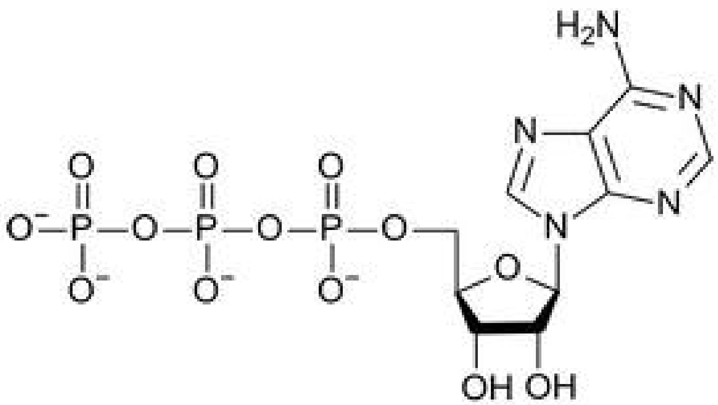
# Energy systems & training

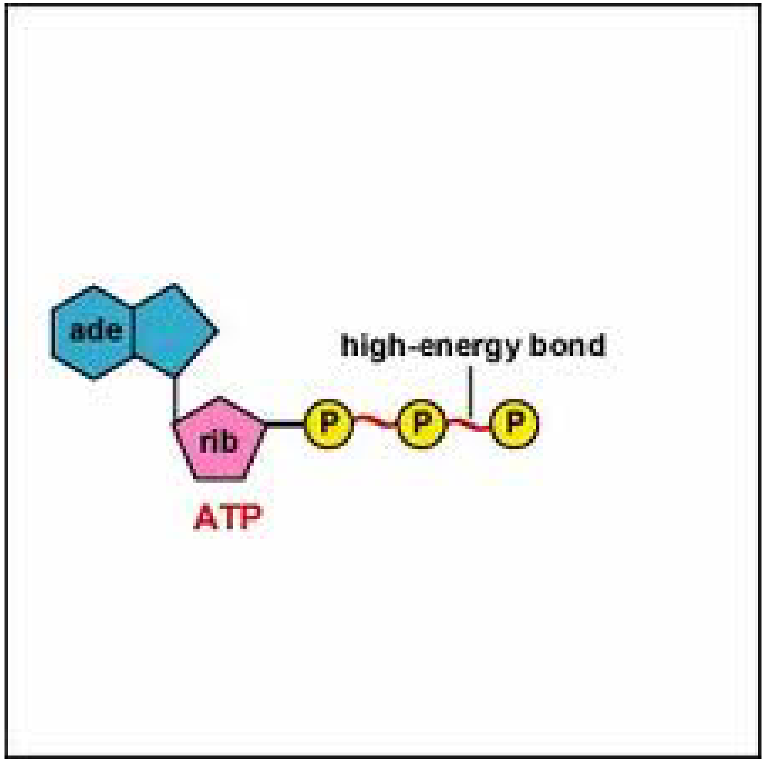
Glasgow Triathlon Club

# Presentation

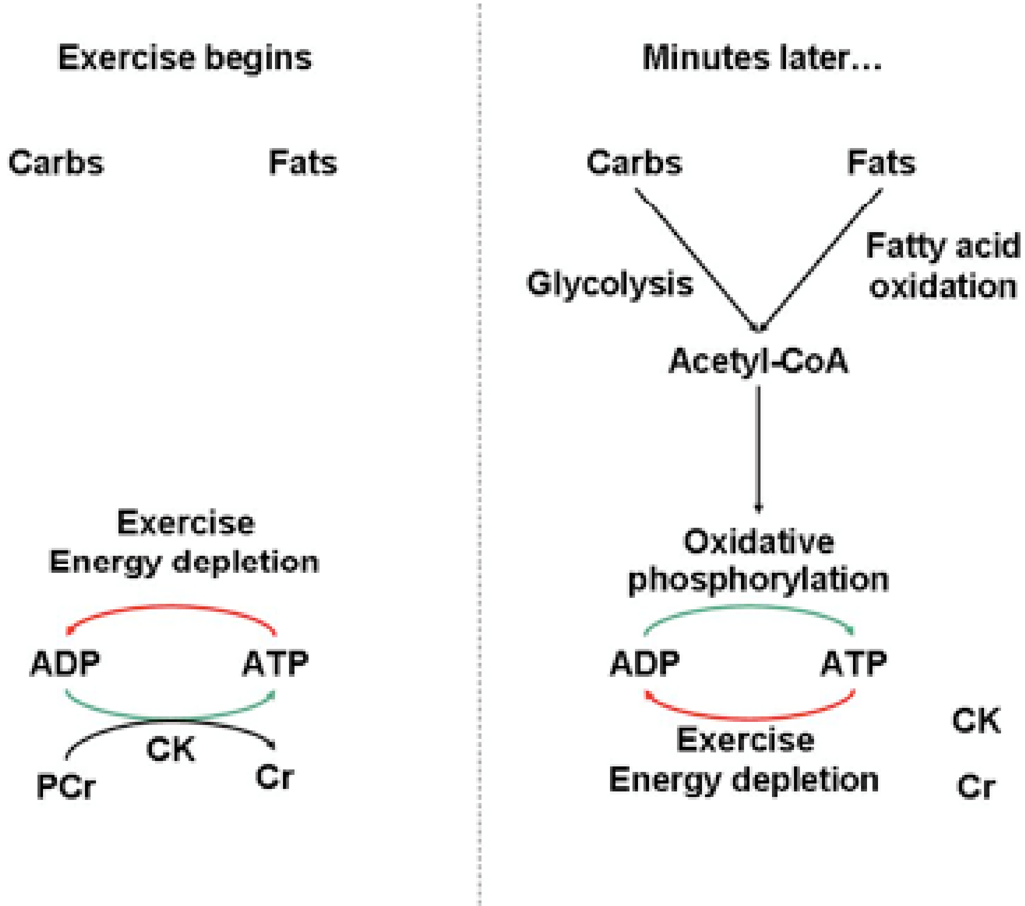
- Part 1: The three energy systems
- Part 2: Types of training and physiologic adaptations
- Part 3: Monitoring

# Energy





# 3 ENERGY SYSTEMS…



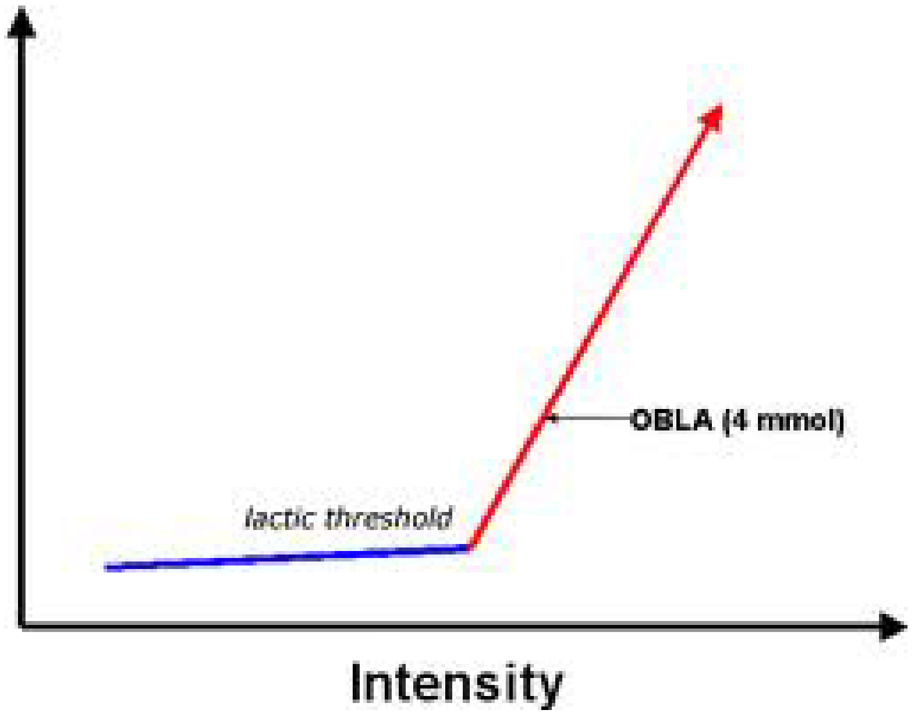
# Immediate Energy: The ATP-PCr system

- <u>Type:</u> High intensity exercise of short duration (100m dash, 25m sprint or weightlifting)
- <u>Source of energy</u>: Intramuscular high energy phosphates (ATP and PCr)
- Sustaining exercise beyond this point and recovering requires an additional source of energy to replenish ATP

# Short-term Energy: The lactic Acid system

- Resynthesis of high-energy phoshates at a high rate to continue strenuous exercise
- Source of energy: Stored muscle glycogen through anaerobic glycolysis
- Rapid and large accumulations of blood lactate occur during maximal exercise that lasts between 60 and 180s

# LACTATE ACCUMULATION



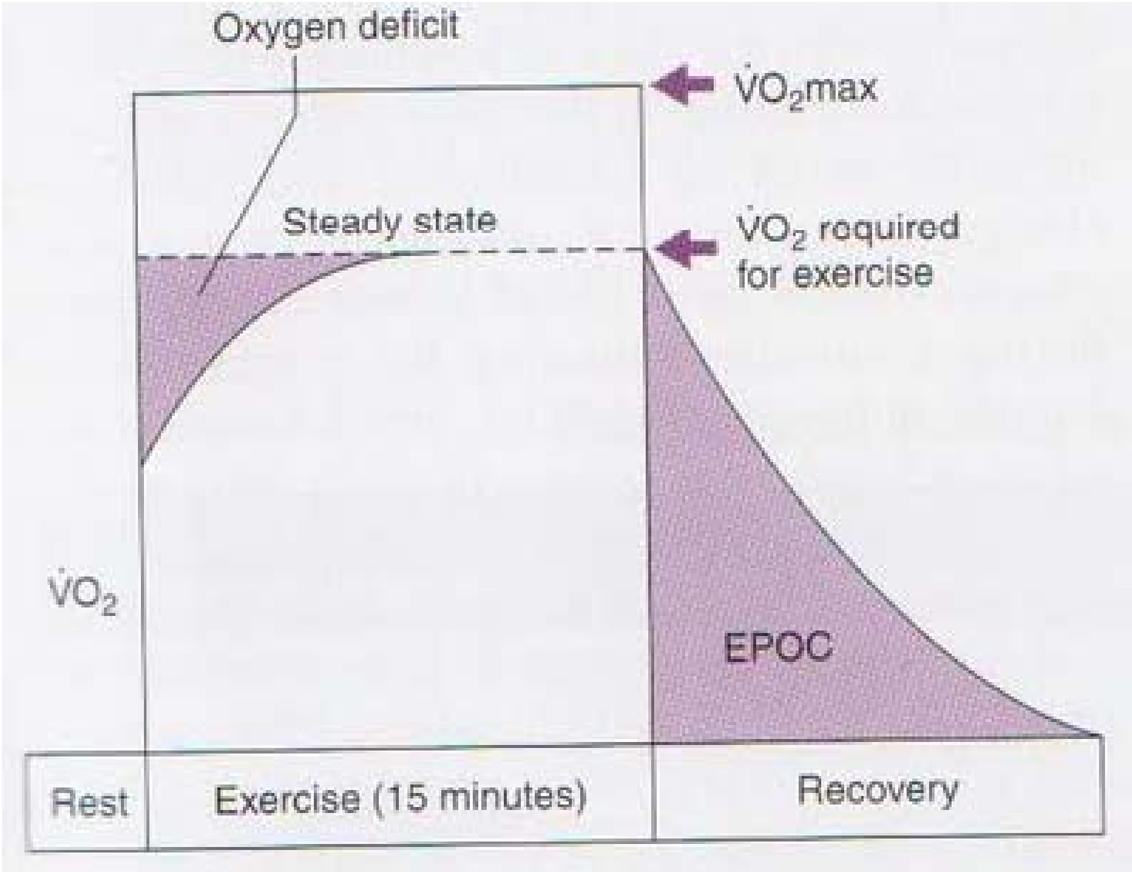

For healthy, untrained persons, blood lactate begins to accumulate and rise exponentially at 55% of maximal capacity for aerobic metabolism.

# LONG-TERM ENERGY: THE AEROBIC SYSTEM

- **Glycolysis** produces relatively little ATP.
- Responsible for most energy transfer
- Oxygen consumption rises exponentially during the first minutes of exercise then plateau at ones steady state
- **Steady state** represents a balance between energy required by the working muscles and ATP production in aerobic metabolism

  (no appreciable blood lactate accumulates here)
- <u>Limitations in this state: </u>fluid loss, electrolyte depletion, other factors?

# Energy consumption during recovery



# ENERGY SPECTRUM OF EXERCISE

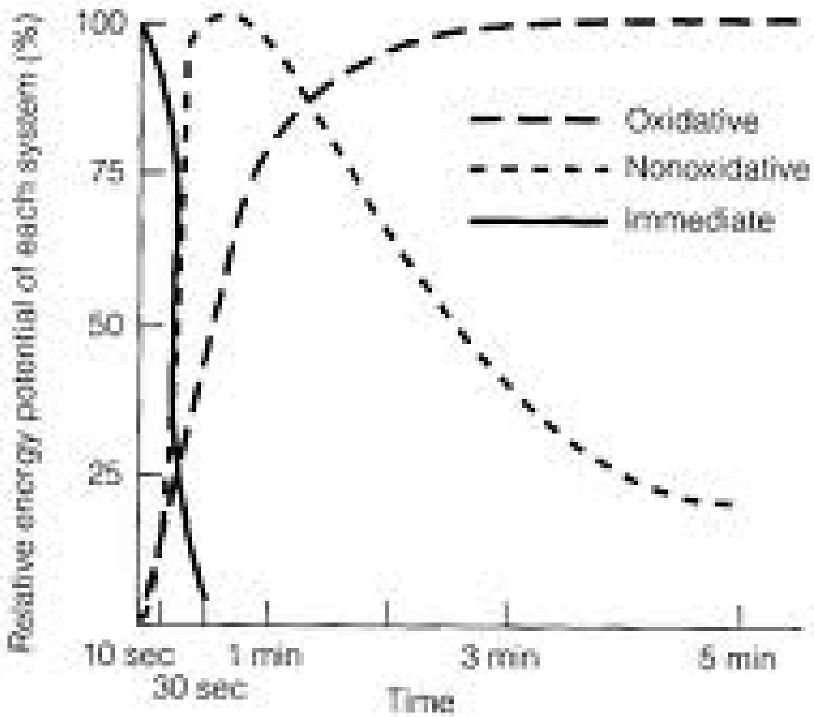



**Figure 3-1** Energy sources for muscle as a function of activity duration. Schematic presentation showing how long each of the major energy systems can endure in supporting all-out work. SOURCE: Edington and Edgerton, 1976. Used with permission.

# Part 2:
# Types of training &
# physiological adaptations

# Training zones

| Level | %HR | %VO2 | Increases | Type of training |
|---|---|---|---|---|
| **Easy:: Level 1** | 60-70 | 55-65 | Aerobic energy, aerobic pathway, capilliary density, mitochondria, FFA utilization | Long slow distance |
| **Steady: Level 2** | 71-75 | 66-75 | Aerobic energy, aerobic pathways | Endurance |
| **Moderate: Level 3** | 76-80 | 76-80 | FOG recruitment, aerobic glycolysis, oxygen transport | Stregth/ endurance |
| **Hard: Level 4** | 81-90 | 81-90 | Anaeobic threshold, lactic acid clearance. | Endurance, interval, threshold power |
| **Very Hard: Level 5** | 91-100 | 91-100 | Maximal oxygen transport, anaerobic energy sources | Interval/ power |

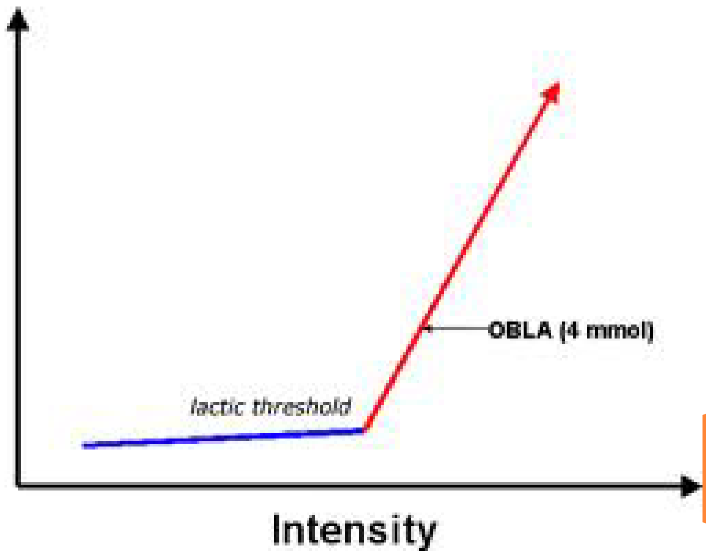
# Anaerobic

# LACTATE THRESHOLD TRAINING

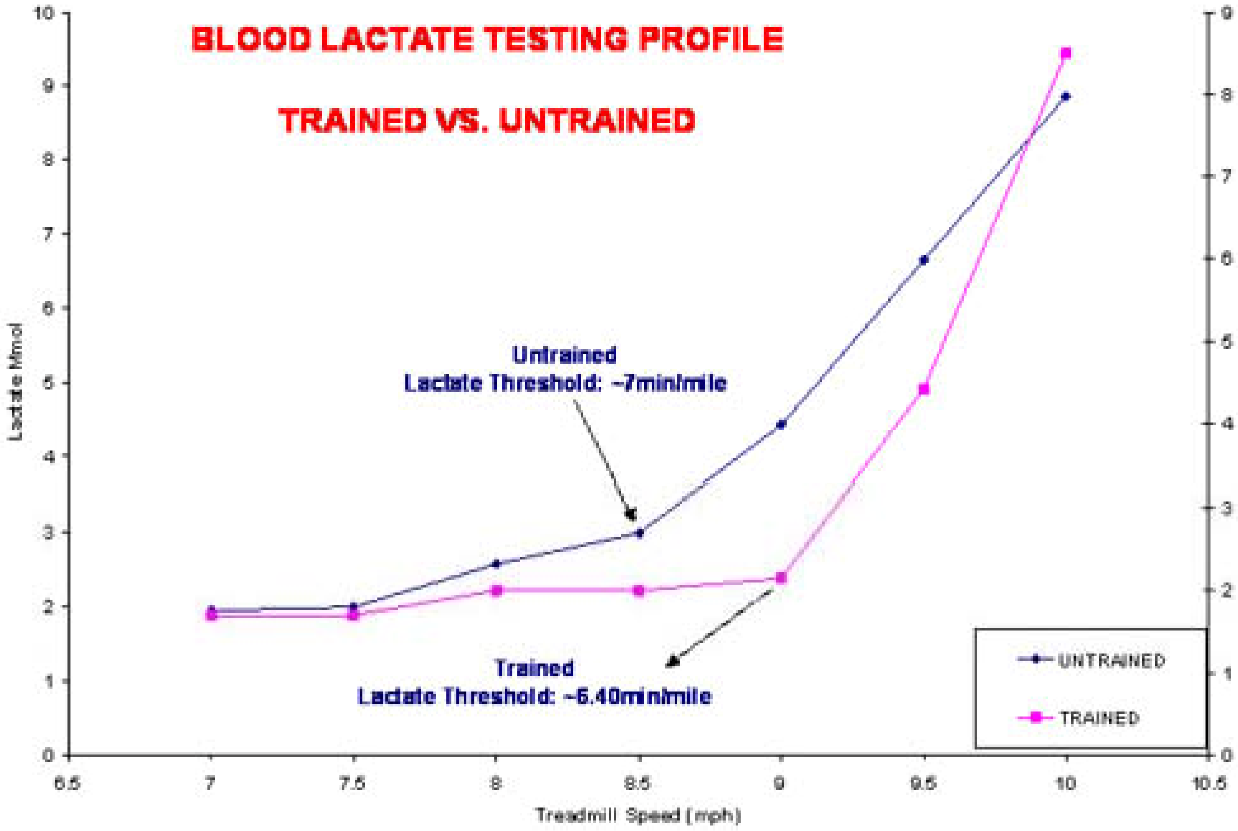
- By-product of glycogen broken down anaerobically is **lactic acid**.

- Accumulation =burning cramping sensation

- **Lactate threshold or OBLA**



# Lactate threshold and OBLA




Speed to $VO_2$: 8.5=50% 9.0=75%

Training aims to shift the lactate threshold or OBLA. $VO_{2max}$ can only improve to a certain degree (genetics) but LT can be shifted meaning…

# INTERVAL TRAINING

- Anaerobic intervals targeting lactic acid system
- **'Lactic stacking'**

| Work: relief | Work interval | Relief interval | Intensity |
|---|---|---|---|
| 1:3 | 30s- 1 minute | Active relief | 85-90% |

- Indicators you are working in the right zone:
- HR (90%MHR), RPE (15 hard-17 very hard), ventilatory threshold.

# Metabolic adaptations to LA intervals

| Adaptation | Outcome |
|---|---|
| Increased levels and activity of the enzyme glycogen synthase | Increased storage of glycogen as long as dietary intake is adequate |
| Improved subjective measurement of exertion | Increased tolerance of lactic acid as the individual becomes accustomed to the feeling of discomfort |
| Increased capilliarization | Improved $O_2$ delivery and lactic acid clearance |
| Increased size and number of mitochondria | Increased capacity for aerobic energy production |
| Increased levels of myoglobin | Improved $O_2$ extraction in the muscle cells |

+ Increased aerobic capacity of the type 2a muscle fibres (FOG)
Note: when anaerobic glycolysis is the main pathway for energy production glycogen stores are rapidly depleted. Adequate recovery necessary to avoid overtraining & injury

# Aerobic

# Constant pace training/ LSD

- Steady, prolonged training at approx. 60-80% VO2max (74-88% MHR) = **conversational pace**
- Usually 1 hour +
- Metabolic adaptations:

| **Area of adaptation** | **Adaptation to training** |
|---|---|
| Muscle fibre recruitment | Increased type 1 muscle fibre recruitment |
| Glycogen stores | 50% Increase |
| Muscle stores of triglycerides | Increased |
| Aerobic enzymes | Increased activity and number |
| Myoglobin levels | 75-80% Increase |
| Mitochondria | Increased number and size |
| Capilliarization | Increased |
| Hypertrophy | Increased hypertrophy of type 1 muscle fibres |
| Fat metabolism | Increased |
| Type 2 muscle fibres | Decreased mass |

# Aerobic intervals

- Scope: allows improvement of aerobic capacity enough to progress onto high intensity continuous training.

| Work: relief | Work interval | Relief interval | Intensity |
|---|---|---|---|
| 1:1 / 1:1.5 | 3-5 mins | Active relief | 75% MHR+ |

| Adaptations to aerobic intervals | |
|---|---|
| **Adaptations** | **Outcome** |
| Increased muscular stores of triglycerides and glycogen | Improved aerobic metabolism of fats and carbohydrates |
| Increased levels and activity of aerobic enzymes | |
| Increased levels of haemoglobin and myoglobin | Improved oxygen delivery and extraction leading to increased $VO_{2max}$ |
| Increased capillarization | Improved oxygen delivery |
| Increased recruitment of fast oxidation glycolytic fibres (type 2a) | Increased aerobic capacity of FOG fibres |

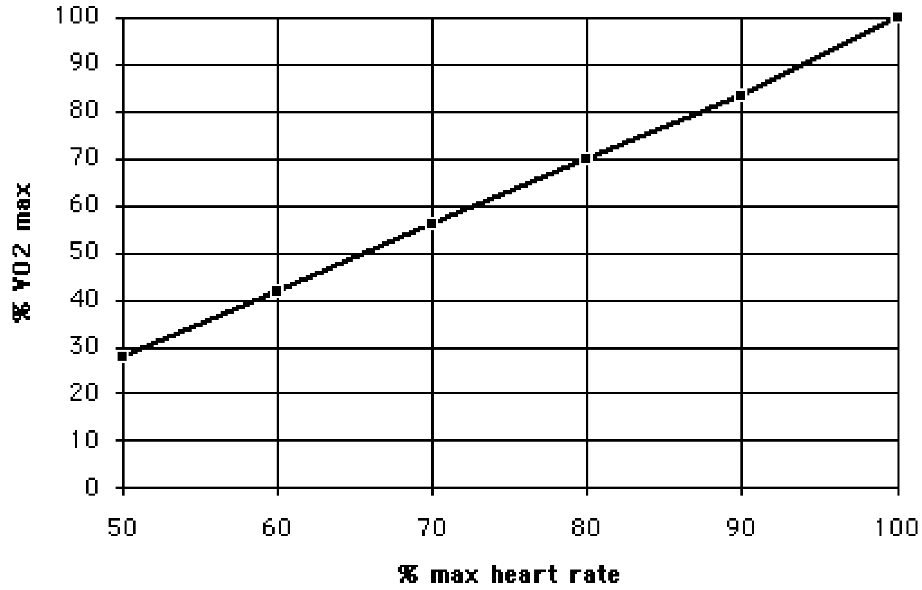
| Adaptations to endurance training | |
|---|---|
| **Respiratory** | Enhanced oxygen exchange in lungs |
| | Improved blood flow through lungs |
| | Decreased submaximal respiratory rate |
| | Decreased submaximal respiratory ventilation |
| **Cardiovascular** | Increased cardiovascular output |
| | Increased blood vloume, red blood cell count & Hb concentration |
| | Enhanced blood flow to skeletal muscles |
| | Improved thermoregulation |
| **Musculoskeletal** | Increased mitochondrial size and density |
| | Increased oxidative enzyme concentrations |
| | Increased myoglobin concentrations |
| | Increased capiliarisation in muscle bed |
| | Increased oxygen difference between arterial and venous blood |

# Part 3: Methods of monitoring exercise intensity

**<u>MHR & %VO$_{2max}$</u>**

- MHR=220-age (30)= 190bpm
- (MHR=200-(0.5 x age)
- Accuracy +/- 12bpm
- 60% of VO$_{2max}$ = 74% MHR
- Assumption: HR drops to zero

| Corresponding percentage $VO_{2max}$ to percentage MHR | |
|---|---|
| $VO_{2max}$ | %MHR |
| 50 | 66 |
| 55 | 70 |
| 60 | 74 |
| 65 | 77 |
| 70 | 81 |
| 75 | 85 |
| 80 | 88 |
| 85 | 92 |
| 90 | 96 |



## HRR and % $VO_{2max}$

Variables: Age and RHR

Using **Karvonen formula**…

e.g 27 year old male with RHR of 65bpm

Target HR 75%HRR

MHR = 220-27 = 193

HRR = 193-65 = 128

%HRR = 128 x 0.75 = 96

96 + 65 = 161bpm

# Rating of Perceived exertion (RPE)

Subjective feeling during exercise

**6-20 scale** (Borg)

**0-10+ scale** (category ratio scale)

**Preferred level of exertion**:

12-14 on Borg scale ←→Steady state

| RPE scale | CR-10 scale |
|---|---|
| 6 | 0.0 |
| 7 Very, very light | 0.0 |
| 8 | 0.5 Just noticeable |
| 9 Very light | 1.0 Very weak |
| 10 | 1.5 |
| 11 Fairly light | 2.0 Light/ weak |
| 12 | 3.0 Moderate |
| 13 Somewhat hard | 3.5 |
| | 4.0 Somewhat strong |
| 14 | 4.5 |
| | 5.0 |
| 15 Hard | 5.5 |
| | 6.0 |
| 16 | 6.5 Very strong |
| | 7.0 |
| 17 Very hard | 7.5 |
| | 8.0 |
| 18 | 9.0 |
| 19 Very, very hard | 10.0 Extremely strong |
| 20 | 10 + highest possible |

# Relationship between MHR, HRR and RPE at different exercise intensities

| Intensity classification | %MHR | %HRR | RPE |
|---|---|---|---|
| Very light | <35 | 20< | <10 |
| Light | 35-54 | 20-39 | 10-11 |
| Moderate | 55-69 | 40-59 | 12-13 |
| Hard | 70-89 | 60-84 | 14-16 |
| Very Hard | ≥ 90 | ≥ 85 | 17-19 |
| Maximal | 100 | 100 | 20 |

***Swimming: MHR approx. 13bpm lower in both trained and untrained individuals compared to running.***

Reasons: musculature, venous return, position, cooling effect

e.G HR calculation for 45 year old swimming at 70% MHR:

220-45=175

175-13= 162

162 x 0.7 = 113

# Conclusion

- Apply the **training principles** to your training:

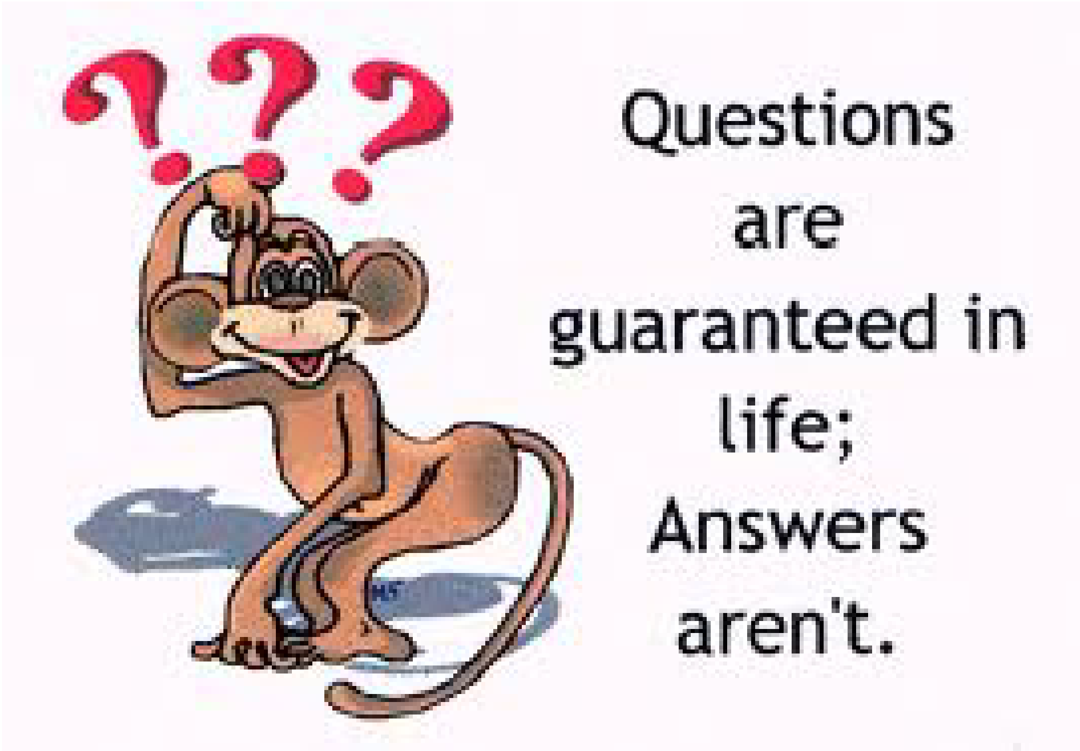
→ *Specific*

→ *Progressive*

→ *Overload*

→ *Reversibility*

***Behaviour change***


Questions
are
guaranteed in
life;
Answers
aren't.

# References

- McArdle Katch and Katch
- Essentials in Strength and conditioning