WORLD ROWING COACHES CONFERENCE
2011 - WINDSOR, GREAT-BRITAIN

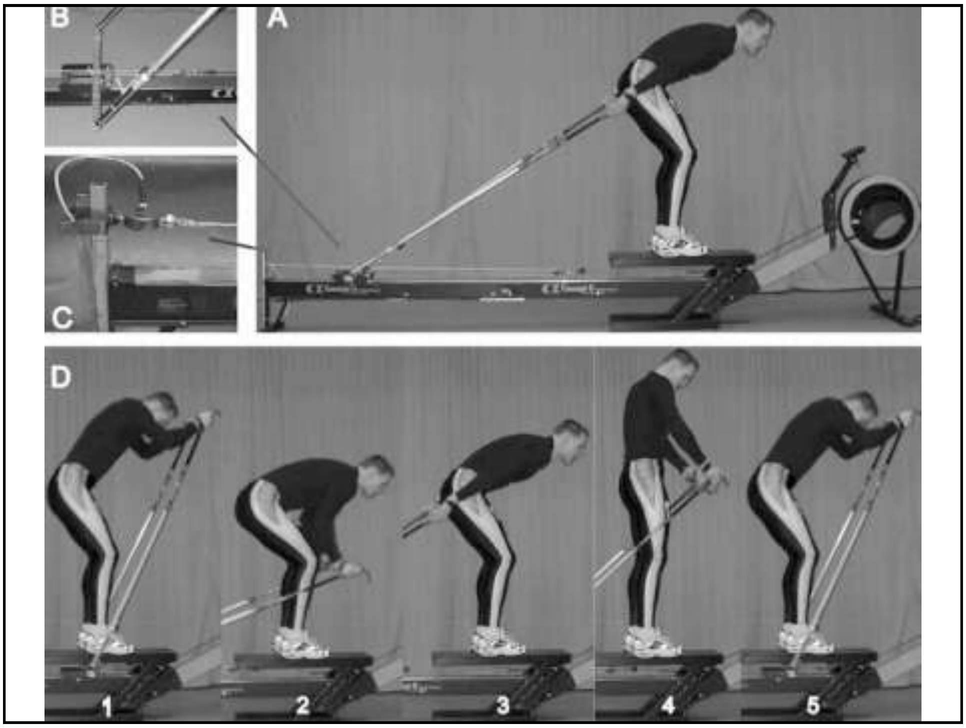
20 – 23 January, 2011

Finding the “Edge” – Talent and Technology

How can Science and Technology help rowing coaches to develop performance?

10.30 – 11.30 **Ergometer Training** Kurt Jensen DEN

11.30 – 12.45 Questions and discussion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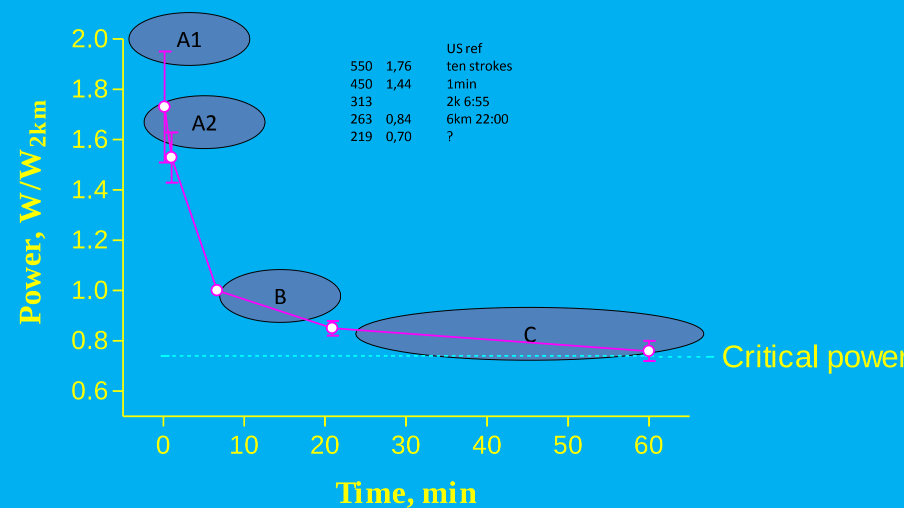
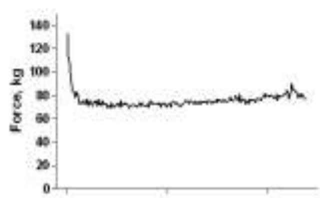
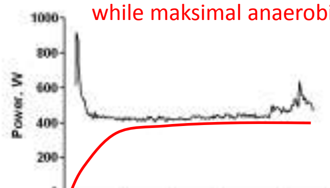
?
2004

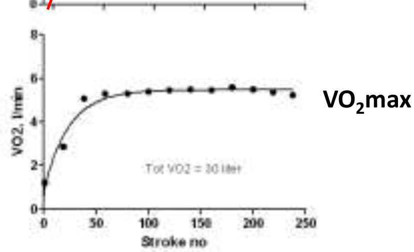
The ”one week test” has been proposed to define the right balance?

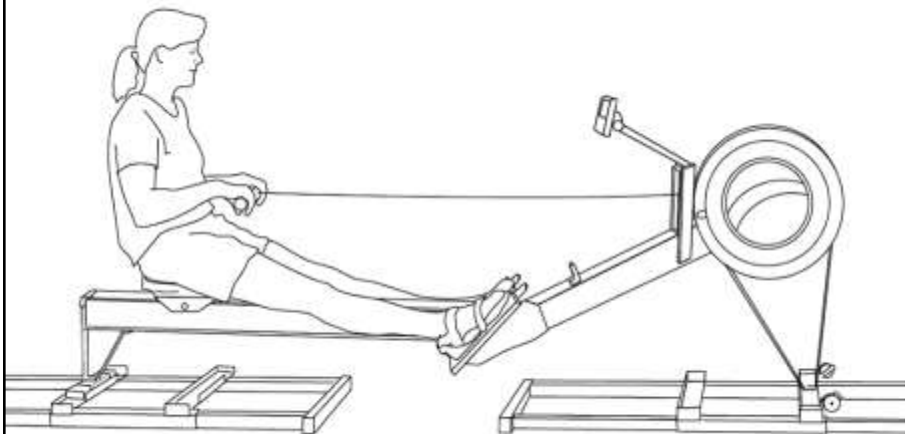


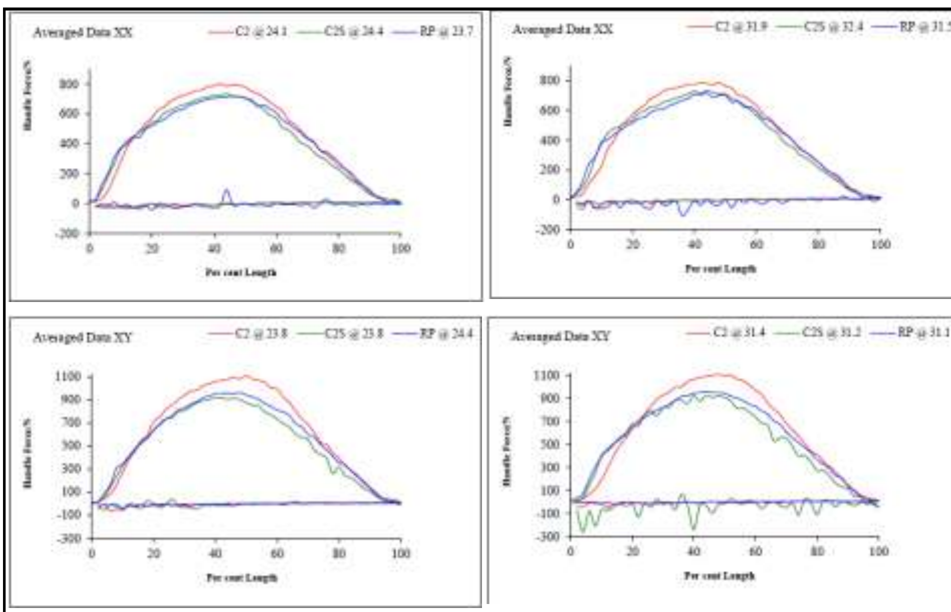


VO_2max increases with body mass lifted in 0.73 power, while maksimal anaerobic capacity increase with muscle mass

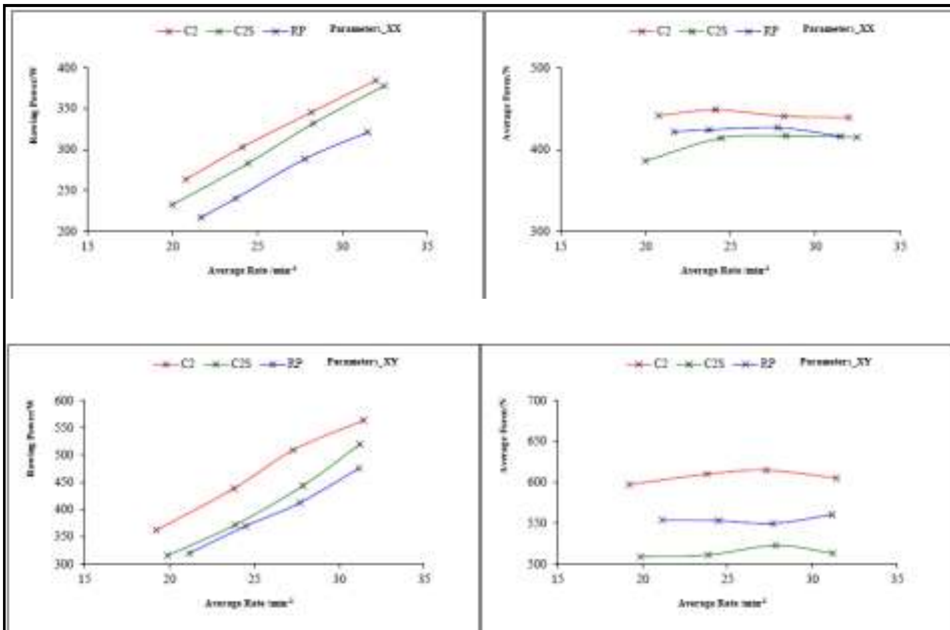








Bruce G. Grainger, 2008, MSc dissertation



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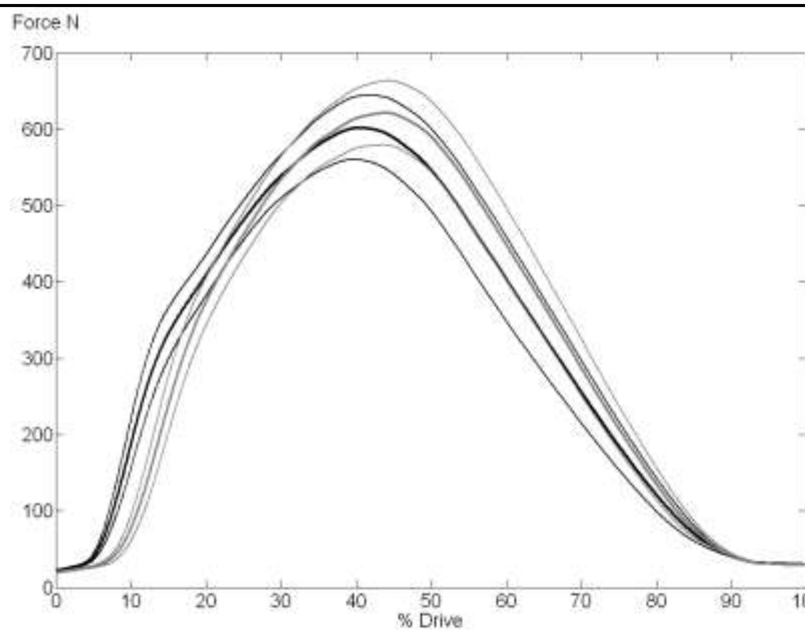
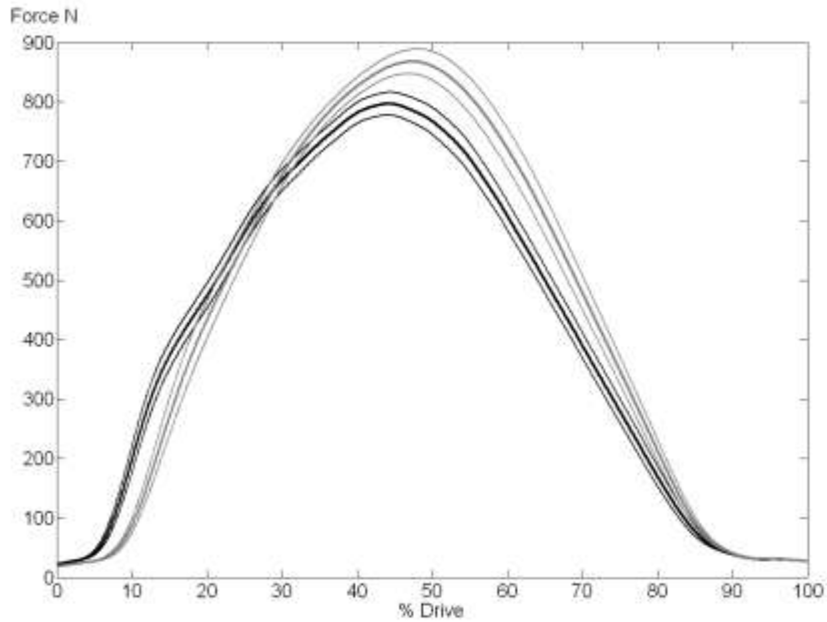


Anders Vinther, 2008



Anders Vinther, 2008

At training venues, boathouses and gyms all over the world right now, athletes are dutifully logging kilometers at low stroke ratings of 18-24 spm. While there are benefits to this practice, Concept2 has some concern over the impact of low stroke rate/high force work done during long training sessions. Coaches and athletes need to understand the effect of stroke rate on the average force required to achieve a desired power output or pace. At low stroke rate the average force will be significantly higher for a given pace. Account for this reality by targeting a slower pace during low stroke rate work. High volume, low stroke rate work at high power output has the potential for causing overuse injury.

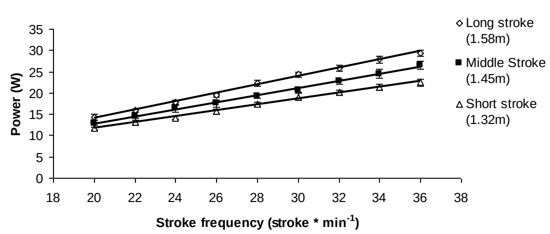
Chris Wilson, 2008

Drag	Pace	SPM	Average Force in lbs. (kgs.) during drive	Average Force in lbs. (kgs.) during drive —erg on a slide
120	2:00	18	127 (58)	127 (58)
120	2:00	24	105 (48)	97 (44)
120	2:00	30	84 (38)	83 (38)
120	2:00	34	83 (38)	78 (35)
120	1:45	18	174 (79)	177 (80)
120	1:45	24	143 (65)	142 (65)
120	1:45	30	115 (52)	111 (50)
120	1:45	34	110 (50)	108 (49)

Regulation of resistance

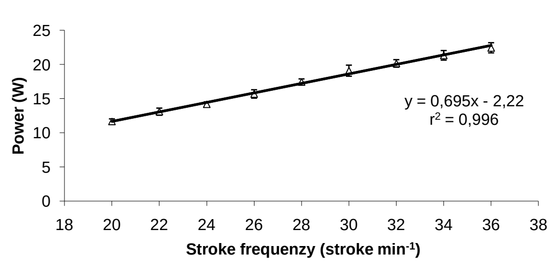
- The elastic band
- The Drag factor

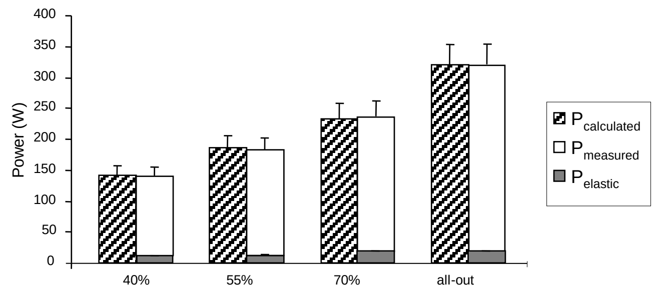
Figure 2 – Regression plot showing the linear relationship between stroke frequency and power at three different stroke lengths at zero



Values are means ± SD, n = 3.

Long stroke:	$r^2 = 0.996$	$y = 0.98x - 5.42$
Middle stroke:	$r^2 = 0.997$	$y = 0.84x - 3.99$
Short stroke:	$r^2 = 0.996$	$y = 0.69x - 2.22$



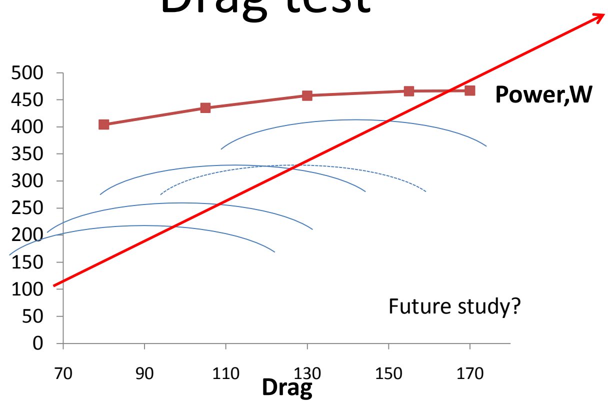


Regulation of resistance

- The elastic band
- The Drag factor

- Personal communication:
- ”I am typically about 110 in drag factor. The ideal is probably higher, but relative to the water is fairly realistic
- The shorter the distance the higher the drag factor
- I perform significantly better at maximum drag when going for 100m all-out.
- At 1 min all-out I will typically choose between the two extremes”

Drag test



Ergometer Rowing With and Without Slides

A. Holsgaard-Larsen, K. Jensen

Training & Testing

Int J Sports Med 2010; 31(12): 870-874

Table 1 – Descriptive characteristics of the subjects

Age (years)	Elite training (years)	Weight (kg)	Height (cm)	VO_2max (L min^{-1})
24 ± 3	6 ± 2	71.3 ± 12.3	177 ± 8	4.2 ± 0.5

Protocol

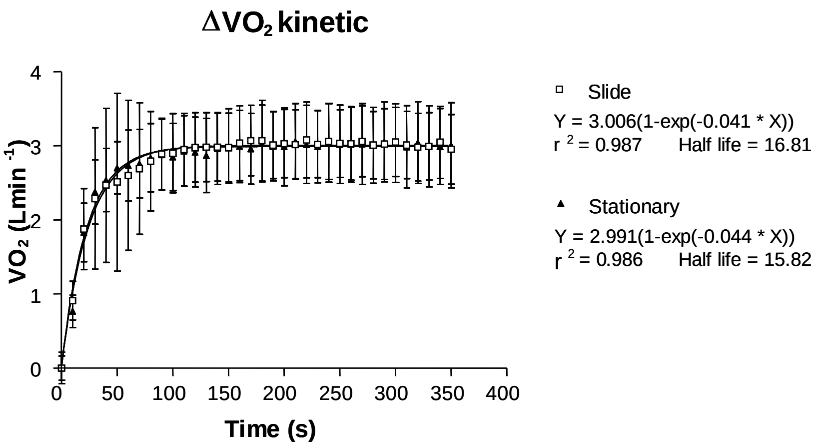
- 3 sub-maximal 6-min tests at 40 % , 55 % , and 70 % of their seasons best 6-min all-out mean power performed on a stationary ergometer and 6-min all-out test to simulate a 2000 meter on-water race
- Stroke rate and drag factor (adjustable resistance) of the ergometer were adjusted by the rowers to be the same during slide and stationary ergometer rowing according to their previous experience

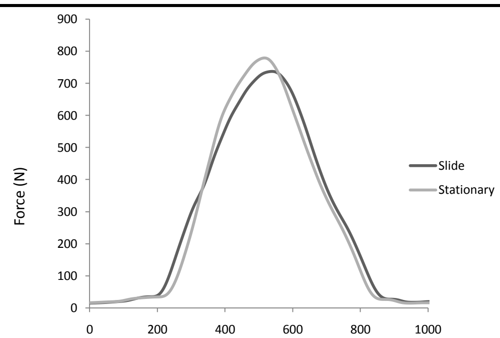
Table 1 Power, heart rate, mean VO_2, R-value, gross economy, and oxygen deficit.

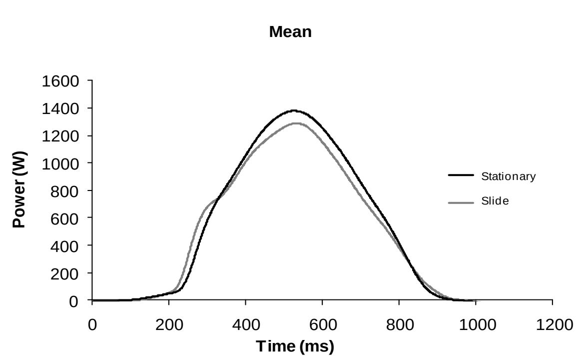
Median	40 %		55 %		70 %		All-out	
(range)	Slide	Stationary	Slide	Stationary	Slide	Stationary	Slide	Stationary
power	128.0	122.9	173.3	167.8	213.4	213.0	305.1	295.0
(w)	(41.7)	(42.8)	(50.8)	(49.5)	(64.8)	(63.9)	(85.0)	(91.1)
heart rate	134	133	155	148	167	168	184	181
(beats min^{-1})	(38)	(19)	(27)	(26)	(27)	(26)	(13)	(14)
VO_2	2.23	2.06	2.91	2.69	3.54	3.46	4.35	4.46
($l\ min^{-1}$)	(0.60)	(0.64)	(0.69)	(0.74)	(0.85)	(0.90)	(1.16)	(1.21)
R-value	0.88	0.86	0.90	0.90	0.93	0.93	1.08	1.06
(CO_2/O_2)	(0.08)	(0.10)	(0.07)	(0.08)	(0.09)	(0.10)	(0.10)	(0.14)
economy	18.2	19.0*	18.9	19.4*	19.5	19.6		
(%)	(1.3)	(2.1)	(1.5)	(1.1)	(2.0)	(1.3)		
oxygen deficit							51.0	39.0*
($ml\ O_2 kg^{-1} min^{-1}$)							(71)	(27)

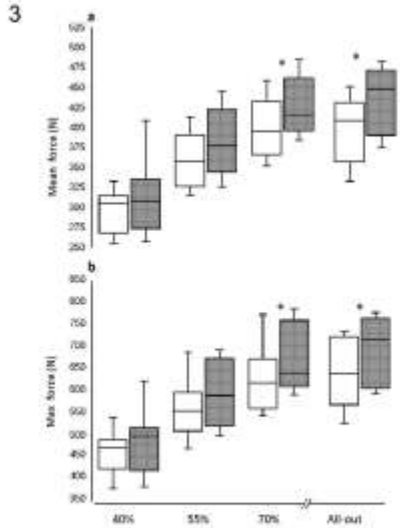
Average power output (watt), heart rate (beats min^{-1}), mean VO_2 ($l\ min^{-1}$), R-value (CO_2-exp/O_2-insp), gross economy (%), and oxygen deficit ($ml\ O_2 kg^{-1} min^{-1}$). Data are averaged from all rowing strokes between 180–300s of the test. Values are expressed as median and range (in parenthesis). * signifies statistical difference between slide and stationary

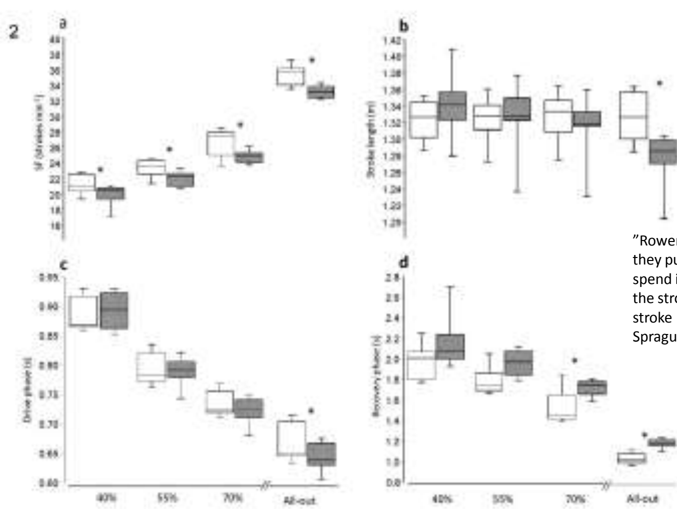
Physiological aspects











”Rowers only make power when they pull, and the more time they spend in the recovery portion of the stroke, the less average stroke power they will produce” Sprague, R., 2007”

Box-plots of a) stroke frequency (SF), b) stroke length, c) time of drive phase, and d) time of recovery phase for slide (open) and stationary (closed) ergometer at 40%, 55%, 70% and at all-out. Data are averaged from all rowing strokes between 180-300s of the test.

May be the solution?

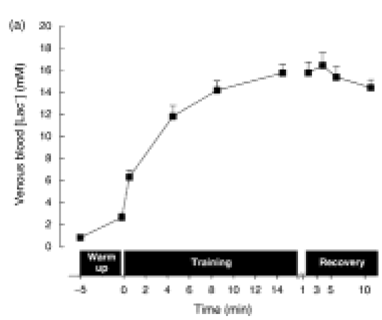
”No ergometer has yet been made that can closely emulate the sensitive response of a racing shell to the movements of the crew in the boat (acceleration of the mass of the crew, pitching, yawing). What we need is a rowing flume, similar to a swimming flume”
Bruce G. Grainger, 2011

Training

Intense Interval Training

Types of anaerobic training

Type of anaerobic training	Exercise intensity (% of maximum speed)	Duration of exercise (s)	Duration of recovery	No. of reps
Speed	100	2–10	50–100 s	5–20
Speed endurance production	70–100	10–40	>5 times exercise duration	3–12
Speed endurance maintenance	50–100	5–90	1–3 times exercise duration	2–25

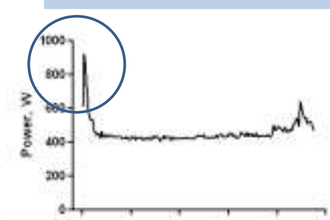


The race

Table 1 Stroke rate, peak force, peak power, work and power per stroke and average power for stroke and recovery during a typical rowing race in the single scull. Results are compiled from biomechanical measurements and evaluations in the former department of biomechanics of the Humboldt-Universität at East Berlin and the center of rowing research of the former East Germany (courtesy of P. Schwanitz and W. Roth).

Time (min, s)	Stroke rate (l/min)	Peak force (N)	Peak velocity (m/s)	Peak power (W)	Work per stroke (Nm)	Power per stroke (W)	Average power (W)
Speed	36–42	1000–1600	3.0–4.0	2500–3000	900–1100	800–1200	600–700
Speed endurance production	34–38	600– 800	2.2–3.5	1400–2800	800– 950	700–1000	450–600
Arobic Power, (VO_2max)	30–36	500– 700	2.0–2.2	1000–1600	650– 800	600– 900	350–450
Speed endurance maintenance	34–38	600– 700	2.2–2.8	1300–1800	700– 800	750–1000	400–500

- Ten of Denmark's best rowers smashed the World Record for a team going 24 hours non-stop on the indoor rowing machine over the 24 - 25 November.
- They set the new World Record by completing a massive 512,649 metres at Copenhagen’s central train station watched over by commuters.
- The Danish team's tactics was to switch rowers every 15 seconds and to row as hard as possible in those 15 seconds. After two hours of rowing, two athletes had a 15 minute break. This made it 45 minutes rowing followed by a 15 minutes break for each rower in the space of an hour.
- “Our tactic was to go hard out and the first 12 hours our pace was 1:21.9/500 metres, so we survived on this big lead over the last 4 to 5 hours where we all really suffered a lot to keep ourselves going”
- 24 hours: 1*15 sec on/9*15 sec off …
- Average Power 585 ~ 1:24 ~ 2000m 5:37 (Rob Waddell, WR)
- 256 *2000 meters at WR Pace

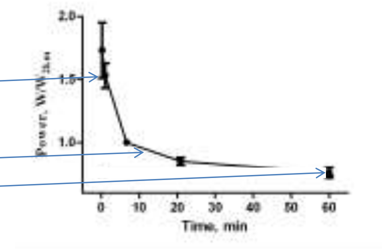


Description of Intensity

A1/A2/A3 high to very high intenity

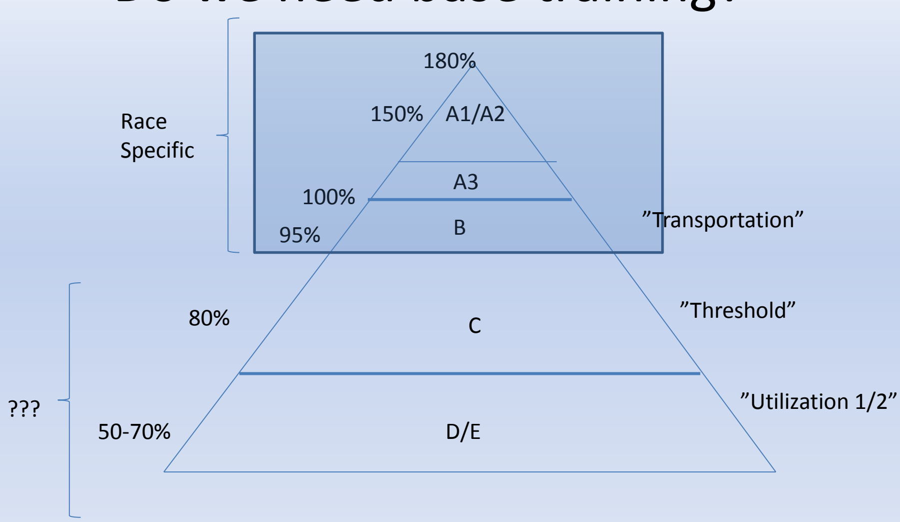
B/C medium to race pace intensity

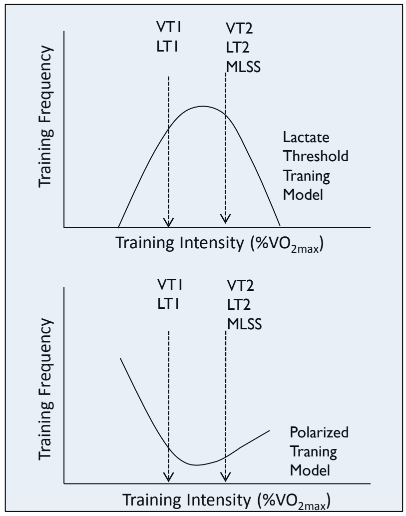
D/E low to very low intensity



	Pace	%2km	Time	Reps	rec	BL	HR%	Physio. Eff.
A1	Start	>180	5-10s	5-10	50-100s			An Power
A2	first 300m	>140	10-40s	3-12	>5 EXD			An Capacity
A3	last 300m	>100	10-90s	3-12	>3 EXD			An Tolerance
B	1-3 km	95	3-9 min	2-8	5-10min	>10	95-100	Ae Power
C	6-8km	80	10-20 min	2-4	5-10min	3-5	90	Ae Capacity
D	12-20km	70	1-2 hours			2-3	80	Ae Endurance
E	Rec	50-60	1-2 hours			1-2	70	Ae Recovery

Do we need base training?





Seiler & Kjerland 2006

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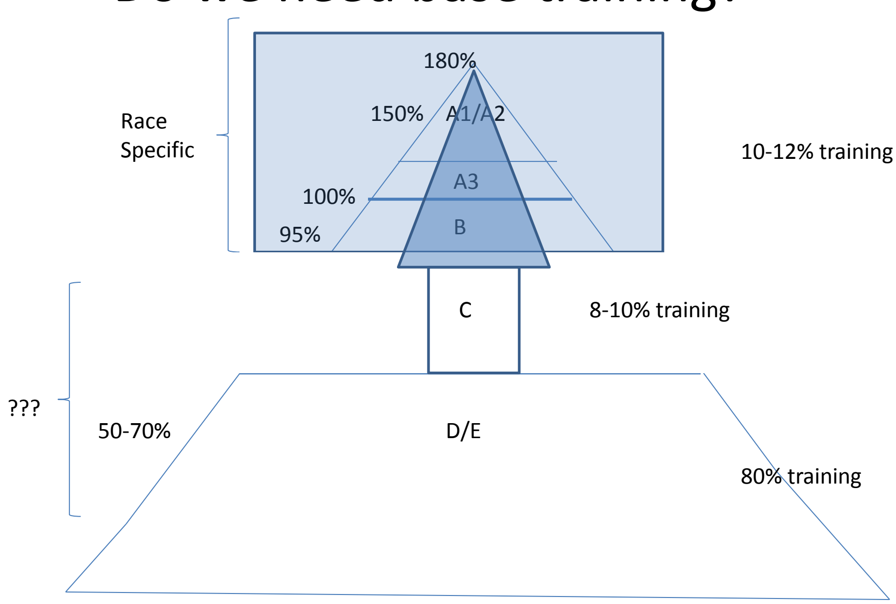
Do we need base training?

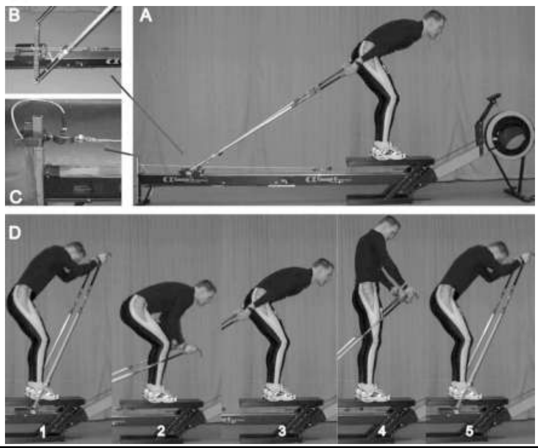


Eur J Appl Physiol (2004) 92: 121–127
DOI 10.1007/s00421-004-1042-4

ORIGINAL ARTICLE

Johnny E. Nilsson · Hans-Christer Holmberg
Per Tveit · Jostein Hallén

Effects of 20-s and 180-s double poling interval training in cross-country skiers



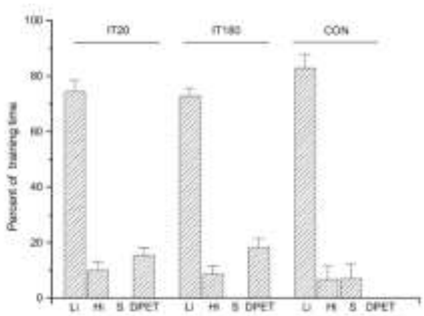


Fig. 3 Mean relative duration (SD) of training time. *IT180* 180-s interval training; *IT20* 20-s sprint interval training, and *CON* control group. *Hi* High intensity training > 75% maximum oxygen uptake; *Li* low intensity training < 75% maximum oxygen uptake; *S* strength training; *DPET* double poling ergometer training

- This study showed that 6 weeks of 20-s or 180-s double poling interval training, three times a week, significantly increased power output in both 30-s and 6-min tests, as well as in selected physiological and biomechanical parameters.
- The significant improvement in the 6-min test, in both IT20 and IT180, indicates that upper body power training might usefully contribute to improvements in performance in cross-country skiing.
- With reference to the training effects found in our study, we suggest that cross-country skiers in general, and sprint skiers in particular, may integrate the interval models used in this study in their training program.
- The sprint discipline consists of 4–5 heats of 3-min high intensity work in each heat, where double poling is one of the most dominant techniques.
- However, the specific relevance of double poling ergometer training for crosscountry skiing in the field condition on snow still remains to be investigated

Table 2 Mean (SD) pre- and post-training results. Peak power and mean power in the 30-s test and mean power, force and cycle frequency in the 6-min performance test. Peak and maximum oxygen uptake as well as work efficiency and blood lactate concentration during double poling at sub-maximal work intensities. The body mass did not change significantly within any of the groups between the pre- and post-test

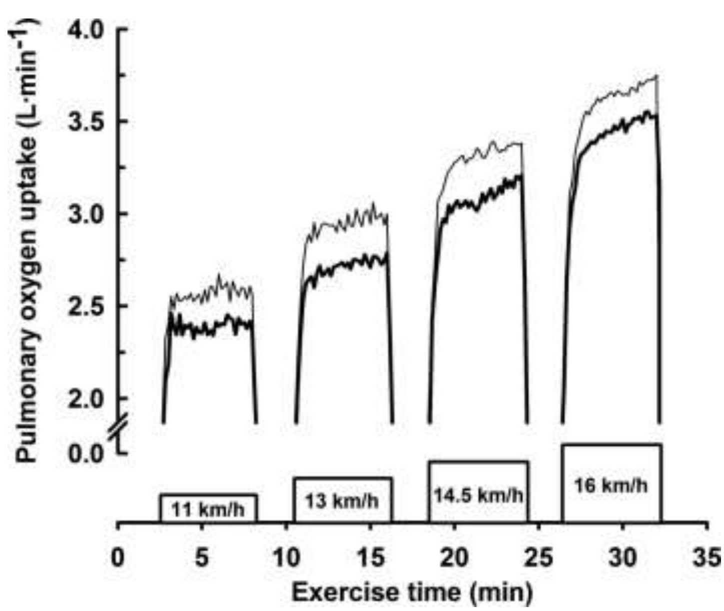
	20-s interval training (IT20)			180-s interval training (IT180)			Control (CON)		
	$n=6$			$n=7$			$n=7$		
	Pre-training	Post-training	% change	Pre-training	Post-training	% change	Pre-training	Post-training	% change
Mean power, 30 s (W kg^{-1})	2.94 (0.65)	3.58 (0.94)	21* (16)	2.73 (0.55)	3.19 (0.59)	17* (5)	3.32 (0.74)	3.35 (0.82)	1 (6)
Peak power, 30 s (W kg^{-1})	3.49 (0.72)	4.28 (1.08)	22* (14)	3.11 (0.64)	3.65 (0.66)	17* (7)	3.81 (0.84)	3.86 (0.85)	1 (5)
Mean power, min (W kg^{-1})	1.91 (0.40)	2.07 (0.47)	8* (8)	1.86 (0.47)	2.13 (0.44)	16* (10)	2.09 (0.43)	2.06 (0.35)	−1 (5)
Average force, 6 min (N kg^{-1})	1.63 (0.36)	1.72 (0.29)	7 (8)	1.64 (0.32)	1.82 (0.30)	15* (11)	1.75 (0.42)	1.78 (0.38)	2 (15)
Cycle frequency, 6 min (c min^{-1})	48.2 (3.9)	53.6 (2.9)	12* (9)	49.4 (3.7)	51.3 (4.4)	4 (6)	48.4 (8.2)	50.3 (7.0)	4 (6)
$\dot{V}O_{2max}$ (ml kg^{-1} min^{-1})	63.8 (9.9)	64.5 (10.3)	1 (4)	61.6 (7.1)	62.4 (8.0)	1 (2)	63.4 (6.2)	62.9 (5.5)	−1 (4)
$\dot{V}O_{2peak}$ ml kg^{-1} min^{-1})	54.2 (10.5)	53.4 (9.6)	−1 (4)	53.0 (7.3)	55.2 (7.8)	4* (3)	53.7 (6.0)	52.4 (4.5)	−2 (5)
Work efficiency[a] (ml kg^{-1} min^{-1})	44.6 (6.1)	40.6 (6.4)	−9* (6)	44.0 (4.8)	41.0 (4.6)	−7* (5)	40.0 (5.5)	39.5 (6.2)	−2 (5)
Blood lactate concentration (mmol l^{-1})	4.6 (1.8)	4.1 (1.3)	−4 (8)	3.8 (1.0)	3.1 (0.8)	−18* (9)	3.2 (1.2)	3.2 (1.3)	0 (24)

* Variable significantly different between pre- and post-test, $P<0.05$
[a] At the 100 and 150 W stage for females and males, respectively

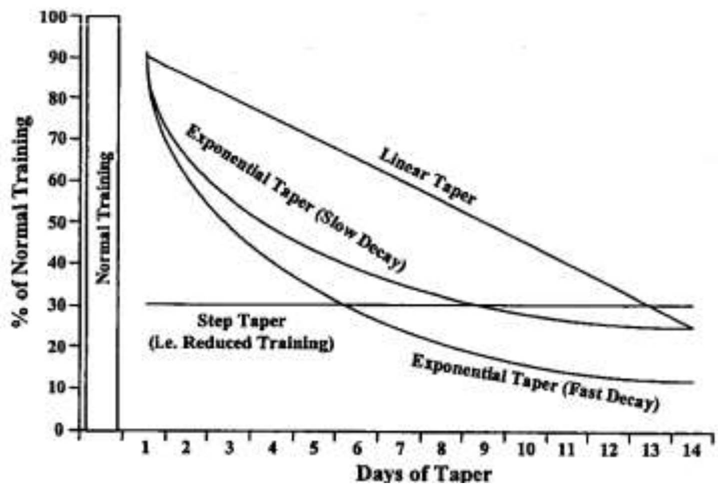
Four weeks of speed endurance training reduces energy expenditure during exercise and maintains muscle oxidative capacity despite a reduction in training volume.

Iaia FM, Hellsten Y, Nielsen JJ, Fernström M, Sahlin K, Bangsbo J.
Dept. of Exercise and Sport Sciences, University of Copenhagen, Copenhagen, Denmark.

Abstract
We studied the effect of an alteration from regular endurance to speed endurance training on muscle oxidative capacity, capillarization, as well as energy expenditure during submaximal exercise and its relationship to mitochondrial uncoupling protein 3 (UCP3) in humans. Seventeen endurance-trained runners were assigned to either a speed endurance training (SET; n = 9) or a control (Con; n = 8) group. For a 4-wk intervention (IT) period, SET replaced the ordinary training (approximately 45 km/wk) with frequent high-intensity sessions each consisting of 8-12 30-s sprint runs separated by 3 min of rest (5.7 +/- 0.1 km/wk) with additional 9.9 +/- 0.3 km/wk at low running speed, whereas Con continued the endurance training. After the IT period, oxygen uptake was 6.6, 7.6, 5.7, and 6.4% lower (P < 0.05) at running speeds of 11, 13, 14.5, and 16 km/h, respectively, in SET, whereas remained the same in Con. No changes in blood lactate during submaximal running were observed. After the IT period, the protein expression of skeletal muscle UCP3 tended to be higher in SET (34 +/- 6 vs. 47 +/- 7 arbitrary units; P = 0.06). Activity of muscle citrate synthase and 3-hydroxyacyl-CoA dehydrogenase, as well as maximal oxygen uptake and 10-km performance time, remained unaltered in both groups. In SET, the capillary-to-fiber ratio was the same before and after the IT period. The present study showed that speed endurance training reduces energy expenditure during submaximal exercise, which is not mediated by lowered mitochondrial UCP3 expression. Furthermore, speed endurance training can maintain muscle oxidative capacity, capillarization, and endurance performance in already trained individuals despite significant reduction in the amount of training



Taper



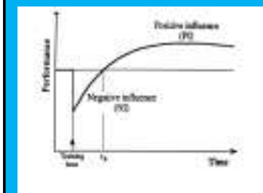
Eur J Appl Physiol (2011) 111:293–301
DOI 10.1007/s00421-010-1654-9

ORIGINAL ARTICLE

Effect of endurance training on performance and muscle reoxygenation rate during repeated-sprint running

Martin Buchheit · Pierre Ufland

- the effect of an 8-week endurance training program on repeated-sprint (RS) performance and post-sprints muscle reoxygenation rate in 18 moderately trained males
- These data also confirm the importance of aerobic conditioning in sports, where repeating high-intensity/maximal efforts within a short time-period are required



Training, individualization

To improve rowing performance

Find the balance!

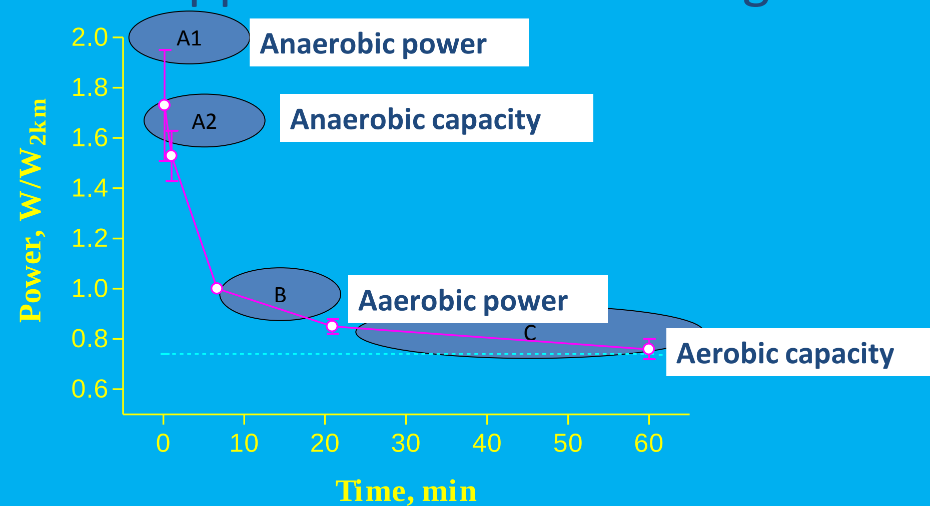
- The role of intensity
- To improve rowing performance
- To improve efficiency and technique
- To improve anaerobic energy system
- To improve aerobic transportation system

- The role of duration:
- To improve efficiency and technique
- To improve aerobic endurance performance
- To improve training resistance, adaptation and recovery?

PHYSIOLOGICAL TRAINING

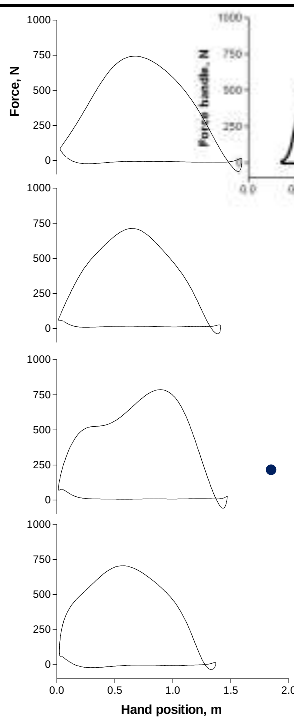
Be specific (and individualize)

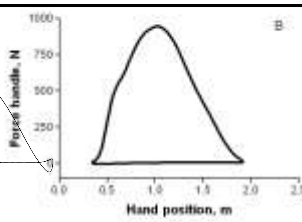
One week test in the Application in the training

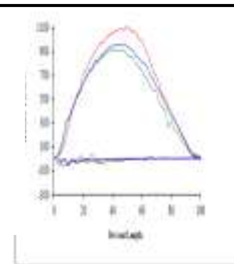


ERGOMETER TRAINING

Be specific (and individualize)







Be specific

- Individual stroke profiles ("fingerprints") during rowing in a boat

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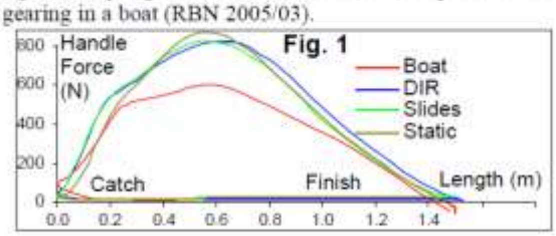
A: Rowing on DIR is quite similar to rowing on an erg on slides: the force increases faster at the catch then on a stationary erg (Fig.1), which is caused by a smaller moving mass and lower inertia forces (RBN 2003/10). The magnitude of the handle force is similar on all types of ergs and significantly higher than on-water, due to the presence of a gearing in a boat (RBN 2005/03).



Recommendations

- Coaches should be prepared to individualize training programs in regard to volume and intensity to suit each athlete
- Provide good supervision of technique while athletes train on an ergometer
- Make sure that the longer session is broken up into shorter pieces with appropriate rest and stretching in between the pieces
- Use (in general) lower drag and adapt the drag factor to increase specificity of the work out
- When appropriate, use a sliding ergometer
- Use some forms of cross training in conjunction with ergometer training in order to achieve the necessary training volume
- Try to place ergometer sessions and weights sessions on separate training days, or at least several hours apart