



Universität Hamburg

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UH Bewegungs- &  
Trainingswissenschaft



# The German Mobile Measuring System

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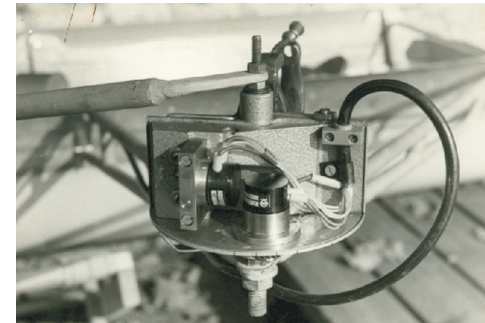
**[klaus.mattes@uni-hamburg.de](mailto:klaus.mattes@uni-hamburg.de)**



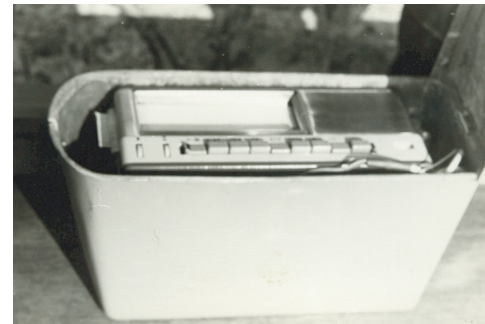
# First measuring boat 1969



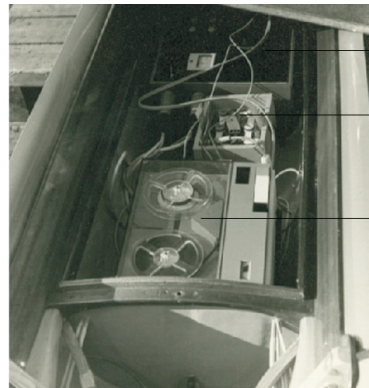
Force and angle  
transducer



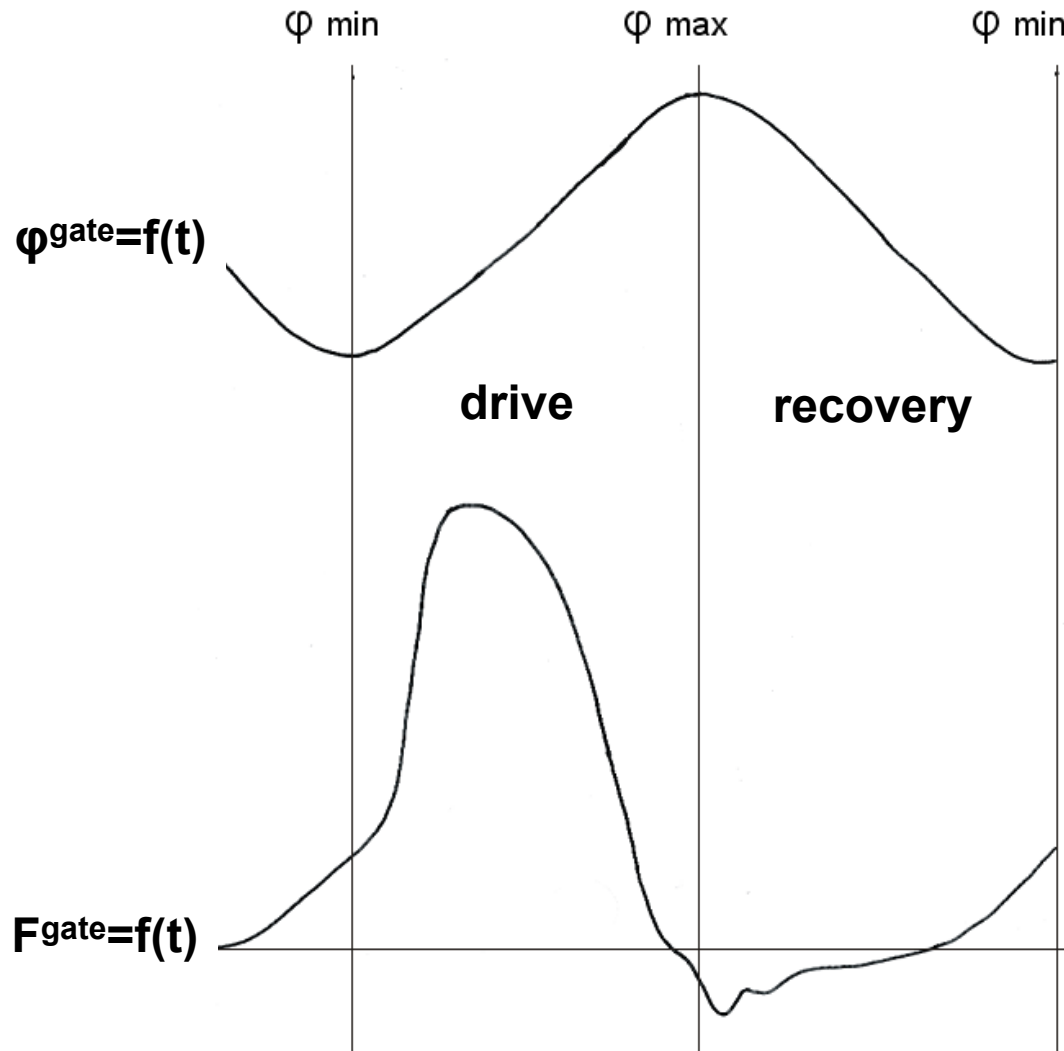
Technical  
data writer



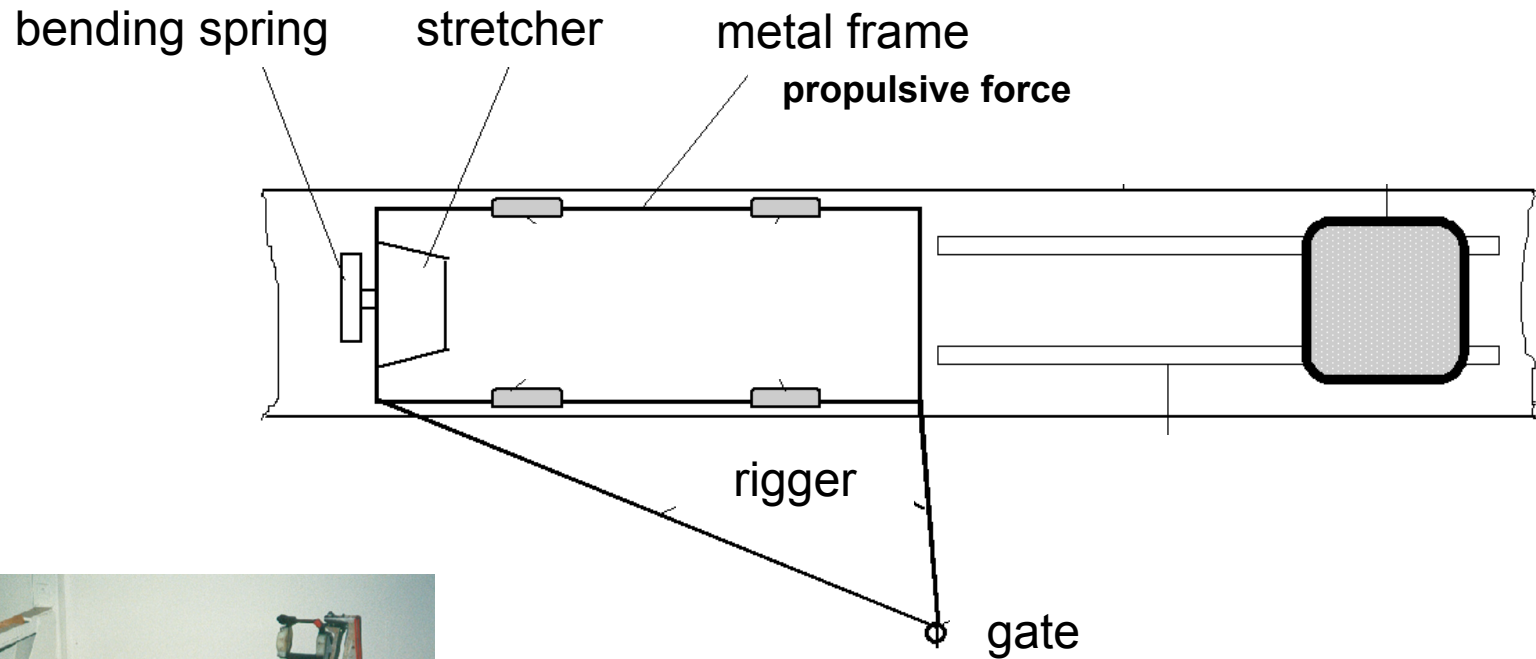
Tape recorder



# Ideal force- and oar angle curves from 1973



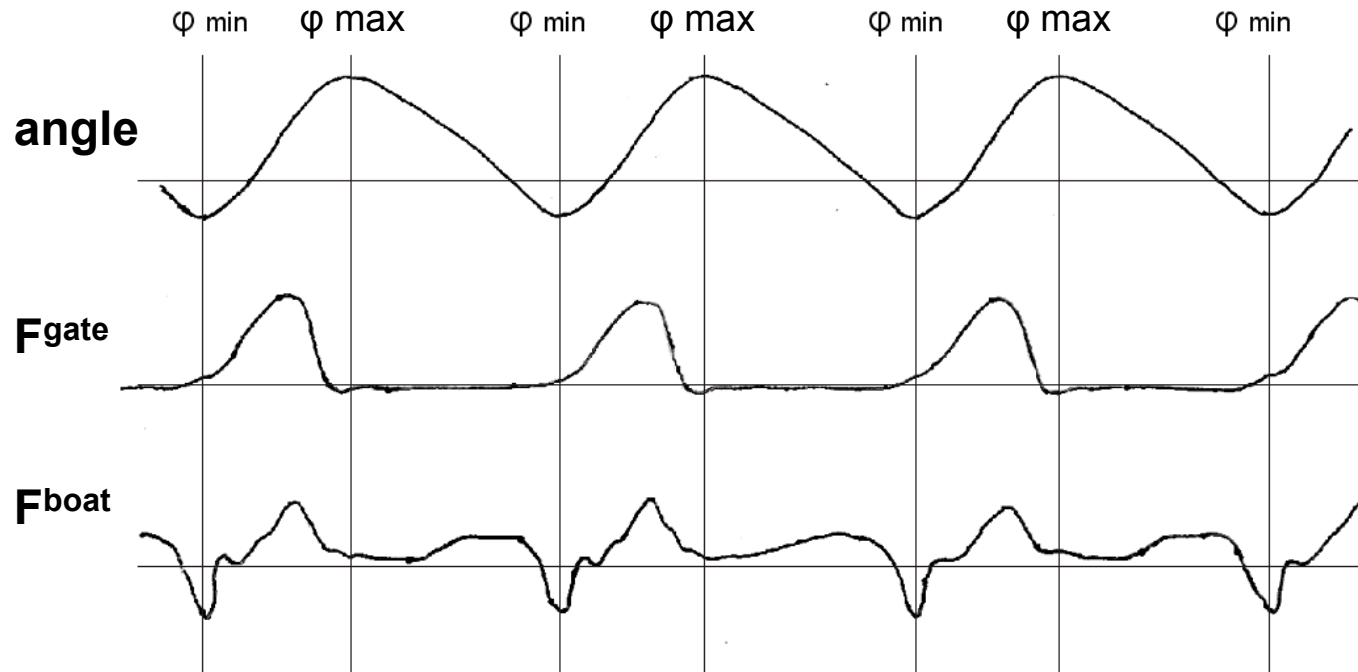
# Propulsive net boat force directly measured



# Individual characteristics from T.L. 1988, 1x, bow side



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# Comparison of aim (2000m) and results of T.L., 500m, 1988

	SR [1/min]	$v_{\text{boat}}$ [m/s]	$P_{\text{handle}}$ [W]	$F_{\text{handle}}$ [N]	$v_{\text{handle}}$ [m/s]	$s_{\text{handle}}$ [m]	$\phi_c$ [°]	$\phi_f$ [°]
Aim (2000m)	33	5.0	1080	780	2.0	1.57	30	138
T.L. (500m)	39	5.09	1539	857	2.18	1.54	34	135
% of aim	118	102	143	110	109	98	88	89

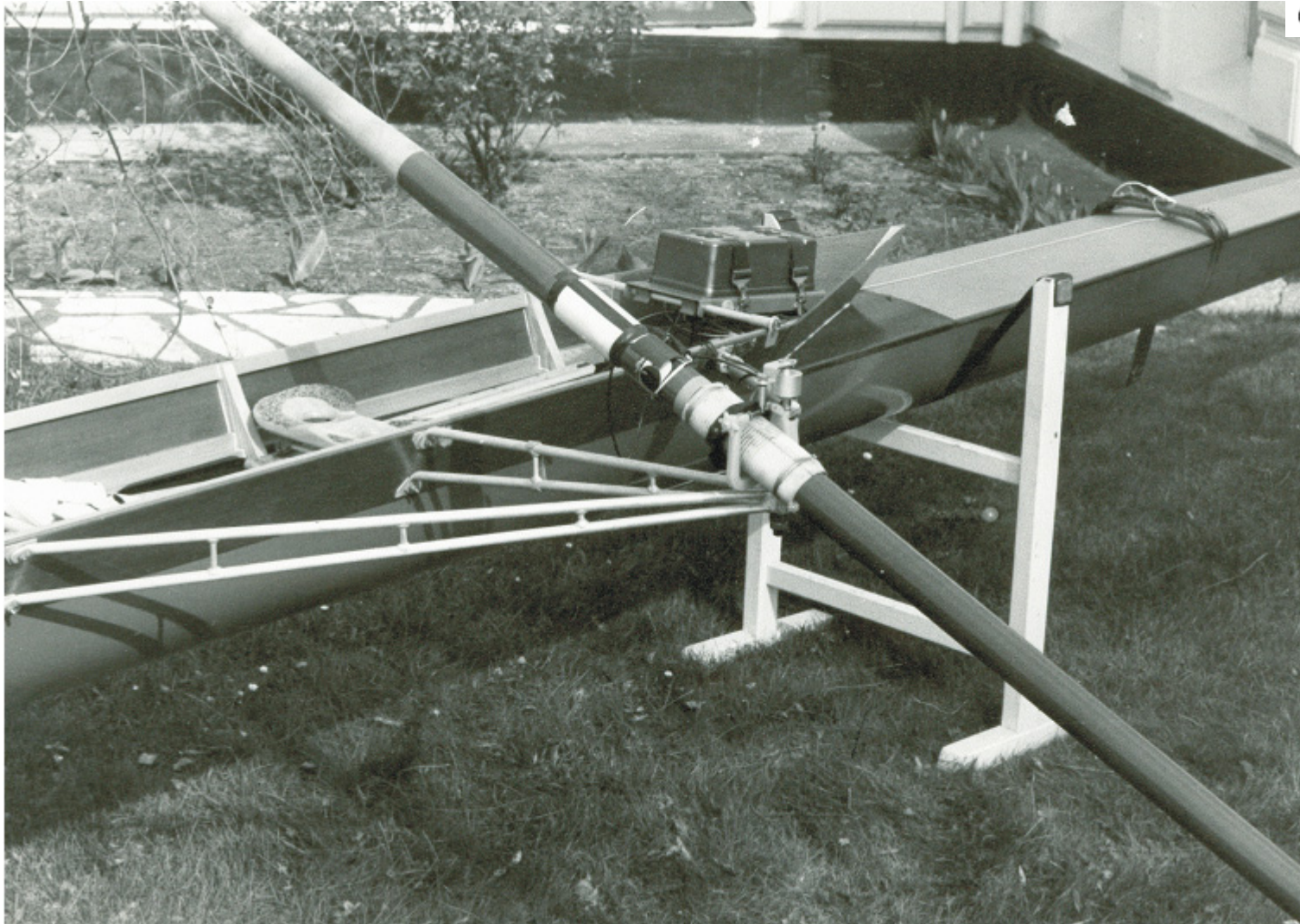


# First mobile measuring system in a racing boat



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# The current mobile measuring and training system



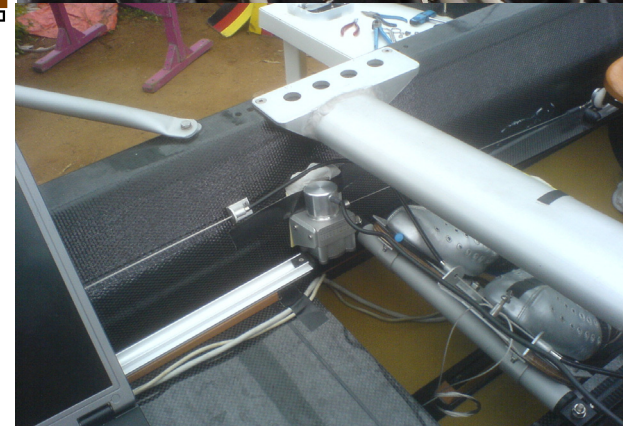
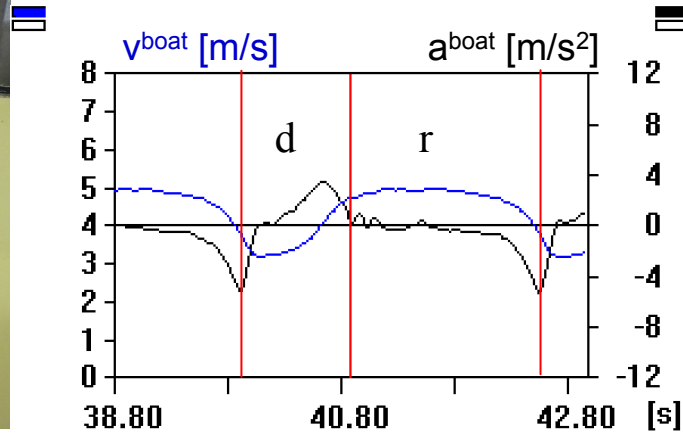
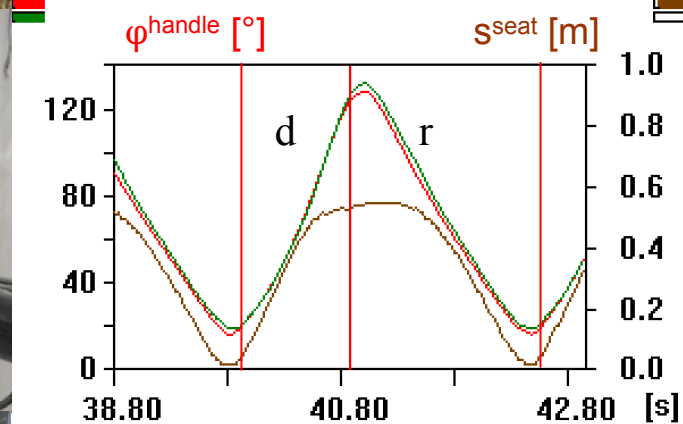
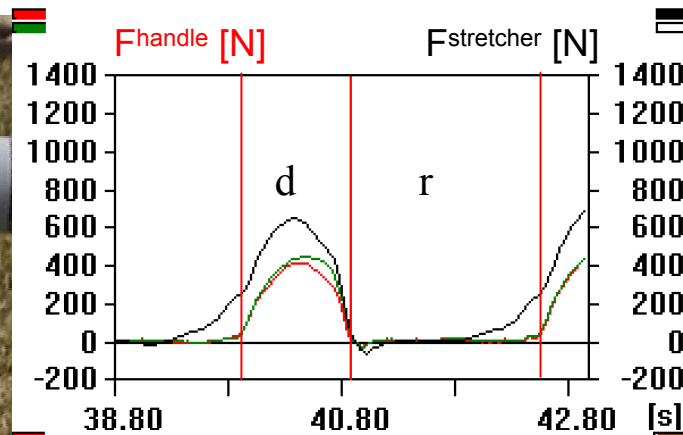
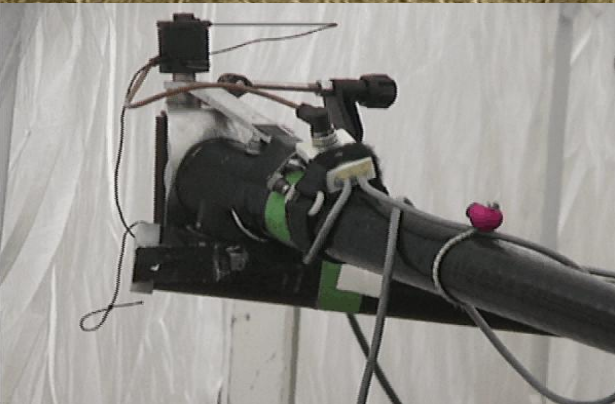
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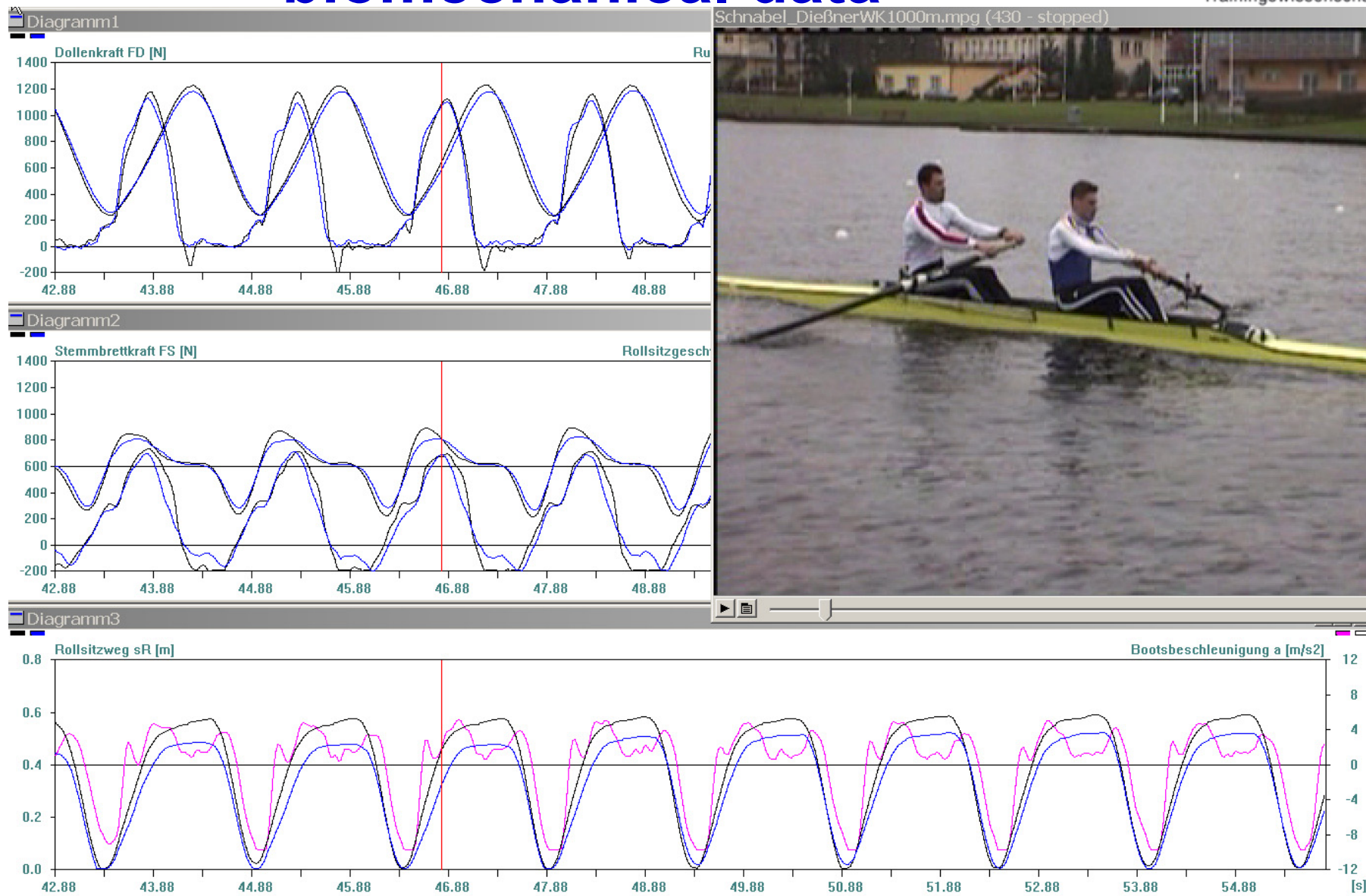




# Transducers used in the Mobile measuring system



# Synchronisation of video and biomechanical data





# Measuring and training system 2000

diagnostic & training/ feedback training/ crew selection  
all boat classes, individuell/ crew

~ 450 meas./ year

Rowing performance  
and technique  
diagnostic

biomechanical  
feedback training

crew selection and  
formation

single stroke

feedback information

rang groups

stroke series

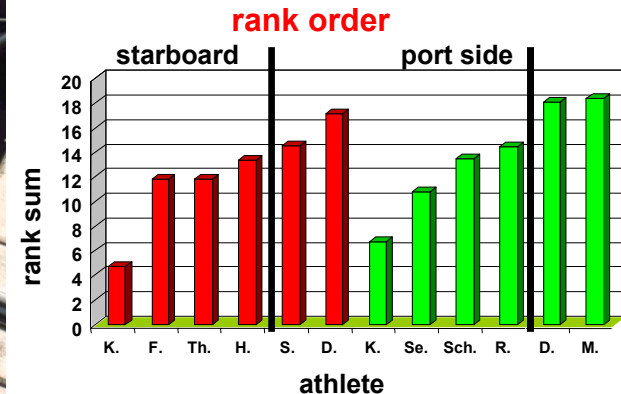
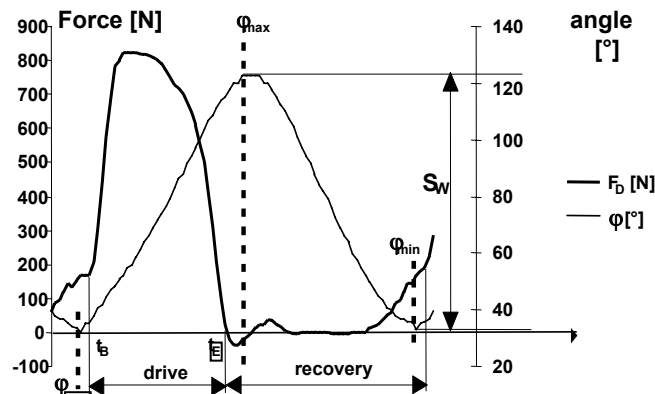
perception

seat position

stroke intensity

changed technique

training recommend.



# Selection and formation of boat crews for big boats



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# Final women's quadruple scull German Championships Berlin, june 2004



Overview of the athletes, women, n=8



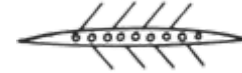
Place	time [s]	number of strokes	SR [1/min]	bh [m]	bm [kg]
Second n=4 	427.1	240.6	33.8±1.3	1.81 ±0.05	72.0 ±4.54
Winner n=4 	425.4	234.7	33.1±1.7	1.80 ±0.04	71.5 ±5.04

# Total evaluation, 2000m

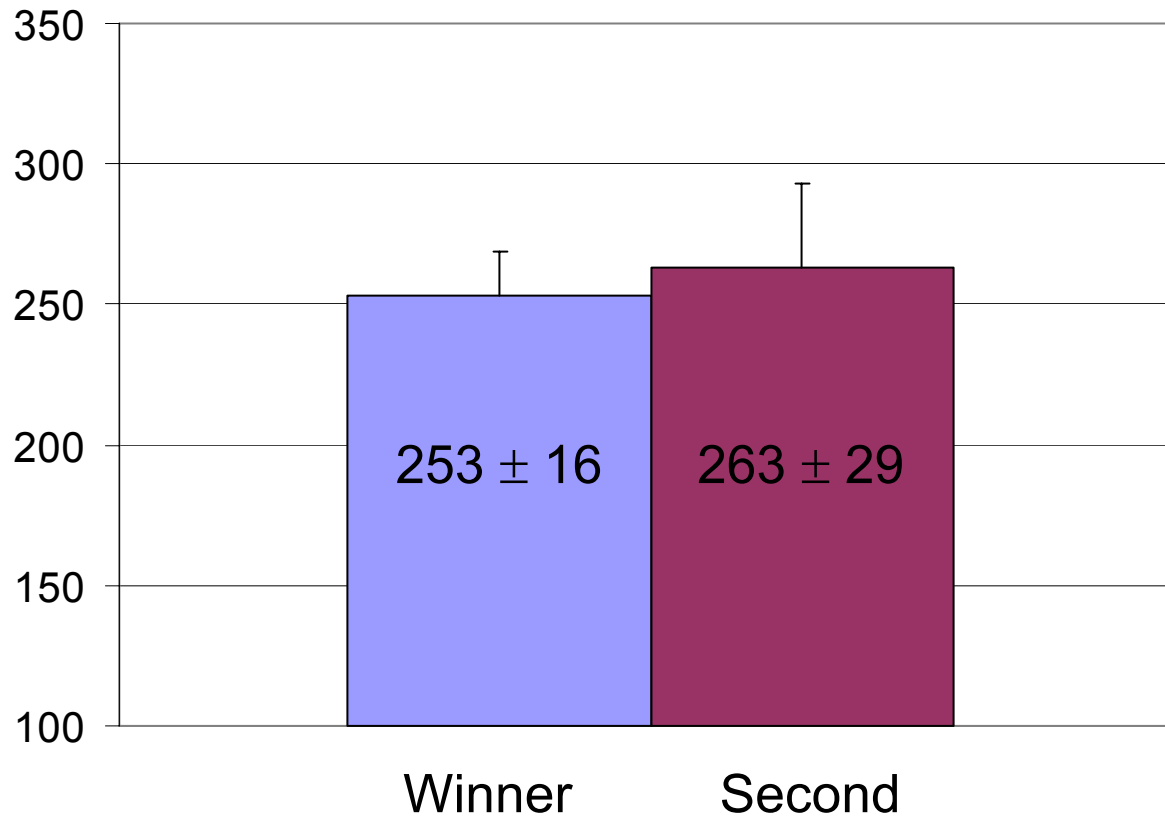


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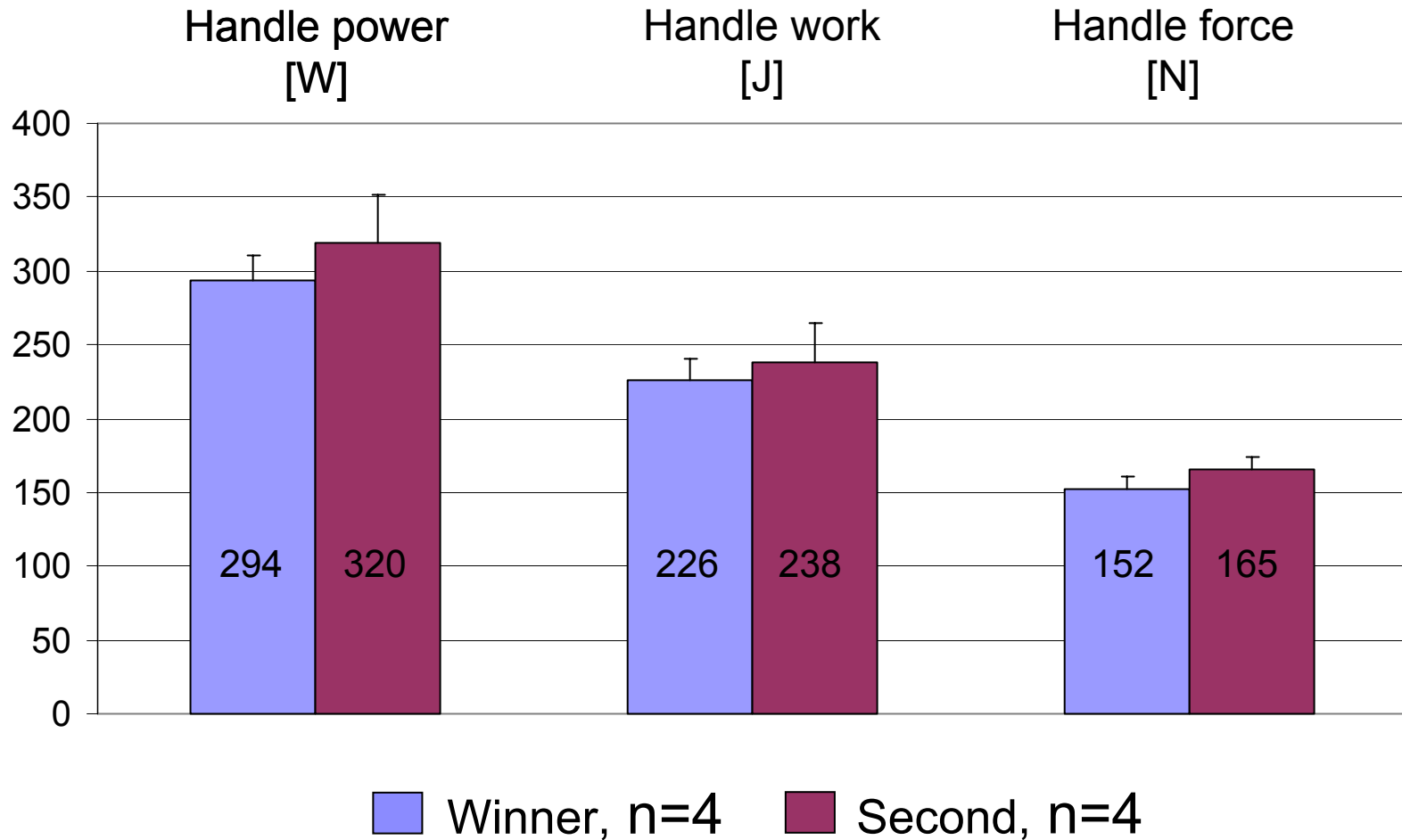
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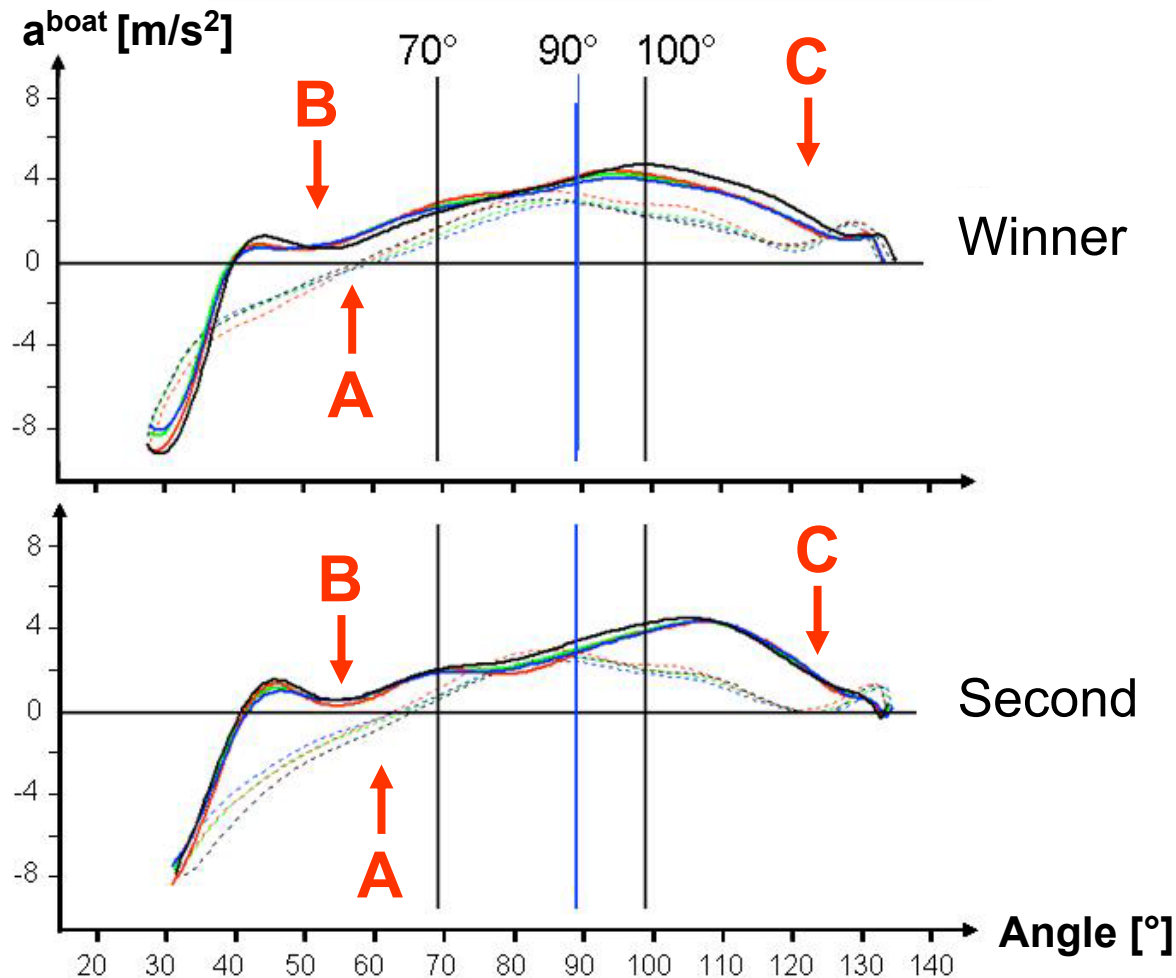
$\Sigma W^{\text{handle}}/t_{2000\text{m}}$  [W]



# Comparison winner vs. second place, race time difference < 2s



# Comparison winner and second place, German Championchips 2004, W4x





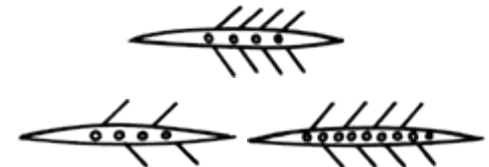
# selection of boat crew according to scientific criteria

criteria:

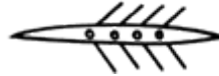
- individual rowing performance over 2,000 m
- the quantity of stroke structure
- quality of rowing technique in the drive phase
- quality of rowing technique in the recovery phase
- stability of rowing technique in the race and the race profile
- variability of rowing technique at various stroke rate increments

➔ Ranking of the athletes

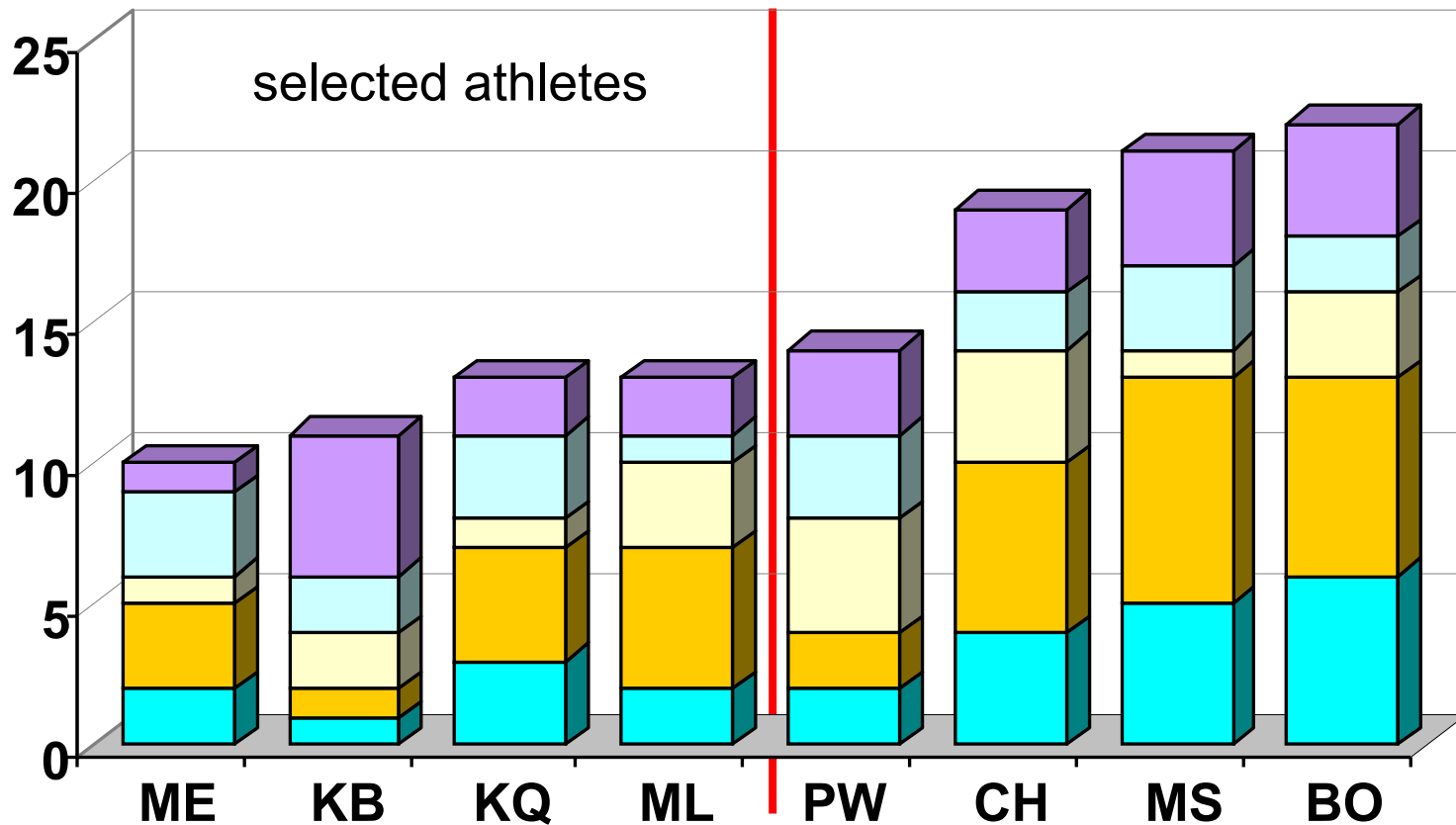
➔ crew selection and seat number



# Test results of the selection women, 4x



rank sum



Phandle 2000m

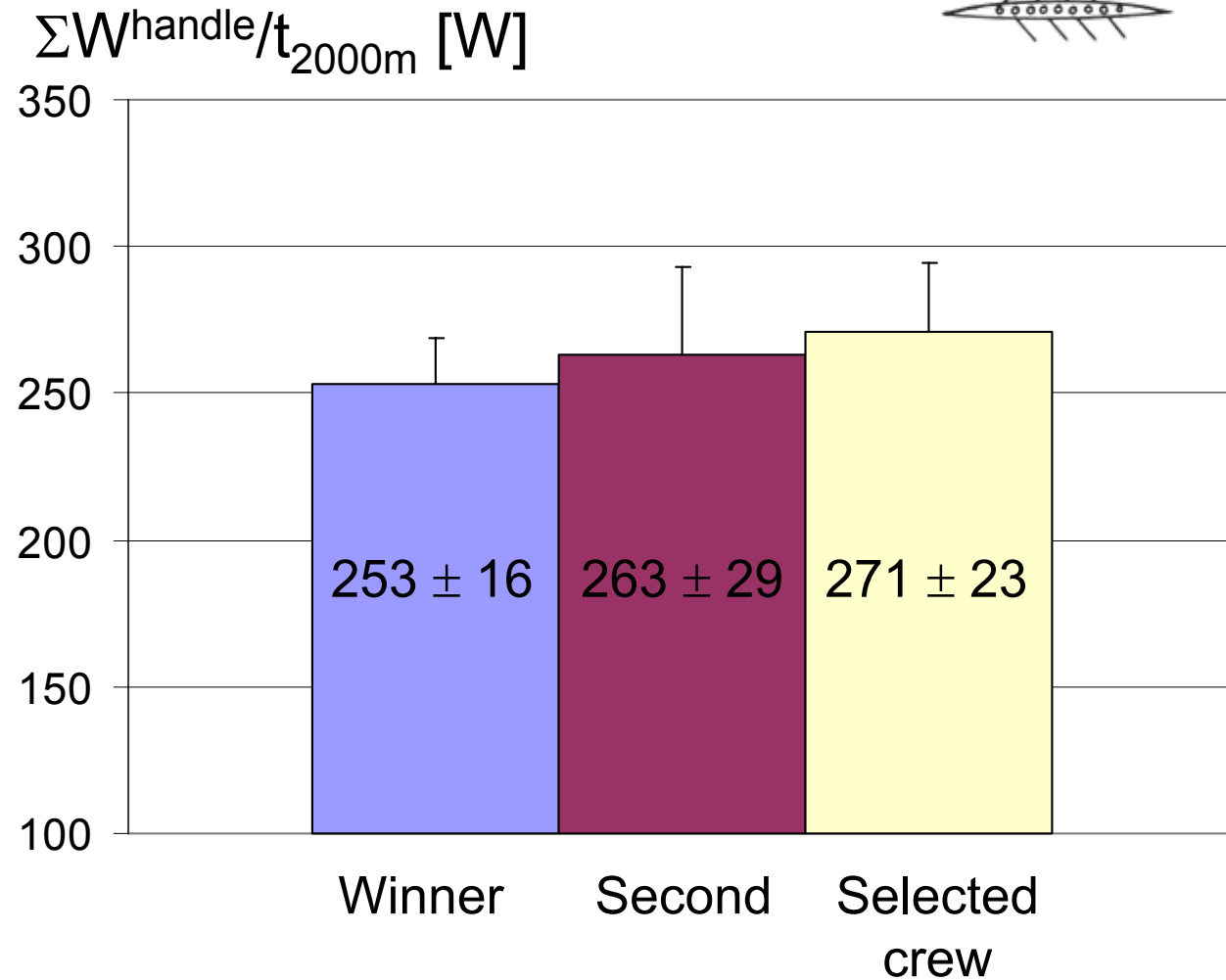
quantity drive structure

quality drive

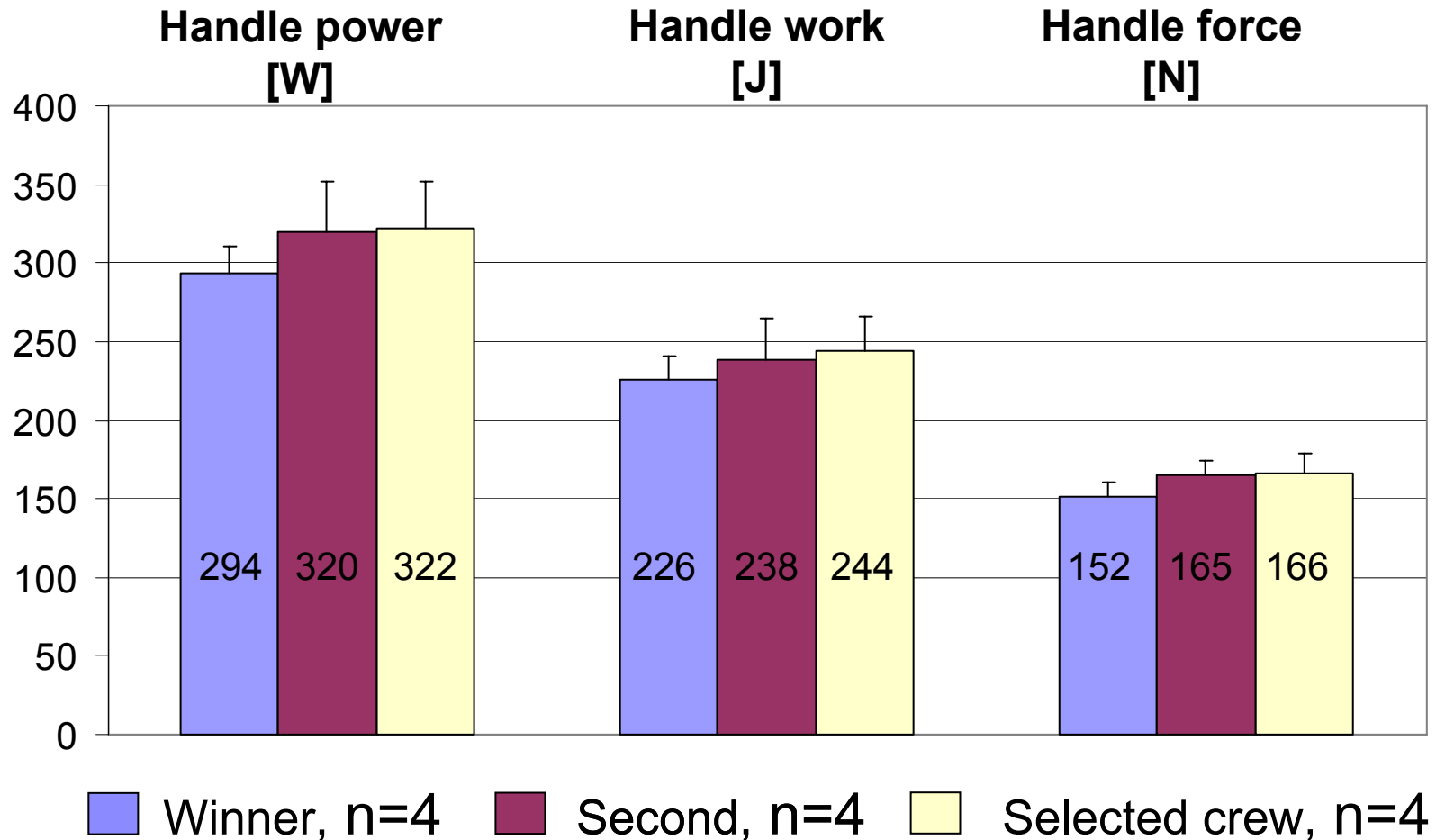
quality recovery

race profile

# Total evaluation, 2000m



# Comparison winner vs. second place, race time difference < 2s

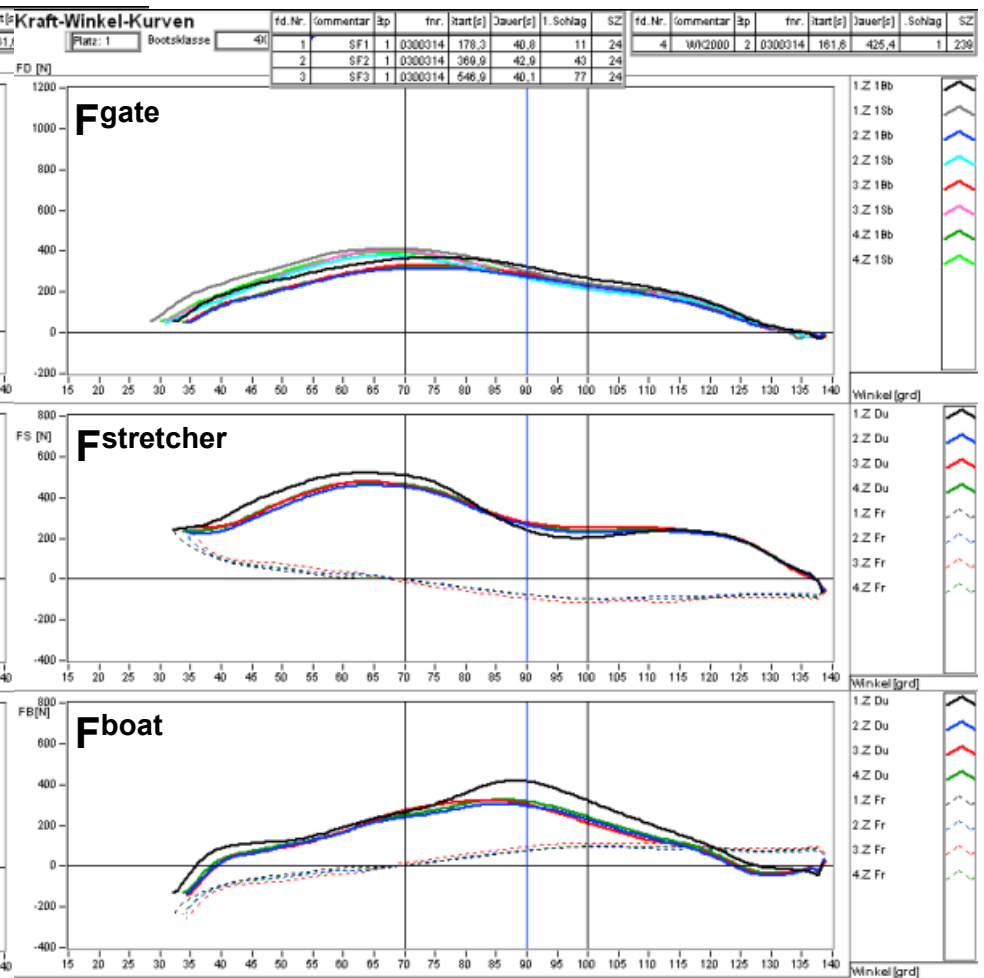
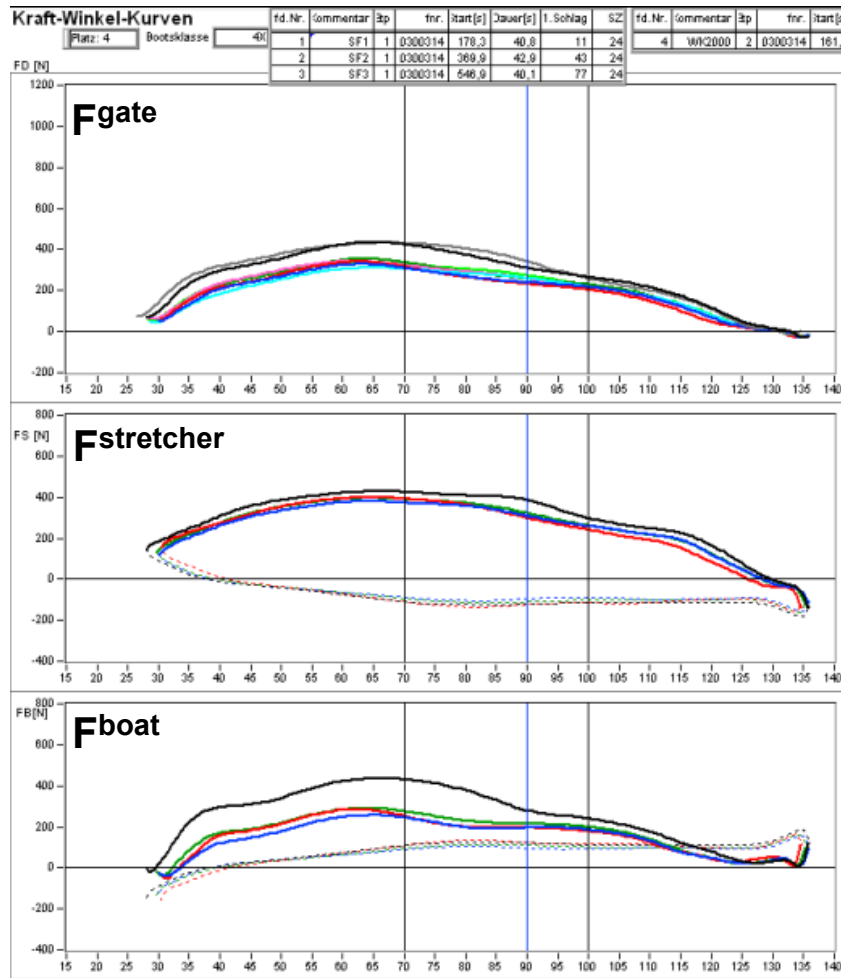




# Comparison of the force curves athlete No. 4 vs. No.1

No. 4, selected

No.1, non-selected





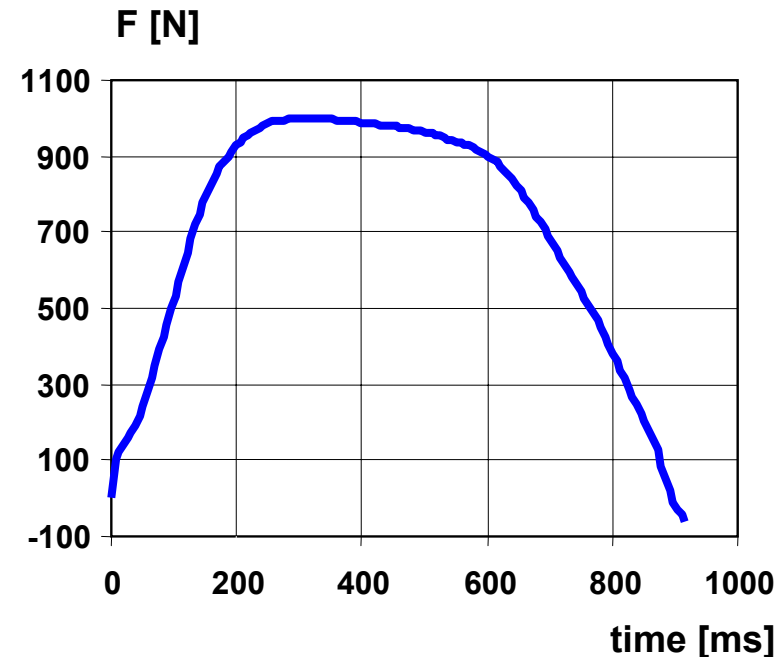
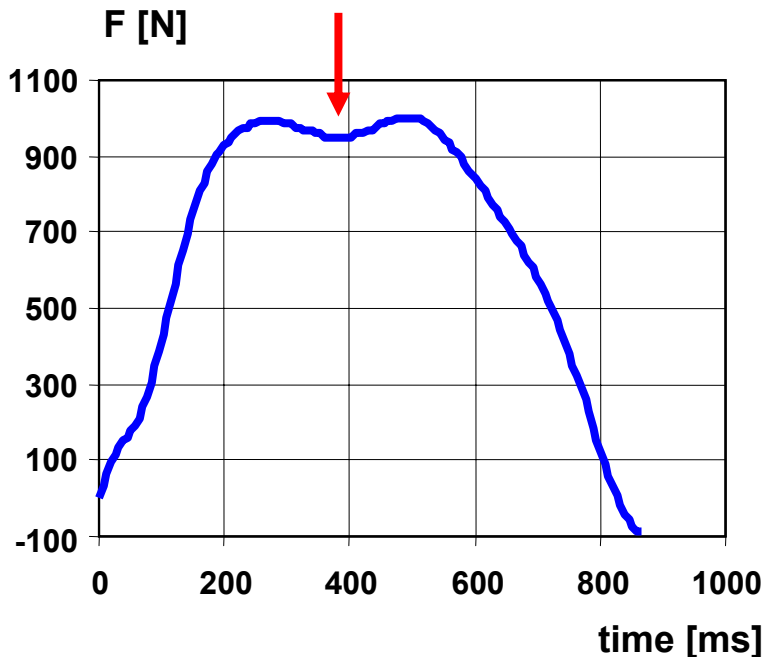
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## Biomechanical feedback in the racing boat

# Intention: Removal of faults in rowing technique

e.g. the dynamic time structure



Current state  
of technique



feedback-  
training



learning  
progress

# Reasons for biomechanical feedback



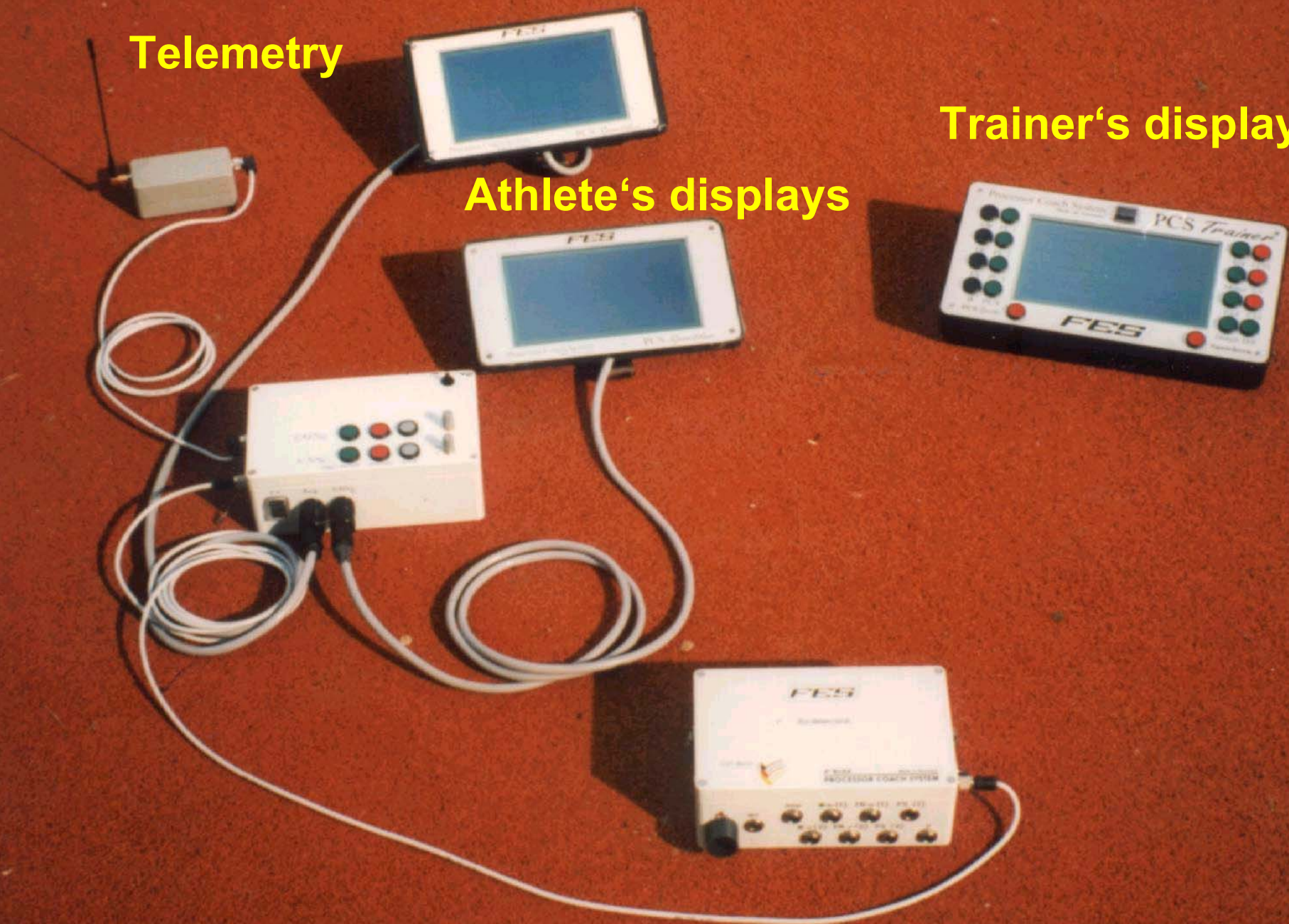
- Some mistakes in rowing technique are hard to eliminate (force structure).
- Kinaesthetic information is unconsciously.
- Force patterns are difficult to observe by the coach.
- Coach and athlete need more quantitative information with higher precision.



Telemetry

Trainer's display

Athlete's displays





# Display for the athlete and for the coach in twin display design



**athlete  
readily visible mounted on the  
stretcher**

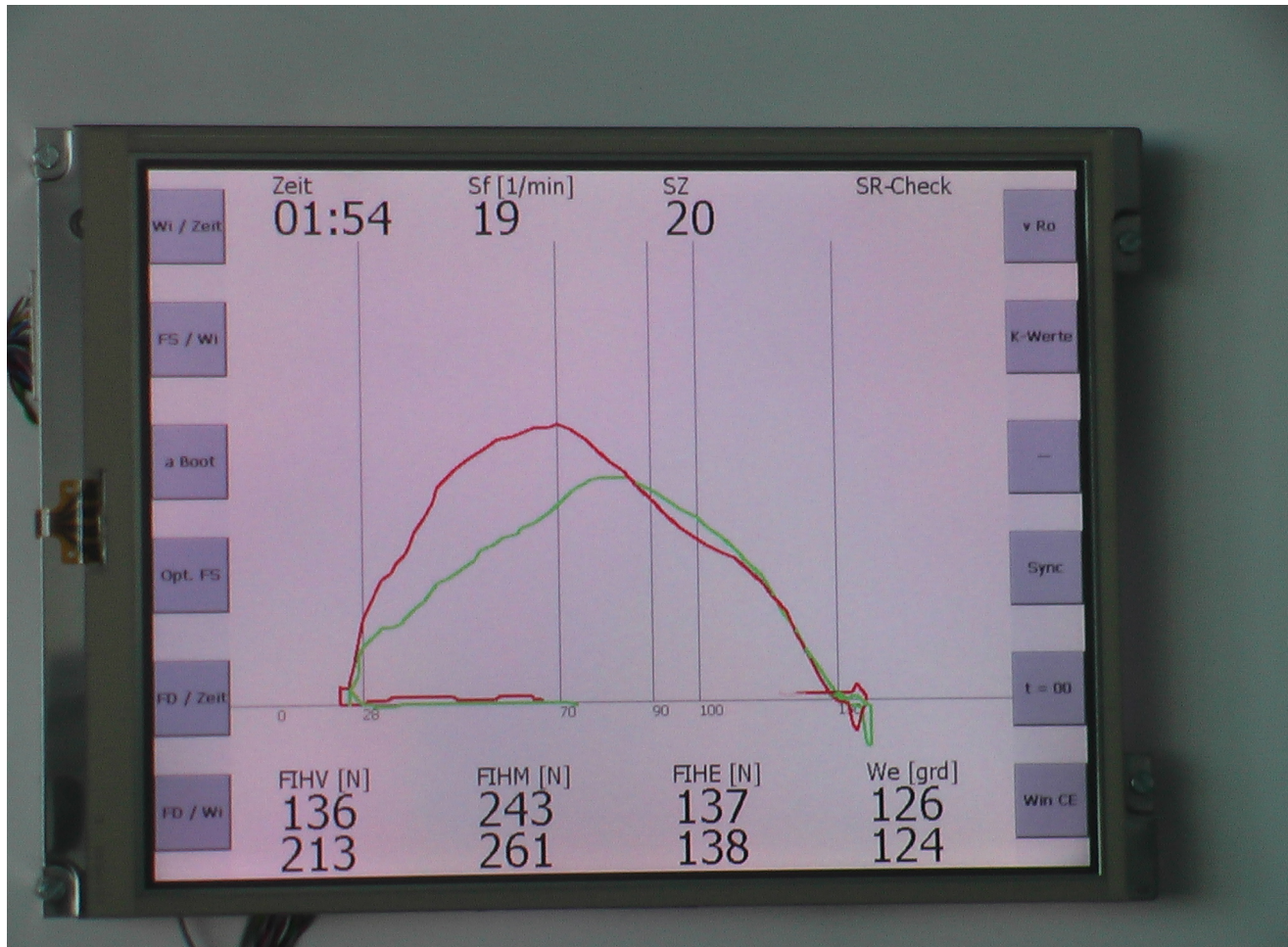


**coach  
in twin display design**

# Feedback display



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# Feedback display



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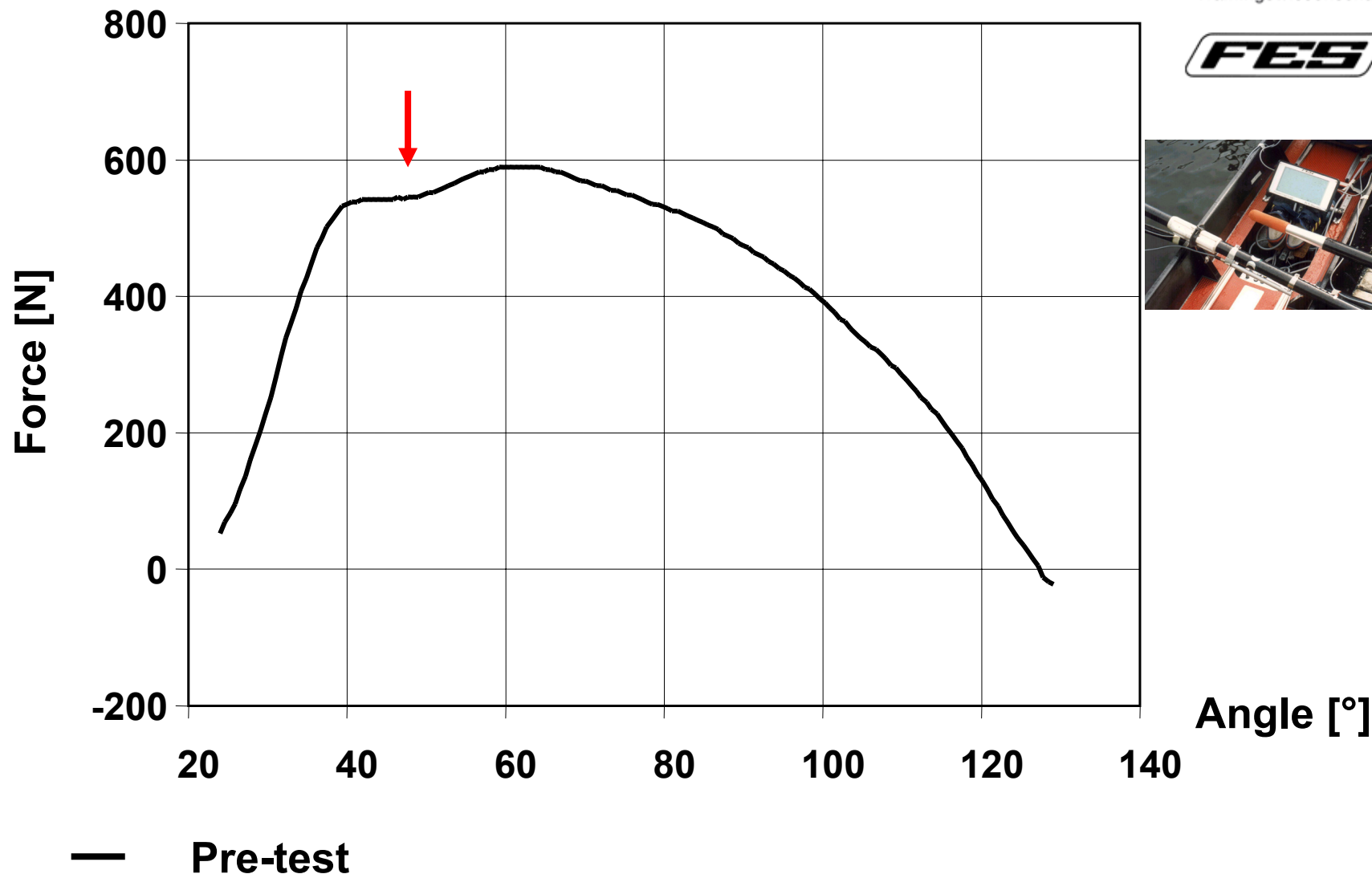
# Feedback training procedure

- Before feedback training: biomechanical analysis of technique to identify the objectives of feedback training
- In feedback training: the athletes are asked to vary the movement in order to change a technical feature. The athlete monitors and regulates the movement with the help of objective feedback
- If the athlete succeeds, the objective feedback information is withdrawn step by step. The athlete learns to produce the altered movement pattern without external feedback
- Retention tests: the altered movement is stable under competitive conditions and without objective feedback



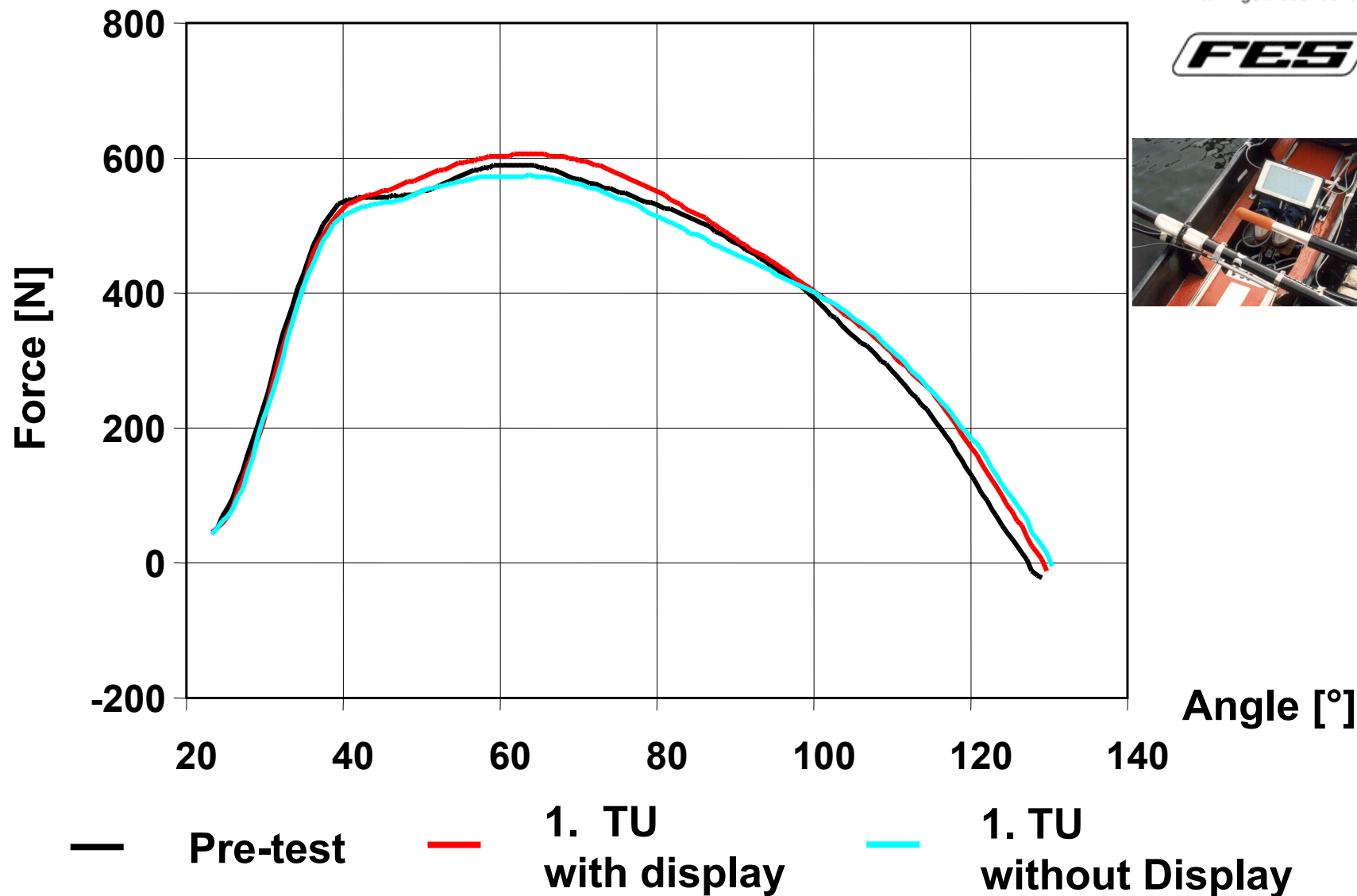


# Comparison between Pre-test und 1. TU, 4x, No. 4, stroke side, stroke rate 20 [1/min]

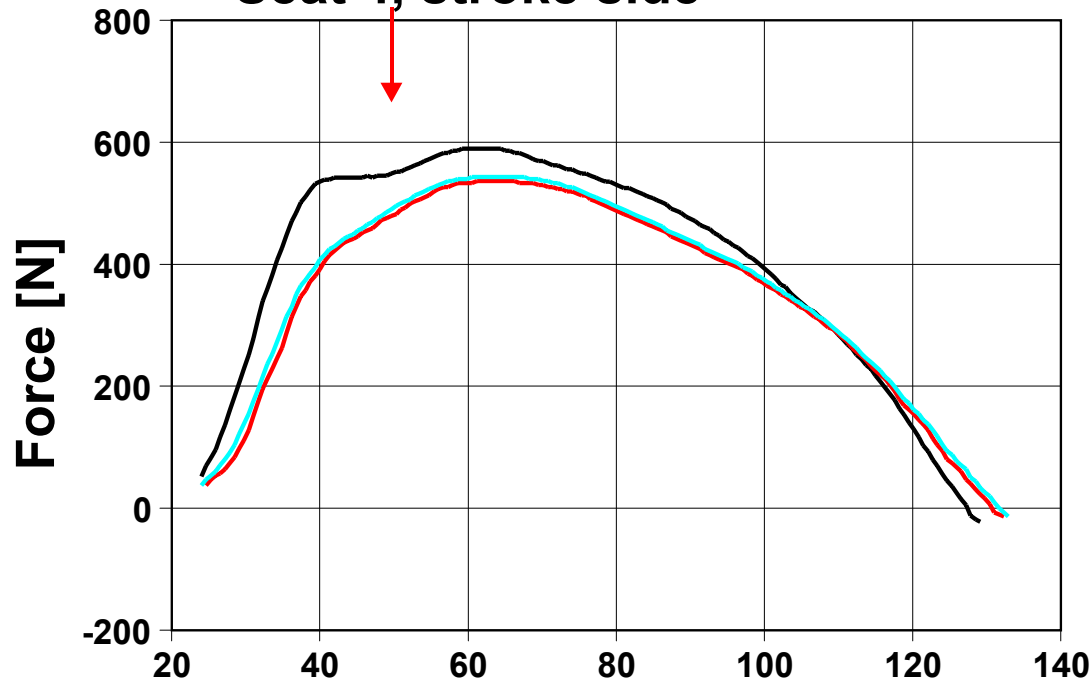




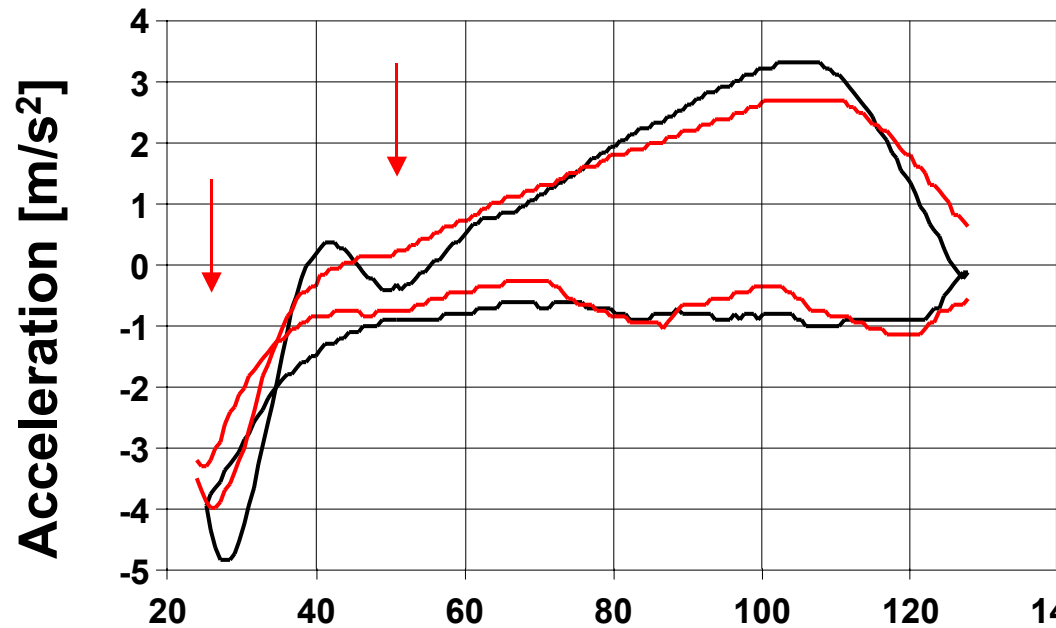
# Comparison between Pre-test und 1. TU, 4x, No. 4, stroke side, strokerate 20



**Seat 4, stroke side**



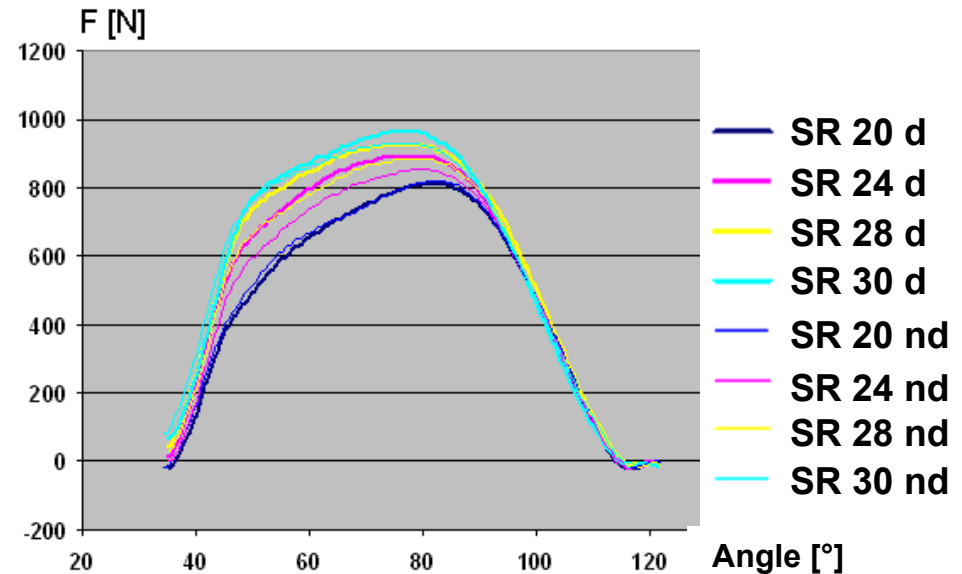
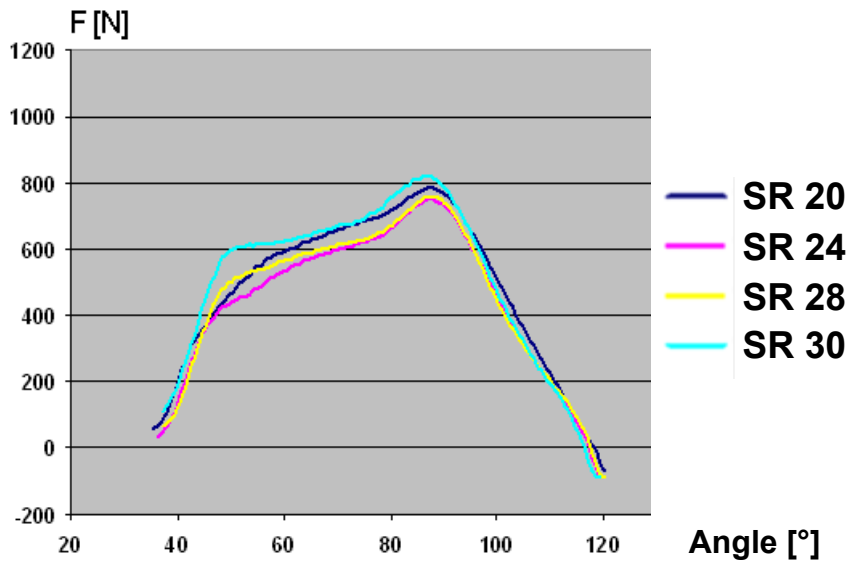
**Comparison between  
pre-test and third  
training unit (TU), 4x,  
SR 20**



— pre-test  
— third TU  
display  
— third TU  
no display

# Gate-force-angle curve for an athlete before, during as well as after feedback

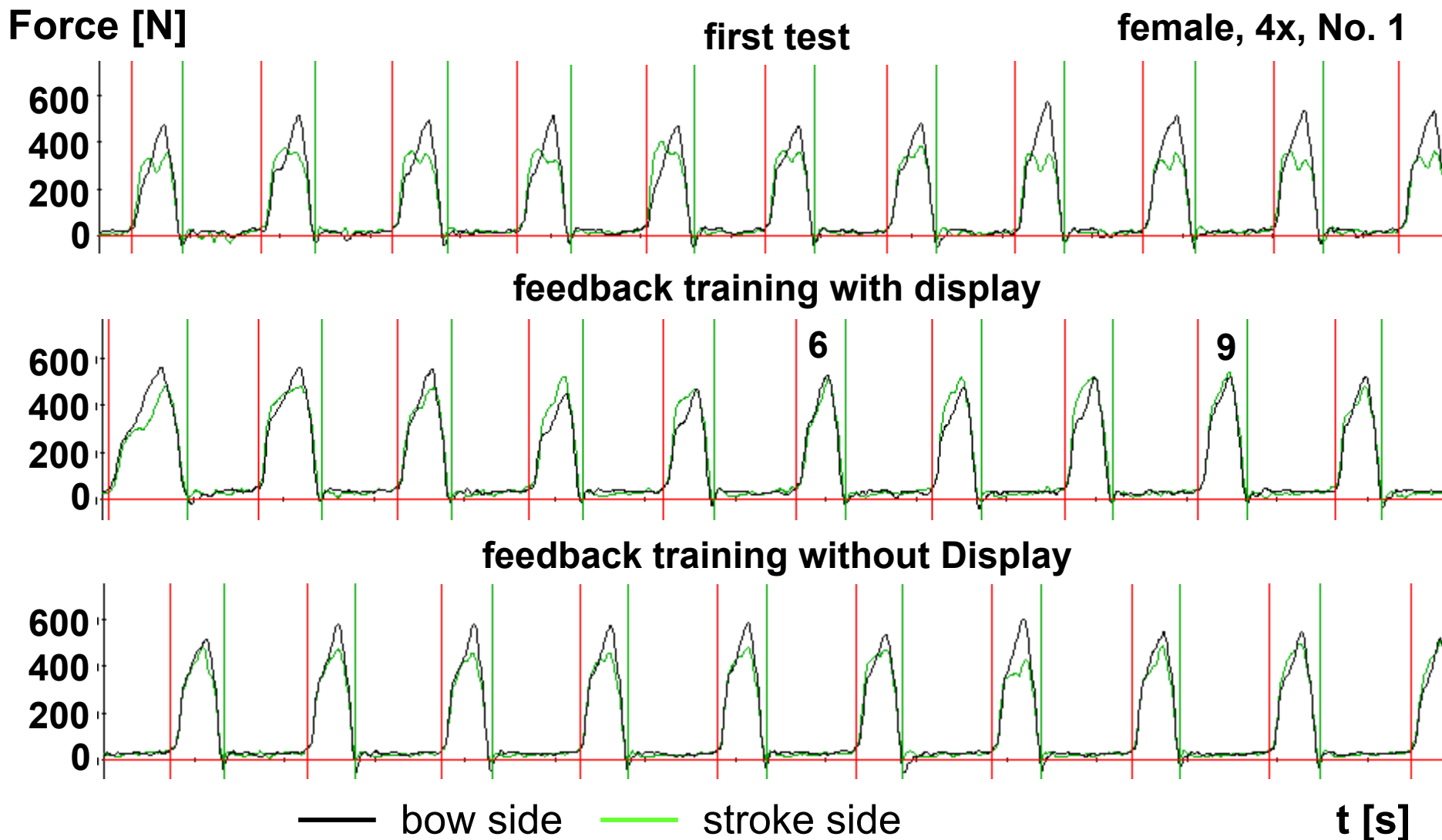
before feedback → during and after feedback



SR = stroke rate  
d = with display  
nd = no display



# Comparison of the first test and deviation of intervention



# Approach using stroke length in big boats, N=4



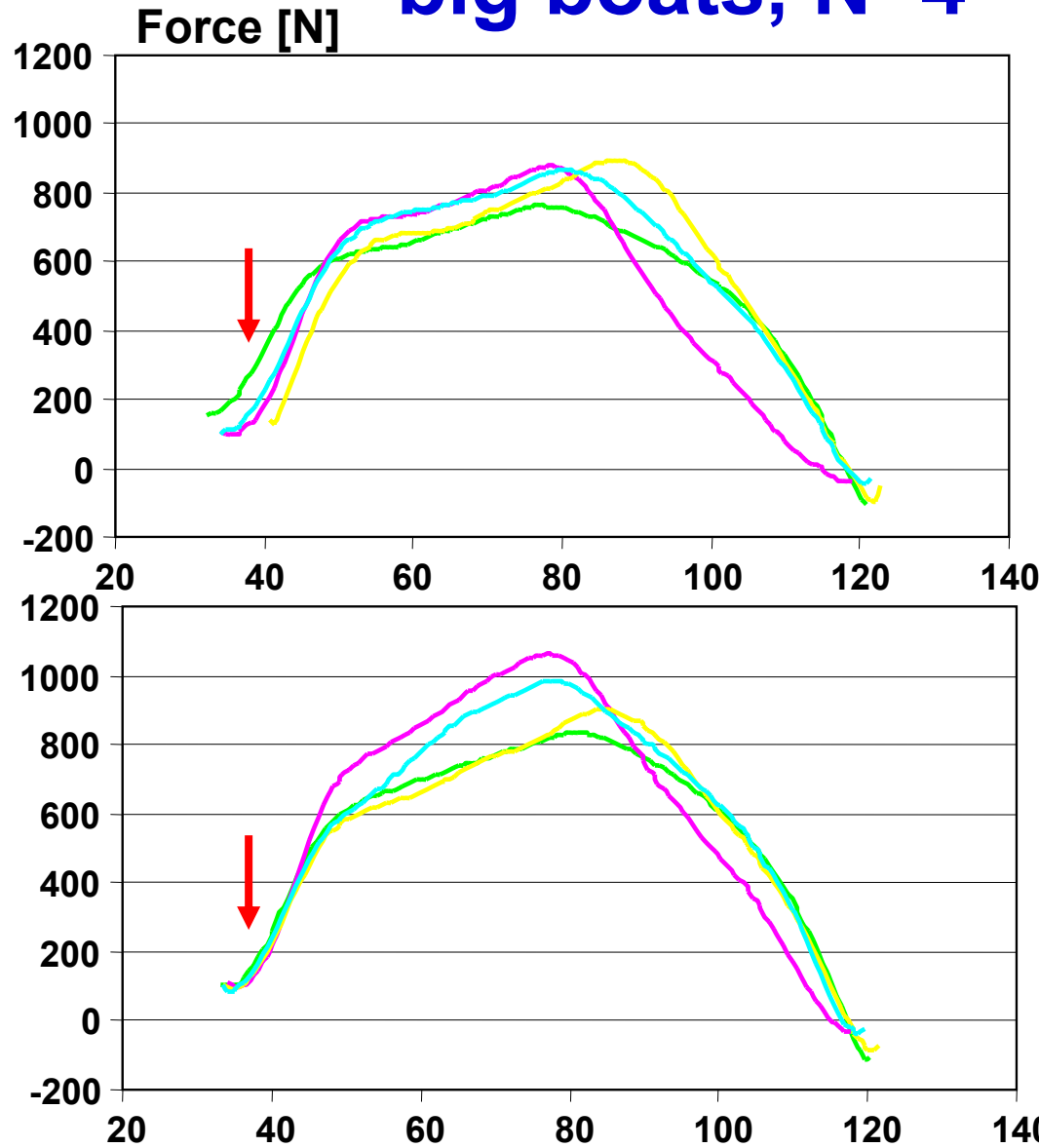
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**first test**

**SR=30 1/min**



- No. 1
- No. 2
- No. 3
- No. 4

**feedback training**

**SR=30 1/min**

**Angle [°]**



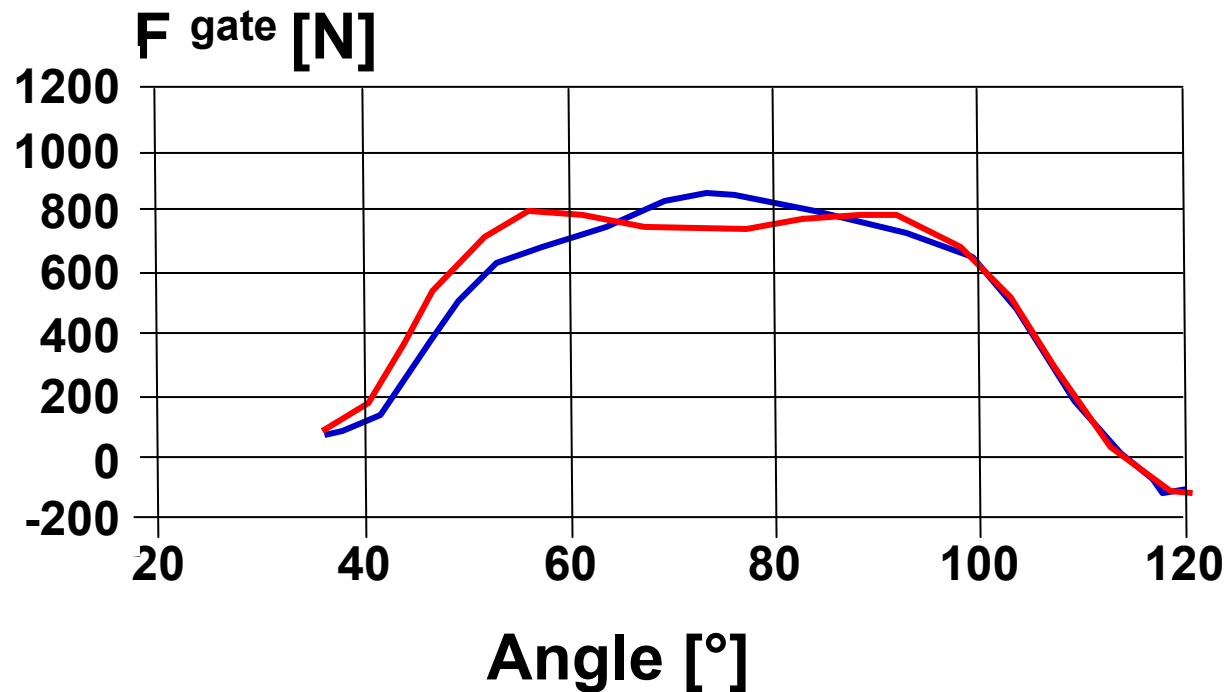
# Feedback training

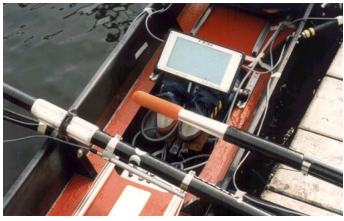
- Information about determining aspects of technique in the propulsive and recovery phases, like
  - Spatial attributes of the stroke length
  - Space-time attributes of the oar and body movement
  - Dynamic-time attributes of the force applied to the handle and stretcher
  - Attributes of the boat movement (speed and acceleration)



# Reinforce strokes with positive characteristics

Positive and negative force curve characteristics for individual strokes





# Feedback training

**short intervention**  
(2-4 TU)



**fine adjustment**  
in crew boat



**technique-practice training**  
(reinforcement of emerging  
movement pattern)

**long intervention**  
(>10 TU)



**error removal**  
in crew boat



**technique-acquisition training**  
(unlearn and learn anew)



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