Science of Training

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SCIENCE OF TRAINING
Perspective

Myth:

Training should be grueling day after day in order to arrive at the event in the best shape possible .

Reality:

Intense training across time leads to over-training, reduced health, injury and burnout.

Overtraining

Increases displayed for

- heart rate or blood pressure
- white blood cells and eosinophils
- cortisol
- lactic acid for sub-max exercise

Decreases displayed for

- blood sugar and muscle glycogen
- testosterone or estradiol
- muscular power at max exercise

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Rules of Engagement

Train healthy – Athletes who are frequently ill or injured cannot accomplish their goals or reach their full potential.

Train sensibly – Managed, varied intensity and volume will safeguard health and provide the endurance to compete successfully and comfortably.

Train intelligently – Learn the fundamentals of the science of training and apply them to work-out design and execution.

SCIENCE OF TRAINING
Scientific Domains of High Performance

Physics

Biomechanics = Mechanics of Sport Skill Proficiency

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Chemistry

Sport Nutrition = Energy Production

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Cardiovascular Physiology = Energy Mobilization

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Muscular Physiology = Energy Utilization

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Psychology

Sport Psychology = Attributes of Achieving

SCIENCE OF TRAINING
Energy Production

During training and during a rowing event, the body needs a constant supply of energy, realized through complex chemical processes that metabolize (break down) food and yield a substance called ATP.

The body uses two general methods to produce ATP – aerobic metabolism or production of ATP with oxygen, and anaerobic metabolism or production of ATP without oxygen.

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Energy System Selection

The method of energy production depends on the demand for energy as measured by INTENSITY (pace) and DURATION (duration or distance) of the activity.

As the pace of activity increases, the body makes greater use of anaerobic metabolism and less use of aerobic metabolism.

As the distance of the activity increases, the body makes greater use of aerobic metabolism and less use of anaerobic metabolism.

SCIENCE OF TRAINING
Aerobic Energy Systems

Slow long distance – aerobic metabolism of fat

REC – Initial level of aerobic fitness

AEG1 - Competitive aerobic fitness

Fast middle and long distance – aerobic metabolism of carbohydrates

AEG2 – Aerobic speed

LAC – Maximum aerobic pace

SCIENCE OF TRAINING
Anaerobic Energy Systems

Fast short distances – anaerobic metabolism of glycogen

ANG1 – Anaerobic speed

ANG2 – Anaerobic endurance

Explosive sprints – anaerobic metabolism of creatine phosphate and ATP in blood and working muscle

ATPCP – Anaerobic power

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Energy System Utilization

Anaerobic and aerobic energy systems work simultaneously and contribute differently at different intensities of performance.

System Role Event Time	ATP-CP	ANG2-ANG1	LAC-AEG2	AEG1-REC
0:00:10	50.0	50.0		
0:00:20	25.0	65.0	10.0	
0:00:45	12.5	60.0	27.5	
0:01:45	5.0	50.0	45.0	
0:03:30		25.0	75.0	
0:15:00		12.5	87.5	
0:30:00		2.5	97.5	
3:00:00			75.0	25.0

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2000 Meter Energy System Utilization

- Using men's and women's lightweight and heavyweight 2000 meters as a training standard:

Gender	PR Range	ATP-CP	ANG2-ANG1	LAC-AEG2	AEG1-REC
Men	6:36-6:47	0.000	0.217	0.783	0.000
Women	7:29-7:11	0.000	0.207	0.793	0.000

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Energy System Utilization

There are several ways to gauge/prescribe intensity of training:

- Caloric expenditure in kcal/min
- Multiples of resting metabolism in METs
- Absolute power in watts
- Aerobic demand in % VO_2 Max
- Heart rate in % of Max HR
- Lactate accumulation in mM lactate
- Perceived exertion in RPE units, descriptors, or breathing

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VO_2max

VO_2max is a measure of the capacity for aerobic metabolism of ATP and is a major determinant in the ability to sustain intense activity over time.

VO_2max is measured in mL of O_2 per kg of body weight per minute as obtained from a progressive exercise test to exhaustion or estimated from power output in 2000 meter erg:

- VO_2max = 1.682+ 0.0097 WM / Wt * 1000 in males
- VO_2max = 1.631+0.0088 WM / Wt * 1000 in females

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Percent Maximum Heart Rate

There is a linear relationship between VO_2max and the percentage of your maximum heart rate (% HR max).

Maximum heart rate is measured in beats per minutes from a progressive exercise to exhaustion or estimated by 220 - age.

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Lactic Acid and Lactate Thresholds

A by-product of anaerobic metabolism is lactic acid.

At low to moderate intensity, lactic acid is re-used to create ATP. As intensity increases, greater need for anaerobic metabolism results in build-up of lactic in the blood faster than the body can remove or re-use it and muscle function becomes impacted.

This point, the first lactate threshold (LT1), is marked by labored breathing and a burning sensation in the muscles. If intensity exceeds LT1, athletes can only continue for a short period of time. The point at which discomfort forces athletes to slow down or stop is called the second lactate threshold (LT2).

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Determination of Lactic Threshold

Blood lactate accumulation is measured in mMol by drawing a small sample of blood from a pin prick of the ear lobe or finger, similarly to measuring blood sugar.

The heart rate associated with LT1 is measured from a progressive exercise to exhaustion or estimated by taking the heart rate following a 20-minute competitive race or time trial.

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Perceived Exertion

The perceived difficulty of a particular training intensity (how it "feels") is critically important for training.

Ratings of perceived exertion are classified by

Numerical values: 1 to 20
Demand descriptions: Light to All Out
Breathing descriptions : Gentle to Max

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Intensity and Training

There is a predictable relationship between the amount of oxygen consumed (% VO_2 Max), cardiovascular demand (% Max HR), the accumulation of lactic acid (mMol) and perceived exertion (RPE).

This relationship is used to establish the level of intensity for training in each of the seven training zones.

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Training Zones

SYSTEM	REC	AEG1	AEG2	LAC	ANG1	ANG2	ATPCP
Training Purpose	Keep Fitness	Raise VO2 max	Aerobic Speed	Raise LT1	Tolerate Lactate	Raise LT2	Increase Power
Word Cue	Light	Moderate	M Hard	Hard	V Hard	Max	All Out
Breathing	Gentle	Deep	Hard	Heavy	Forced	Labored	Max
RPE Scale	<11	11-13	14-15	16-17	18-19	>19	N/A
% Max HR	<75	75-81	82-87	88-92	93-97	>97	N/A
% VO_2 Max	<60	60-69	70-78	79-86	87-93	>93	N/A
% LAC HR	<89	89-94	95-100	101-104	105-106	>106	N/A
Lactate (mM)	<2	2-4	4-8	8-12	12-18	>18	1-3
Duration	Any	0:40	0:30	0:20	0:15	0:10	0:05
Rest:Work	N/A	Any	0.5:1	1:1	2:1	4:1	6:1

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Heart Rate Monitors

Training must focus on the energy systems required for successful performance in the desired event.

In order to ensure that training is occurring at an intensity appropriate for each energy system, it is essential to monitor heart rate.

A critical piece of rowing training equipment is a heart rate monitoring system that includes a transmitter chest belt and a receiver wrist watch.

SCIENCE OF TRAINING
Training Principles

Individuality – every athlete responds differently

Specificity – specific adaptation to imposed demand

Progressive overload – systematic small adjustments

Periodization – cyclical and phasic adjustments

Reversibility – overtraining and under-training yield regression

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Overload Variables

Intensity – effort required; the most important training variable,

Rest – recovery time between intervals, sets, training bouts; the intensity-rest ratio controls energy system used

Volume – duration or distance

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Overload and Fatigue

Intense training causes physiological strain and psychological stress. Athletes must replenish energy and emotional readiness. Training must be designed with intensity gradients, regeneration (physiological) and rejuvenation (mental).

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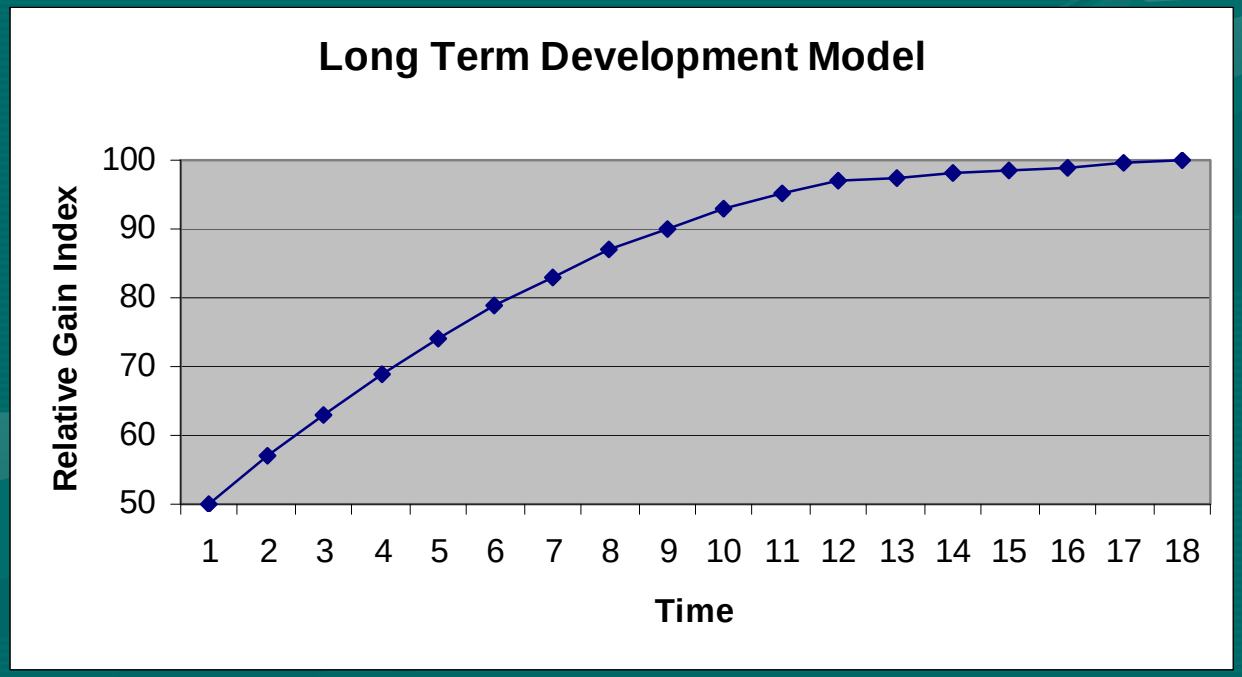
Adaptation and Staleness

Physiological gain from training (adaptation) occurs rapidly in initial phases but continued gain toward genetic capacity is minimum and increasingly difficult thereafter (staleness).



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Nutrition

Dietary planning centers on nutrient supply for energy (carbohydrates) and caloric demand, all of which is calculated per kg of body weight.

Daily lifestyle demand = 30kcal per kg

Rowing demand = .32 kcal per minute

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Fueling

Meet your caloric demand with 4-6 small meals during the day.

60-65% carbohydrates (fruits, vegetables, whole grains, beans)

15-20% protein (soy, low-fat dairy, chicken, fish, turkey)

15-25% fats (avocado, nuts, seeds, olives)

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Carbohydrates

The most important macronutrient for rowers are carbohydrates from fruit, 100 percent fruit juice, whole grains, starchy vegetables and low-fat milk.

Training volume impacts carbohydrate intake:

- <90 min/day =5-7 grams/kg of body weight
- 90-120 min/day = 7-10 grams/kg of body weight
- >120 min/day = 10+ grams/kg of body weight

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Protein and Fat

Rowers also need protein at approximately 1g/kg for light training and 1.2-1.7g/kg for moderate to intense training.

Healthy proteins occur in chicken, eggs, soy, beans, legumes, nuts, and fish.

Fat intake for rowers should is most often acquired in association with protein intake and must be monitored to prevent excessive cholesterol.

Science of Training
Hydration

Rowers should drink:

- 16 to 20 oz. 2-3 hours prior to training
- 8 to 10 oz. every 20 minutes during warm-up and training
- 16 to 24 oz. for every pound that is lost

Water is the best fluid to meet hydration needs but rowers who train for >60 minutes many benefit from beverages to replace the loss of electrolytes.

Science of Training
Pre- and Post-Workout Meals

Pre-workout meals should include carbohydrates and be consumed two to three hours before an activity.

Post-workout meals, especially after an intense training session or long race, should include carbohydrates and protein.

Snacks that combine protein and carbohydrate include soy milk and fruit smoothies, yogurt with fruit and granola, peanut butter sandwich, apples with cheese, turkey wrap or chocolate milk with a whole wheat bagel.

Science of Training
Making Weight

Rowers who need to make weight for a competition still need to focus on eating healthy.

Healthy weight loss occurs at one to two pounds per week and can be achieved through a moderate reduction in calories.

A severe reduction in calories in order to lose weight fast can result reduction of metabolic rate, loss of power and muscle mass.

Enjoy the training!