Endurance training and young people

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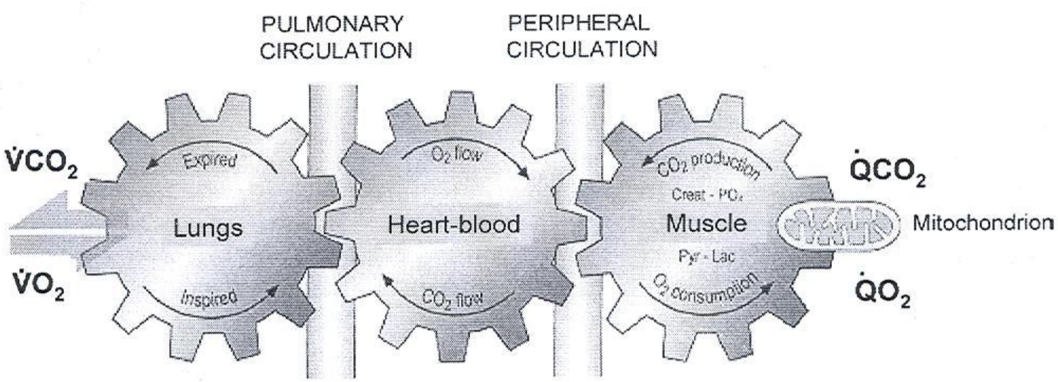
Overview

- Training young people
  - Unique considerations
  - Application to developing athletic potential
- Can young people benefit from endurance training?
- Training recommendations
- Conclusions

Exercise training: definition

<u>Exercise training</u>

"exercise is physical activity that is planned, structured, repetitive, and purposive in the sense that improvement or maintenance of one or more components of physical fitness is an objective" Caspersen et al. (1985)



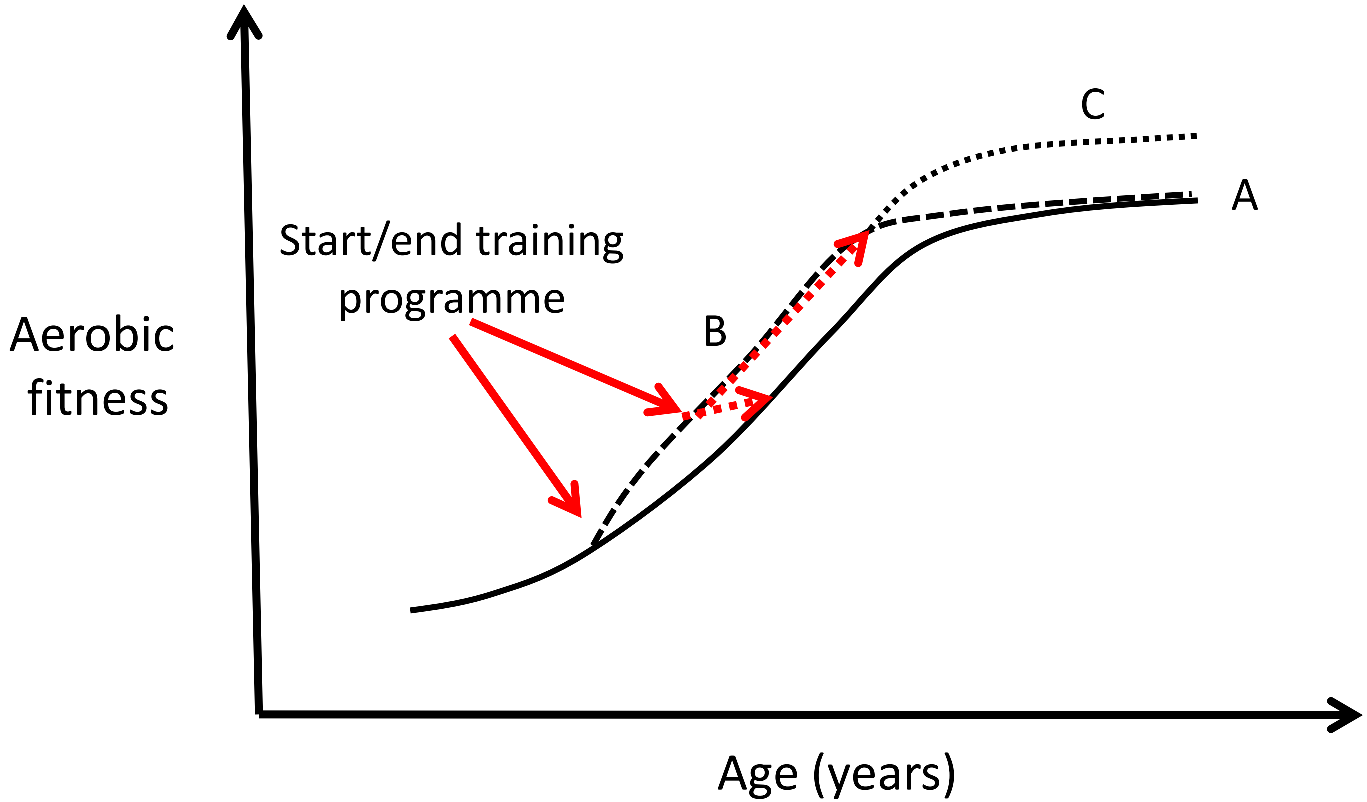
Uses the principles of:

- Frequency, intensity, duration and programme length
- Must be individualised, specific, cause overload and accommodate progression

"It is a grave mistake to submit children to training programs of adults. After all, children are not simply little adults" (Bompa, 2000)

- Health and well-being concerns
  - Musculoskeletal injury
  - Growth and maturation
  - Overtraining/burnout
  - Dropout
- Is training effective in this population?
  - Changes mirror that gained due to growth and maturation
  - Different aerobic and anaerobic capacities
  - Having the 'right' hormonal milieu
  - Young people are already habitually active

Exercise training in young people: possible responses

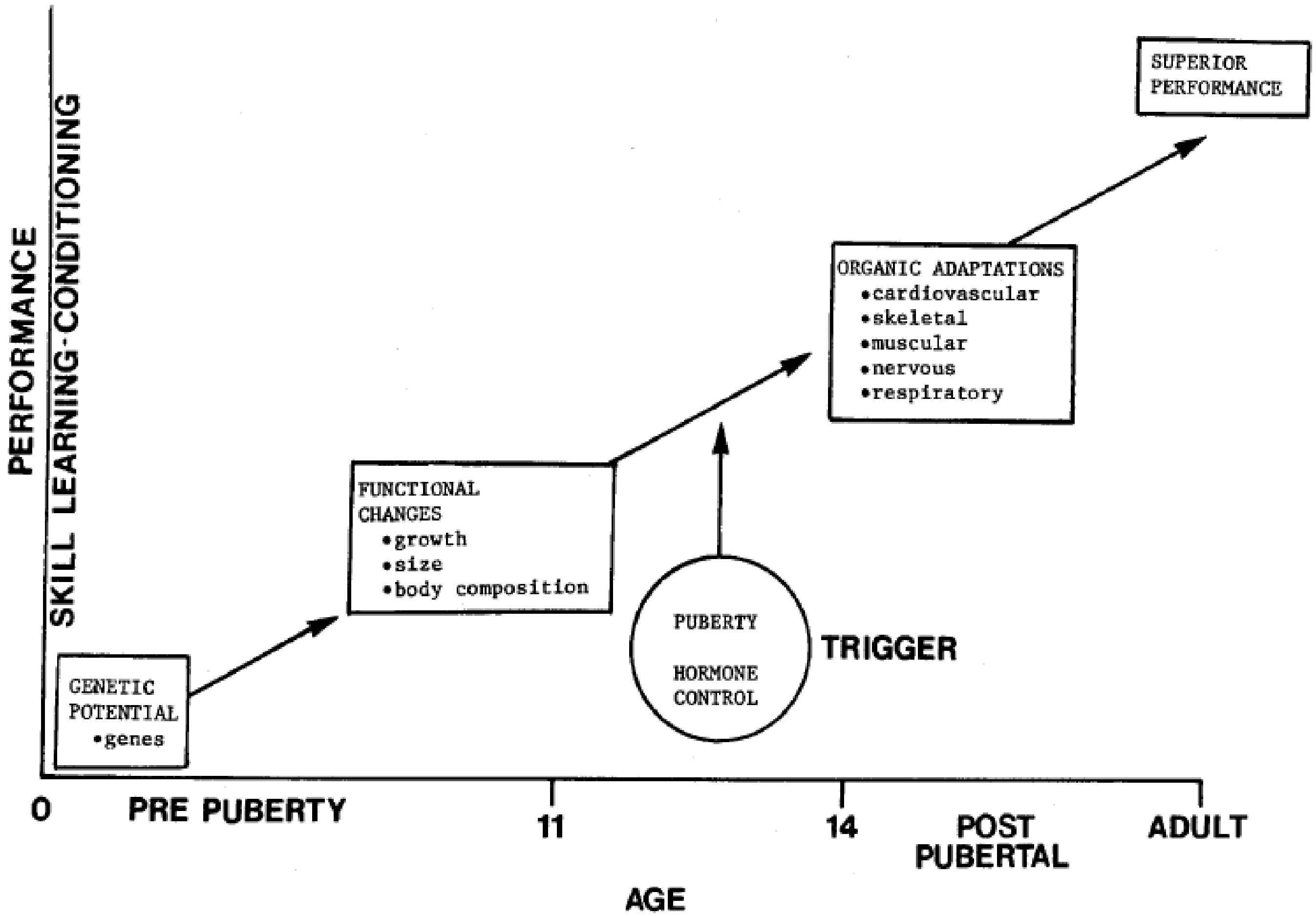


Is there a “golden period” for training young people?

Katch’s trigger hypothesis

“this hypothesis predicts that, pre-pubertally, there will be only small training-induced biological alterations because of the lack of hormonal control.....post-puberty exercise-induced changes are well documented and follow predictable patterns” (Katch 1983)

Katch's 'trigger hypothesis'

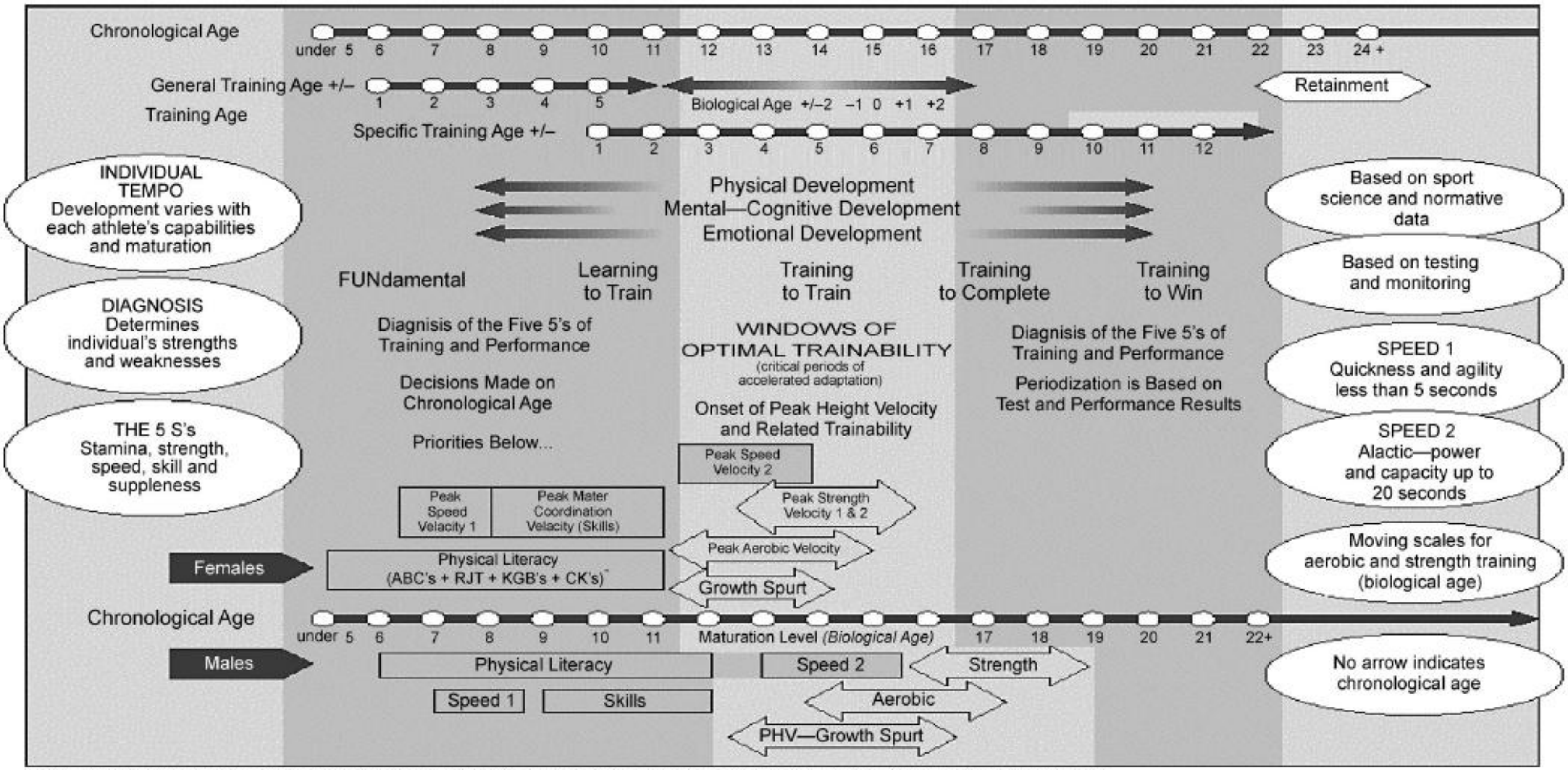


From Katch (1983). *J Adol Health Care*. 3: 41-246

The young athlete and training

- Long-term athlete development model (LTAD)
- Used by UK national governing bodies as the first step for talent development
- Model ties together athletic development alongside the principles of biological growth and maturation
  - Optimise performance longitudinally
  - Proposes a number of 'windows of opportunity'

LTAD model and ‘windows of opportunity’



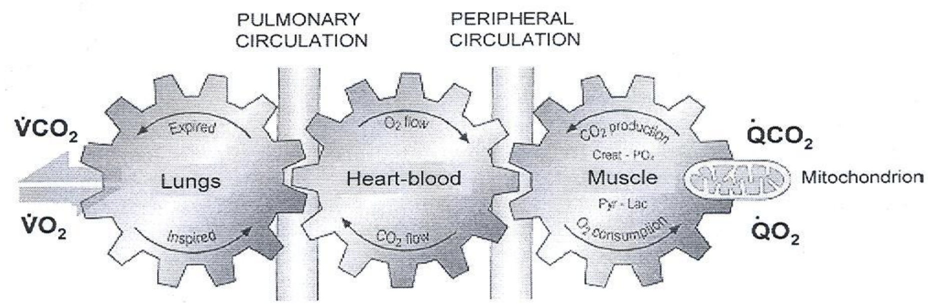
*ABC's – Agility Balance Coordination Speed + RJT = Run Jump Throw + KGB's = Kinesthesia Gliding Bouyance Striking with object + CK's = Catching Kicking Striking with body

Ford et al. (2011). *J Sport Sci. 29: 389-402*

Can young people benefit from endurance training?

- Cross sectional studies
  - Peak oxygen uptake
  - Lactate markers
  - Exercise economy
  - Oxygen uptake kinetics

- Training studies
  - Peak oxygen uptake



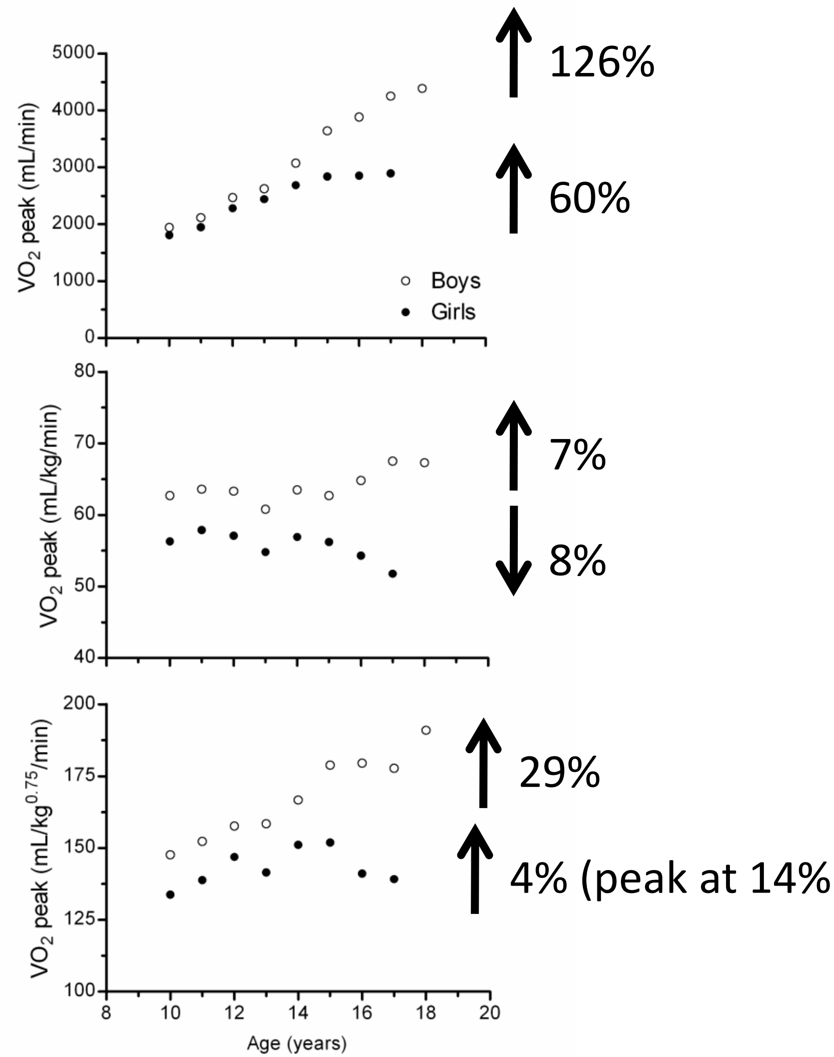
Why these markers?

Study	Participants	Performance measure	Predictors
Daniels et al. (1978)	10-18 year old male middle and long distance runners	1 mile time 2 mile time	Economy Economy
Sjodin (1982)	11-15 y old male middle distance runners	400 m 1,000 m 3,000 m 4.2 km x-country	OBLA, muscle power OBLA, muscle power OBLA Peak VO_2
Unnithan et al. (1995)	11-12 y old male middle distance runners	3,000 m	Peak VO_2, lactate threshold, economy
Almarwey et al. (2003)	16 y old male and female middle distance runners	1,500 m	B: Velocity at 2.5 mM, peak VO2, v-VO_2max G: Velocity at 2.5 mM, peak VO2, v-VO_2max
Unnithan et al. (2009)	15 y old female swimmers	200 – 1,000 m and ranking	Economy

Development of peak VO_2 in young athletes

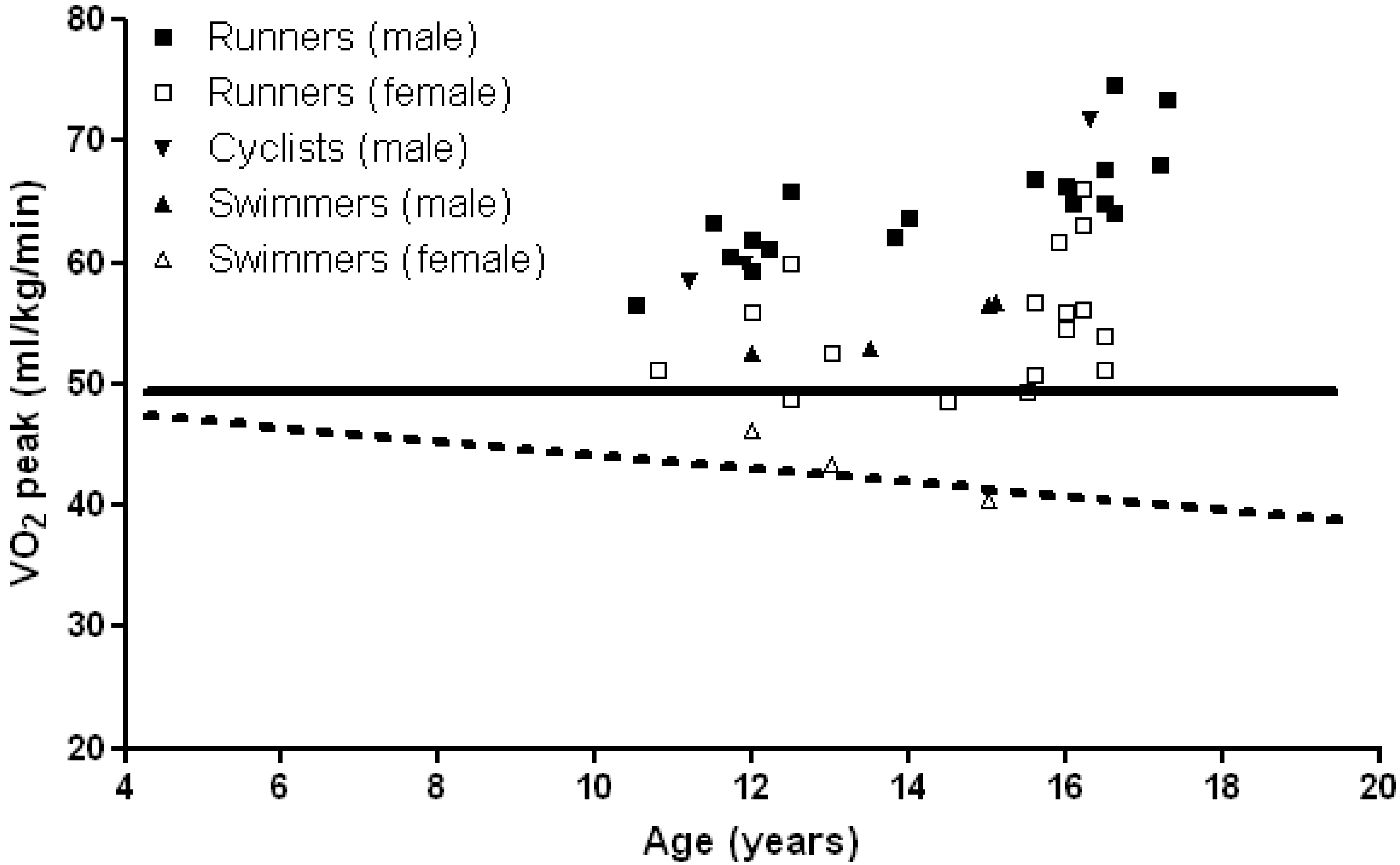
1. 8-15 y (27 boys, 27 girls) road racers (>10 k) undertook annual measures over 3-5 y. Training volume was ~ 35-40 km/wk

2. 10-19 y (48 boys, 22 girls) x-county or track runners. Training volume was ~ 48 and 35 km/wk for boys and girls respectively.



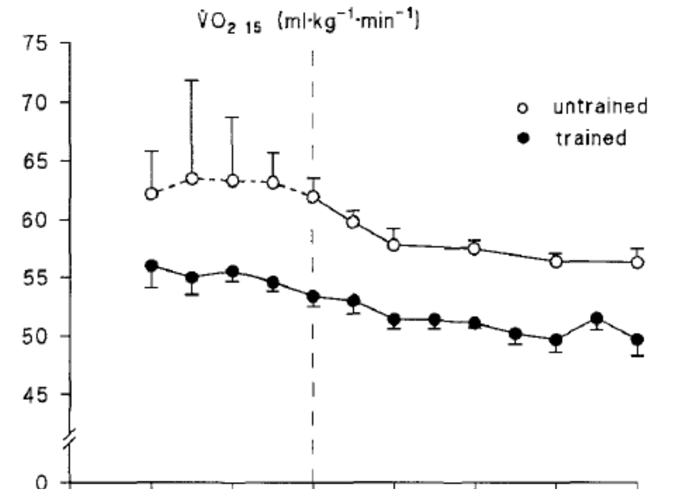
Eisenmann et al. (2001). *J Appl Physiol*. 90: 2172-2180

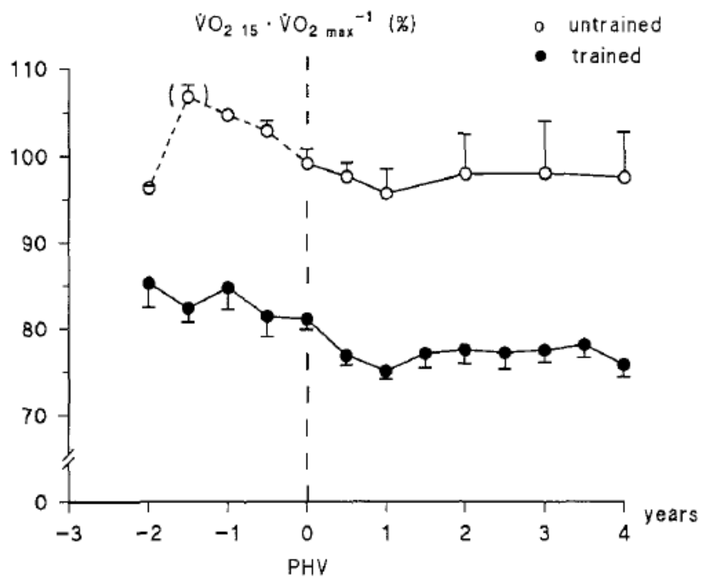
Trained vs. untrained for peak VO_2

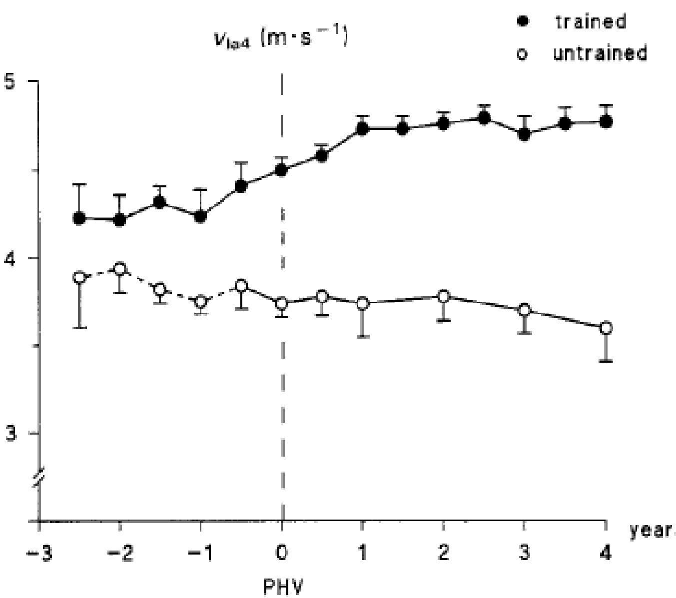


Mahon (2008). Aerobic Training. *Paediatric Exercise Science and Medicine.*

Blood lactate and exercise economy





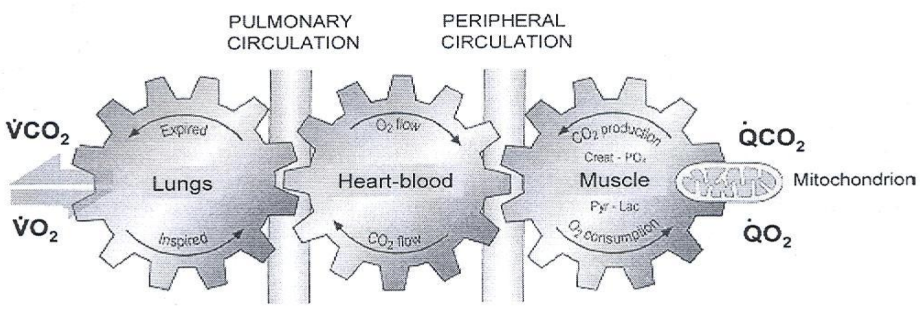


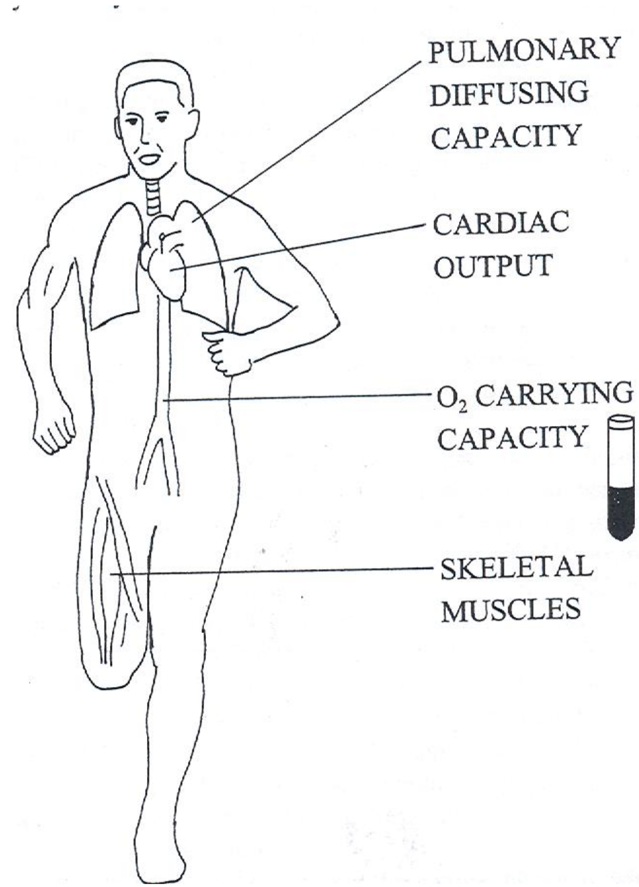
Sjodin and Svedenhag (1992). *Eur J Appl Physiol*. 65: 150-157

Considerations

- Nature or nurture the cause?
- Problems with control group selection
  - Age, sex and maturity
  - Physical activity status
- Training recommendations are difficult
  - Not always described
  - Volume not standardised or objectively quantified
    - Often days/wk or yr, km/day or min/day
    - Basic descriptors: continuous or interval
  - Dose-response not possible

Why do trained young people have a superior peak VO_2 peak compared to their untrained counterparts?





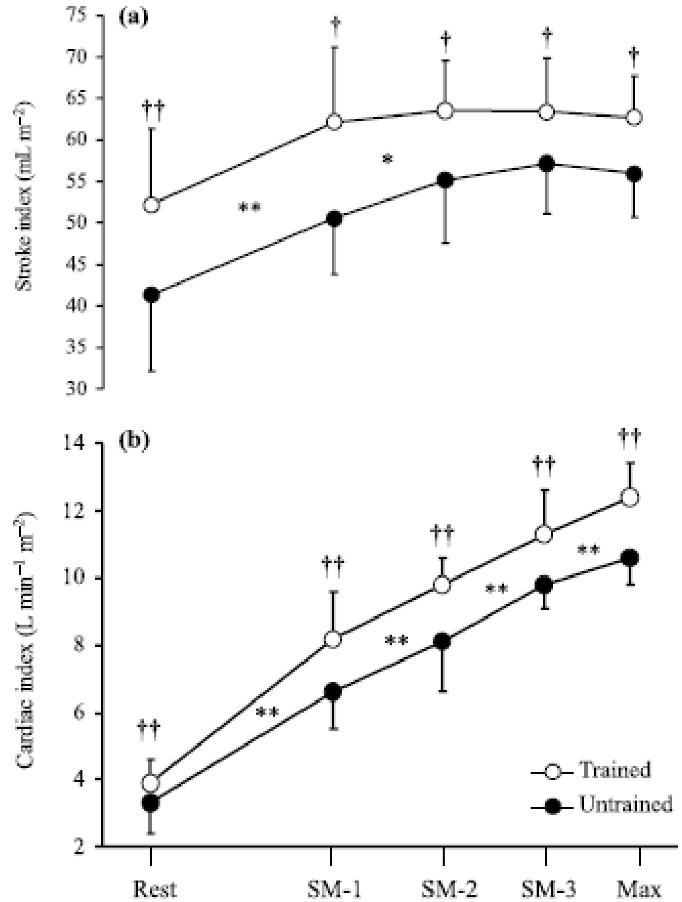
<u>Fick equation</u>

$$VO_2 \max = Q_{max} \cdot (CaO_2 - CvO_2)$$

Basset and Howley (2000) *Med Sci Sport Exe*. 32, 70-84

Central and peripheral factors

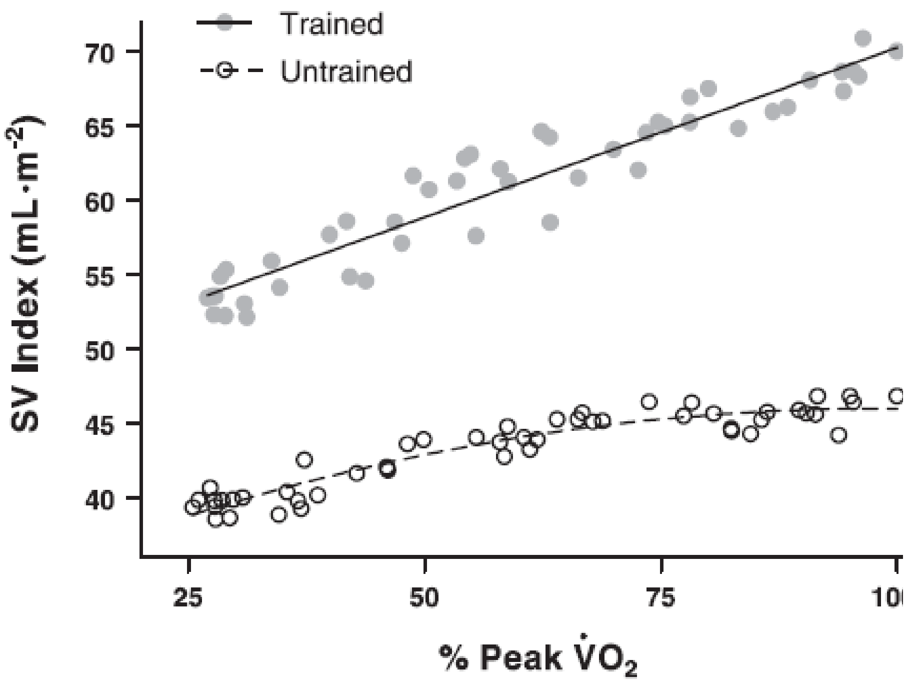
	Maximal	
	Untrained	Cyclists
$\dot{V}O_2$ (mL min^{-1} kg^{-1})	45.9 ± 6.7	58.5 ± 4.4***
Heart rate (beat min^{-1})	191 ± 9	195 ± 7
Stroke index (mL m^{-2})	56 ± 5	63 ± 5**
Cardiac index (L m^{-2})	10.6 ± 0.8**	12.2 ± 1.0
Arterio-venous difference (mL 100 mL^{-1})	13.4 ± 1.2	14.0 ± 1.5
Left ventricular end-diastolic diameter (mm BSA$^{-0.5}$)	33.5 ± 2.9	37.6 ± 4.0*
Left ventricular end-systolic diameter (mm BSA$^{-0.5}$)	16.2 ± 2.0	19.6 ± 3.2**
Shortening fraction (%)	51.3 ± 6.4	48.0 ± 5.8
Systolic time (ms)	134 ± 12	131 ± 8
Diastolic time (ms)	195 ± 13	181 ± 11
Systolic arterial pressure (mmHg)	153 ± 17	153 ± 16
Diastolic arterial pressure (mmHg)	68 ± 10	71 ± 8
Systemic vascular resistance (AU)	6.7 ± 1.1	6.8 ± 1.1



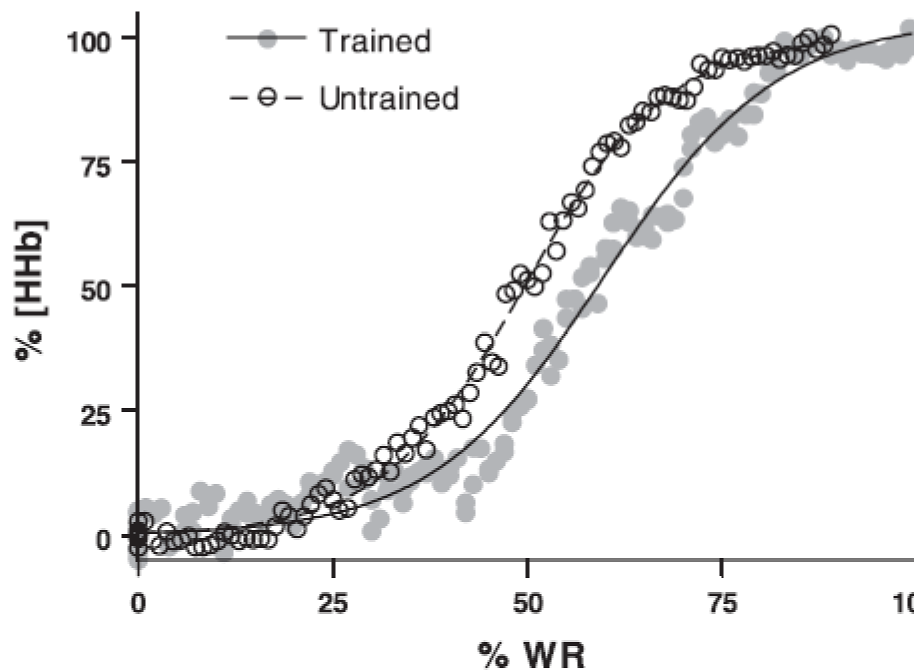
Nottin et al. (2002). *Acta Physiol Scand*. 175: 85-92.

Augmented SV and muscle O_2 extraction patterns in trained youth

Stroke volume



Deoxy Hb+Mb

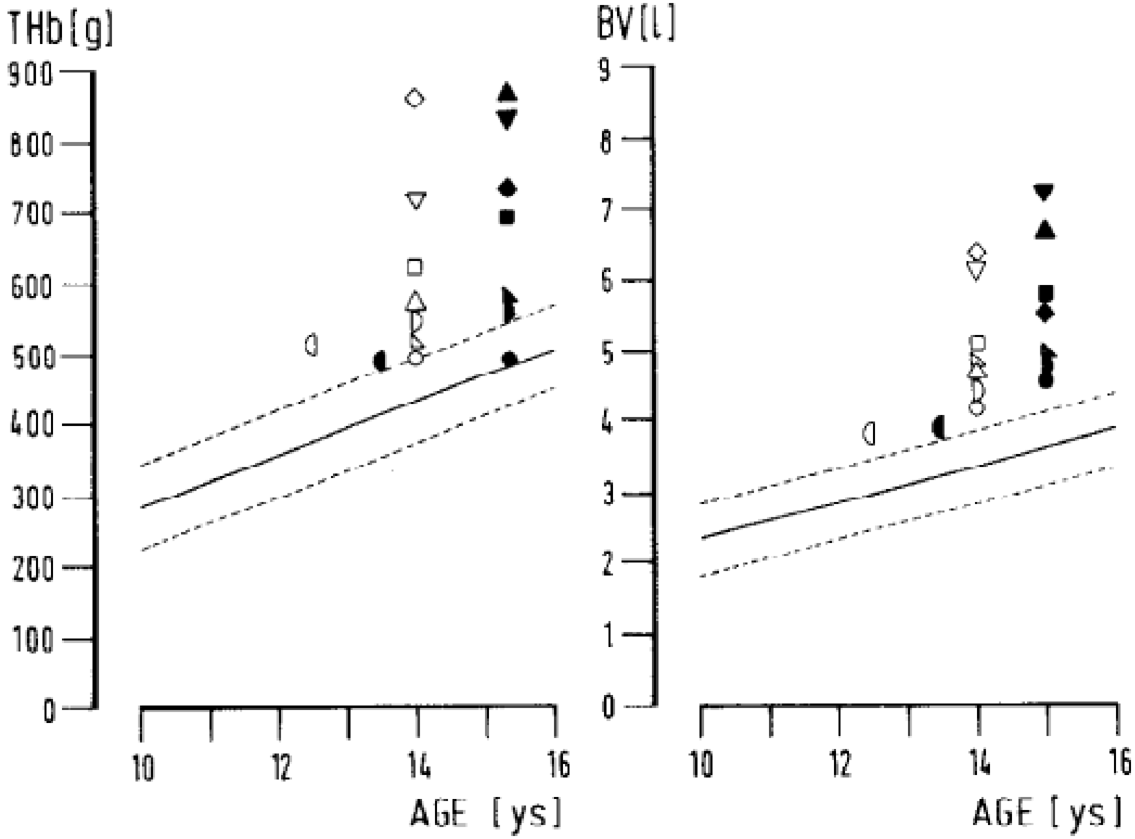


McNarry *et al.* (2011). *J Appl Physiol*. 110:375-381

Blood O_2 carrying capacity and volume

Eight well-trained boys

VO_2 peak = 59.6 ± 6.5 ml/kg/min



Koch and Rocker (1977). *J Appl Physiol*. 43: 1085-1088

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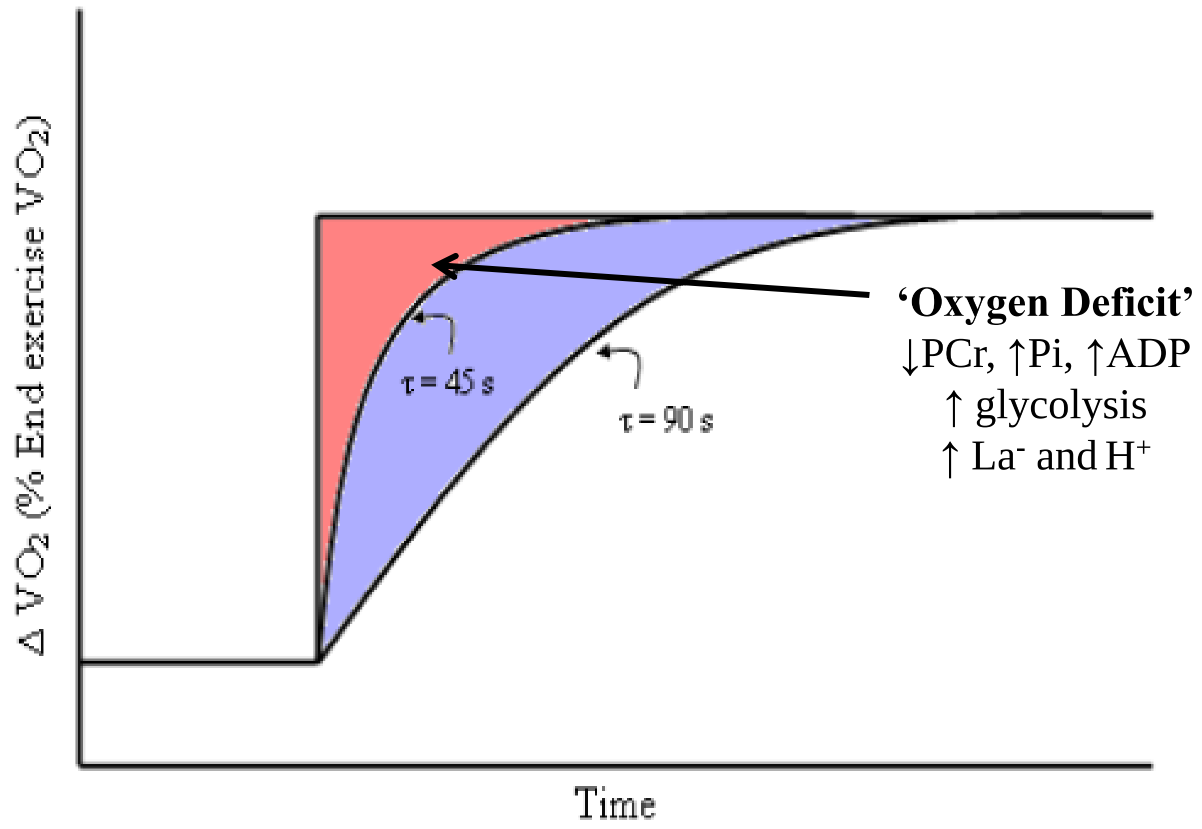
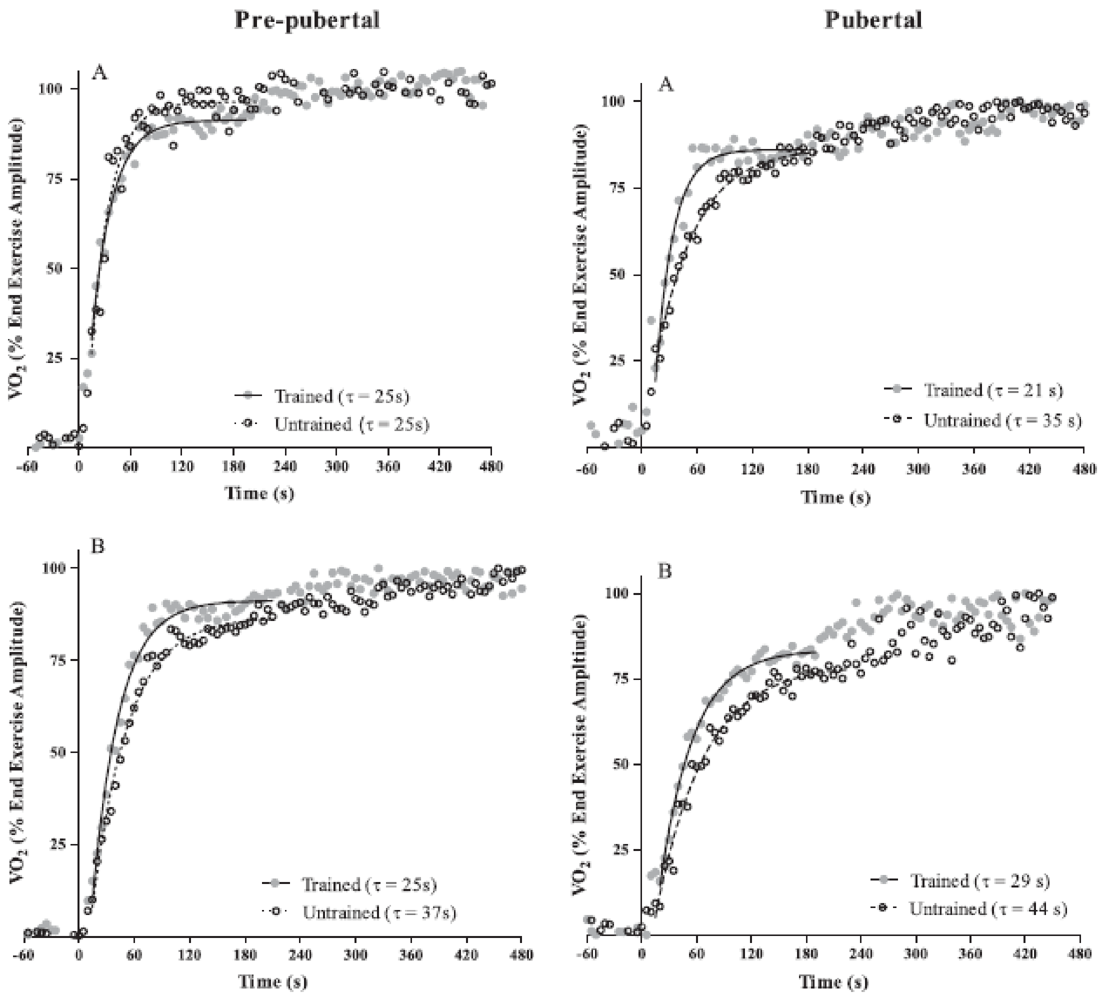
Trained status and O_2 uptake kinetics

- Successful sports performance requires rapid changes in energy demand to be achieved aerobically preventing the premature depletion of finite anaerobic energy stores

O_2 uptake kinetics and the O_2 deficit

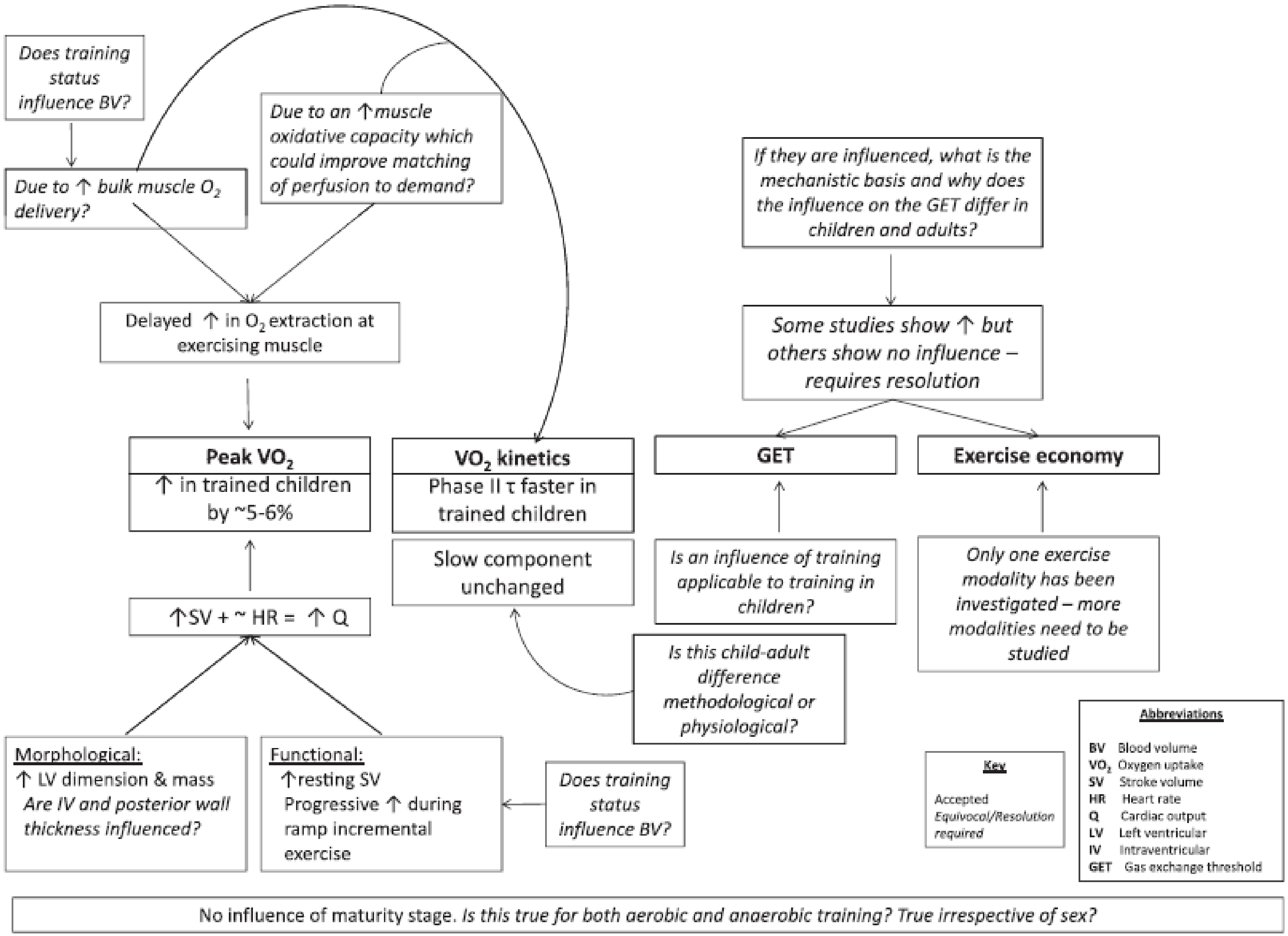


Can VO_2 kinetics be trained in youth?



Winlove et al. (2010). *Eur J Appl Physiol*. 108: 1169-1179
McNarry et al. (2011). *Eur J Appl Physiol*. 111: 621-631

Physiological adaptations summary



McNarry and Jones (in press). *Eur J Sport Sci*.

Review of endurance training interventions

Criteria for inclusion:

- Published in peer-reviewed literature
- Participants are 'normal' and healthy
- Aged between 8.0 to 17.9 y
- Included a control and experimental group
- Used appropriate statistical analysis techniques
- Provide a clear training prescription
- Directly determined VO_2 peak

69 studies were located but only 21 satisfied the criteria
Studies reported as two groups: 8.0-10.9 y and 11.0-17.9 y

Armstrong and Barker (2011). *Med Sport Sci*. 56: 59-83

Methodological considerations

- Participants are not randomly allocated
- Sample sizes are small and often uneven
  - EXP: 8-37, mean = 15; CON: 7-37, mean = 12
- Drop-out rates and training adherence is poorly reported
- Testing and training specificity is generally high although exceptions are evident
- Heart rate is used to quantify training intensity
  - All participants, random selection, self-report, none

Armstrong and Barker (2011). *Med Sport Sci*. 56: 59-83

Key findings

8.0-10.9 y

- 9/14 (64%) studies reported a significant increase in VO_2peak (mean = 6.7%)
  - 7.7% if only considering the successful studies
- Nine studies confirmed participants were pre-pubertal
- No sex differences evident

11.0-17.9 y

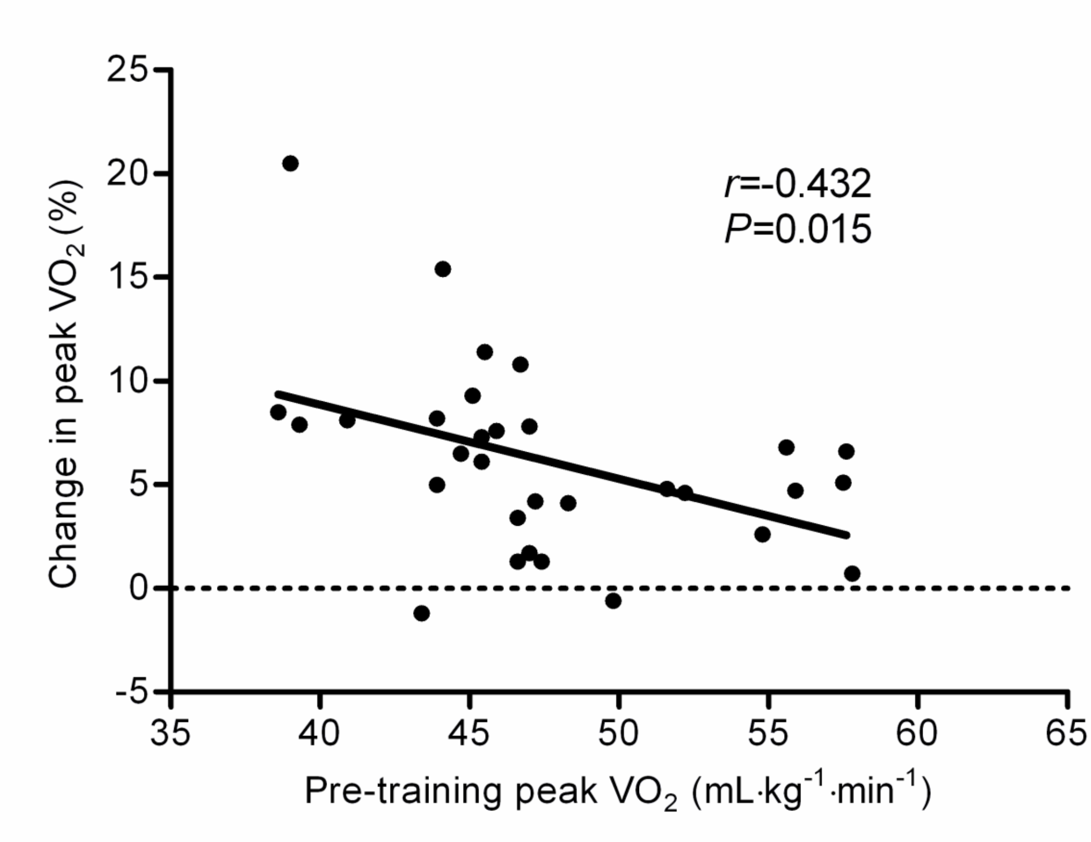
- 4/7 (57%) studies reported a significant increase in VO_2peak (mean = 5.5%)
  - 8.6% if only considering the successful studies
- Only a single well-controlled study is available > 14 y (9.3% improvement)
- No sex differences evident

Armstrong and Barker (2011). *Med Sport Sci*. 56: 59-83

Do children have a dampened aerobic trainability?

- Does their high initial fitness reduce the scope for improvement?
- Does their higher level of habitual physical activity reduce the scope for improvement?
- Is a maturational 'trigger' needed to promote improvements?
- Do they require a different training stimulus compared to that normally recommended for adults?

Does baseline fitness matter?



Confirmed in original investigations Mandigout et al. (2001). *Acta Paediat* and Tolfrey et al. (1998). *Pedaitr Exe Sci*.

Armstrong and Barker (2011). *Med Sport Sci*. 56: 59-83

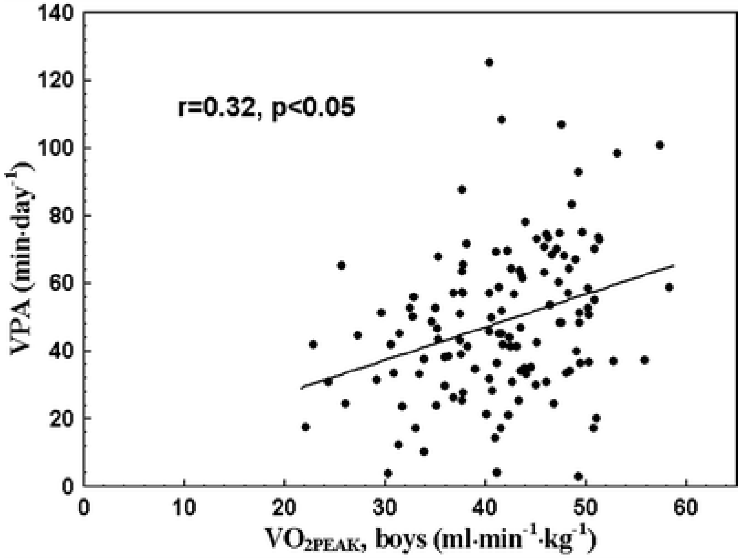
Are children too active to improve their fitness?

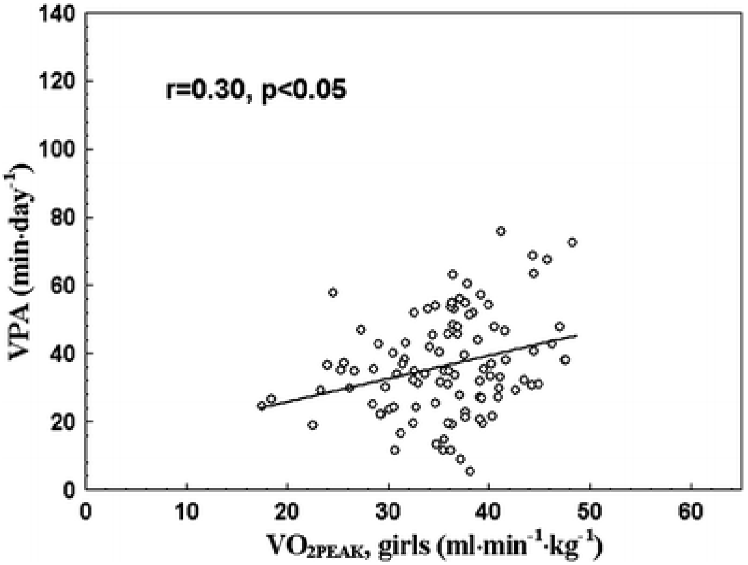
Dencker et al. (2006). *Eur J Appl Physiol.* 96: 587-592

140 boys and 108 girls aged 8-11 y

Vigorous PA and peak VO_2 significantly correlated in boys and girls (~ 9% variance)

Tolfrey et al. (1998) found no relationship between initial physical activity level and the improvement in VO_2 peak over a 12 week training programme in prepubertal children



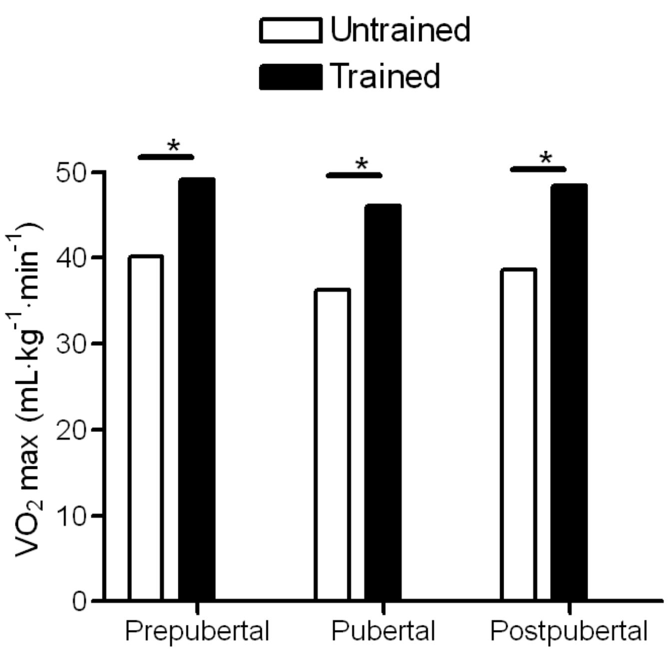


The "trigger hypothesis": is there a golden period?

Weber et al. (1976). *J Appl Physiol.*

12 pairs of *mz* twins completed a 10 wk endurance training

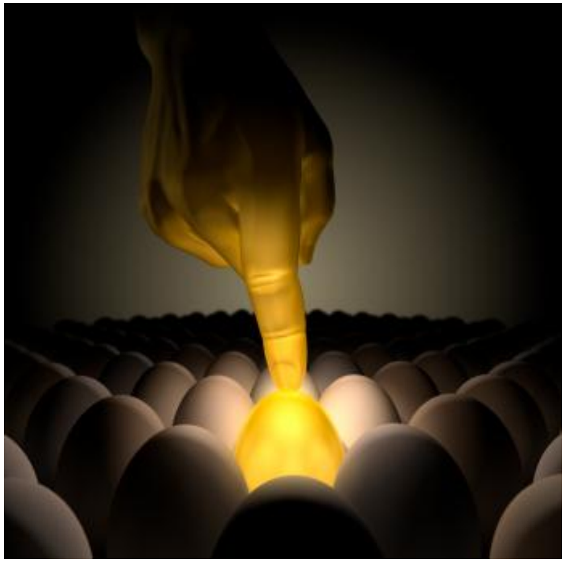
McNarry *et al.* (2011). *J Appl Physiol*



No interaction between training status and maturity group found

The "trigger hypothesis": evidence from review articles

- Armstrong and Barker (2011)
  - 8-10.9 y = 6.7% (n=14)
  - 11-17.9 y = 5.5% (n=7)



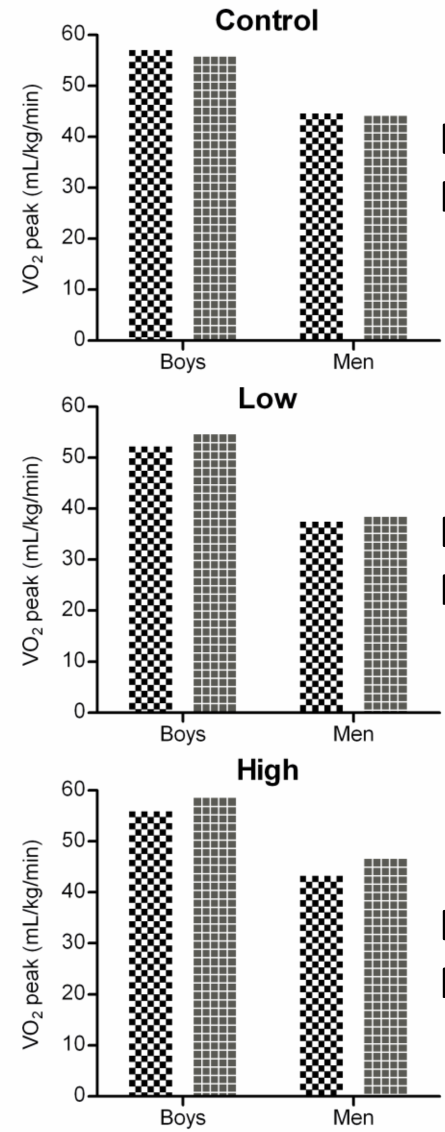
- Baquet *et al.* (2003)
  - Prepubertal boys = 6.1% (n=11)
  - Prepubertal girls = 6.9 % (n=7)
  - Circumpubertal boys = 7.6% (n=1)
  - Circumpubertal girls = -1.5% (n=1)

Are children less trainable than adults?

Prepubertal boys and men were assigned to a high, low or control training group:

- High = 85% HRmax
- Low = 68% HRmax

Training occurred 3 times/wk for 10 wk and ranged from 2.4-4.8 km



B:-2.3%
M:-1.1%

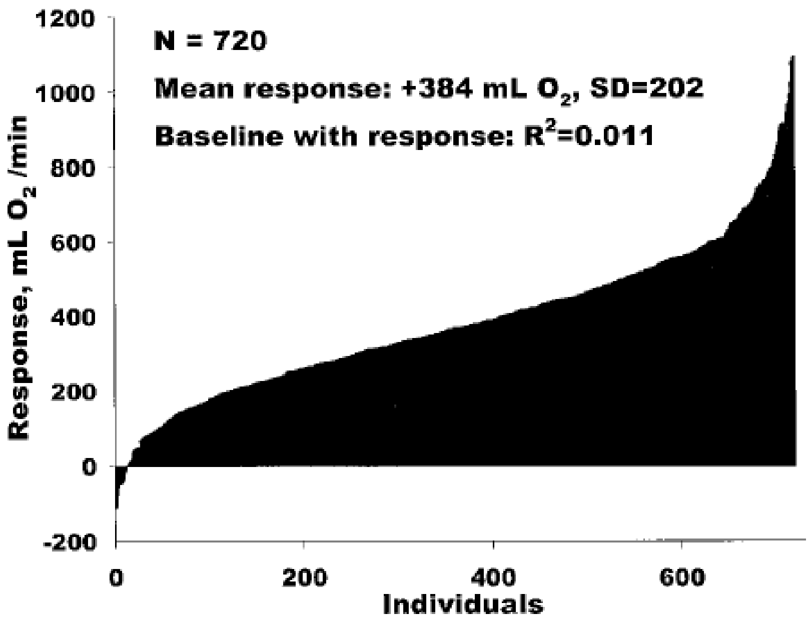
B: +4.3%
M:-2.7%

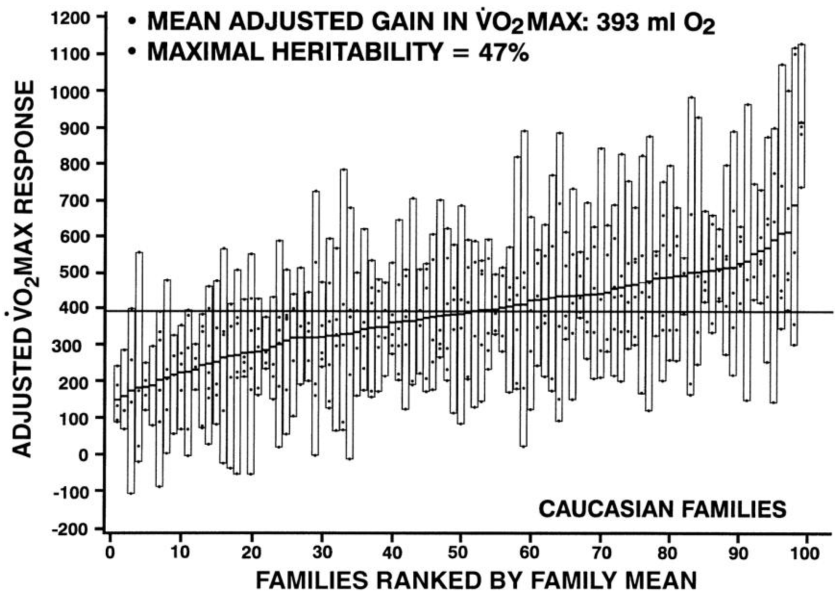
B:+4.7%
M:+7.8%

Savage et al. (1986). *Med Sci Sport Exe*. 18: 197-204

Large inter-individual differences exist for aerobic trainability

Data from Williams et al. (2000) noted a 7.2 and 3.8% improvement in peak VO_2 following 8 weeks of continuous cycling or sprint running respectively. However, the range varied from -9.8 to 25.3% and -6.1 to 16.4% for cycling and running.





Teran-Garcia et al. (2008). *J Appl Physiol*. 105: 988-1001

Training design

- Mode
  - Improvements can be seen with cycling, running, circuit training, swimming and resistance exercise

- Frequency and duration
  - Most studies show 3-4 session/wk (range 1-5) with a 30-45 min duration will elicit a ~ 5-6% improvement
  - Few studies suggest 2-3 sessions/wk < 30 min in duration can be beneficial (~8-10%) providing intensity is high (> 80-95% HRmax)

Training design

- Intensity
  - 80% of studies with an intensity > 80% HRmax show improvements
  - Only two studies have specifically addressed exercise intensity but did not work match the conditions
- Length of programme
  - No clear consensus with studies ranging from 6 to 52 weeks
  - Frequency, duration and intensity appear more important

Training design

- Continuous exercise
  - 15-40 min of continuous exercise at ~ 80% HRmax
- Interval exercise
  - 30-60 min of interval runs at 80-95% HRmax
  - Sets of ~ 1-3 min exercise with recovery time
  - Limited evidence suggests sets of 'all-out' sprints of 10-30 s may be highly effective
- Mixed continuous and interval exercise show positive adaptations

Training design summary

- Mode: Continuous or interval training using large muscle groups
- Frequency: Minimum of 3-4 sessions per week
- Duration and intensity
  - 40-60 min at 80-85% HRmax for continuous training
  - 30-60 min at > 90% HR max using training intervals of 1-3 min duration with appropriate recovery
  - < 30 min of ‘all-out’ sprints using training intervals of < 30 s duration with appropriate recovery
- Length: Above 12 weeks

IOC consensus statement (2008). *Br J Sports Med*. 42: 163-164
Armstrong and Barker (2011). *Med Sport Sci*. 56: 59-83

Conclusions

- There are few well-controlled training studies on elite young athletes with holistic aerobic endurance outcomes
- Aerobic fitness is trainable in young people:

  Peak O_2 uptake ✓
  O_2 uptake kinetics ?
  Lactate markers ?
  Exercise economy ?

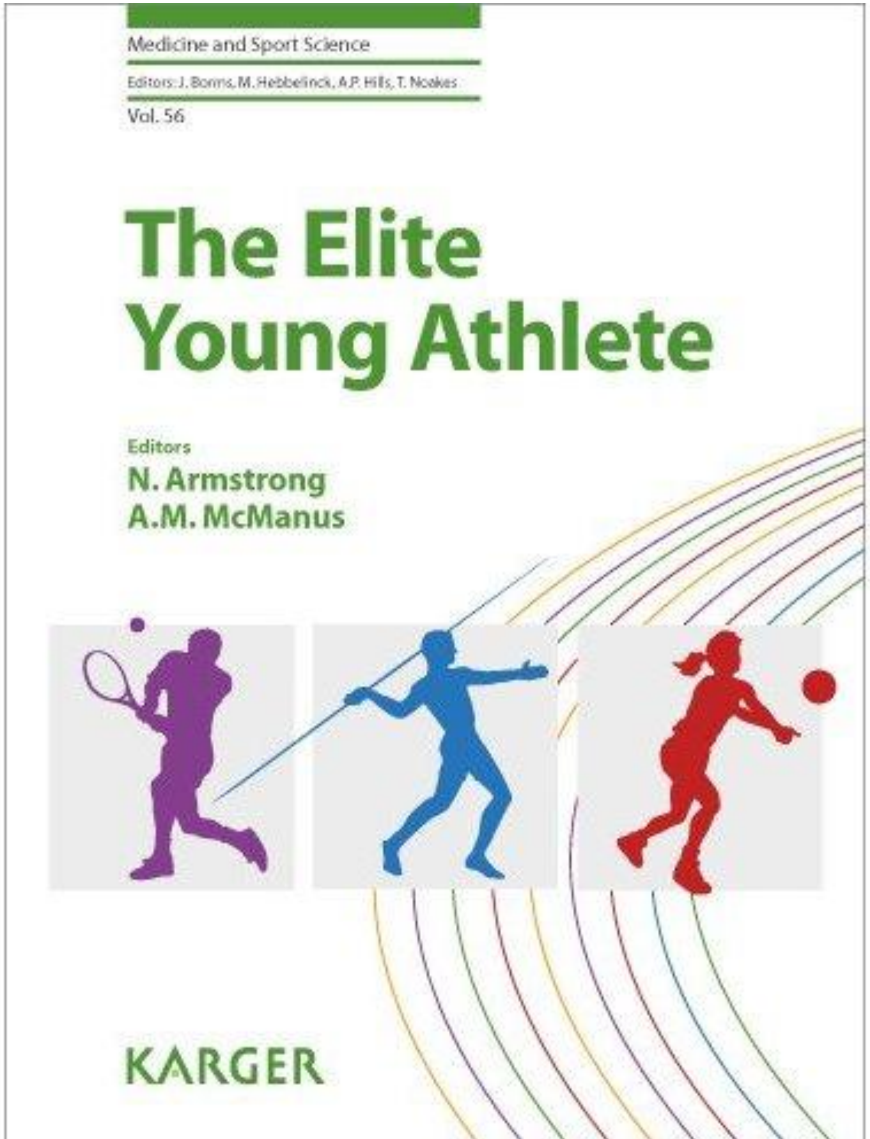
- Prescribing a training intensity above 80%HRmax appears the critical factor to elicit positive adaptations
- A maturity trigger threshold has yet to be proven but improvements may be blunted in those with a high baseline aerobic fitness

Sport should be pleasurable and fulfilling

Sport must focus on promoting the health and well-being of young people

<u>NOT</u>

Young people promoting the health and well-being of sport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