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Introduction and Basic Principles of Rowing Biomechanics

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Example of using biomechanics to improve rowing technique

ü Educational movie, 1963, USSR



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Common "myths" of rowing biomechanics:

- ? Variations of the boat velocity is the main reason of the energy losses?
- ? Long oar angles decrease rowing efficiency?
- ? Inertia forces is a serious problem, which can be reduced with good technique?
- ? Peak force must be applied at the middle of the drive?
- ? Stretcher force is negative, handle force is positive?
- ? Ergo-meter rowing has the same mechanics as on-water rowing?

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Why variations of the boat velocity is NOT the main reason of the energy losses

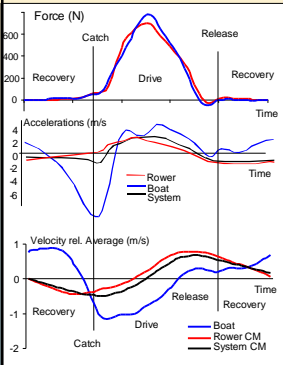


ü Variation can be decreased by means of increasing the mass of the boat, decreasing the rowers' mass and amplitude of their travel.
ü However, the losses on higher drag and lower power will be much higher.

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There are two main reasons of the variation of the boat velocity:



- ü Periodical production of the propulsive force;
- ü Movement of the rower's mass relative to the boat shell.


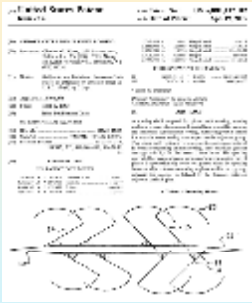
We can not change these factors without changing the nature of rowing

- ü Increase of the boat velocity during recovery caused by transfer of **KINETIC ENERGY** from the rower's mass to the boat.

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Boats for asynchronous rowing – monuments to misunderstanding of mechanics of rowing mechanics

1929. "Syncopated Rowing". London Rowing Club, Major Hellyer's revolutionary experiment, designed to do away with checking "the run of the boat" in the orthodox style. Putney, Greater London.

1970-s. W4- for asynch. Rowing was build in USSR and won Worlds, but was rowed synchronously.

2005. The latest US Patent for a boat for asynchronous rowing

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How can we decrease variation of the boat velocity?

Efficiency of the boat speed (%) vs Rate (1/min):

Rate (1/min)	Efficiency (%)
20	97.0%
25	96.5%
30	96.0%
35	95.5%
40	94.5%
45	94.0%
50	93.5%
55	93.0%
60	92.5%
65	92.0%

Boat velocity reLaverage (m/s) vs Rate (1/min):

Rate (1/min)	Recovery (m/s)	Finish (m/s)	Drive (m/s)	Catch (m/s)
20	1.0	0.5	0.0	-0.5
25	0.8	0.4	0.0	-0.4
30	0.6	0.3	0.0	-0.3
35	0.4	0.2	0.0	-0.2
40	0.2	0.1	0.0	-0.1
45	0.1	0.0	0.0	0.0
50	0.0	0.0	0.0	0.0
55	-0.1	0.0	0.0	0.0
60	-0.2	0.0	0.0	0.0
65	-0.3	0.0	0.0	0.0
70	-0.4	0.0	0.0	0.0
75	-0.5	0.0	0.0	0.0
80	-0.6	0.0	0.0	0.0
85	-0.7	0.0	0.0	0.0
90	-0.8	0.0	0.0	0.0
95	-0.9	0.0	0.0	0.0
100	-1.0	0.0	0.0	0.0

- Variation of the boat velocity increases with the stroke rate;
- This is related to faster rower's movement during recovery, higher pull force on the stretcher and higher boat acceleration.
- The only way to decrease variation of the boat speed is a smooth jerkless movement of the rower during recovery (Sanderson and Martindale, 1986)

Why inertia forces is NOT a serious problem and can NOT be reduced with good technique

- Displacements of the rower's CM and the boat are reversely proportional to their masses (boat displacement is 5-6 times longer);
- Inertial losses are proportional to ratio of boat/rower masses and their relative displacement;
- Inertial losses are 7-12% and can NOT be changed with rowing technique;

Why long oar angles does NOT decrease rowing efficiency

- sideward force does not produce any power and can not cause energy waste itself;
- longer catch angle makes the oar gearing heavier.

"Gearing" at different angles

$G(a) = G/\cos(a)$

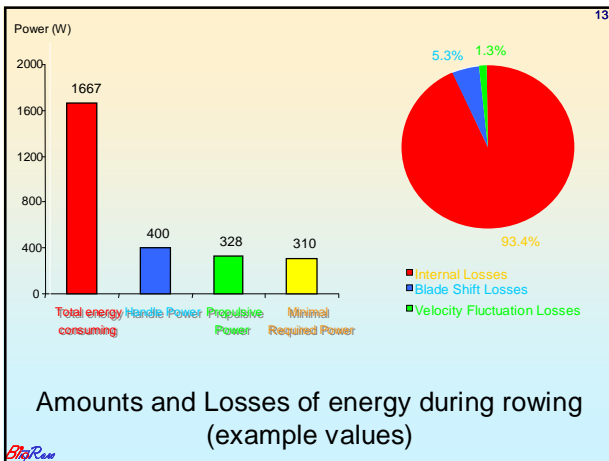
- Effect of the angle on gearing is not significant at the angles below 45°;
- The angle of 60° makes the gearing as twice as heavier;
- The angle of 70° makes the gearing three times heavier;
- The angle of 80° makes the gearing six times heavier.

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

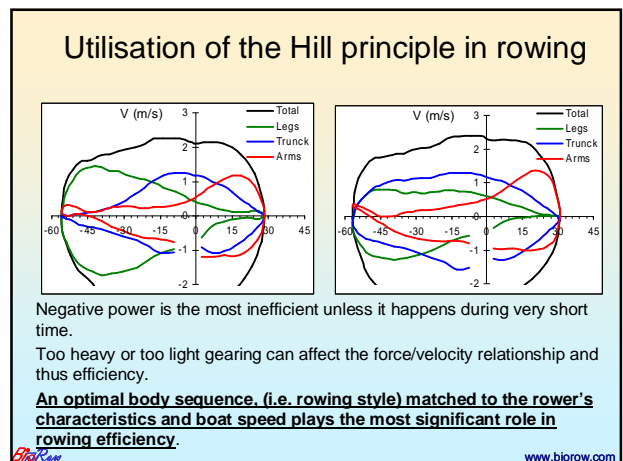
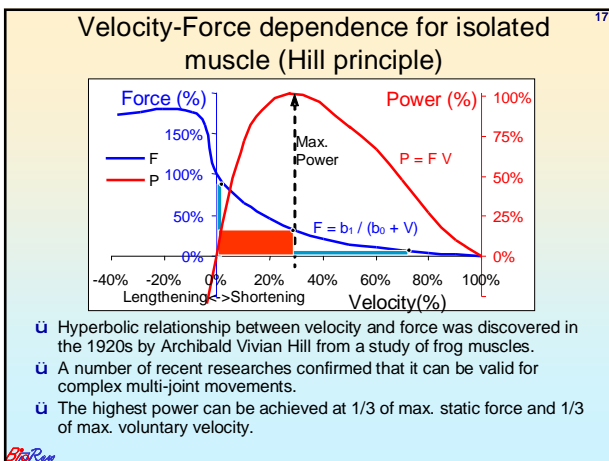
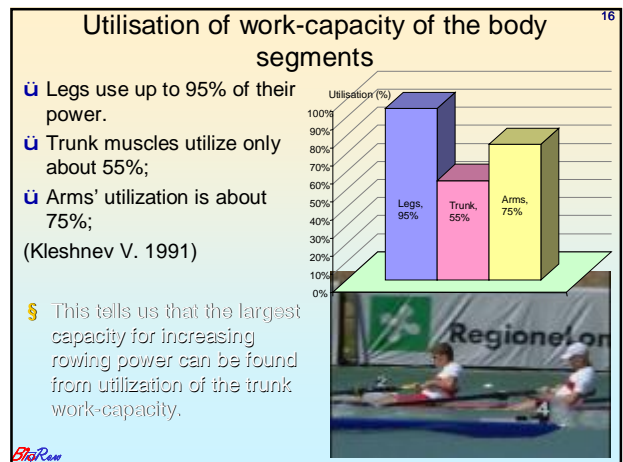
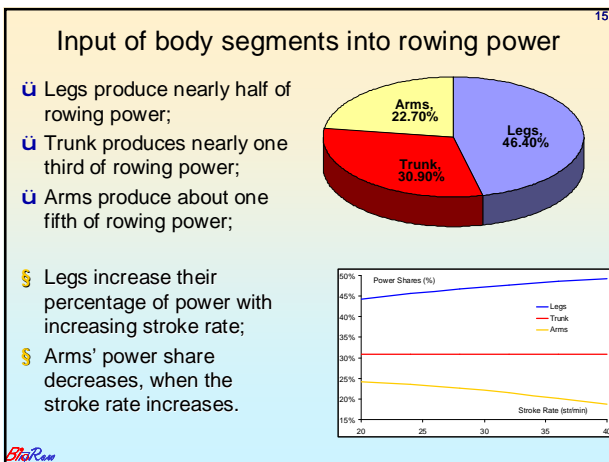
Internal Muscle Efficiency 24±4%
 Blade Propulsive Efficiency 82±5%
 Boat Velocity Efficiency 94.5±1%

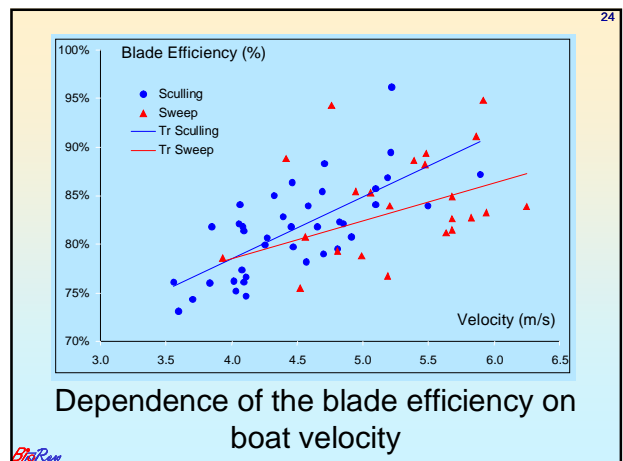
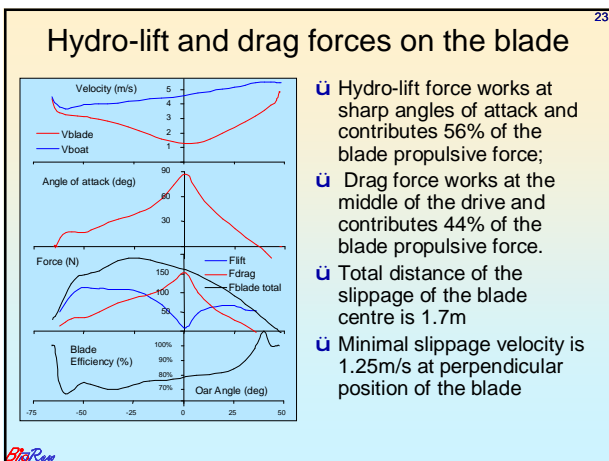
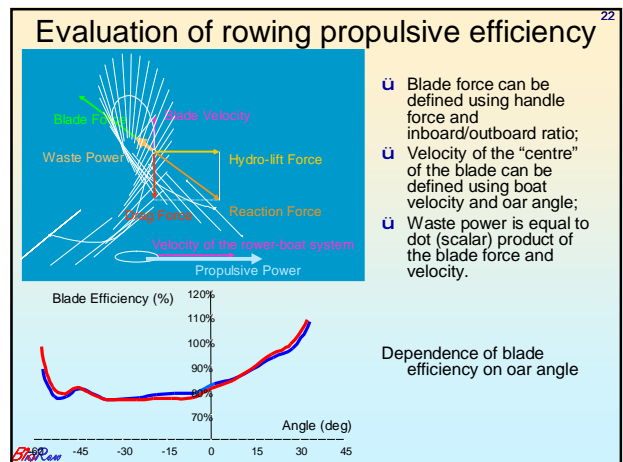
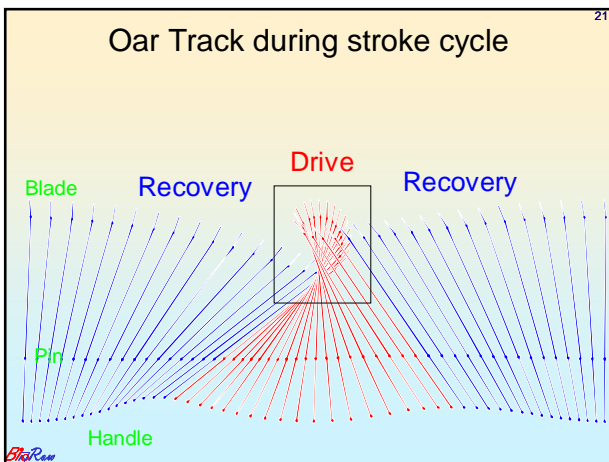
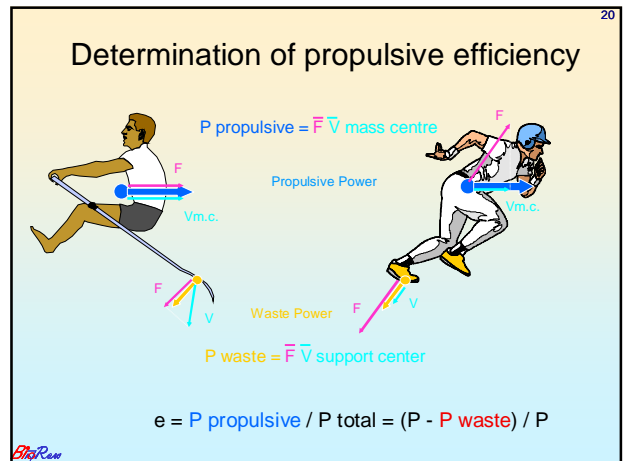
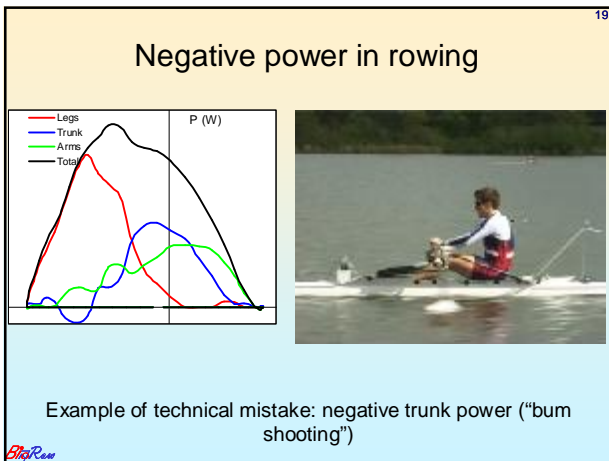


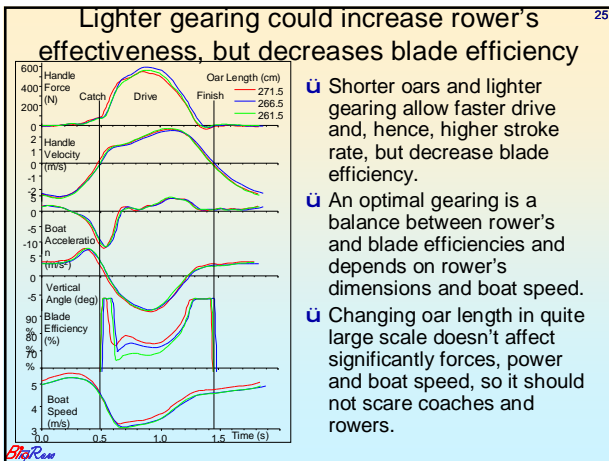
How can we increase the rower's efficiency?

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

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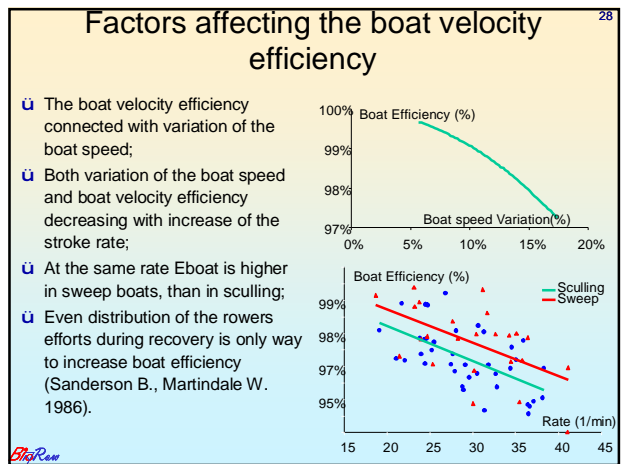
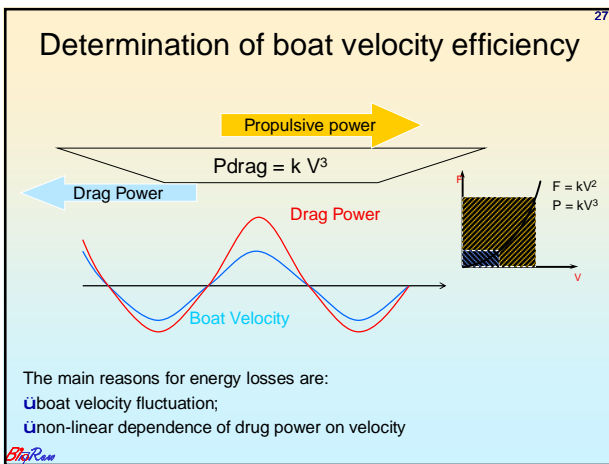






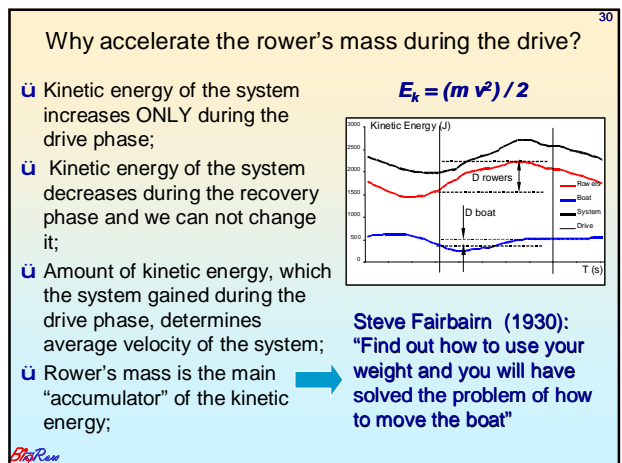
How can we increase the blade propulsive efficiency?

- Use bigger blade area;
- Use heavier gearing;
- Utilise hydro-lift effect -> apply more force at sharp oar angles at catch;
- Place the blade at the optimal depth under the water (4-6 deg).



Why the stretcher force is positive?

- Drive phase must be emphasised, because the system velocity increases only during the drive;
- During the drive, acceleration of the rower's mass must be emphasised, because it is the main "accumulator" of the kinetic energy;
- The stretcher force must be emphasised, because this is the only force, which accelerated the rower's centre of mass;



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Power transfer through the stretcher

$P = F \cdot v$

Squat: power transfer through upper body only

Legs press: power transfer through the foot-stretcher only

ü In rowing the power is transferred through BOTH handle and stretcher in the proportion about 60/40%

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Analogy with canoeing makes it easier to understand why the stretcher force is important

1. Athlete apply action forces
2. Action forces create opposite reaction forces
3. Reaction forces move centres of mass

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Conclusion:

ü Foot-stretcher force must be emphasised, providing the blade is placed into the water.

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Synchronisation in a crew

ü The most simple and accurate method is measurement of synchronisation of the handle velocity;

ü Synchronisation at the catch depends completely on the skills of every crew member;

ü To achieve the same drive time, difference in the drive length can be compensated by reversely proportional difference in gearing ratio.

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Coordination of forces in a pair

To prevent rotation of the boat:

- § Stroke rower must apply higher force at catch;
- § Bow rower must apply higher force at finish;

§ Average force of the stroke rower must be about 5% higher than of the bow rower

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Catch Middle of the drive Finish

Lever of force of bow rower is longer
Levers are equal
Lever of force of stroke rower is longer

The difference in force lever is the main reason of boat rotation in a pair

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Effect of the span on the torque in pair

U A rower with longer span produces higher torque relative to the centre of the boat (CB) at the same force (or the same torque at lower force);

§ This is not a real “gearing” because the ratio of velocities and forces on the handle and the blade remains the same irrespective of the span.

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Big boats with the normal rig

U In the four and eight with the normal rig the sum of the levers turns the bow to the port side;

U The stroke rower can turn the eight at catch to the same side;

Each stroke with synchronous force application creates the boat yaw angle:

- U 0.37 deg in a pair,
- U 0.076 deg in the four,
- U 0.015 deg in the eight

Mass moments of inertia in various boat types (kg m²)

	Boat	Rowers	Total
Pair	15	88	103
Four	243	882	1125
Eight	3360	7400	10760

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The normal and Italian rigs in the four

Average levers in fours (in meters)					
Seat	4	3	2	1	Sum
Normal	2.66	-2.90	3.13	-3.36	-0.47
Italian	2.66	-2.90	-3.13	3.36	0.00

U In the Italian rig the sum of levers is zero, so the boat goes straight at the equal force application;

U The boat with normal rig can go straight, if stroke rowers apply force earlier and/or higher (5% difference in the average force).

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Thank you for attention

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