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Physiology of training and workouts

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2012 ASCTA Convention
Broadbeach, QLD

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Outline

- Long-term swimmer development models
- Physiological models of exercise performance

Coach's and Scientist's Perspective

- Effective Planning
- Good Organisation
- Preparation Phase
- Endurance Phase
- Tapering
- Competition
- Recovery

- Energy Systems
- Physiological Models – A Contemporary Approach
- Periodisation and Conditioning
  - Periodisation
  - Macrocycle
  - Microcycle

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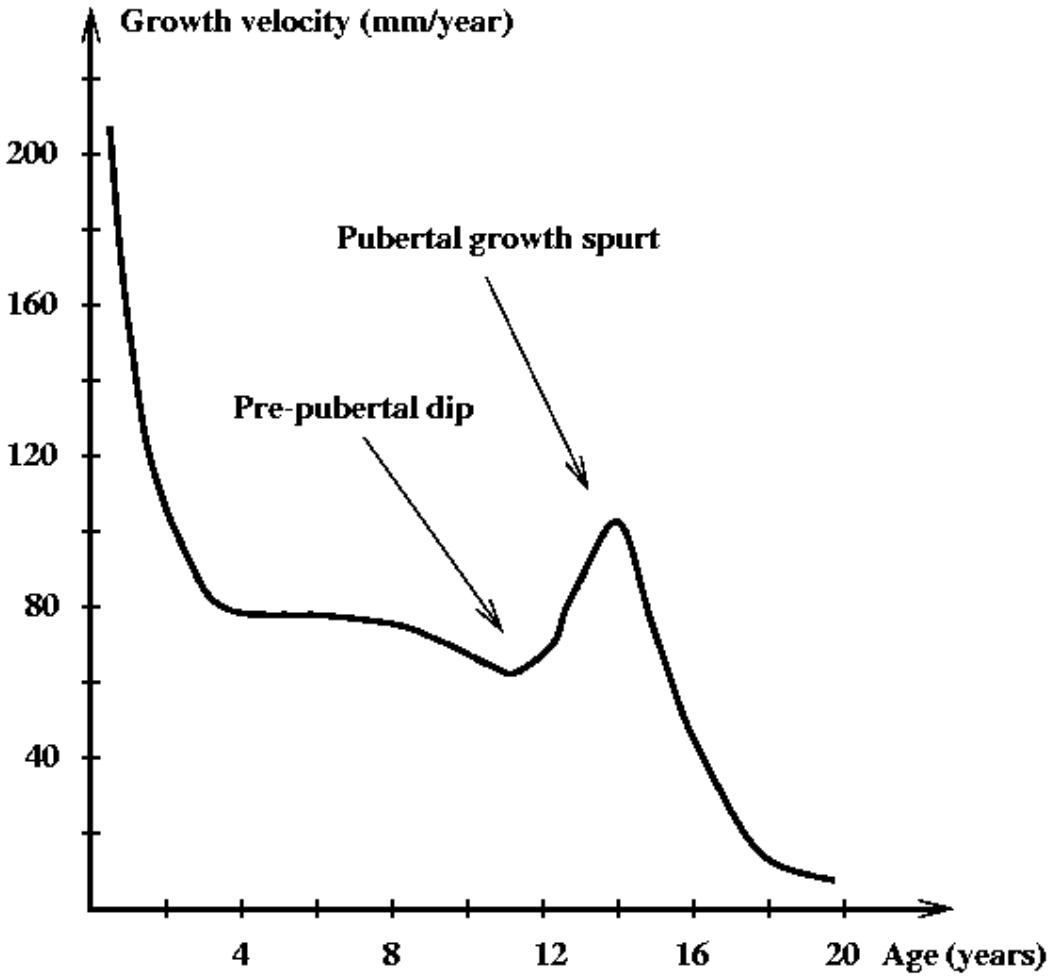
Human growth curve



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Evidence-Based Research

Level I: At least one properly designed randomised controlled trial.

Level II-1: Well-designed controlled trials without randomization.

Level II-2: Well-designed cohort or case-control analytic studies.

Level II-3: Multiple time series with or without the intervention.

Level III: Opinions of respected authorities, based on clinical experience, descriptive studies, or expert committees.

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Long-term swimmer development models

- *Traditional Model of Athlete Development*
- Carlile*, Carlile on Swimming (AUS, 1963)*
- Bompa, *Periodisation of Training* (Canada, 1970's -)
- Counsilman, *Residual Effects of Training* (USA, 1991)
- Balyi, *Long-term Athlete Development Model* (Canada, 1990's)
- Richards, *Multi-year Age-group Swimmer Development Model* (AUS, 2000's)
- Issurin, *New Horizons for Training Periodization* (Israel, 2010)

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Traditional pyramid model of sports development

(adapted from Tinning, Kirk and Evans, 1993)

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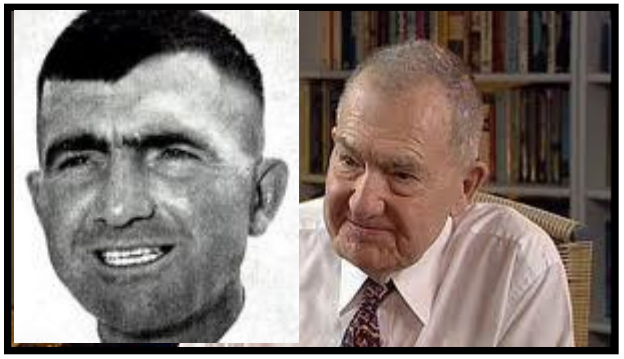
Forbes Carlile



- 'Carlile on Swimming' (1963)
- Philosphy of speed through endurance.
- Pioneered interval training and tapering.
- Heart rate monitoring, log books, blood tests, two- and four-beat kicking.
- Lane ropes, pace clock, nutrition, recovery, drugs in sport, swimsuits.
- *"Used his skills, experiences and opportunities to improve the lives of swimmers and swimming coaches around the world".*

http://www.amazon.co.uk/FORBES-CARLILE-SWIMMING-Forbes-Carlile/dp/B000LRA2CS

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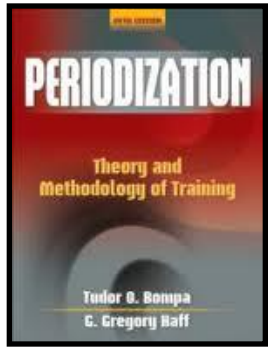
Tudor Bompa

Bompa (1996) identified a two phase long term-periodization model, including the generalized (6 to 14 years) and specialized (15 + years) phases.

'Theory and Methodology of Training'

Each phase is broken down into two stages.

- Generalized phase comprising the initiation stage (6 to 10 years) and the athletic formation stage (11 to 14 years).
- Specialized phase are referred to as specialization (15 to 18 years) and high performance (19+ years) stages.



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James 'Doc' Counsilman
Residual effects of training (USA, 1991)

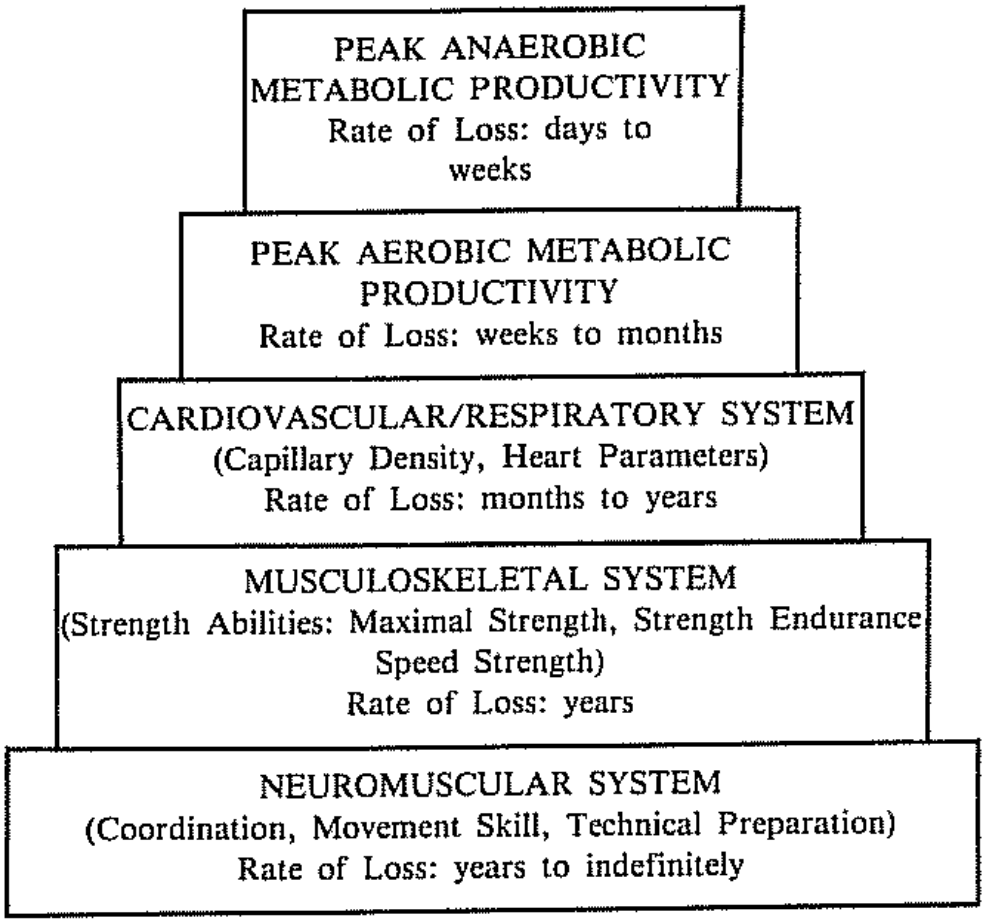

Figure 1. Model depiciting theoretical magnitude of training residuals for different physical systems and their rate of loss.

James 'Doc' Counsilman

'Science of Swimming' (1968)

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Counsilman, Residual effects of training (USA, 1991)

Factor	Influence
Duration before cessation	Longer training longer residuals
Load before cessation	Highly concentrated shorter residuals than complex-multi component
Age and duration of career	Older experienced athletes longer residuals
Training after concentrated training	Stimulation prolongs residuals prevents detraining
Biological nature of abilities	Strength & aerobic longer residuals; anaerobic shorter residuals

James 'Doc' Counsilman

Counsilman,J. and B.Counsilman (1991). *J. Swimming Research 7(1):5-12.*

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Long-term athlete development stages

Early Specialisation	Late Specialisation
FUNdamental	FUNdamental
Training to Train	Learning to Train
Training to Compete	Training to Train
Training to Win	Training to Compete
Retaining	Training to Win
	Retaining

Istvan Balyi

Balyi, I., and Hamilton, A. Key to Success: Long-term Athlete Development. Sport Coach, Canberra, Australia. Vol.23. No.1. Autumn 2000. pp. 30-32.

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Learning and training to train

Learning to Train

- Boys aged 9–12 and girls aged 8–11 y.
- Learn all fundamental sports skills.
- Further develop movement skills, strength and endurance
- Learn general sports skills
- Introduce basic flexibility exercises
- Agility, quickness and change of direction
- Warm-up, cool-down, stretching, hydration, nutrition and recovery
- Ratio of 70:30 training/competition

Training to Train

- Boys aged 12–16 and girls aged 11–15 y.
- Aerobic conditioning and fundamental movement skills.
- Further develop speed and sport-specific skills
- Learn correct weightlifting techniques
- Dryland work, optimise nutrition and hydration; mental preparation; how and when to taper and peak
- Establish training and competition routines
- 60% training to 40% competition ratio

Balyi, I., and Hamilton, A. Key to Success: Long-term Athlete Development. Sport Coach, Canberra, Australia. Vol.23. No.1. Autumn 2000. pp. 30-32.

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Learning and training to win

Learning to Win

- Boys aged 16–18 and girls aged 15–17 y.
- Optimise fitness preparation, sport/event-specific skills and performance.
- 50% technical, tactical skills, fitness
- 50% competition-specific training
- Learn under different conditions
- Competition modelling
- Individual fitness and recovery programmes
- Psychological preparation

Training to Win

- 17+ yr (females)/18+ yr (males)
- Assumes all relevant capacities have been developed
- Focus of selected competitive events
- Planned rest breaks to avoid burnout and injury
- Increase in sport-specific training loads
- Multi-periodisation approach developed.

Balyi, I., and Hamilton, A. Key to Success: Long-term Athlete Development. Sport Coach, Canberra, Australia. Vol.23. No.1. Autumn 2000. pp. 30-32.

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Ralph Richards Multi-Year Age-Group Swimmer Development Model


Ralph Richards

PHYSICAL DEVELOPMENT

- Aerobic system develops most rapidly <12 yr
- <16 yr biological development whereas success at the senior elite level is the result of many factors
- late maturers tend to stay in the sport longer
- sporting preparation that coincide with developmental stages will result in better long-term improvements
- endurance-based training may be the single most important component of success
- capacities for effort and physical & psychological recovery must be developed concurrently for long-term success
- physical preparation is a major prerequisite for skill development

Ralph Richards Multi-Year Age-Group Swimmer Development Model

Age	8 ± 1 yr		10 ± 2 yr		Girls 12 ± 1, Boys 13 ± 1 yr		14 ± 2 yr	
Training period	2 yr		2 yr		2-3 yr		3 – 5 yr	
Pool Land	2-4 sessions, 40-60 min 1-2 sessions, 15-25 min		3-5 sessions, 60-75 min 2 sessions, 20-30 min		4-6 sessions, 75-90 min 2-3 sessions, 30-45 min		6-10 sessions, 90-120 min 2-3 sessions, 45-60 min	
Volume / Session	0.75 - 2 km		2 - 3.5 km		3.5 - 6 km		4 – 8 km	
Yearly Training	24 - 30 weeks		30 - 36 weeks		36 - 44 weeks		40 - 46 weeks	
Volume (Pool)	75 -250 km		250-500 km		500-1000 km		1000-2500 km	
Technique and Strength Objectives	**Technique** all strokes Racing skills – starts, turns, pace Aerobic endurance Speed at 25-50m Simple training sets and games	**Strength** Movement coordination Group activities	**Technique** Racing skills Aerobic Activities Speed <50m Acceleration Greater mix of training methods	**Strength** Increase strength to body mass ratio Even development of muscle groups Core strength	**Technique** Increase training Volume Racing skills Speed (<50m) Acceleration Interval training	**Strength** Musculo-skeletal assessment Body weight exercises Simple gym Flexibility Body strength	**Technique** Increase volume and intensity of training Integrated model Specialisation Perfect technique and skills	**Strength** Periodize strength Transfer power into swimming Cross-training Maintain flexibility

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Issurin, New horizons for training periodization (Israel, 2010)

Component	Content
Multi-year preparation	Long-lasting systematic athlete training composed of 2 and 4 yr cycles
Macrocyle (months)	Large size training cycle (annual) with preparatory, competition and transition periods
Mesocycle (weeks)	Medium size training cycle consisting of a number of microcycles
Microcycles (days)	Small cycle typically 1 week
Workout (h/min)	Single session

Vladimir Issurin

- History of periodization
- Principles of periodization
- Major limitations of traditional model
- Alternative models of periodization
- Linear and non-linear periodization
- Block periodization

Sports Med. 2010, 40(3):189-206.

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Physiological Models of Exercise Performance

- Three energy systems model (various, 1970-1990's)
- Training for capacity or power/utilization (Olbrecht, Rushton, 1990's -)
- Noakes, Physiological systems model (South Africa, 2000)
- Noakes, Central Governor model (South Africa, 2004-)
- Smith, Framework for understanding training (Canada, 2003)
- Paton and Hopkins, Interval training (New Zealand, 2004)
- Seiler, Best practice for training intensity and distribution (Norway, 2010).

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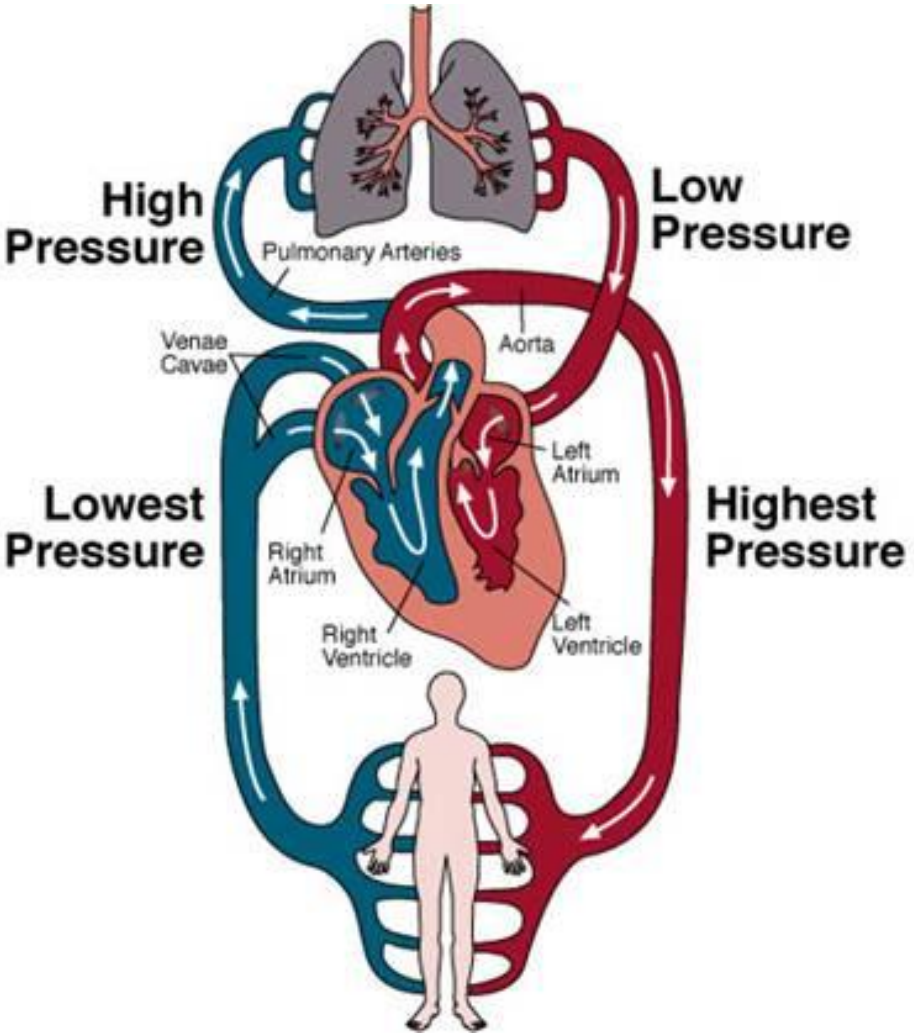
Three energy systems model
Physiological systems

- Musculo-skeletal
- Neuro-muscular
- Cardio-respiratory
- Gastrointestinal
- Immune
- Endocrine
- Biochemical



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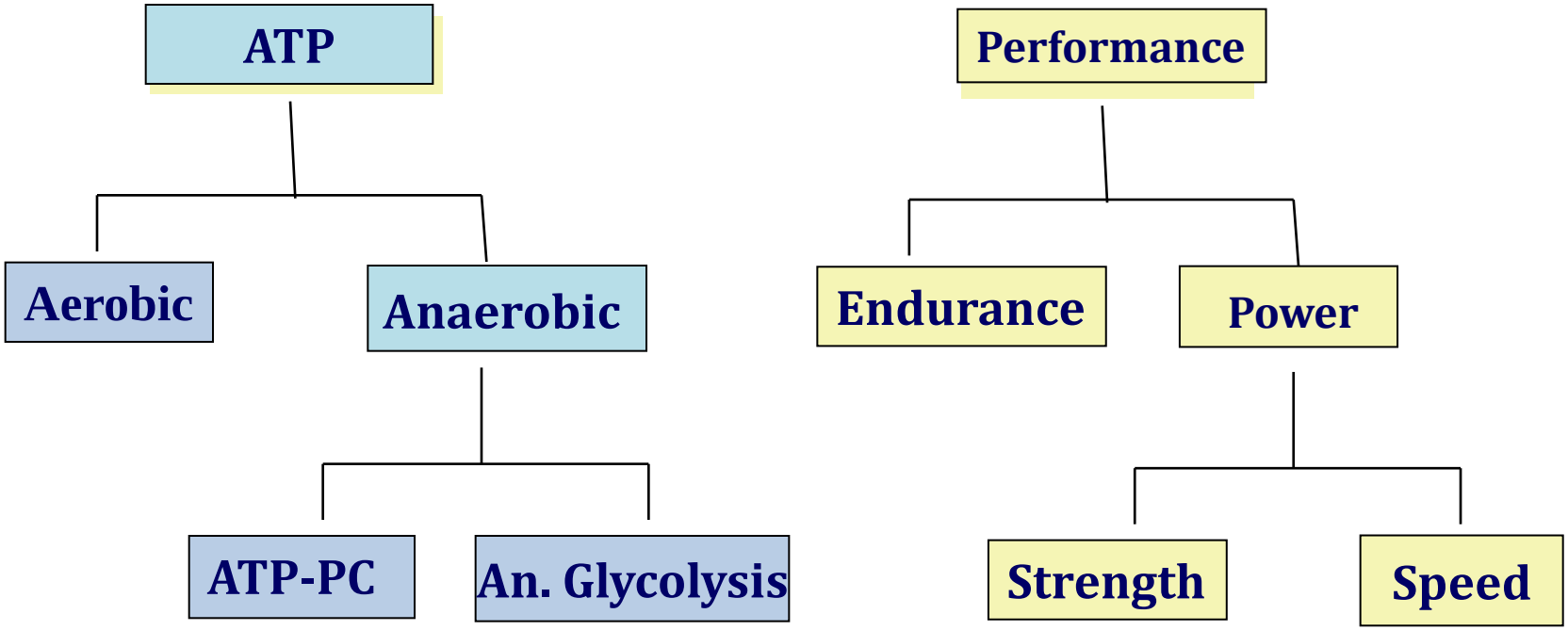
Three Energy System Model (various 1970-1990's)



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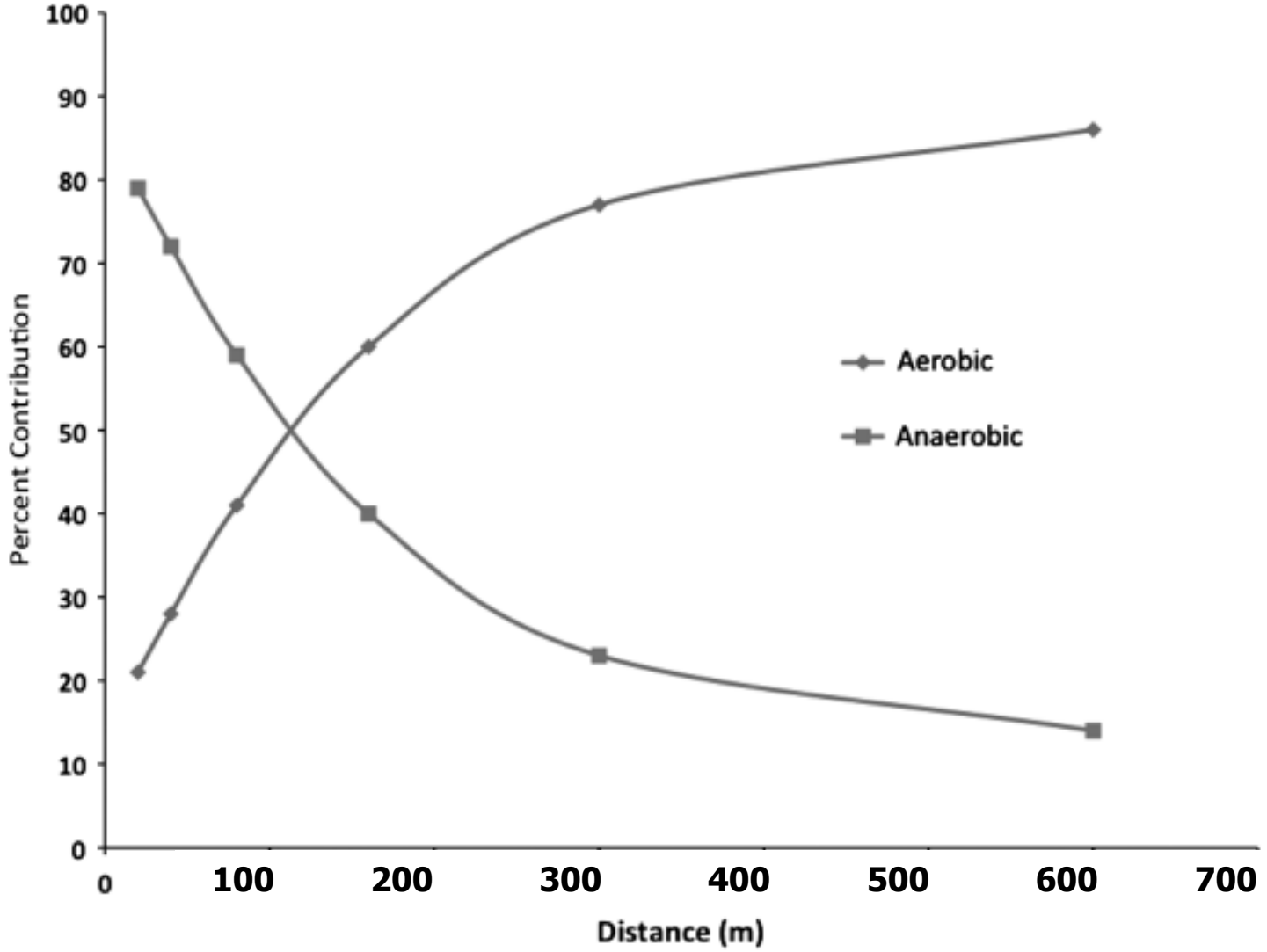
Aerobic-anaerobic contribution in swimming



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Training for capacity or power/utilisation

Jan Clive Bob

- Olbrecht (2002) 'The Science of Winning'
- Rushton (2012) http://www.smashwords.com/extreader/read/146070/1/selected-works-a-thimble-half-full-and-other-thoughts-on-swimming
- Bowman (2011 ASCA) 'Training for Capacity or Utilization.'
  - '**capacity**' training develops how good the swimmer can be , 'building the inventory', 'operates within the swimmer's capability', long-term,
  - '**utilization**' training develops how good they are now, selling inventory, getting sales, and getting them NOW!, operates at the edge the swimmer's capability, short-term.
  - **"utilization sacrifices potential for actual:**
- Rushton "make sure your cup is as big as possible and full to the brim. That way, when it's time to do the sharpening/utilization/power training, you have sufficient reserves of capacity to fuel your endeavour and enough left over to lay the foundations for the next seasonal thrust."

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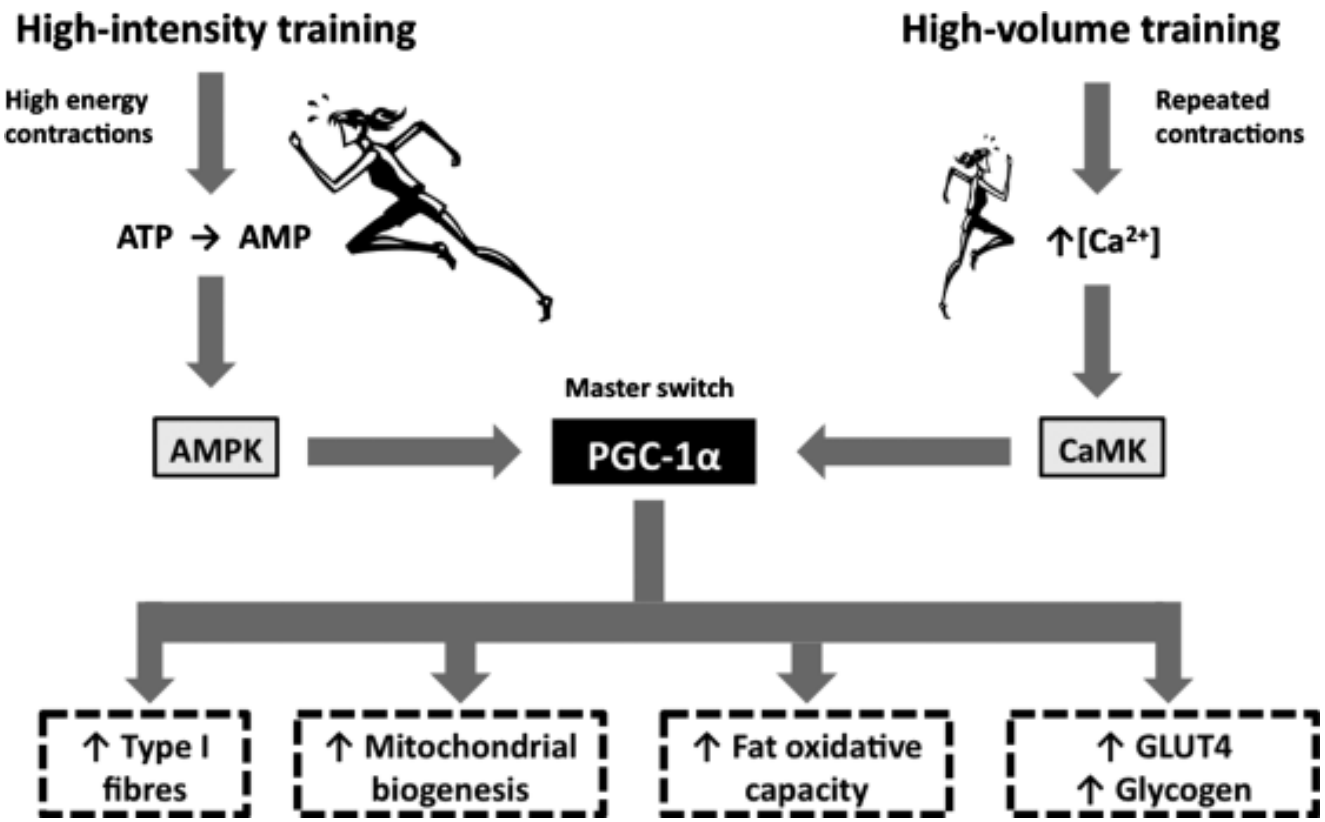
Biochemical model



Paul Laursen

Simplified model of the adenosine monophosphate kinase (AMPK) and calcium–calmodulin kinase (CaMK) signaling pathways, as well as their similar downstream target, the peroxisome proliferator-activated receptor-g coactivator-1a (PGC-1a). This ''master switch'' is thought to be involved in promoting the development of the aerobic muscle phenotype. High- intensity training appears more likely to signal via the AMPK pathway, while high-volume training appears more likely to operate through the CaMK pathway. ATP, adenosine triphosphate; AMP, adenosine monophosphate; GLUT4, glucose transporter 4; [Ca_{21}], intramuscular calcium concentration.

Laursen, Scand. J. Sci. Med. Sport, 2010.

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Noakes, Physiological systems model (South Africa, 2000)

Tim Noakes

- The cardiovascular / anaerobic model
- The energy supply / energy depletion model
- The muscle recruitment (central fatigue) / muscle power model
- The biomechanical model
- The psychological model

Scand J Med Sci Sports. 2000 Jun;10(3):123-45.

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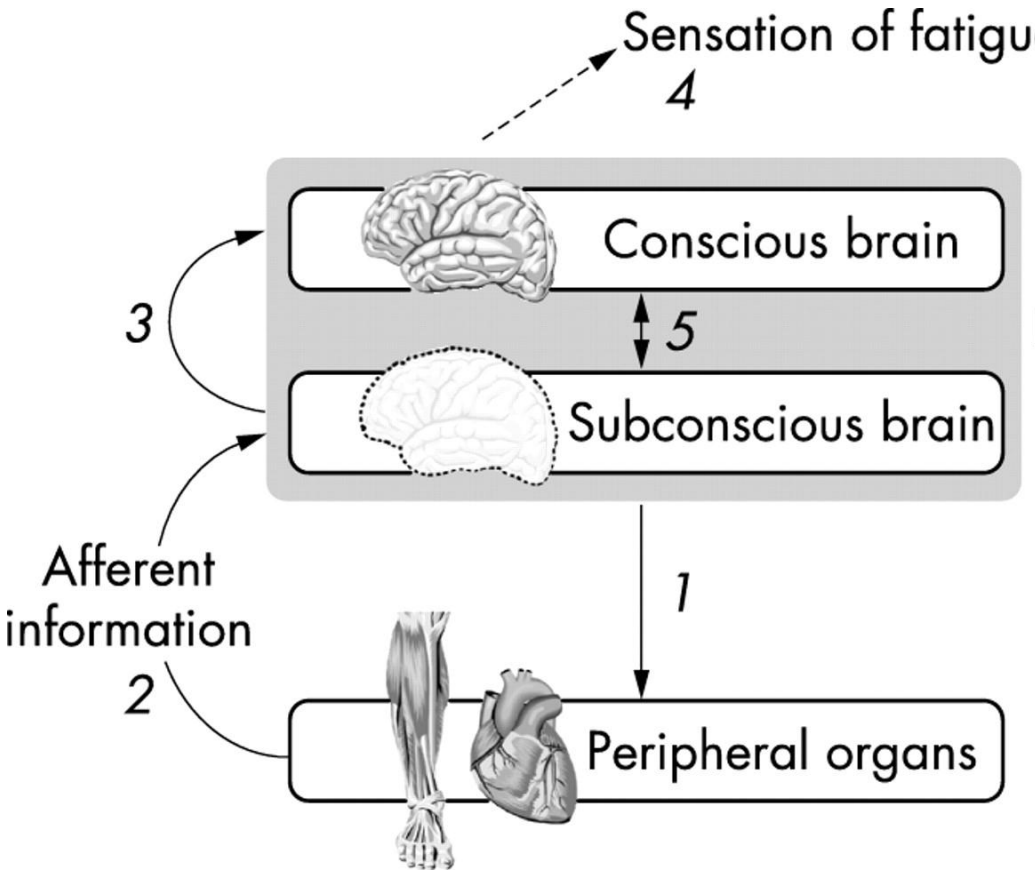
Noakes, Central Governor model (South Africa, 2004-)



"Activity is controlled as part of a pacing strategy involving active neural calculations in a "governor" region of the brain, which integrates internal sensory signals and information from the environment to produce a homoeostatically acceptable exercise intensity. A complex, non-linear, dynamic system in which physiological systems interact to regulate activity."

Noakes and St Clair Gibson, Br J Sports Med 2004;38:797-806

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Smith, Framework for understanding training (Canada, 2003)

Dave Smith

Athletic Performance				
Physiology	Biomechanics	Psychology	Tactics	Health
poor- optimal ⟷	poor- optimal ⟷	poor- optimal ⟷	poor- optimal ⟷	poor- optimal ⟷
• Volume • Intensity • Recovery • Weight training • Body composition	• Technique • Repetition ability • Equipment	• Emotional stability • Confidence • Discipline • Cognitive stress • Social	• Competition analysis	• Health • Sickness • Fatigue • Work • School • Finances

Sports Med. 2003;33(15):1103-26.

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Paton and Hopkins, Interval training (New Zealand, 2004)

Will Hopkins

- Meta-analysis of 22 high-intensity training studies
- Intervals (supramaximal, maximal, submaximal)
- Resistance (explosive, plyometrics, weights)

- **Conclusion:** Shorter events improved most by supramaximal intervals (~4%) and explosive sports-specific resistance training (4-8%).
- **Conclusion:** Longer events improved most by maximal and supramaximal intervals (~6%) while resistance training had smaller effects (~2%)

- **Recommendation:** Add explosive resistance and high-intensity interval training to generally low-intensity training program.

Sportscience 8, 25-40, 2004.

Seiler, Best practice for training intensity and distribution (Norway, 2010)

Stephen Seiler

- Elite athletes typically undertake 10-13 sessions/wk with 80% training at low intensity and 20% high intensity intervals.
- Self-organize toward a high-volume training with careful application of high-intensity training
- Training studies are not definitive but 80/20 model gives good results
- Both low and high intensity training generate overlapping physiological profiles i.e. complementary in nature
- Endurance base a pre-condition for high intensity intervals

Int J Sports Physiol Perform 2010, 5:276-291.

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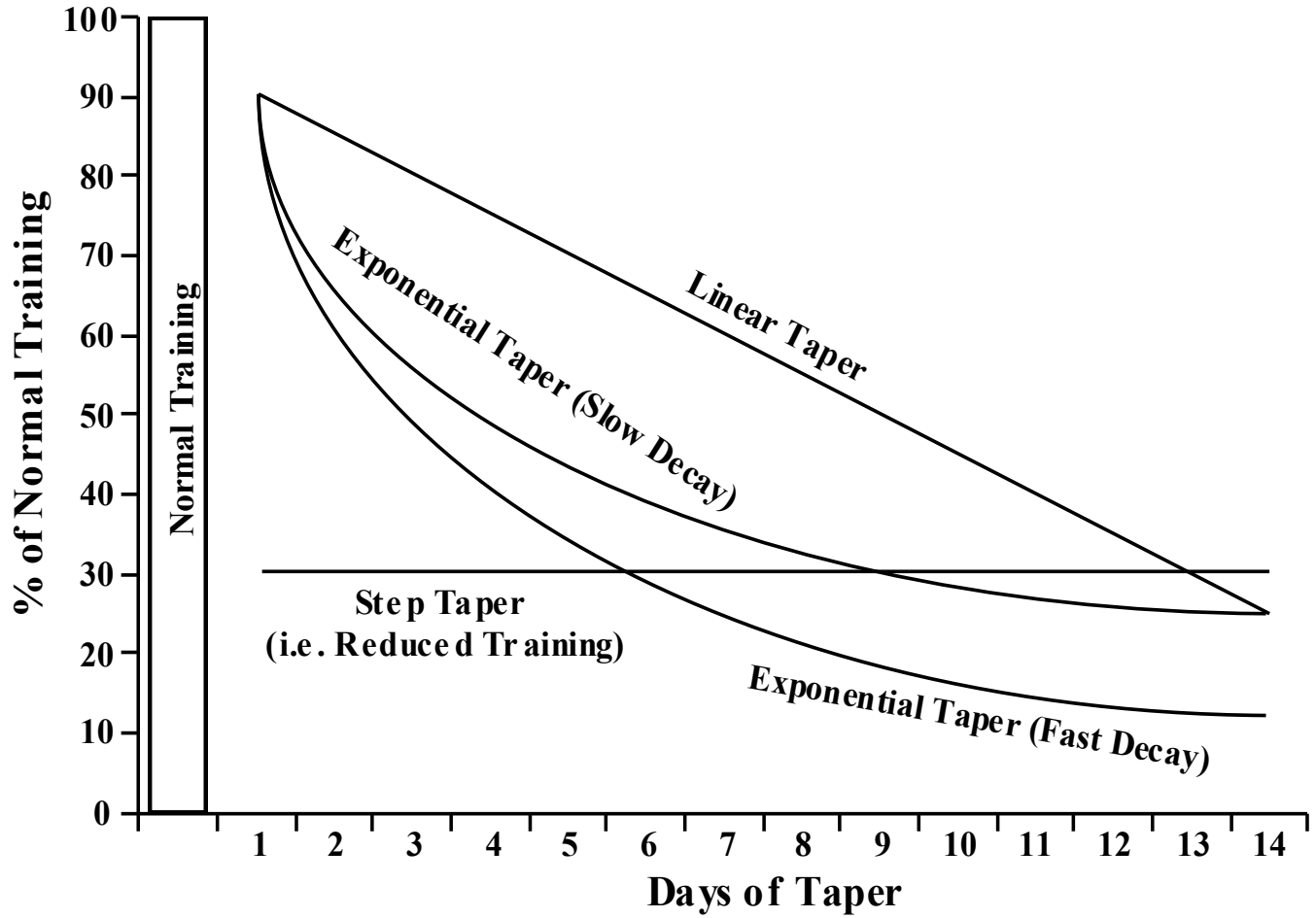
Taper



Pyne, O'Reilly and Mujika, *J. Sports Sci,* 2009:195-202.

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