# Physiology Talk

## Energy Systems / Training Intensity Zones as it applies to training swimmers

*Presenter*

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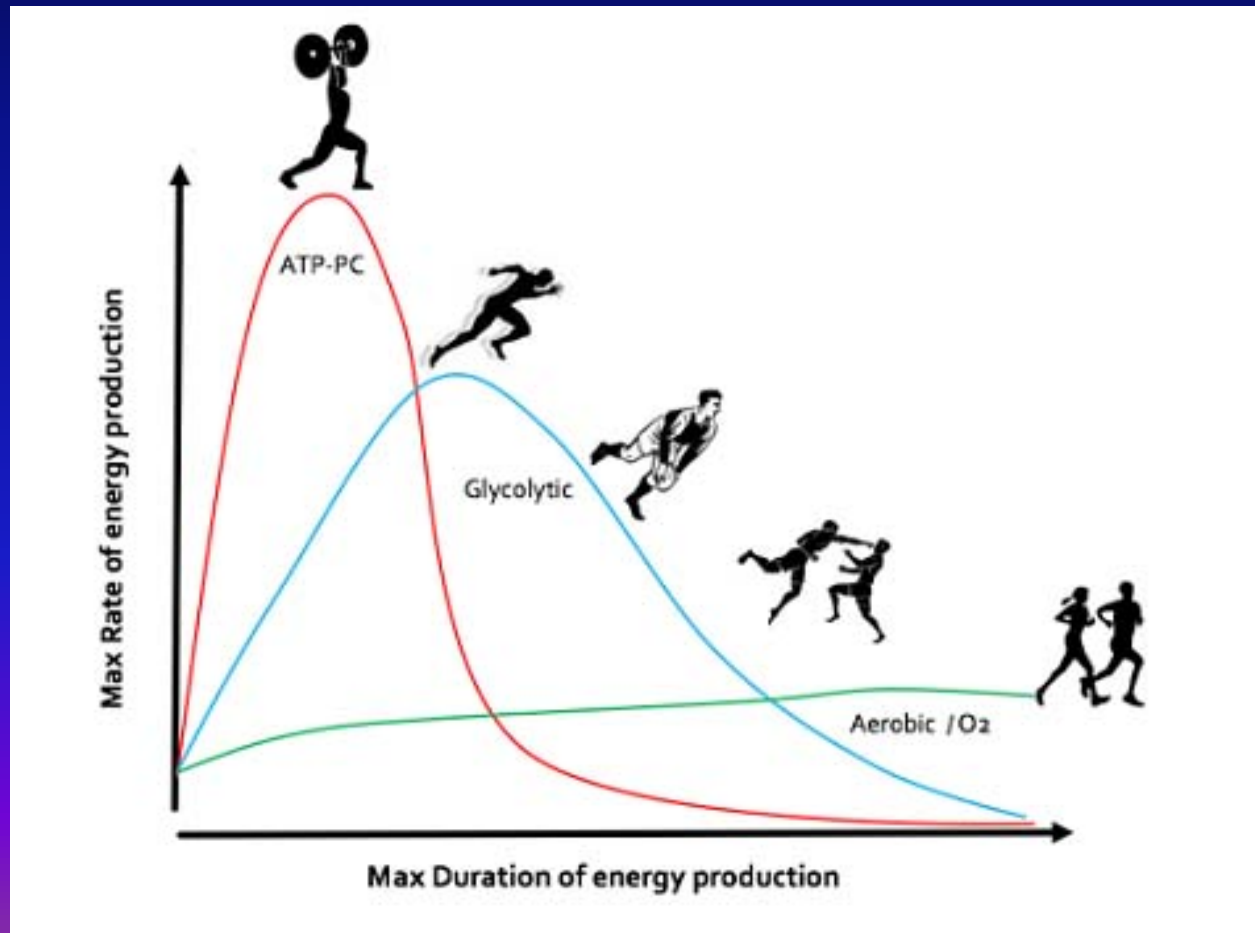
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**OSI Swimposium,**

**September 2021**

# Intent & Purpose

◆ To offer *miminal* but *essential science* for better understanding physiological processes of training and performance

◆ To offer practical information useful to you *immediately*

◆ To create a foundation for the upcoming talks, and future learning

# Energy Sources (systems) Physiology

# Energy Systems Comparison

| System | Power (rate of ATP production) | Capacity (total ability to produce ATP) | Fuels Used |
|---|---|---|---|
| phosphagen system | very high | very low | creatine phosphate stored ATP |
| glycolysis | high | low | blood glucose muscle & liver glycogen |
| aerobic system | low | very high | blood glucose muscle & liver glycogen adipose & intramuscular fat |

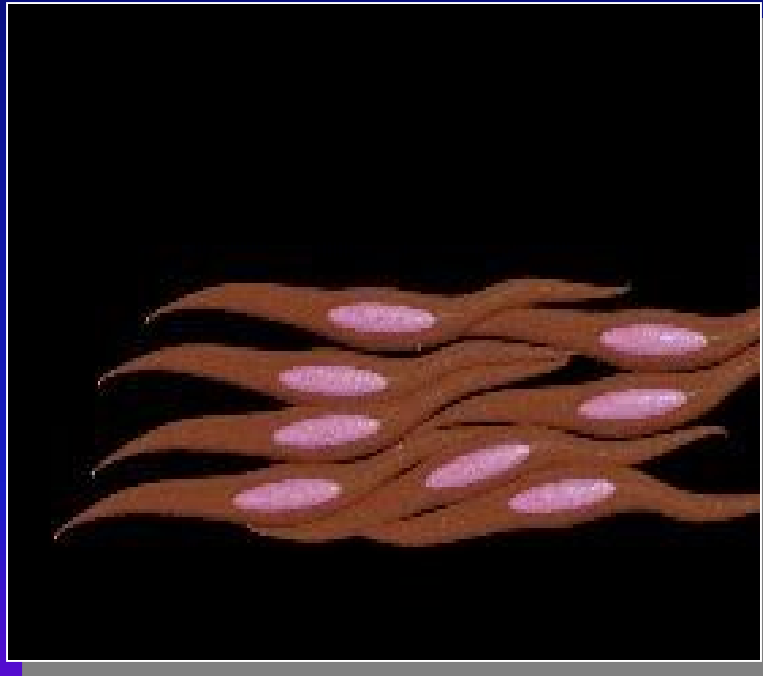# Energy contribution to swimming events
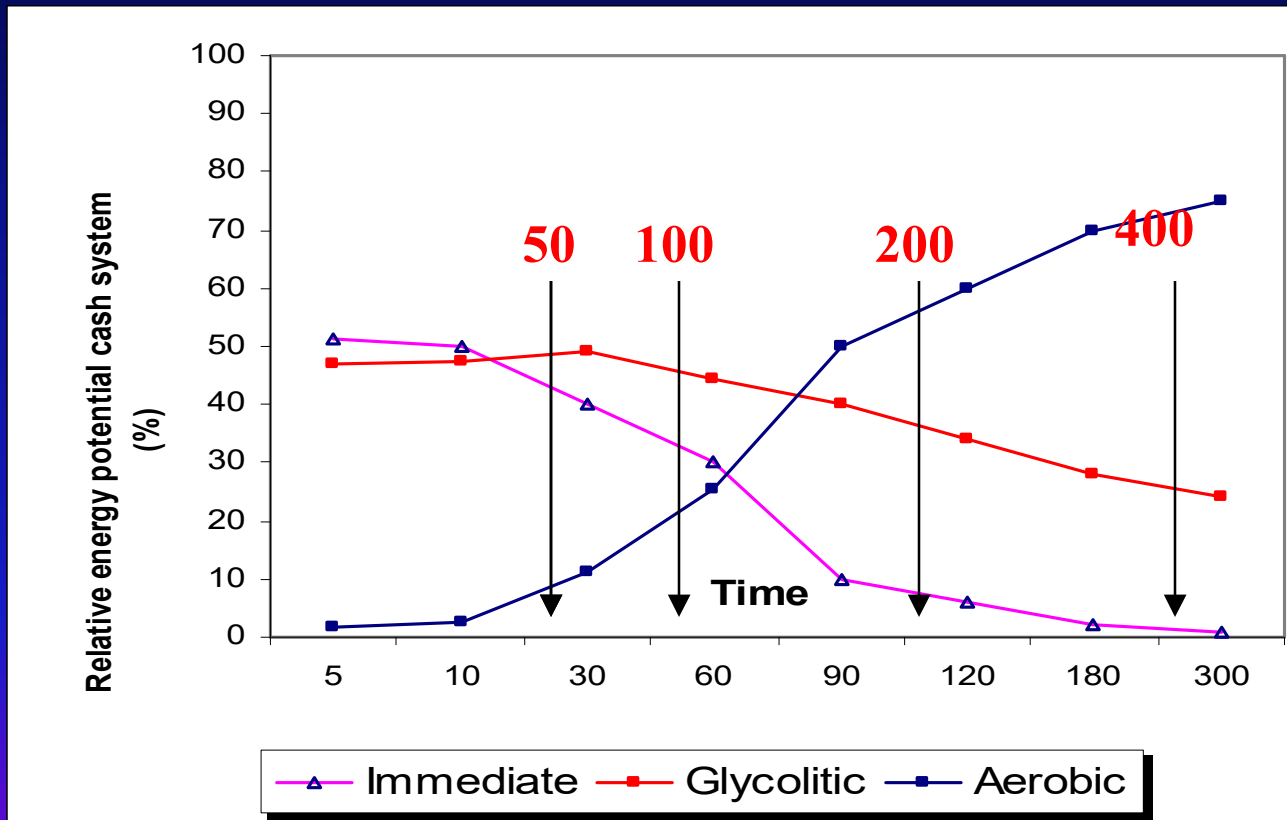
# Two Properties of Energy Systems



**Capacity    +    Power    =    System**

**"The Tank"   +   "The Nozzle"  =  System**

# Sub-systems of muscle cell



- **Executive** *(myofibrilles) - provides contraction*

- **Energy Providing** *(mitochondria) - creates and supplies energy*

# Effects of Anaerobic training regime on a muscle cell structure

**Develops "Executive" sub-system of the cell**

- *Muscles increase in size*
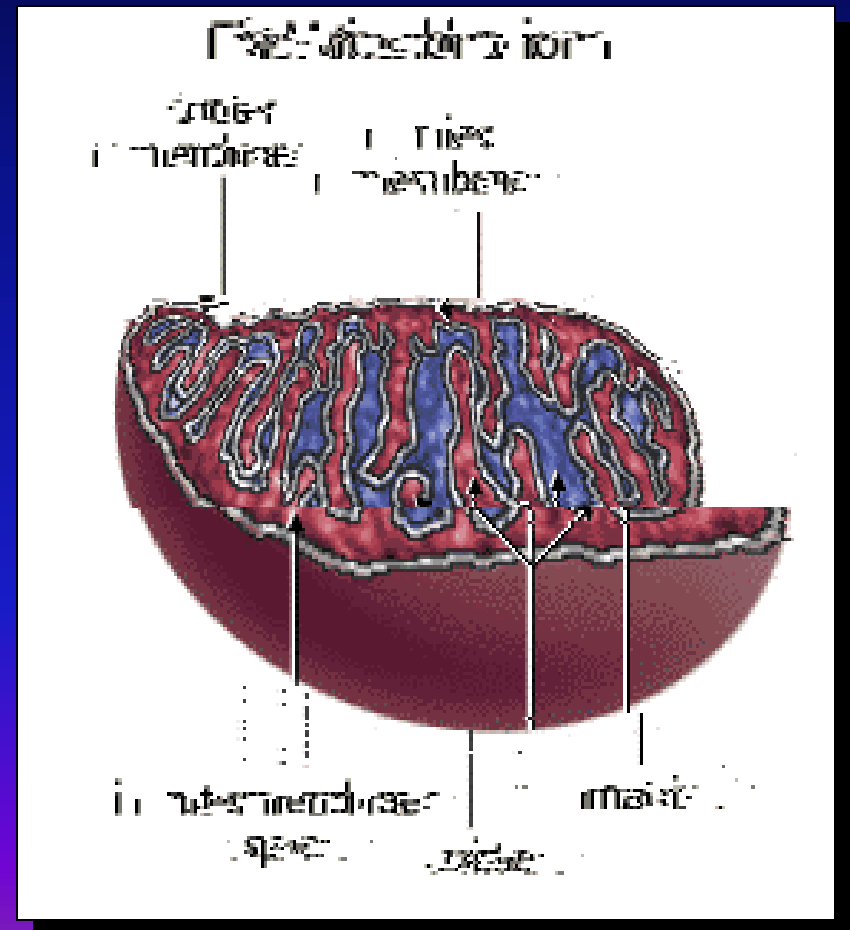- *Strength gains, increased power*

# Effects of Aerobic training regime on a muscle cell structure

**Develops "Energy Providing" sub-system**

- *Increases mitochondrial count*

- *Increases volume of oxidative enzymes*

- *Improves ability to retain more $O_2$ and efficiently recycle Lactate*

- *Improves specific endurance*

# Physiological Qualities (PQs) Swimmers Need For Performance

◆**Aerobic Endurance**

◆**Aerobic Power**

◆**Lactate Tolerance**

◆**Lactate Production**

◆**Anaerobic Power (Sprint Ability)**

# Training Intensity Zones
## as related to Physiological Qualities

| Intencity Zones | Abbr | Physiological Qualities |
|---|---|---|
| Aerobic Recovery | REC | Aerobic Endurance |
| Aerobic Development | EN1 | |
| AnaerobicThreshold | EN2 | Aerobic Power |
| Max Oxygen Uptake | EN3 | |
| Lactate Tolerance | SP1 | Anaerobic Enndurance |
| Lactate Production | SP2 | |
| Maximum Speed | SP3 | Anaerobic Power |

# Training Intensity Zones
## as related to Physiological Qualities

◆ No exact boundaries between zones

◆ Each zone has a pathway for producing energy

◆ More intensity zones in use – more complicated to track

◆ Start with basic 4, and advance to 7 as you get better at it

# Aerobic Endurance: EN1

◆ **The ability to maintain a submaximal pace (70% from PR) for an extended period without accumulating lactic acid and experiencing early muscular fatigue**

◆ **Time to develop: long, 10-16 weeks**

# Aerobic Development EN1 (lower end spectrum)

◆ **Develops the ability to produce energy without depleting muscle energy stores**

◆ **HR= 20 (:10")**

◆ **Time to Full Recovery (Hours) 6-12**

◆ **Stroke Rate: very slow**

◆ **Stroke Length: maximal**

# Aerobic Development EN1 sets, examples

Set=3000

- 15 x 200 :30s
- 2 x (3 x 300 :30s + 3 x 200 :20s) :90s
- 2 x 1500 :90s
- 2 x (500+400+300+200+100 :30s) :90s
- 6 x 500 :45s
- 12 x 250 :20s
- 3 x 1000 :60s
- 1000 + 800 + 600 + 400 + 200 :30s
- 20 x 150 :30s
- 3 x 400 :30s + 3 x 300 :20s + 3 x 200 :10s + 3 x 100 :10s

# Aerobic Overload
# EN1 (higher end spectrum)

◆ **Optimizes the ability to use the respiratory & cardiovascular systems.**

◆ **HR= 24 (:10")**

◆ **Time to Full Recovery (Hours) 12-24**

◆ **Stroke Rate: mod-slow**

◆ **Stroke Length: sub-maximal**

# Aerobic Overload EN1 sets, examples

Set=1500

- ◆ 1 x 1500
- ◆ 3 x 500 :30s
- ◆ 15 x 100 :30s
- ◆ 5 x 300 : 20s
- ◆ 500 + 400 + 300 + 200 + 100 :30s
- ◆ 5 x (2 x 150 :20s) :90s
- ◆ 6 x 250 :40s
- ◆ 10 x 150 :45s
- ◆ 3 x (2 x 250 :30s) :90s

# Benefit of Aerobic Endurance Training EN1
## *(The Glue That Holds It All the Parts Together)*

- ◆ Decreased glycogen use
- ◆ Decreased lactic acid accumulation
    - ◆ Less lactate production
    - ◆ Greater clearance
- ◆ Improved stroke economy
- ◆ Combined with focus on low stroke count develops power and doubles the effect (see note)
- ◆ Easier to swim at given pace
- ◆ Better recovery in all forms of training

# Aerobic Power: EN2-EN3

◆ Using a mix of glycogen and $O_2$ to produce energy

◆ Sets ceiling for aerobic endurance

◆ Time to develop: long, 8-16 weeks

# Aerobic Power
# An. Threshold: EN2
# (lower end of spectrum)

◆ **Least efficient aerobic energy intensity but an important component to power output.**

◆ **Helps you delay the build up of lactate in muscles, you can go stronger longer.**

◆ **HR= 26-28 (:10")**

◆ **Time to Full Recovery (Hours) 24-48**

◆ **Stroke Rate: moderate**

◆ **Stroke Length: near-race, but longer**

# Anaerobic Threshold EN2 sets, examples

Set=800 (*a starting point*)

◆ 2 x 400 :45s

◆ 4 x 200 :20s

◆ 8 x 100 :10s

◆ 50 + 100 + 150 + 200 + 150 + 100 + 50 :10s

◆ 800 for time

◆ 16 x 50 :20s

◆ 2 x 200 :20s + 4 x 100 :10s

◆ 300 + 200 + 100 + 2 x 50 :15s

◆ 4 x 200 :30-20-10s

◆ 2 x 200 :20s + 2 x 100 + 4 x 50 :10s

# Anaerobic Threshold EN2 sets, examples

Can build up to a set=1500

◆ 5 x 300 :40-30-20-10s

◆ 500 + 400 + 300 + 200 + 100 :30s

◆ 5 x (6 x 50 :30-25-20-15-10s) :90s

◆ 15 x 100 :30s

◆ 3 x 200 :30s + 3 x 150 :20s + 3 x 100 :15s + 3 x 50 :10s

◆ 10 x 150 :45s

◆ 3 x (200 + 150 + 100 + 50 :20s) :60s

◆ 3 x (5 x 100 :40-30-20-10s) :90s

# Max VO2: EN3

◆ **Holding a stronger pace each repeat, but given more rest to be able to recover enough for the next rep. This allows you to learn to train faster as the season progresses.**

◆ **HR= 28-32 (:10")**

◆ **Time to Full Recovery (Hours) 48-96**

◆ **Stroke Rate: at or near mid. dist. race**

◆ **Stroke Length: at mid. distance race**

# Aerobic Power EN3 sets, examples

Set=500 (a starting point)

◆ 10 x 50 :15s

◆ 6 x 50 :10s + 2 x 100 :20s

◆ 50 + 100 + 200 + 100 + 50 :30s

◆ 3 x 100 :30-20-10s + 4 x 50 :20-15-10s

◆ 5 x 100 :60s

◆ 2 x 100 :30s + 4 x (75 fast, 25 ez) :30s*

◆ 6 x 50 :30s + 4 x 50 :10s

◆ 4 x (75 fast, 25 ez) :30s* + 4 x 50 :30s

◆ 5 x 100 :60-50-40-30s

◆ 200 + 150 + 100 + 50 :30s

# Aerobic Power EN3, examples

Can build up to a Set=1000

◆ 400 + 300 + 200 + 100 :60s

◆ 5 x 200 :60-50-40-30s

◆ 10 x 100 rest :45-40-35-30-25-20-15-10-5s

◆ 20 x 50 :20s

◆ 5 x 100 :45s + 10 x 50 :30s

◆ 3 x 300 :60s + 100

◆ 2 x 300 :60s + 2 x 200 :30s

◆ 50 + 100 + 200 + 300 + 200 + 100 +50 :30s

◆ 2 x 200 :30s + 2 x 150 :20s + 2 x 100 :10s + 2x50 :5s

◆ 3 x 200 :60s + 4 x 100 :30s

◆ 4 x 250 :60-40-20s

# Benefit of Aerobic Power Training
## (EN2-EN3)

◆ **Raises ceiling for improving Aerobic Endurance (AE)**

◆ **Improves AE (a little)**

◆ **Improves lactate tolerance (a little)**

◆ **This type of training allows you to be great the last ¼ of the race.**

# Lactate Production: SP2

◆ **The ability to produce maximal anaerobic energy**

◆ **This ability is the combined effect of physiological and psychological adaptations**

◆ **Race Pace – Broken swims at race speed or predictor swims at race speed. Helps you learn pace and race rehearsal.**

◆ **Time to develop: 4-6 weeks**

# Lactate Production: SP2

◆ **Work/Rest ratio 1:2 – 1:4**

◆ **Maximal Intensity**

◆ **HR= Maximal**

◆ **Time to Full Recovery (Hours) 24-120**

◆ **Stroke Rate: at race, optimal**

◆ **Stroke Length: at race, efficient**

# Lactate Production: SP2 sets, examples

Set=300

- 2 x 100 :90s + 2 x 50 :90s
- 6 x 50 :60s holding ¼ of race 200 time
- 4 x 50 :90s + 4 x (25 fast 25 ez) :60s*
- 12 x (25 fast 25 ez) :60s
- 150 :90s + 100 :60s + 50
- 3 x 100 from a dive :3min holding ½ of race 200 time
- 100 :90s + 2 x 50 :60s + 4 x (25 fast 25 ez) :30s
- 4 x 50 :90s + 2 x 50 :60s
- 6 x 50 :30-40-50-60-70s
- 3 x 100 :3min resting :10 at 50/75
- 6 x 50-2:00 holding ½ of race 100 time.

# Lactate Tolerance: SP1
## Anaerobic Capacity

◆ **Develops ability to maintain muscle fuction in fatigue-causing conditions.**

◆ **This ability is the combined effect of physiological and psychological adaptations**

◆ **Time to develop: medium, 4-6 weeks**

# Lactate Tolerance: SP1

◆ **Work/Rest ratio 1:2-1:1**

◆ **Max Intensity**

◆ **HR= 29-32 (:10")**

◆ **Time to Full Recovery (Hours) 72-96**

◆ **Stroke Rate: at race, optimal**

◆ **Stroke Length: at race efficiency**

# Lactate Tolerance: SP1 sets

Set=400

- 4 x (50 fast 50 ez) :10s* + 8 x (25 fast 25 ez) :10s*
- 2 x 100 :20s + 4 x 50 :20s
- 8 x 50 :60s, 4 x 100 :2min
- 200 :60s + 100 :30s + 2 x 50 :10s
- 2 x 200 :3min
- 4 x 50 :30s + 2 x 100 :60s
- 100 :45s + 200 :90s + 100
- 16 x (25 fast 25 ez) :20s
- 8 x 50 :60-50-40-30-20s
- 150 :30s + 100 :30s + 2 x 50 :20s + 2 x(25 fast 25 ez) :10s*
- 6 x 50 :30s + 100

# Benefit of Lactate Tolerance Training
## (Anaerobic Capacity SP1- SP2)

◆ **Can hold near-max pace longer**
  - ◆ **Less pH disturbance**
  - ◆ **Less pain**
  - ◆ **Less muscle fatigue**

◆ **Maintains Aerobic Power**

◆ **Better late-race mechanics**

◆ **This type of training allows you to be great the 2nd & 3rd ¼ of the race.**

# Anaerobic Power
## (Maximal Speed - SP3)

◆ **Ability to reach maximum velocity as quickly as possible and maintain this velocity for :20"**

◆ **Helps you to set fast pace the first ¼ of the race**

◆ **Time to develop: medium, 6-8 weeks**

# Maximal Speed: SP3

◆ This can only be developed by working at maximal speed over very short distances (15" max) with long rest (4').

◆ HR= 26-30 (:10")

◆ Time to Full Recovery: 12-72 hours

◆ Stroke Rate: maximal

◆ Stroke Length: shortest

# Speed Training: SP3

A. Unassisted (develops stroke rate, breathe control, coordination)

B. Assisted (fins, tubing, etc.) allows for more hand acceleration)

C. Resisted (parachutes, buckets, etc.) teaches you to hold more water each pull)

# Anaerobic Power
## (Maximal Speed) SP3 sets

Set=75

- 3 x (25 fast 25 ez) :30s*
- 6 x (12.5 fast 12.5 ez) :40s*
- 6 turns :60s @ race effort
- 6 dives :90s* @15 m time
- 3 x 25 :60s @sprint rate, or ¼ of 100 time
- 2 x 25 :60s + 2 x (12.5 fast 12.5 ez) :30s*
- 4 x (12.5 fast 12.5 ez) :40s* + 25
- 2 x (turn + 25 fast 25 ez) :60s*
- 2 x (25 ez + 25 fast with turn) :60s*
- 2 x (25 fast + 12.5 ez + 12.5 fast) :90s*
- 6 x (12.5 fast 37.5 ez) :30s*

# Benefit of Sprint Training
## Anaerobic Power - SP3

◆Increased max speed

◆Ability to hold max speed 1-4 " longer

◆Ability to accelerate in race

◆Improves lactate tolerance (a little)

# Training Intensity Zones
## as related to Physiological Qualities

| 7 Energy Zone System | Total Set Duration (m) | Total Set Duration (min) | HR (bpm) | HR (% max) | Work:Rest ratios | Sample Set (*for a Sr. Age Group swimmer) |
|---|---|---|---|---|---|---|
| AEROBIC (RECOVERY) | Variable | Variable | < 140 | < 70 | N/A | 600 Easy Swim |
| AEROBIC DEVELOPMENT (EN1) | 1500 - 4000 | ≥ 15 | 140 - 160 | 70 - 80 | 10 - 30 sec rest | 6-10 x 400 Swim/ 10 sec rest |
| AEROBIC/ANAEROBIC MIX 1 (EN2) | 800 - 2000 | 10 - 40 | 160 - 180 | 80 - 90 | 15 - 30 sec rest | 4-6 x 300 Swim 15 sec rest |
| AEROBIC/ANAEROBIC MIX 2 (EN3) | 600 - 1600 | 8 - 30 | 180 - Max | 90 - 100 | 30 - 60 sec rest | 4-8 x 150 Swim/ 30 sec rest |
| ANAEROBIC 1 (SP1) | 200 - 600 | 2 - 15 | Max | 100 | 2:1 - 1:1 | 2-3 sets of 6-8x50 race tempo/ 10-30 sec rest or 4 x 125 Rotate IM/ 45 sec rest |
| ANAEROBIC 2 (SP2) | 200 - 600 | 4 - 12 | Max | 100 | 1:2 - 1:4 | 4 x 75 Swim/ 3-4 min rest or 6 x 50/ 2 min rest |
| SPRINT (SP3) | 25 - 100 | 1 - 2 | Max | 100 | 1:3 - 1:4 | 4-6 x dive 15m/ 1 min rest or 6-8 x 12.5 Swim/ 45 sec rest |

# Effect Of Training

| | | 50 | 100 | 150 | 200 | Time |
|---|---|---|---|---|---|---|
| Poor Training | Split | 00:27.0 | 00:29.5 | 00:30.8 | 00:31.9 | 1:59.2 |
| | Lactate | 7 | 12 | 13 | 14 | |
| | | | | | | |
| Improved AE & Economy | Split | 00:27.0 | 00:28.5 | 00:28.7 | 00:28.3 | 1:52.5 |
| | Lactate | 4 | 6 | 8 | 9 | |
| | | | | | | |
| Improved LA tolerance & Speed | Split | 00:26.7 | 00:28.3 | 00:28.5 | 00:27.9 | 1:51.4 |
| | Lactate | 4 | 7 | 10 | 14 | |

# Takeaways

◆ Swimming is an endurance sport

◆ Energy Systems vary by power and capacity, depending on the source

◆ All energy systems are active during swimming competition

◆ Training Intensity Zones designed to help develop exercises for specific physiological qualities (PQs)

◆ Training Intensity Zones don't have clear boundaries

◆ Each quality contributes to a good race at a certain point

# Takeaways

◆ Successful performance requres balanced development of PQs

◆ Training program should address development of all PQs

# A Word Of Wisdom

◆ Consuming information is not the same as acquiring knowledge.

◆ Learning means being able to use new information.

◆ If you don't make time to think about what you've heard, you won't be able to use any of the ideas you've been exposed to.