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Improving Diver Performance with Breathing exercise and Fin Training

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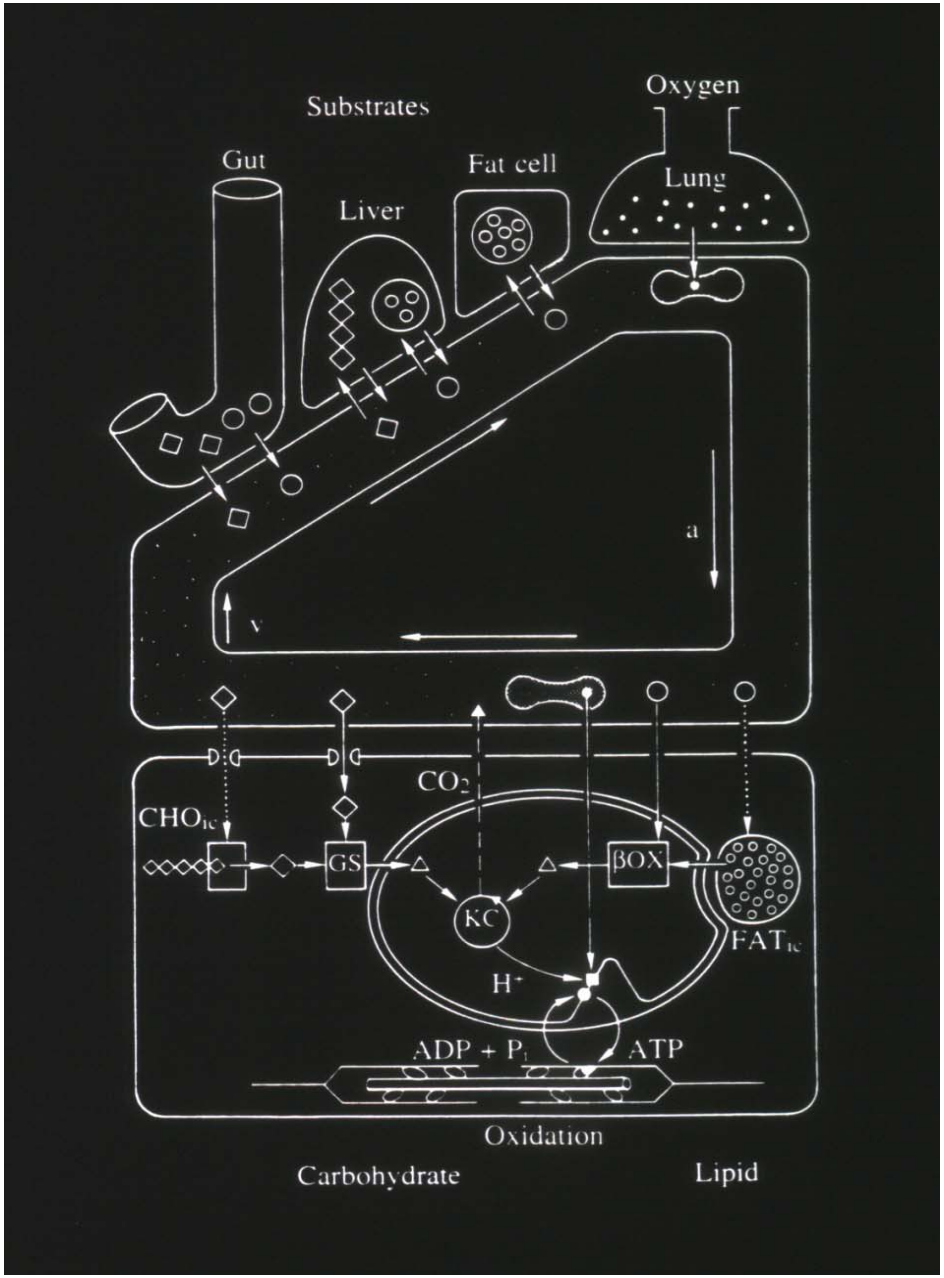
Diver Performance

- Sustained exercise at low to moderate intensity
  - > Aerobic energy: Oxygen + substrates
  - > Blood flow from the heart-cardiac output
    (Heart rate as an index)
  - > Blood flow to the muscles (locomotor and respiratory)
  - > Defined by the maximal O2 consumption and
    the percentage of VO2max that can be sustained
    as a function of time (endurance)

- Periods of high intensity for short periods
  - > Anaerobic energy: uses glycogen in muscle and
    produces lactic acid
  - > limit is the tolerance to La
    pain in muscles
    increased ventilation as a compensation
  - > La is consumed by the body during exercise and is related to VO2max
    Post-exercise it takes 10-20 min to eliminate exercise (exercise/rest)

Limitations to Diver Performance



- Gas exchange at lung
- Transport by circulation

  Cardiac Output

  Muscle blood flow
- Energy production in mitochondria
- Force and velocity contraction by muscle
- Fuel availability: CHO and Fat
- Sustained exercise (end)

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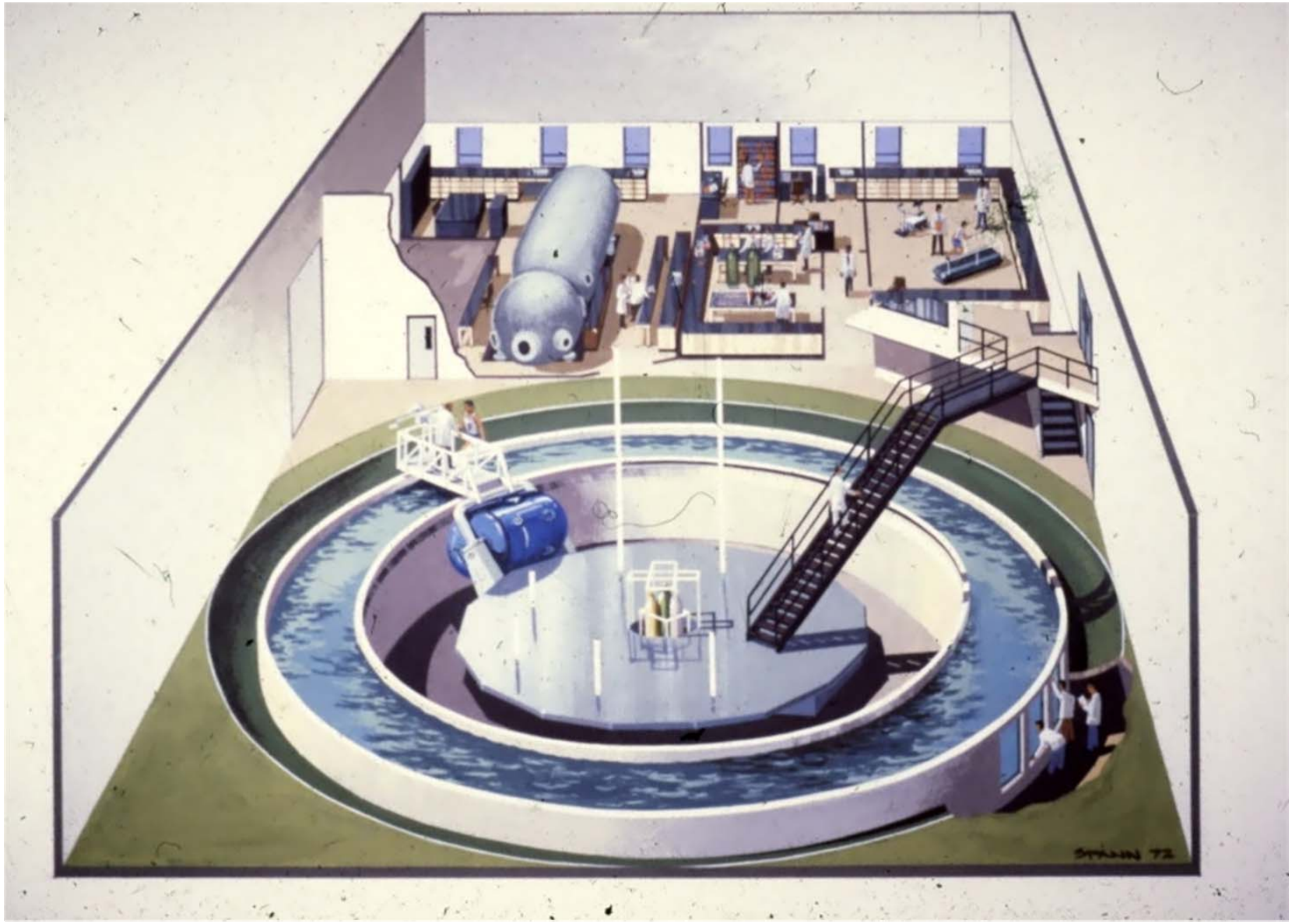
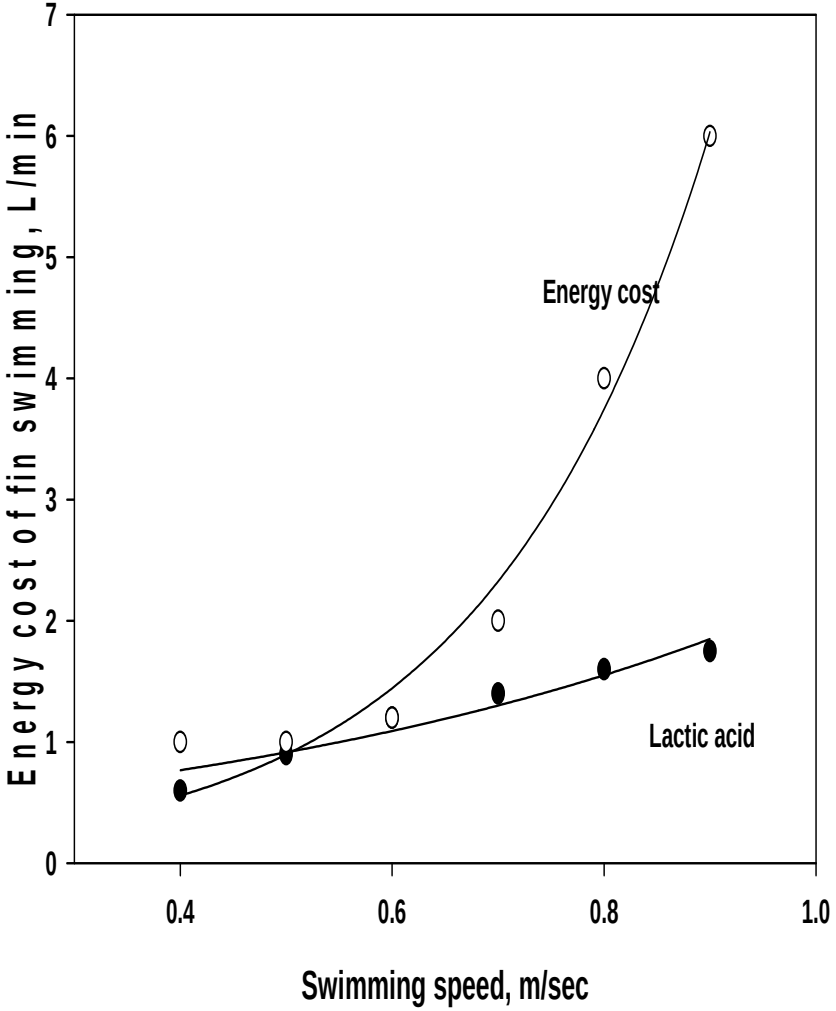


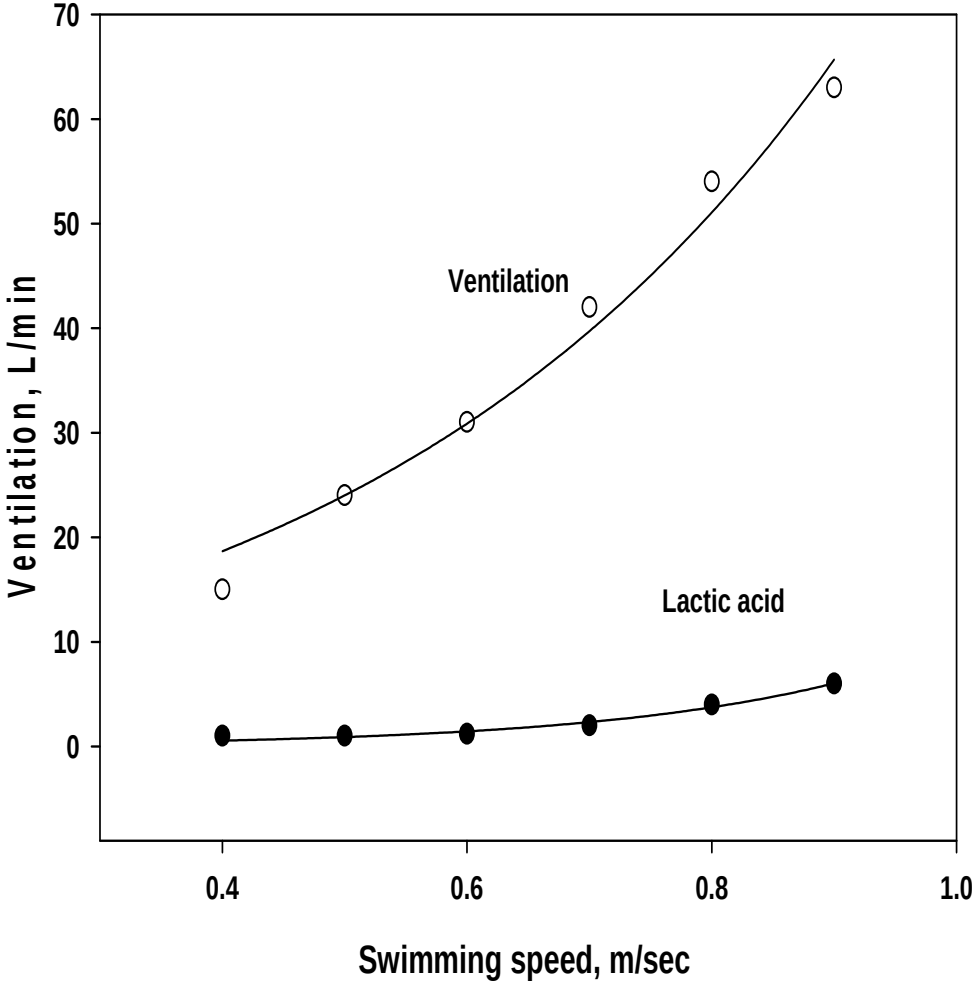
Free swimming testing for V_{O2} and active drag

Energy Requirement of Fin Swimming

Locomotor muscles



Respiratory muscles



Locomotor Muscle Training Protocols

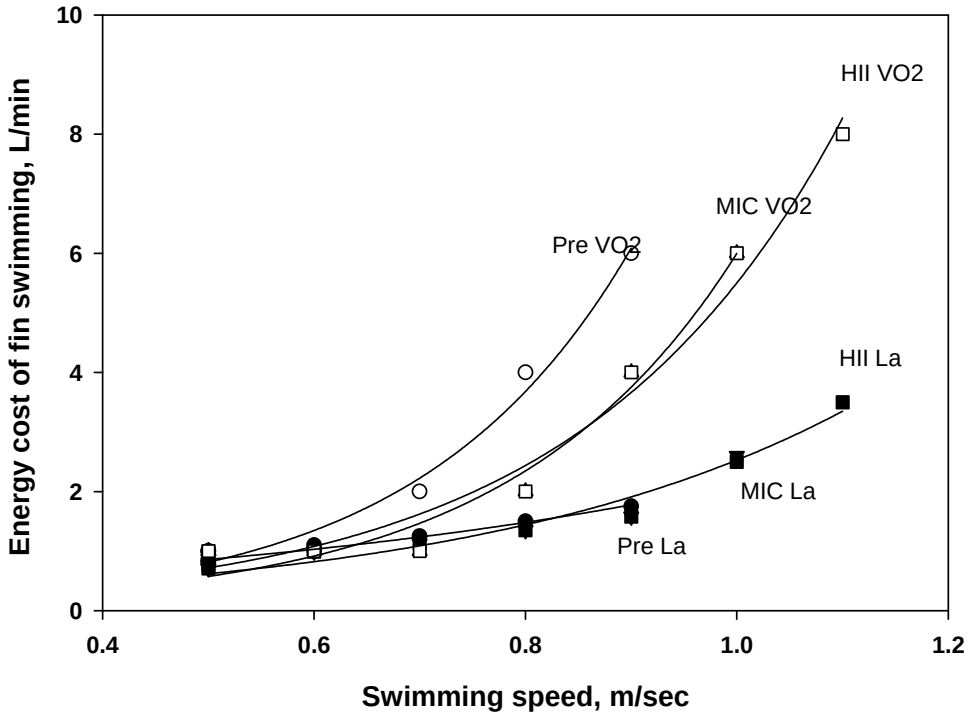
Medium Intensity Continuous

- Fin swimming in a 60m circumference pool
- Underwater pace light system
- 3 days per week for 4 weeks
- 50 min training
- 65% of their max Heart rate
- Continuous swimming

High Intensity Intermittent

- Fin swimming in a 60m circumference pool
- Underwater pace light system
- 3 days per week for 4 weeks
- 50 min training
- 90-95% of their max HR
- Intermittent swimming
- 3 cycles 10 min swim/rest

Effect of Training on Fin Swimming

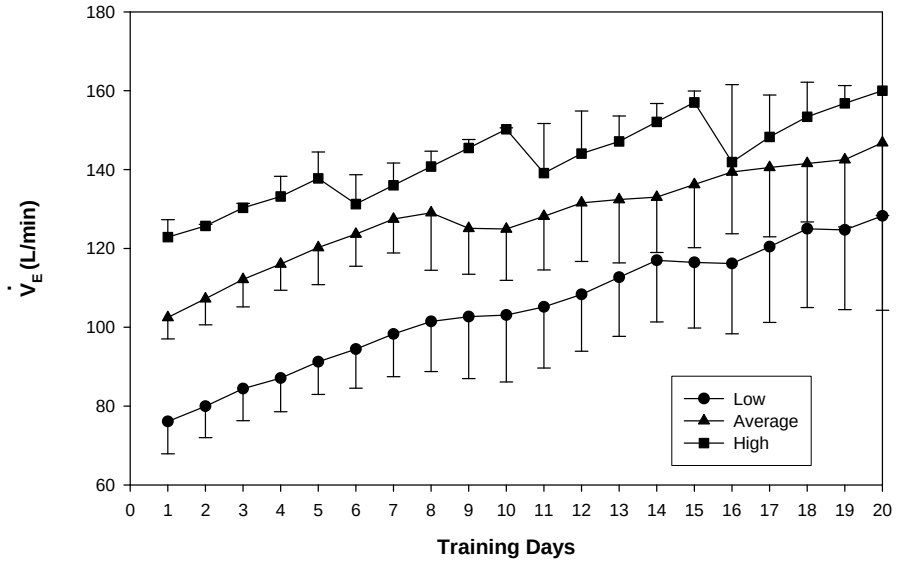


- Reduced energy cost of fin swimming and lactic acid build up
- Increased maximal swimming speed and lactic acid

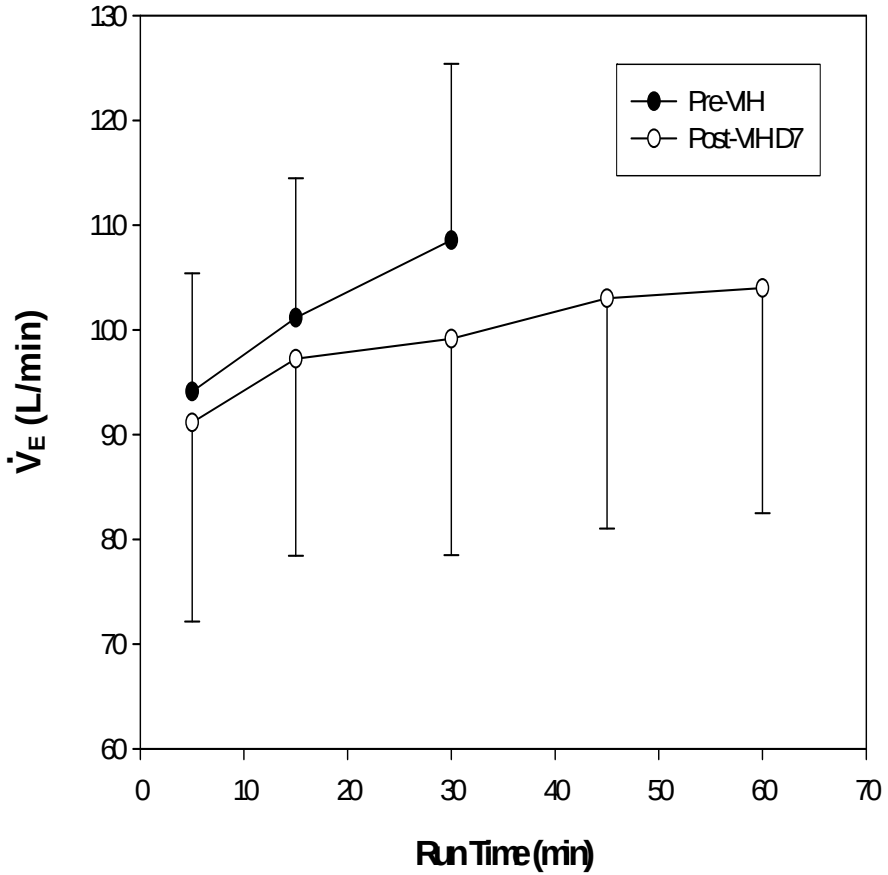
> High intensity intermittent better than continuous

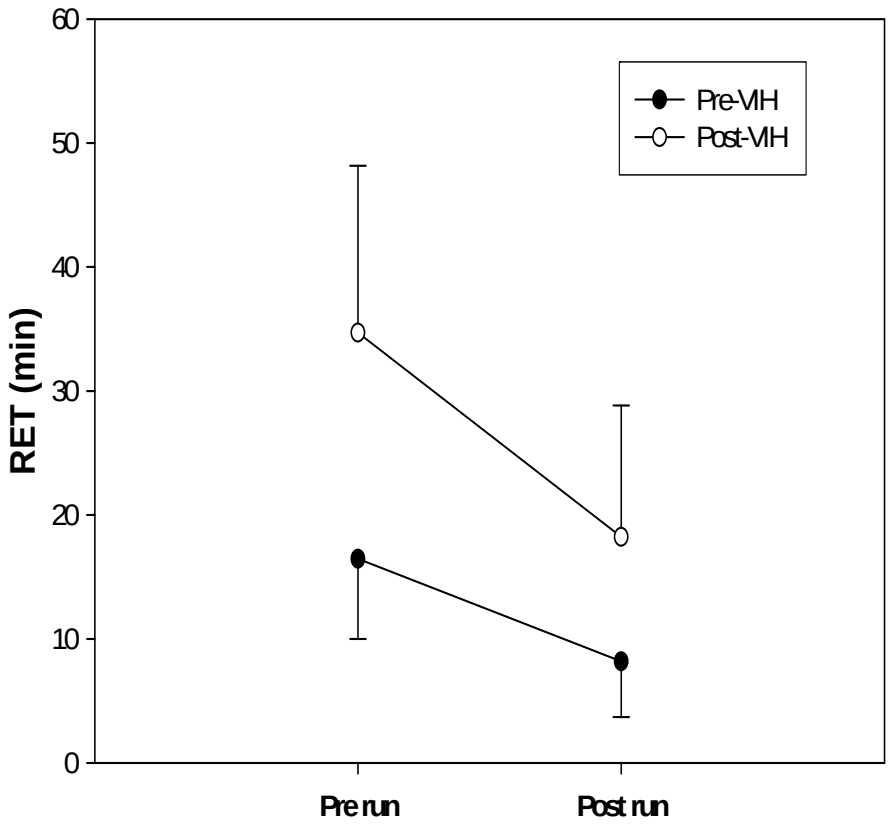
VIHT: Method

- **device built in-house**
- **Paced breathing (freq and TV)**
- **partial rebreathing- volume = to 50% of the subject□s' VC**
- **30 min long sessions**
- **30 breaths/min- about 50% MVV.**
- **Increase frequency 1-□2 b/min**
- **30 m/day, 5 d/week for 4 weeks**
- **Maintained by 30 m/day, 2 d/wk**



Results of VIHT

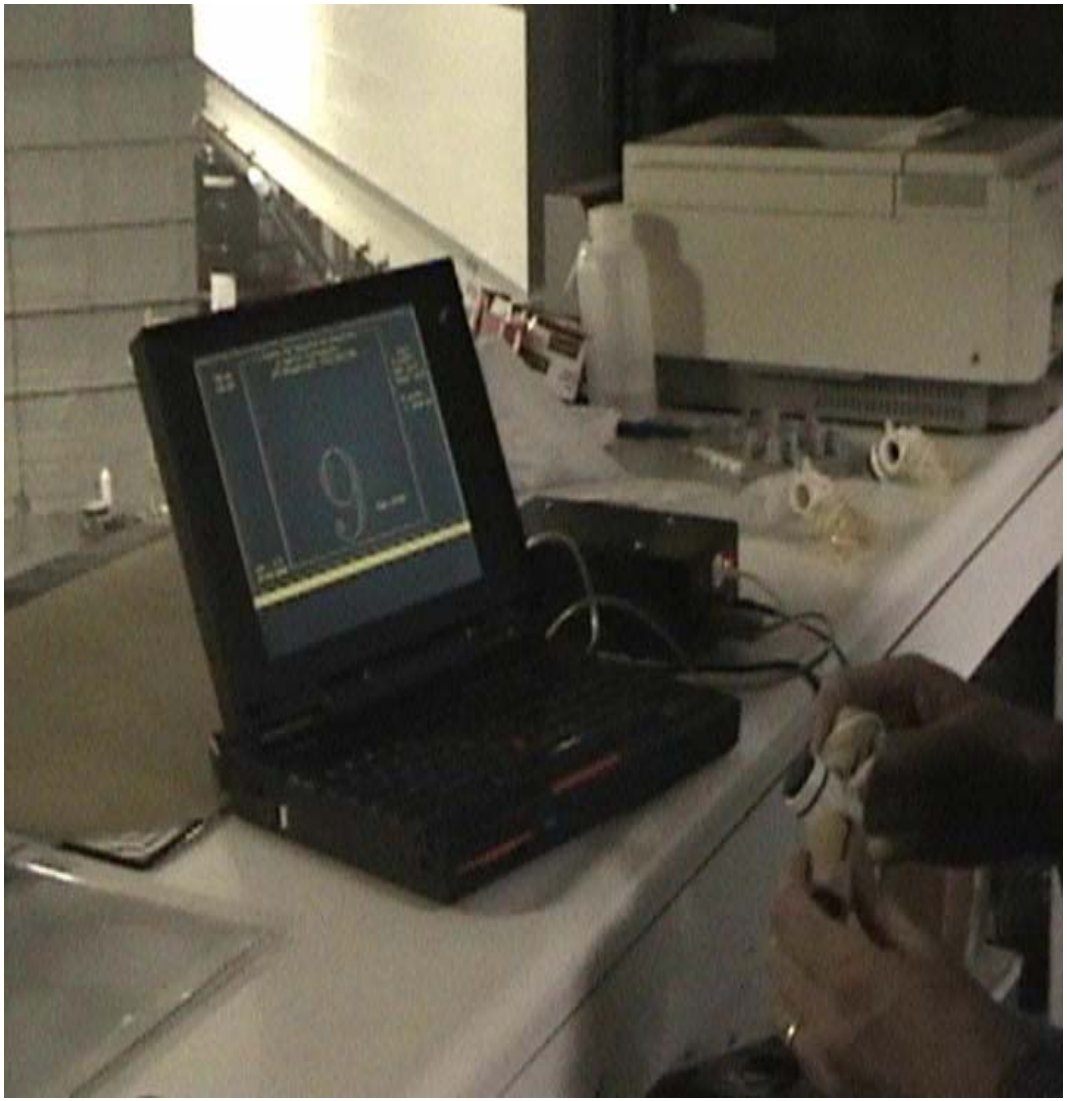




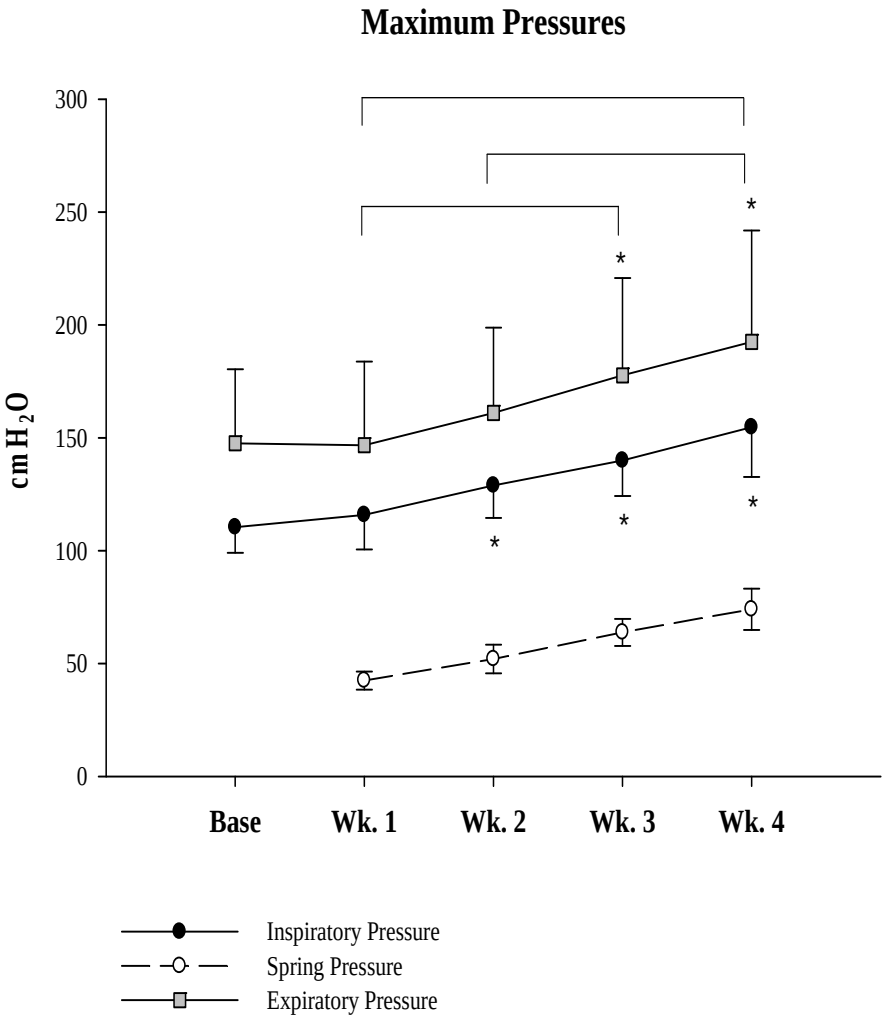
- VIHT Reduced ventilation and led to increased performance time by 50%
- VIHT also reduced respiratory muscle fatigue leading to increased performance

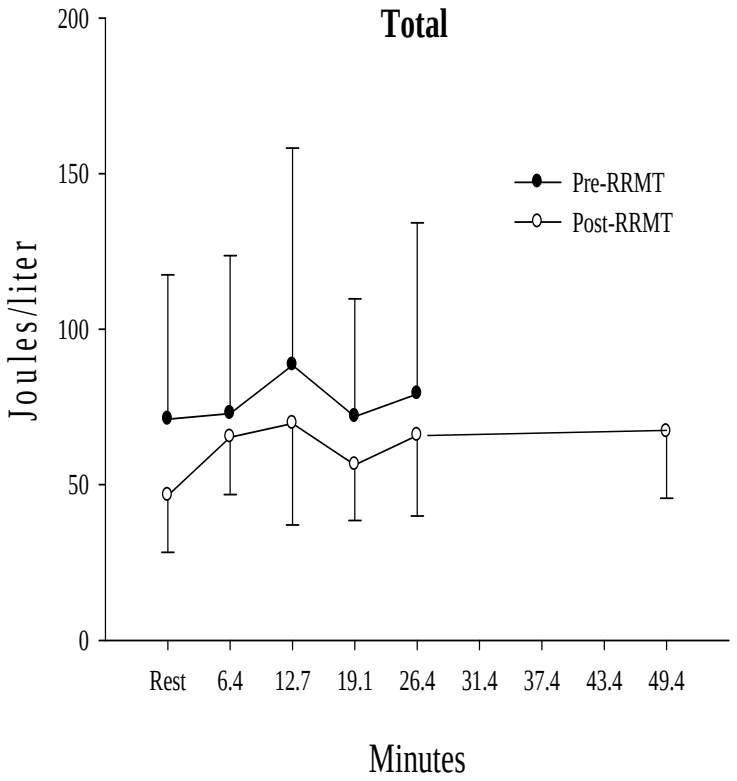
RRMT Method

- device built in-house
- Paced breathing (freq)
- Inspiration from FRC to exhalation to RV
- Rest off mouth piece
- 30 s cycles for 30 min
- Spring loading to 50% of maximal pressure (±50 cm H_2O)
- 30 m/day, 5 d/week for 4 weeks
- Spring pressures were increased



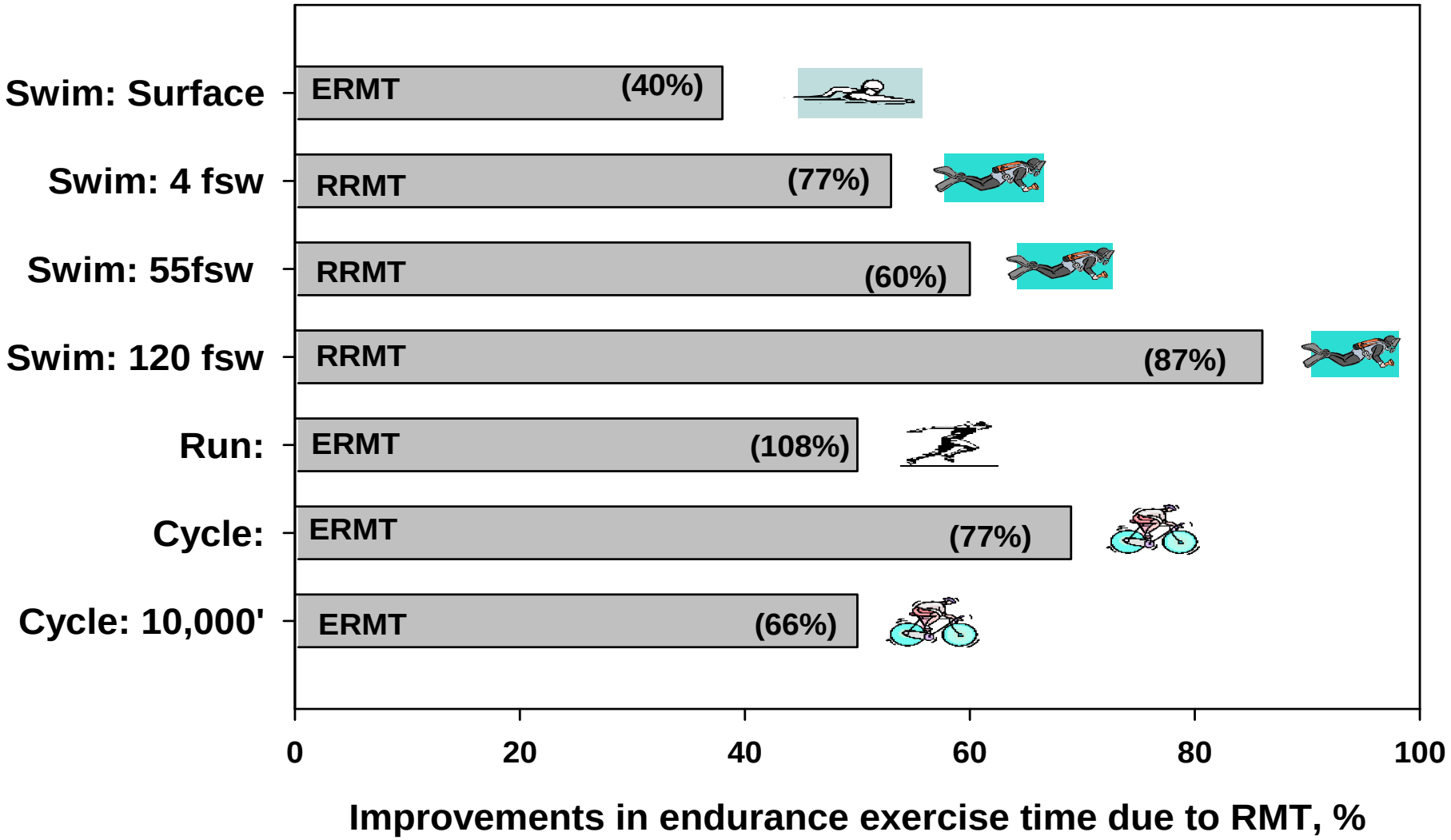
Results of RRMT





- RRMT significantly increased respiratory muscle strength
- RRMT reduced the work of breathing and increased exercise performance

Overall Improvements from RMT



Summary

- **Locomotor and Respiratory muscles fatigue at maximal and during endurance exercise**
- **Training is specific to muscle groups trained: Fins**
- **HII Training improves maximal and endurance performance more than MIC training**
- **VIHT improves respiratory endurance (200%)**
- **RRMT improves strength (35%) and endurance (75%)**
- **VIHT better for air and surface swimming, RRMT better at depth**
- **Combined locomotor and respiratory training should be performed to reduce fatigue and optimize performance**