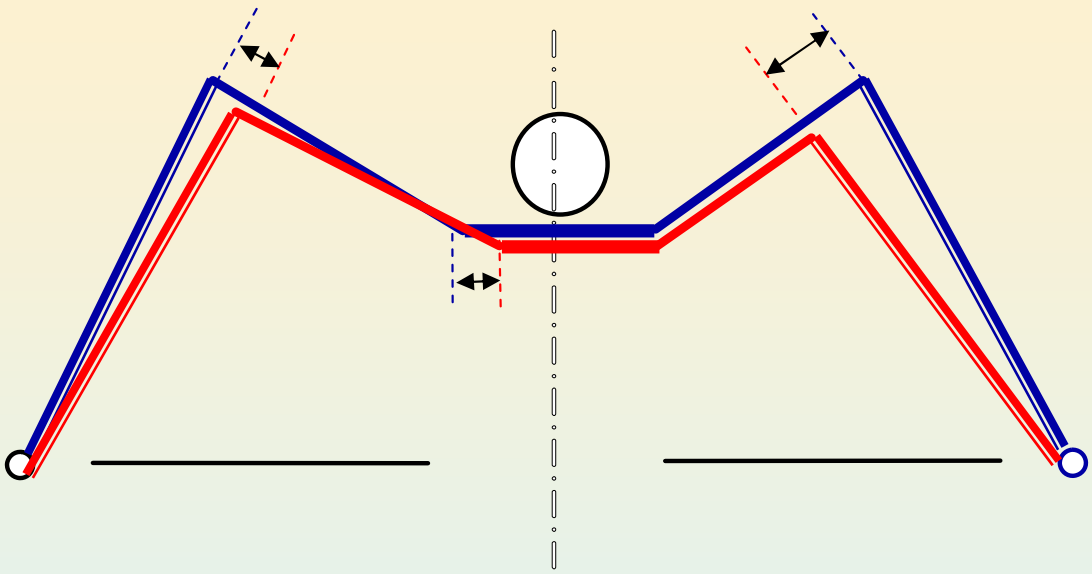
Effect of the trunk length on the drive length

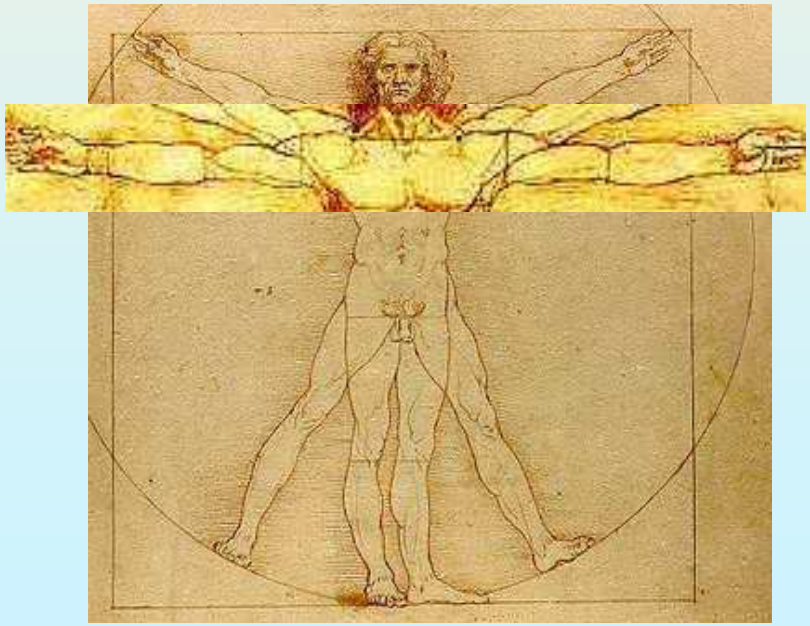




- Effect of the trunk length on the drive length depends on the angular displacement of the trunk during the drive;
- At the most common angular displacement about 45º every 1cm of extra trunk length gives 0.8cm of extra drive length;
- The close the knee angle at catch to 90º – the less advantage of longer legs.

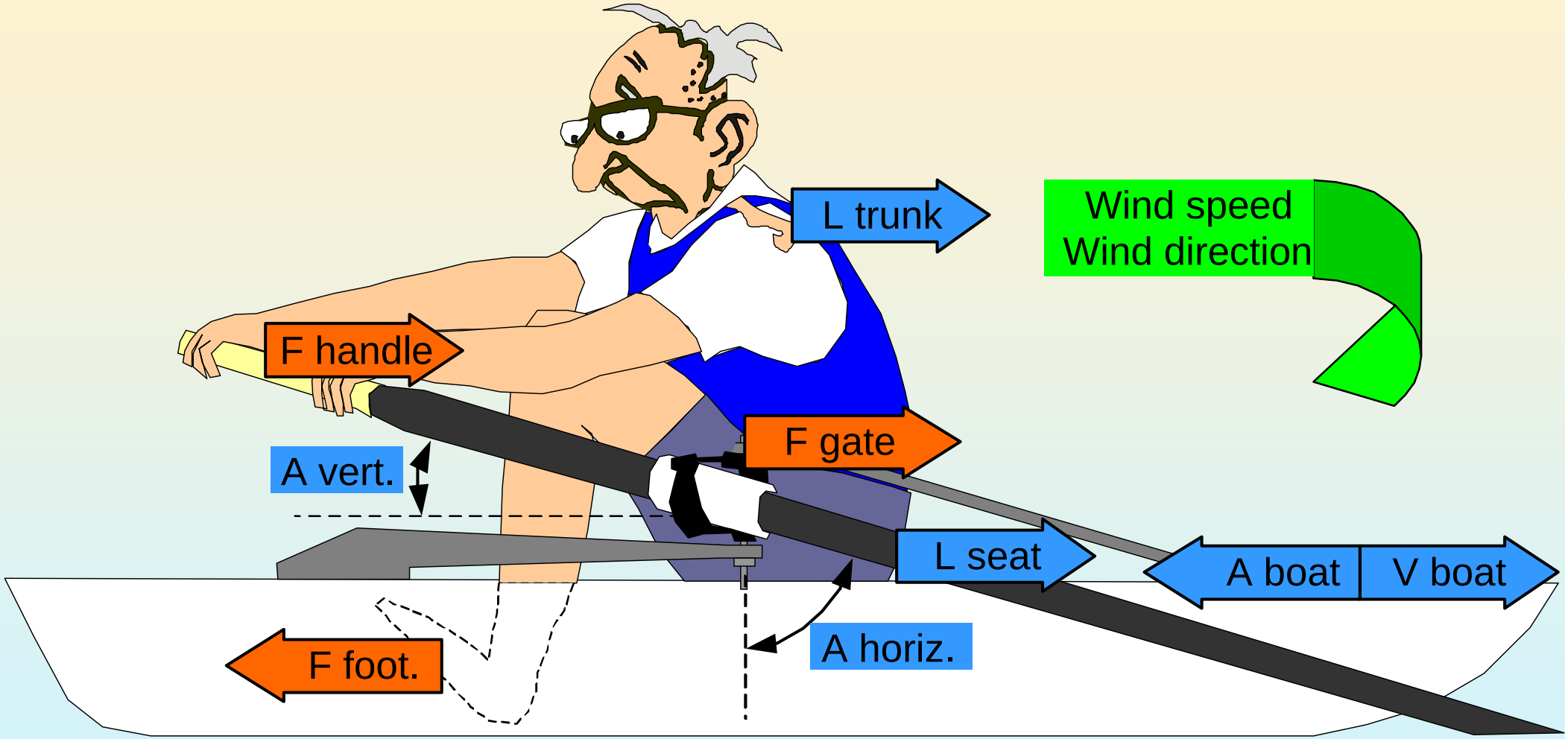
Effect of the arms span on the drive length





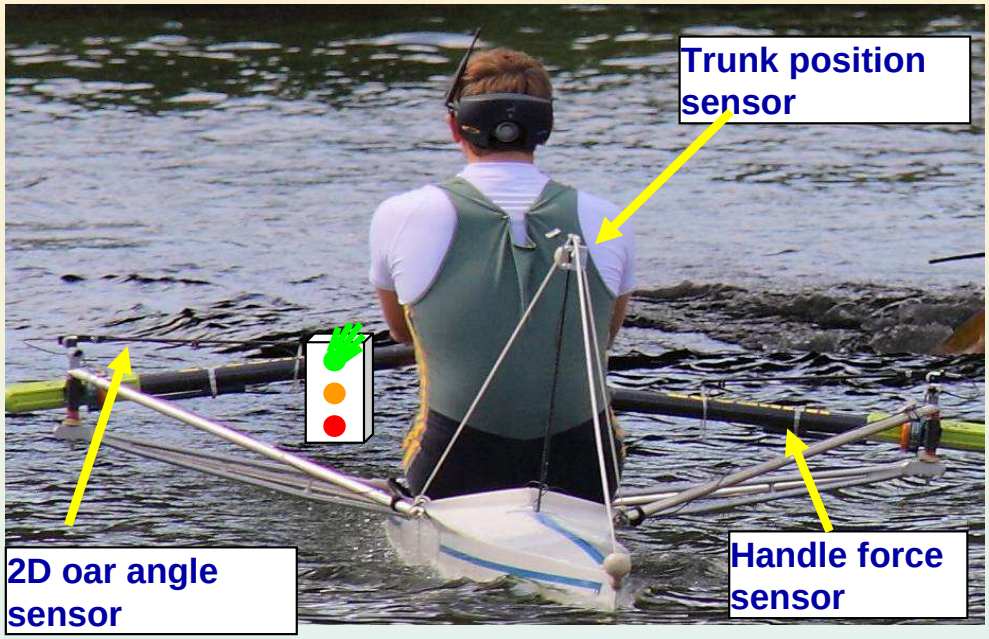
- ✓ Arms length is directly proportional to the drive length;
- ✓ In sculling, shoulders width is also important for longer drive;
- ✓ Arms span is a good combined indicator.

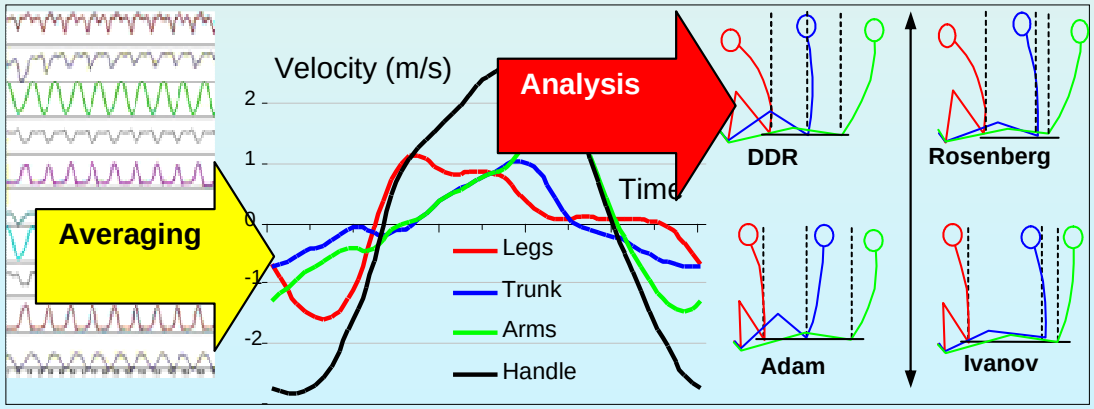
Biomechanical measurements and tools



The main kinematics, kinetics and environmental variables measured in rowing.

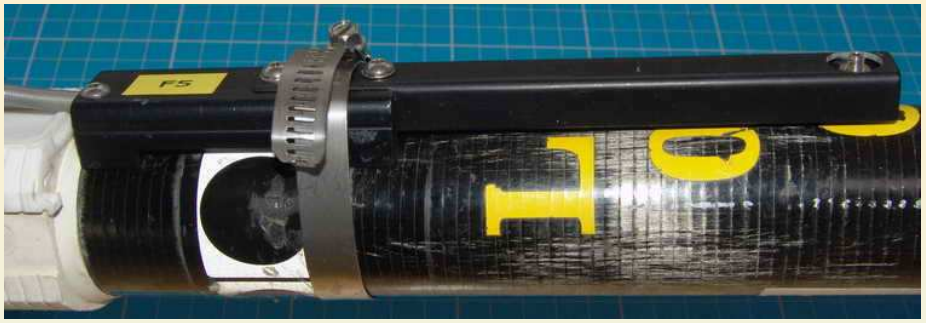
BioRowTel telemetry system v.4





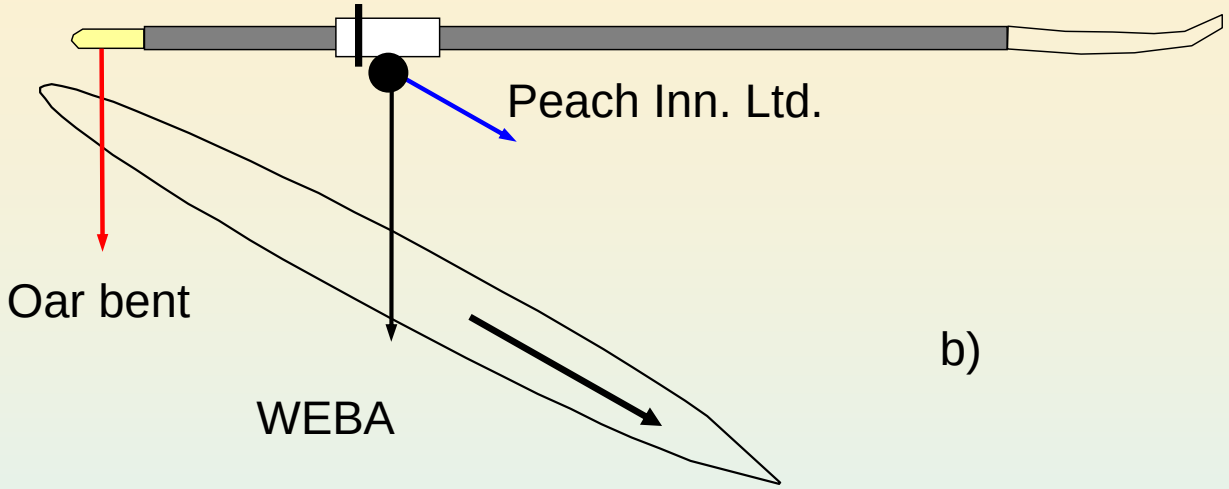
- ✓ The system is quick to setup and does not affect any rigging settings, which is important before regattas.
- ✓ Unique averaging algorithms allows unambiguous analysis of massive rowing data, easy comparison of various samples (rowers in the boat, various stroke rates, previous and current data).
- ✓ Each seat of the system is equipped with a portable feedback device, which emits a “traffic-light” signals. The criteria of the evaluation can be quickly programmed from the coach’s laptop or on-board PC.

Force transducers

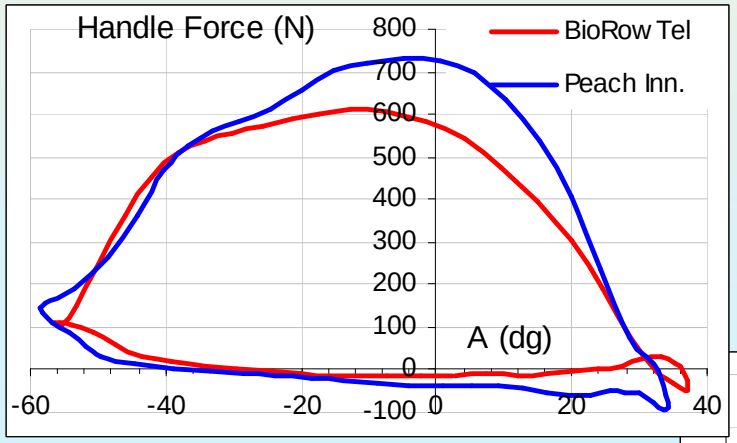


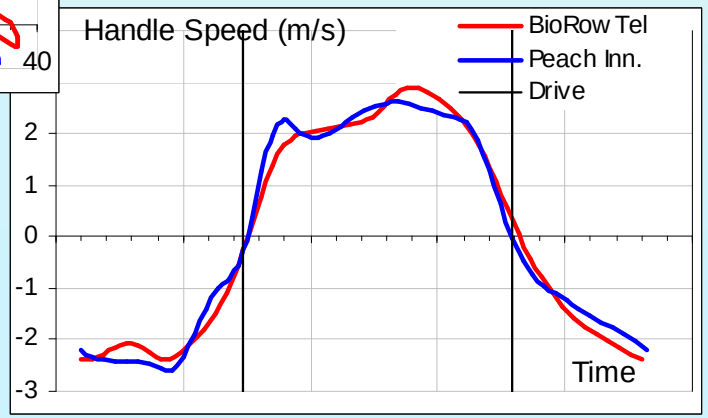
- ✓ Oar bend transducer measures the force applied to the handle;
- ✓ Oarlocks with rotating sensor (WEBA, Kleshnev's dev.s) measures the gate force perpendicular to the oar shaft;
- ✓ Peach Innovation Ltd. oarlock with stationary sensor measures the gate force parallel to the boat.

Force measurements with different transducers



b)

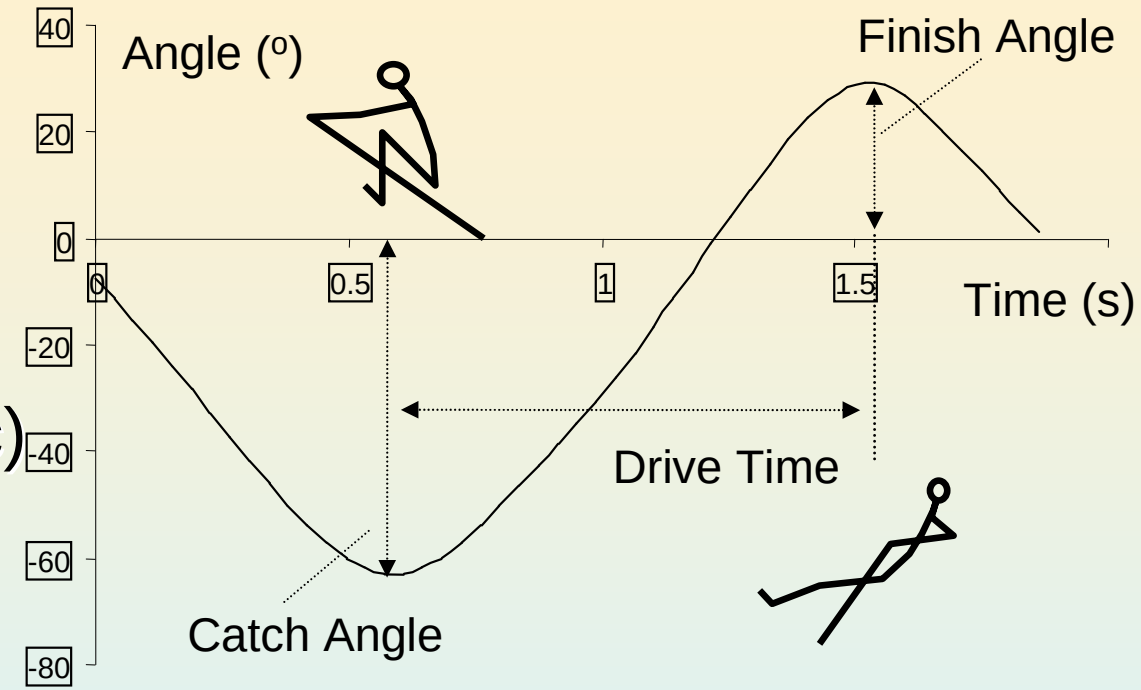




- ✓ Peach Inn. Ltd. measures only half of the pin force at catch;
- ✓ WEBA gate is better, but power calculations in a range ±5%;
- ✓ Oar bent is the most accurate method, but require calibration of every oar.

Vertical and horizontal oar angle transducer

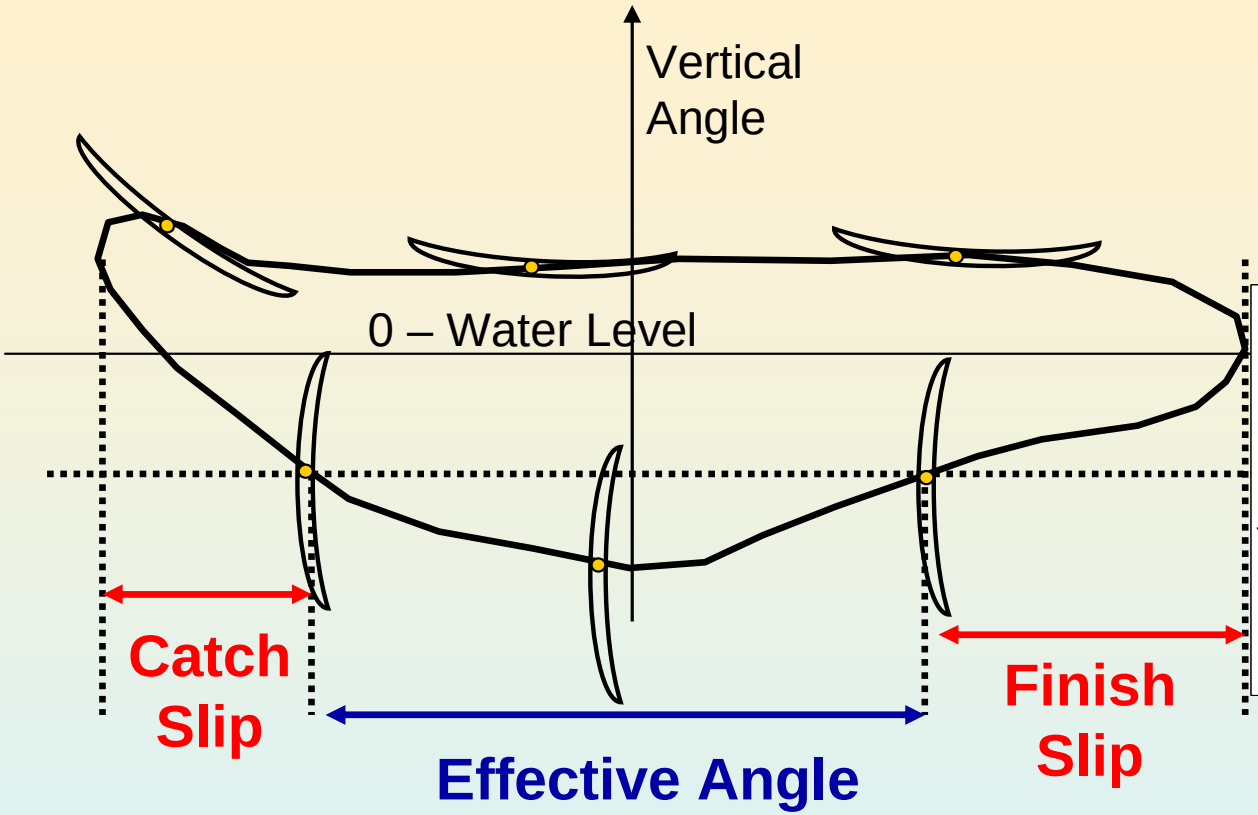
- ✓Catch angle Acatch is negative;
- ✓Release angle Arel is positive;
- ✓Total angle (or rowing arc) is Atot = Arel – Acatch

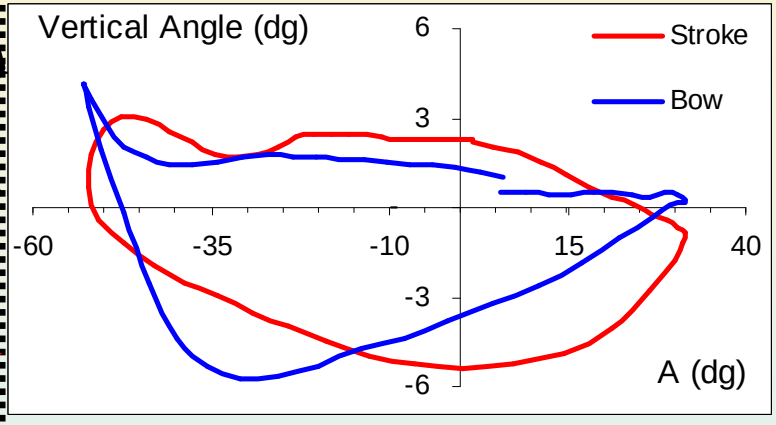


Current version,

m = 60g

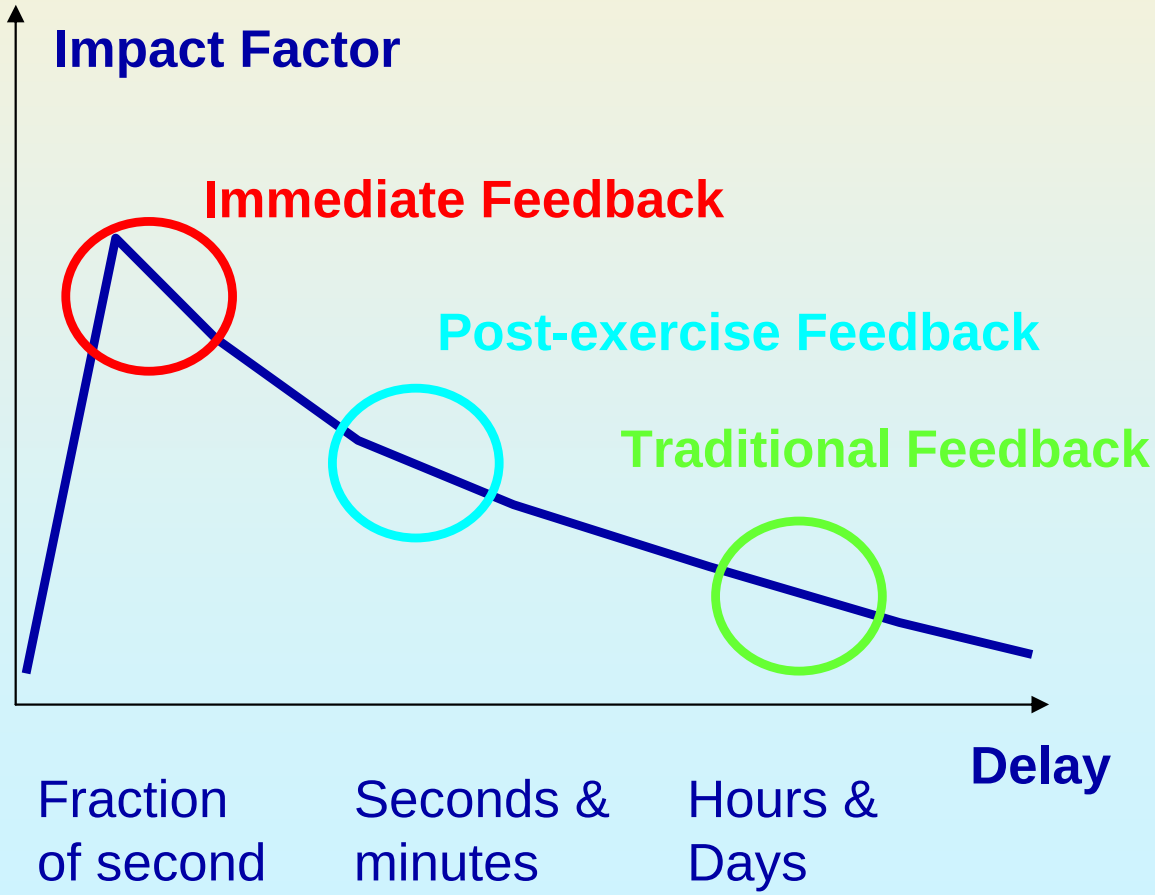
Criteria of Vertical Angle





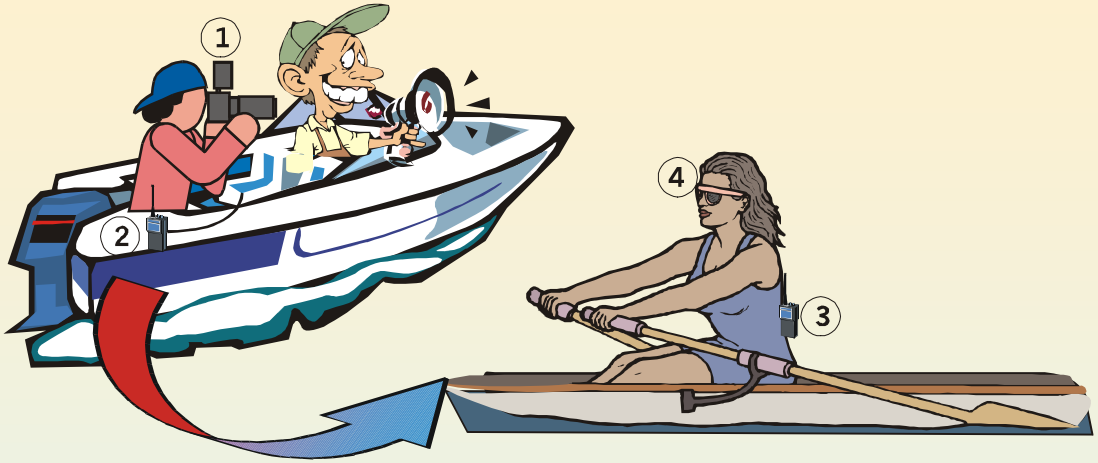
- ✓ Effective angle (%) has positive moderate correlation with relative blade efficiency (r = 0.48);
- ✓ Blade curve allows to define oar handling skills, which are very important in using bigger blade area (Nolte, Shorter Oars Are More Effective, *Journal of Applied Biomechanics,* 2009, 25, 1-8)

Impact factor: How can we make a video-feedback more efficient?



- ✓ Traditional feedback is observing a video after training or rehab session. Time delay is usually hours and days;
- ✓ Post-exercise feedback is observing video straight after completion of a specific exercise. Time delay is usually seconds and minutes;
- ✓ Immediate feedback is observing video in a process of performing an exercise. Time delay is fraction of a second.

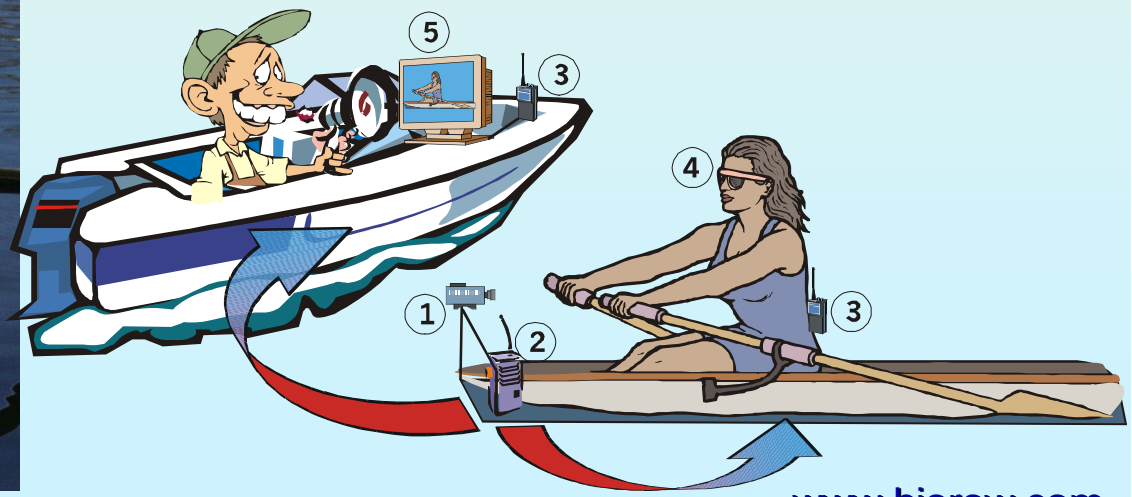
Visual Immediate Feedback System:



Two modes:

✓Cameraman mode can be used for fast switching between various elements . E.g.: oar blade work, leg work, arm work, synchronization of the crew, etc.).

✓Stationary mini-camera can be used for constant visual feedback from directions, which usually inaccessible for operator.



Visual Immediate Feedback System

- ✓ In 1999 we invented Visual Immediate Feedback System, which consists of a head-mounted monitor (“Virtual Realty Goggles”), video source and radio link;
- ✓ Originally it was intended to provide feedback on biomechanical information measured using a telemetry system;
- ✓ Later it was found that display a simple video could be equally or even more effective.

The latest version: VFS-3

- ✓ The athletes wears only 500g of equipment in one piece (no wires);
- ✓ The coach can use the system to emphasise specific components of rowing technique (e.g. leg drive, blade work or elbow position);
- ✓ Very effective tool is displaying a video of a “model” rowing technique of elite crews during pauses of rest between rowing

Thank you for attention

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- ✓ Rowing Biomechanics Newsletter
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