Physiological and methodological aspects of swimming training for young and elite swimmers

Marco Bonifazi

Czech Republic Coaches Seminar
24 September 2017

The goal of the swimmer during competition is to be fastest as possible for a given distance

$$\text{speed (m/s)} = \frac{\text{metabolic power } (E/\text{s})}{\text{energy cost } (E/\text{m})}$$

	100% Paer 100% Pan 100% EC	**110% Paer** 100% Pan 100% EC	100% Paer **110% Pan** 100% EC	100% Paer 100% Pan **90% EC**
50	27.1	27.0	26.4	26.3
100	57.9	57.3	56.4	55.9
200	2.04.4	2.02.2	2.02.3	2.00.2
400	4.23.3	4.15.9	4.20.0	4.13.8

Touissant & Hollander, *Sport Med* 1994

Energy cost of locomotion (EC)

Total amount of energy expenditure per unit of distance covered

- Walking or running: kcal (or kJ) per km covered per kg of body mass
- Swimming: kJ per meter covered

Like fuel consumption of the cars in liters to cover 100 km (one liter of gasoline contains 7660 kcal)

A simple way to calculate energy cost

Walking: 0,5 kcal per kg per km covered

A person with a body mass of 70 kg
walking 4 km burns about 140 kcal

2-3 g of amino acids
10 g of fatty acids
10 g of glucose

A simple way to calculate energy cost

Running: 1 kcal per kg per km covered

A person with a body mass of 70 kg
running 10 km burns about 700 kcal

10 g of amino acids
40 g of fatty acids
80 g of glucose

Running at low-moderate intensity

Energy cost of swimming (EC)

Swimming is the slower form of locomotion:

– Water density is 800 greater of air density and this fact increases drag

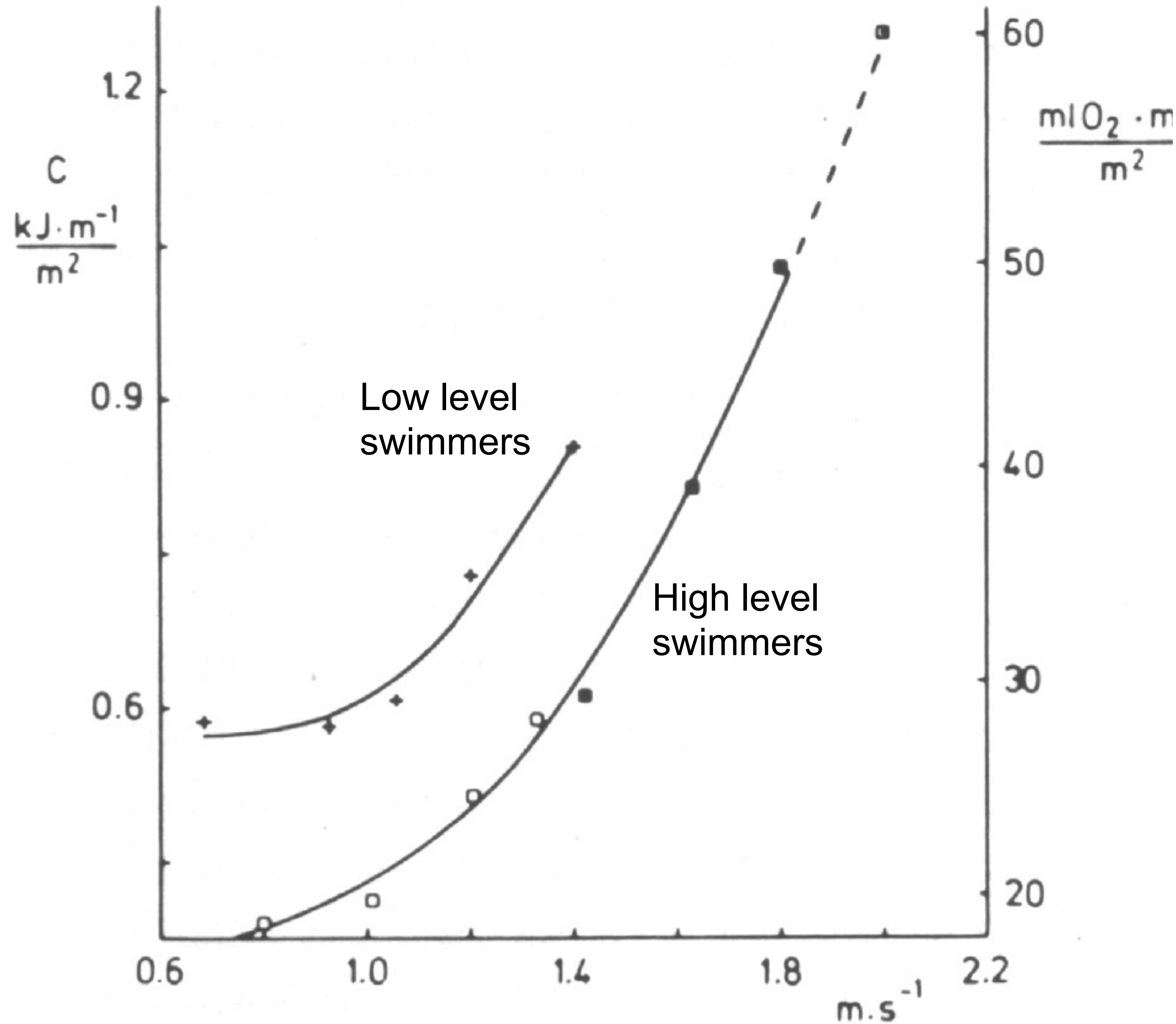
– Overall efficiency is less than 10% (for example, in running and cycling is more than 20%)

Energy cost of swimming (EC)

It has a great individual variability: according individual technical level may change over than 300%. In addition, it increases in a exponetial way increasing swimming speed.

For these reasons, predetermined values of energy consumption are unreliable

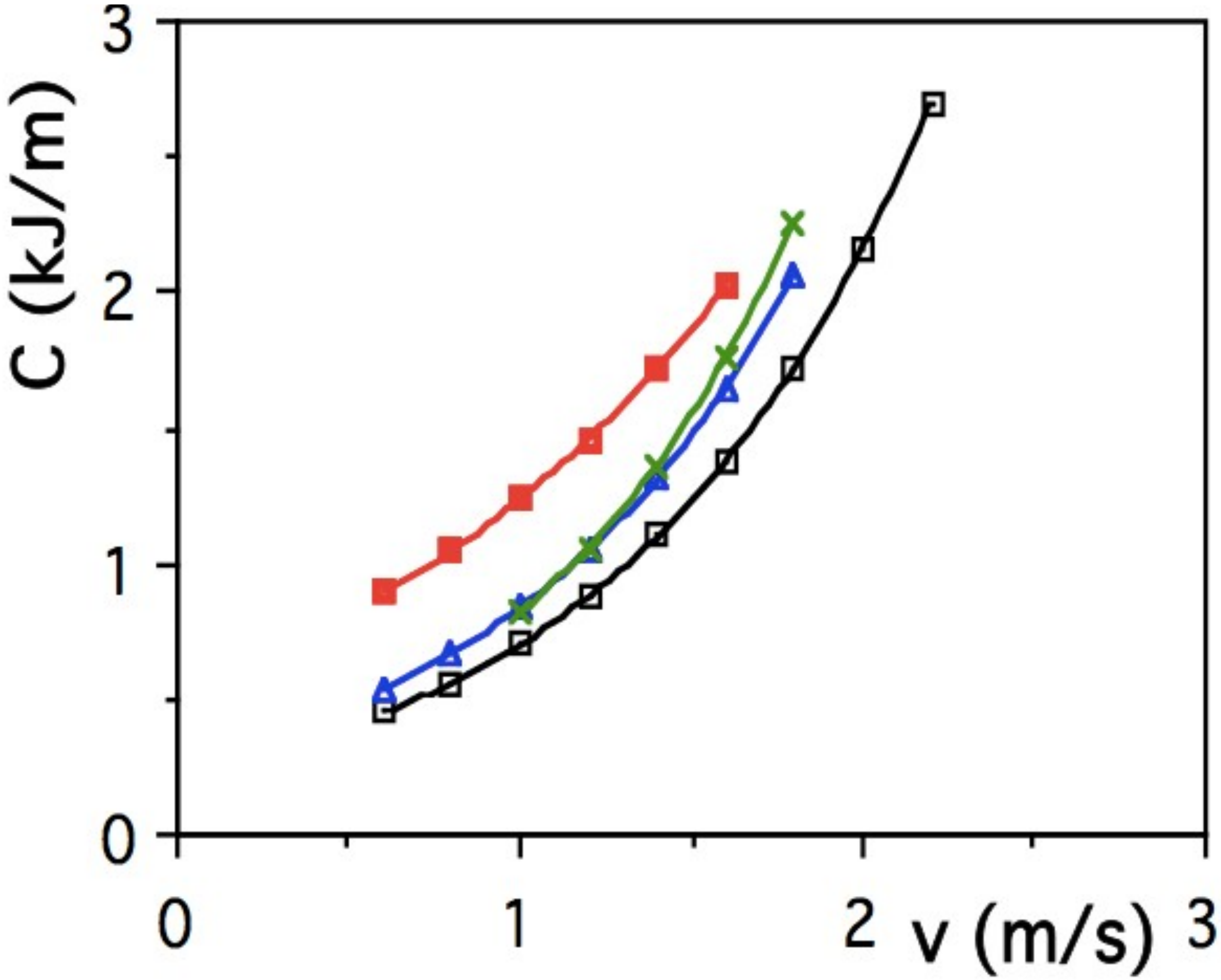
In women, EC is about 30% less than in men



di Prampero, *Int J Sports Med* 1986

Energy cost of swimming

Red: breaststroke, Green: butterfly,
Blue: backstroke, Black: crawl



di Prampero, 2014

Energy cost at 1,43 m/s – males

	C (kJ/m)	Sf (cycles/min)	Ds (m/cycle)
At rest	1,10±0,17	40±1	2,12±0,08
With fatigue	1,19±0,17	43±1	2,04±0,07

Energy cost at 1,34 m/s – females

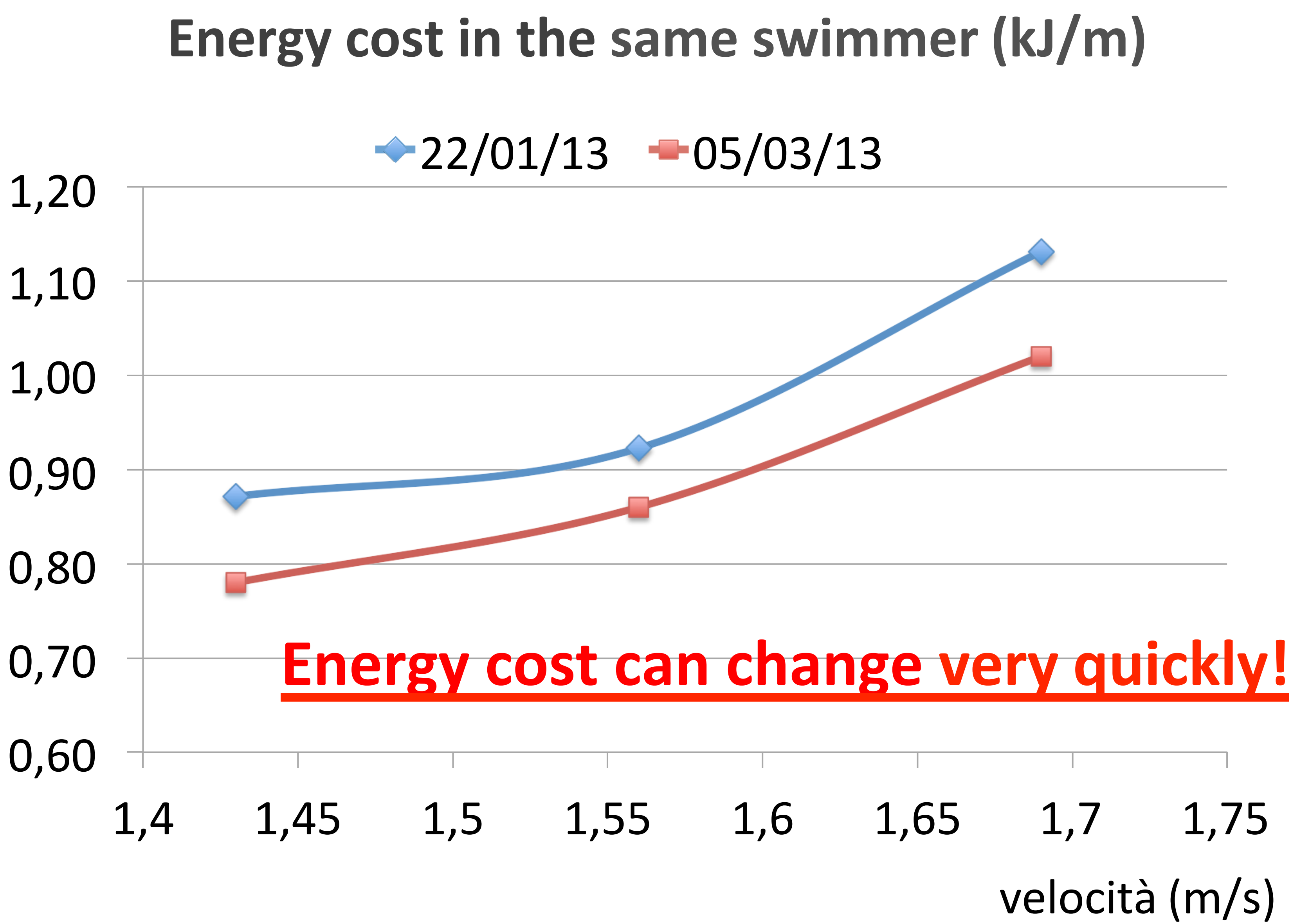
	C (kJ/m)	Sf (cycles/min)	Ds (m/cycle)
At rest	0,72±0,13	43±1	1,84±0,08
With fatigue	0,93±0,10	46±1	1,75±0,07

Eur J Appl Physiol (2005) 94: 697–704
DOI 10.1007/s00421-005-1337-0

ORIGINAL ARTICLE

P. Zamparo · M. Bonifazi · M. Faina · A. Milan
F. Sardella · F. Schena · C. Capelli

Energy cost of swimming of elite long-distance swimmers


Energy cost in the same swimmer (kJ/m)
22/01/13
05/03/13
1,20
1,10
1,00
0,90
0,80
0,70
0,60
1,4
1,45
1,5
1,55
1,6
1,65
1,7
1,75
velocità (m/s)
Energy cost can change very quickly!

Energy needs in swimming

Nutrition for power sports: Middle-distance running, track cycling, rowing, canoeing/kayaking, and swimming

Trent Stellingwerff [a], Ronald J. Maughan [b] & Louise M. Burke [c]

Journal of Sports Sciences, 2011; 29(S1): S79–S89

The training load of swimmers involve daily swim practices lasting more than 3 h with over 10,000 m covered, and daily energy needs are calculated to be in a wide range: **3000–6800 kcal/day for males** and **1500–3300 kcal/day for females.**

Main factors influencing energy cost

- **Active and passive drag (F_d)**
- **Propelling efficiency (*ep*)**

DRAG

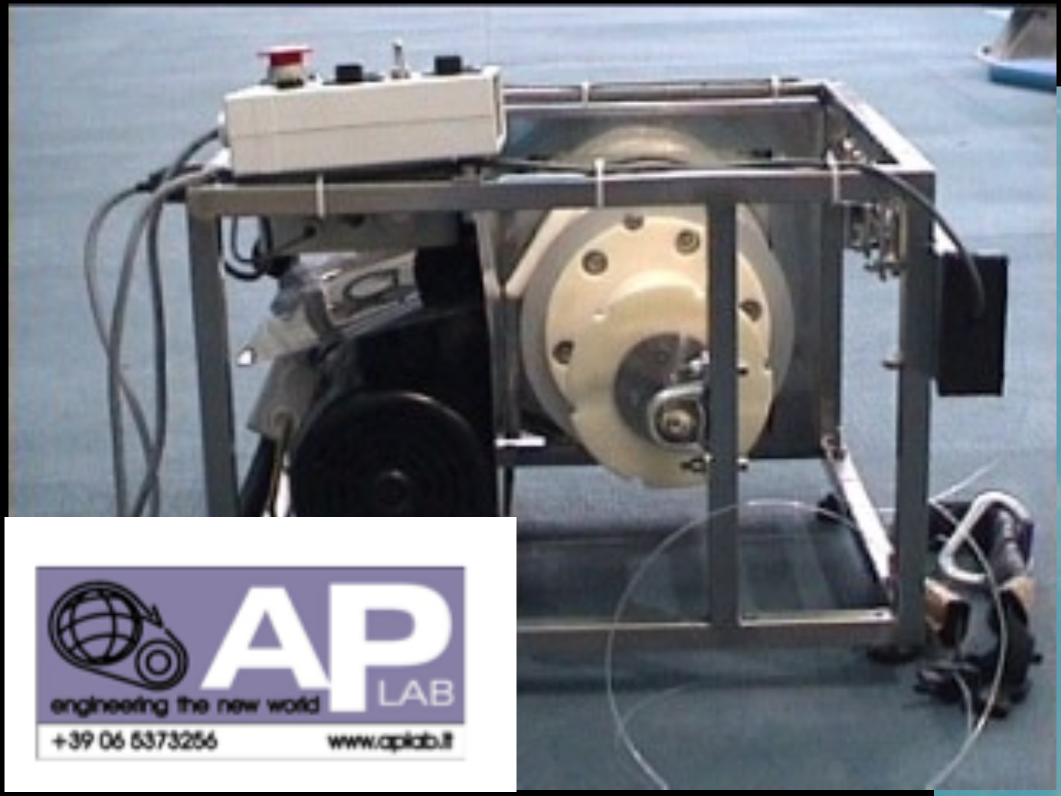
When a body moves in the water, it is submitted to the action of a braking force called ***drag*** **(F_d)**

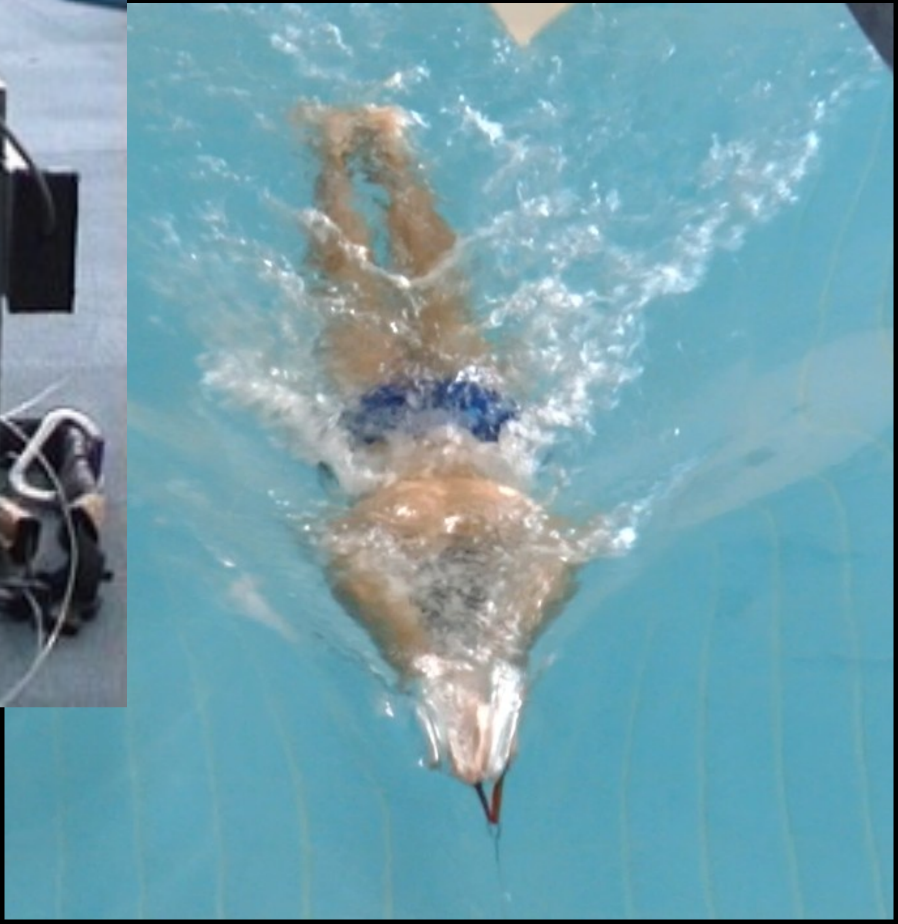
$$\mathbf{F_d = k \cdot v^2}$$

where F_d is force of drag, k is a costant including water density, Cx and frontal area and v is the swimming speed

PASSIVE DRAG: gliding without movements
ACTIVE DRAG: during active swimming

Measure of passive drag (F_d) with Ben Hur (APlab, Roma)

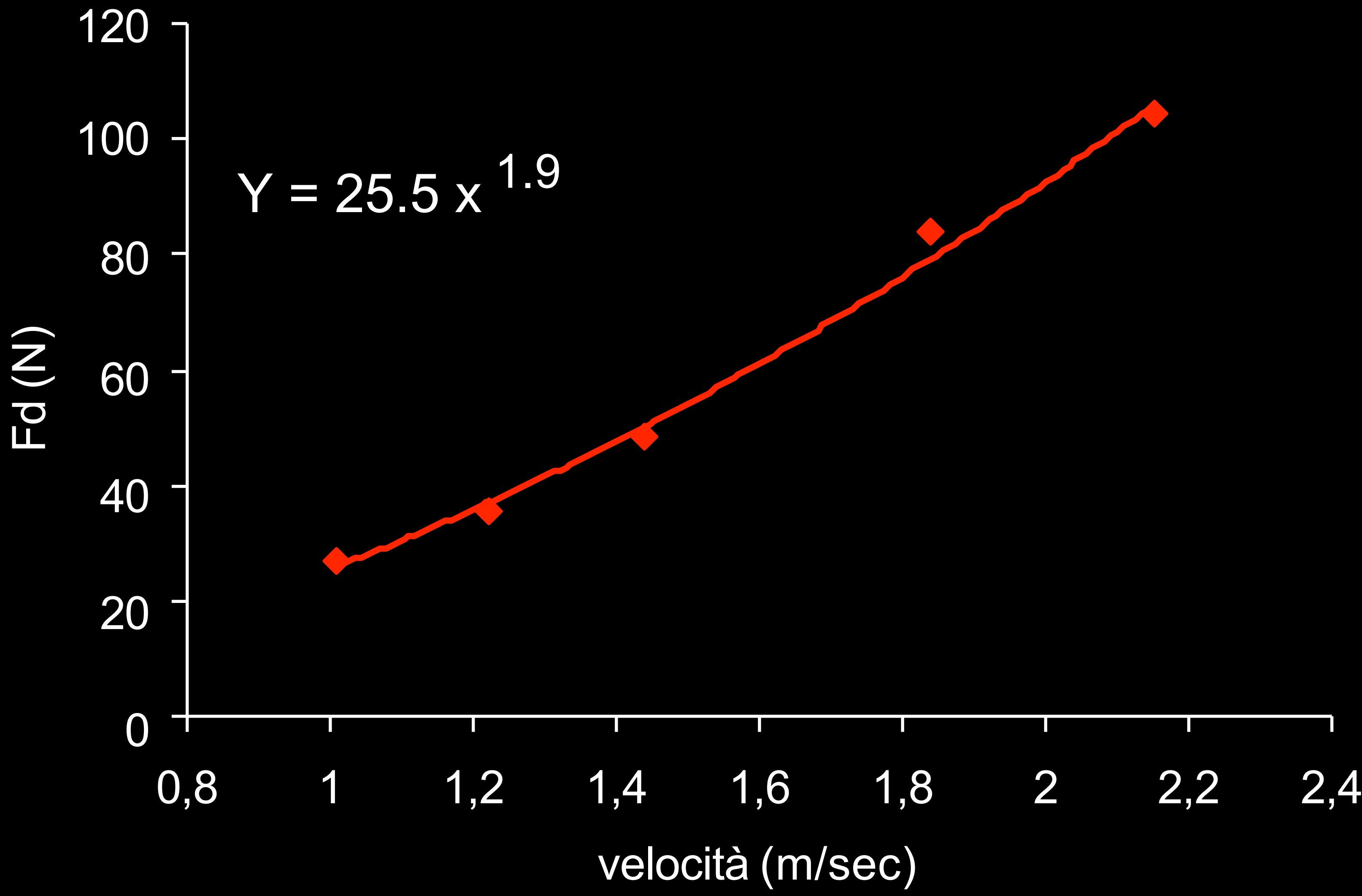




Changes of F_d according swimming speed

velocity (m/s)	F_d (N)	k
1.01	27.1	26.6
1.22	35.4	23.8
1.44	48.3	23.3
1.84	83.8	24.2
2.15	104.2	22.5

MEASURED PASSIVE DRAG (F_d)



Mean values of k

Male (n=16)	23.11 ± 4.36
Female (n=20)	20.37 ± 2.08

Mean values of k (n=11)

On surface	22.18 ± 3.66
In immersion	18.32 ± 2.14

Propelling efficiency (*ep*)

In swimming, mechanical work useful to overcome drag (W_d) do not correspond to total external work (W_t) since water do not offer a fixed point to push the body forward.

About 50% of the external work is wasted
In this case *ep* is corresponding to a value of 0,5

Propelling efficiency (*ep*)

Then $W_d = ep \cdot W_t$

Since the work per cycle is $W_d = Ds \cdot F_d$

We obtain $Ds \cdot F_d = ep \cdot W_t$

$$Ds = \frac{ep \cdot W_t}{F_d}$$

Main factors influencing energy cost

- **Active and passive drag**
  - Height
  - Body shape
  - Body composition
  - Legs floating
  - Core stiffness
  - Smoothing limbs action
  - Swimming skill (body roll, head position, etc.)

- **Propelling efficiency (ep)**
  - Arms lenght
  - Hands size (paddles)
  - Foot size (fins)
  - Muscle strenght
  - **Swimming skill (aquaticity)**

Definition of acquaticity

Aquaticity is the capacity of a terrestrial mammalian organism to function and habitualise in the aquatic environment.

The level of aquaticity depends on mental and physical characteristics and can be improved by frequent exposure to the water element

The ideal state of aquaticity is achieved through the activation of the diving reflex, when the human body is totally immersed in water.

Varveri et al, *J Bodyw Mov Ther* 2016

ENERGY ORIENTED

$$V = Sf \times Ds$$

SKILL ORIENTED

Ds (distance per cycle) is the best simple index of swimming efficiency: an increased Ds is expression of improved propelling efficiency and/or reduced active drag and thus decreased energy cost.

<u>Main technical goal:</u>

To reduce the number of stroke count every lap at the same swimming speed

Sports Medicine 13 (1): 8-24, 1992
0112-1642/92/0001-0008/$08.50/0

SPO1 83

Biomechanics of Competitive Front Crawl Swimming

Huub M. Toussaint and *Peter J. Beek*
Department of Health Science, and Department of Psychology, Faculty of Human Movement Sciences
Vrije Universiteit and Universiteit van Amsterdam, Amsterdam, The Netherlands

Swimmers can be challenged to swim at their greatest distance per stroke possible by introducing a little game. While swimming a rather short distance (e.g. 25m), the time is taken and the number of strokes is counted. The sum of the 2 must be smaller than before on each consecutive lap.

It.urbandic8onary.com

SWOLF:

A combination of the words "swim" and "golf". Swolf is a common game played by swimmers in which ones time for a lap is added to the number of strokes that they have taken to the time it took to swim the laps.

I swam two laps in 30 seconds and took 25 strokes. My swolf score was 55!

Luca Dotto – 6x50 a 2’ (10/01/15, vasca 50)
pace second 50 of 100 m freestyle

t	n	SWOLF	Sf	Ds
25,4	34	59,4	42,9	2,62
24,7	36	60,,7	47,0	2,47
24,9	37	61,9	47,3	2,43
25,3	37	62,3	46,6	2,42
25,5	37	62,5	46,5	2,41
26,5	38	64,5	45,5	2,36

Thomas Ceccon – 6x50 at 2’ (29/01/17, vasca 50)

pace second 50 of 100 m freestyle

t	n	SWOLF	Sf	Ds
27,4	32	60,4	44,2	2,30
27,1	30	57,1	42,4	2,50
27,3	29	56,3	40,8	2,60
27,2	32	59,2	45,5	2,31
27,7	31	58,7	42,7	2,44
27,4	32	59,4	46,1	2,28

Thomas Ceccon – 6x50 at 2’ (29/01/17, vasca 50)

pace second 50 of 100 m freestyle

Best Swolf in the set: 56,3

This value can be used to indicate the ideal number of strokes for aerobic pace.

For example:

50 m in 33 s: 56 − 34 = 23 strokes (or less)

Thomas Ceccon – 6x50 at 1’ (29/01/17, vasca 50)
pace increasing

t	n	SWOLF	Sf	Ds
34,0	25	59,0	24,3	3,28
32,1	26	58,1	26,2	3,25
31,1	26	57,3	28,6	3,14
29,4	28	57,4	31,6	2,87
27,8	29	57,8	42,7	2,66
25,4	31	57,4	46,1	2,50

Important take home message……

Automatic component of motor control is determinant for best efficiency of movement (maximum result with minimum effort).

To improve automatic motor control, coach should create motor problems for his swimmers (throught swimming exercises)

It is the solution to the motor problem, not the exercise itself, which causes the improvement

The goal of the swimmer during competition is to be fastest as possible for a given distance

$$\text{speed (m/s)} = \frac{\text{metabolic power } (E/\text{s})}{\text{energy cost } (E/\text{m})}$$

ENERGY CONTRIBUTION

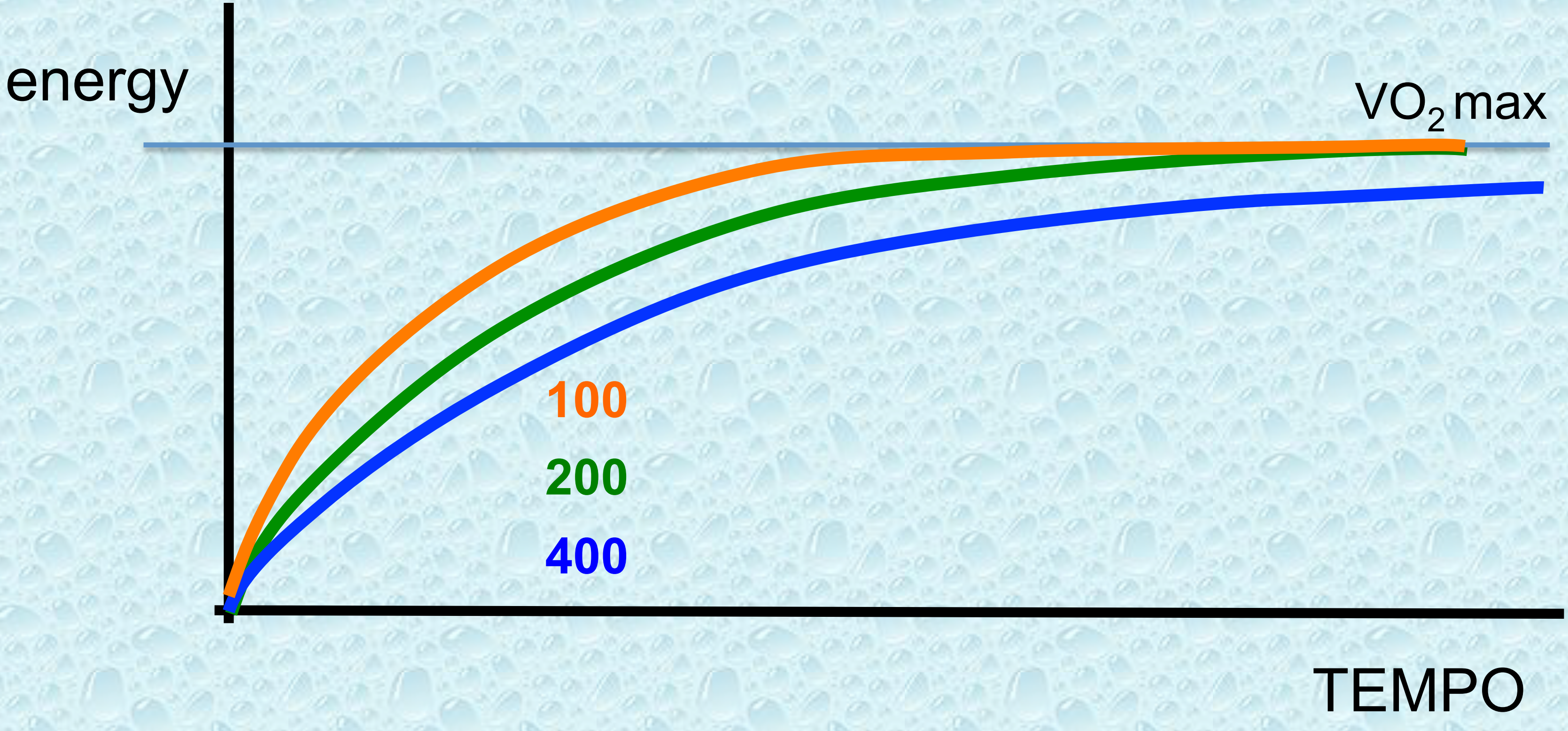
	Aerobic	An. Lact.	An. Alact.	mM
50	15-25	45-60	20-30	8-13
100	35-50	35-50	15-20	12-18
200	60-70	20-30	10-12	12-18
400	75-85	15-20	5	10-14
1500	90	10	-	6-10
5000	100	-	-	3-6

VO_2 rise progressively during maximal effort

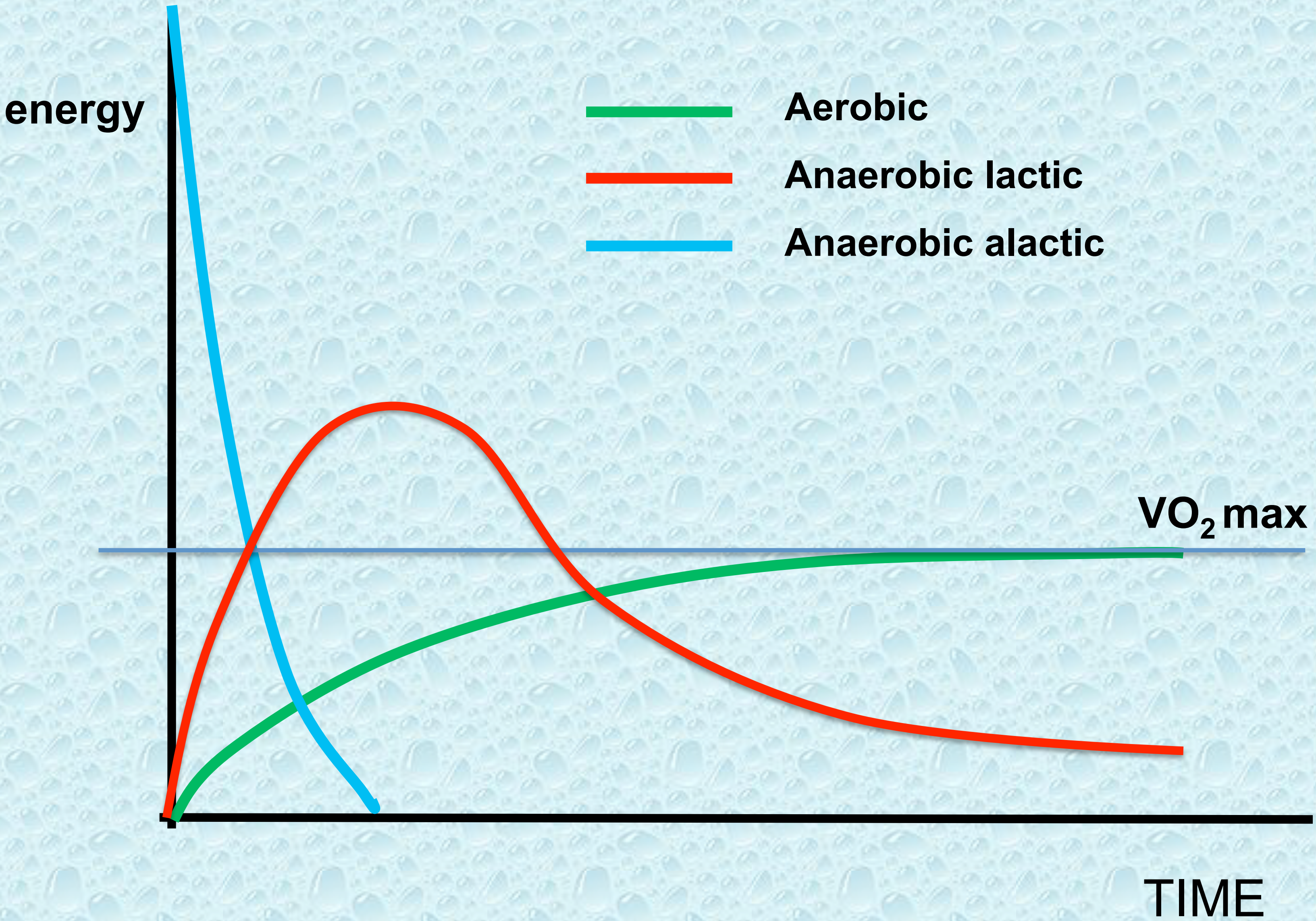
$$E = \alpha VO_{2max} t_p - \alpha VO_{2max} \tau (1 - e^{(t_p/\tau)})$$

τ duration is proportional to the intensity of the effort

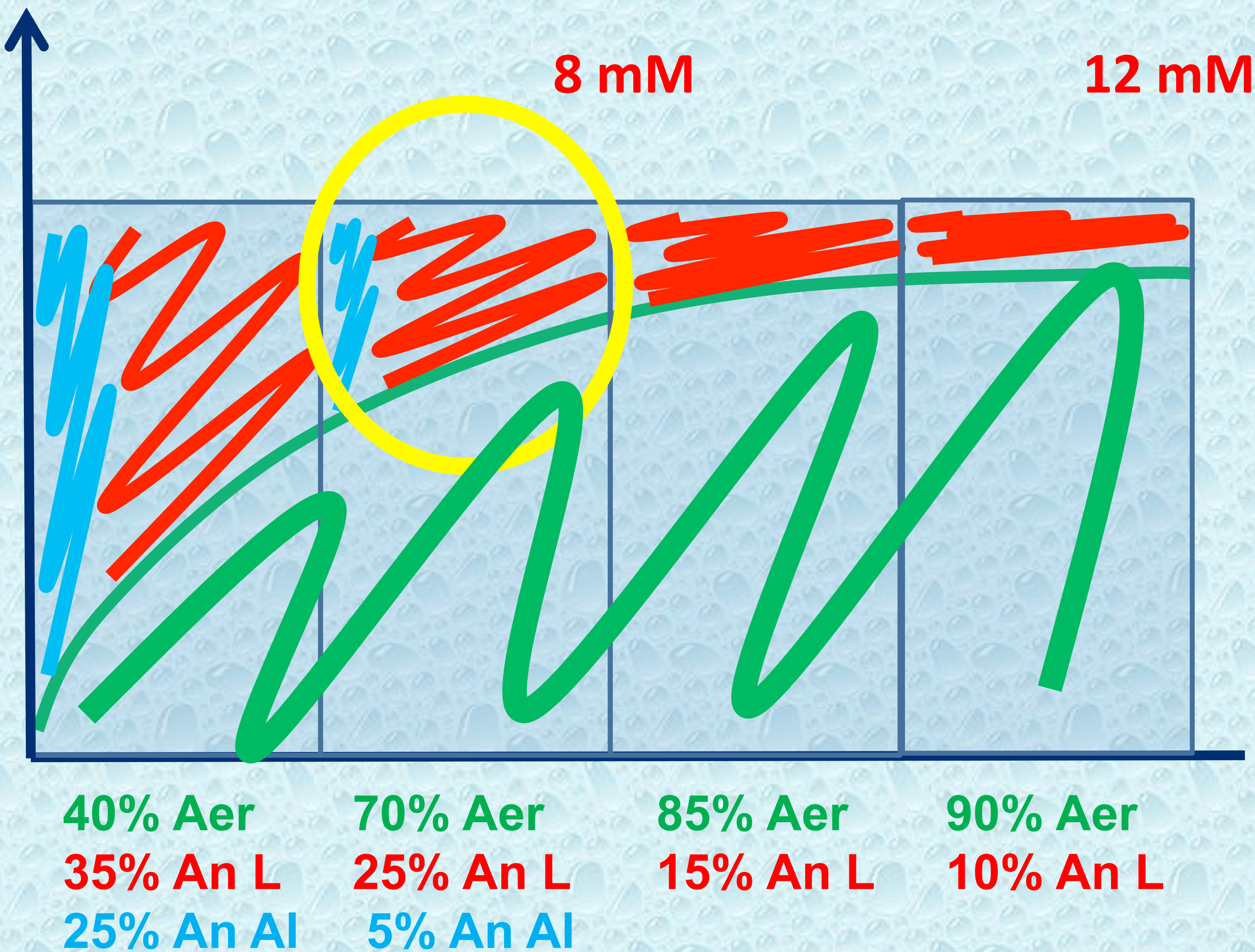
τ: 10 – 24 s



Change in the energy supply during maximal effort



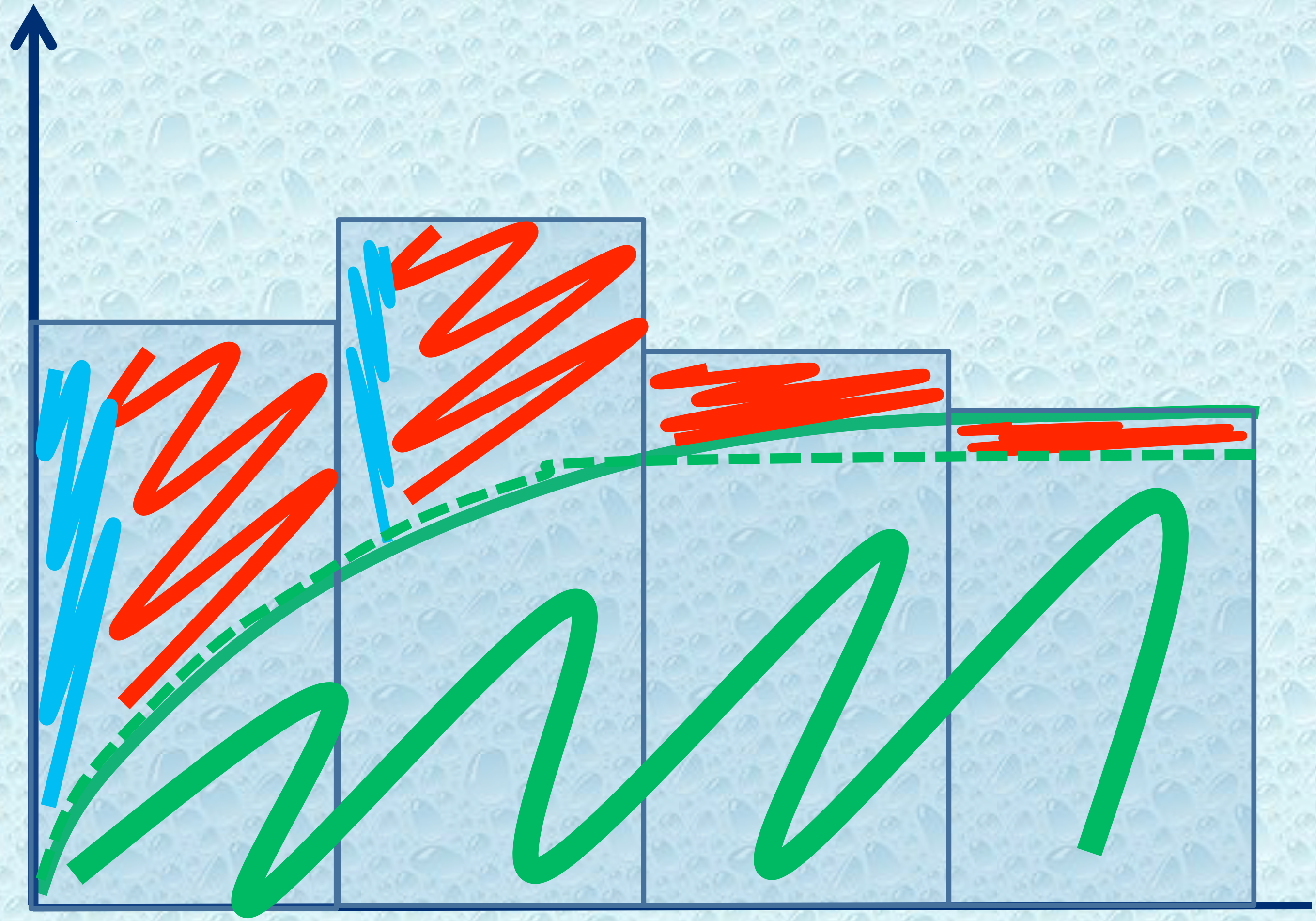
ENERGY SUPPLY TO COVER EACH QUARTER
400 m at constant intensity (speed)



OVERALL ENERGY SUPPLY: 75% Aer, 20% An L, 5% An Al

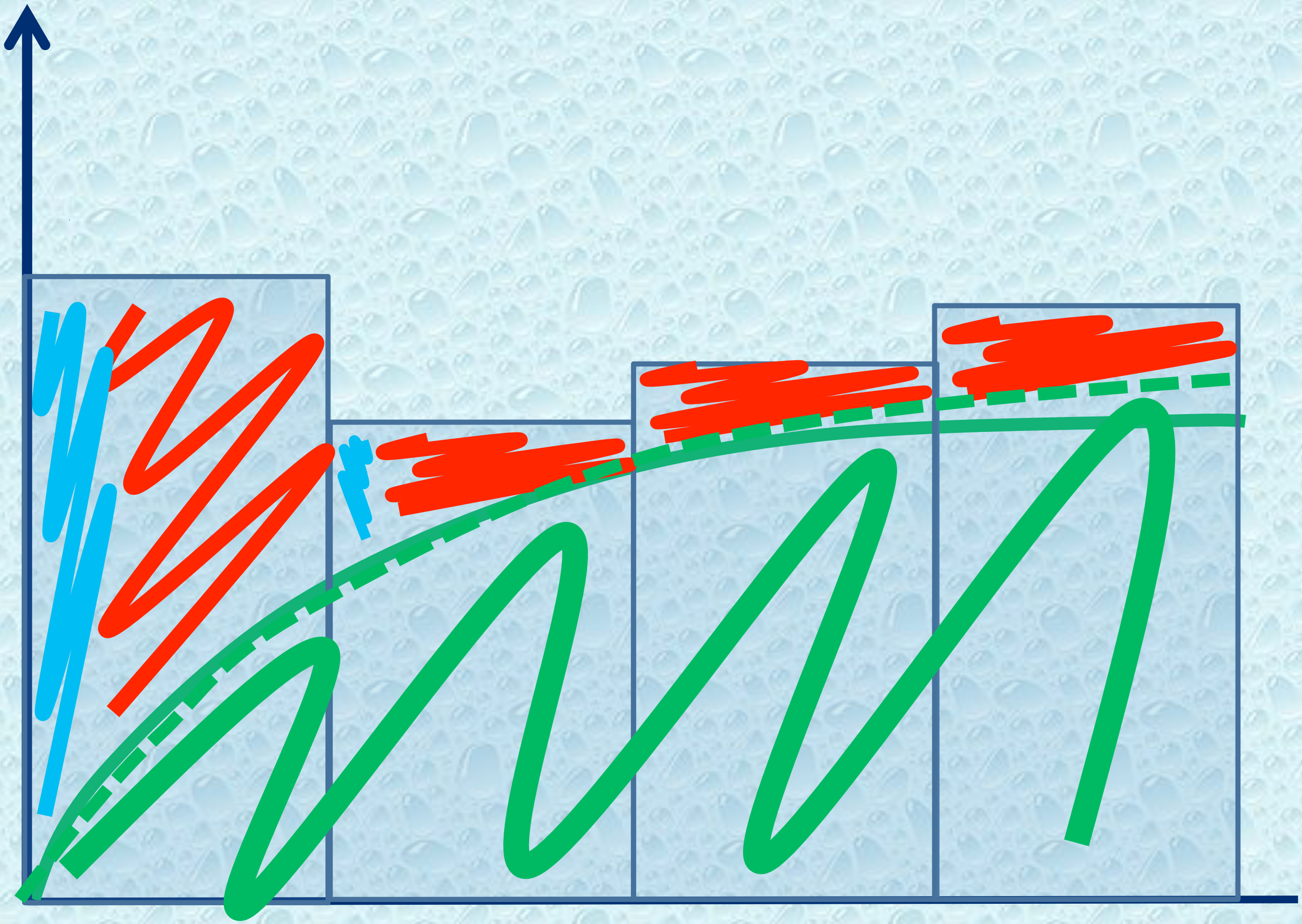
ENERGY SUPPLY TO COVER EACH QUARTER

400 m – increasing intensity the second quarter



ENERGY SUPPLY TO COVER EACH QUARTER

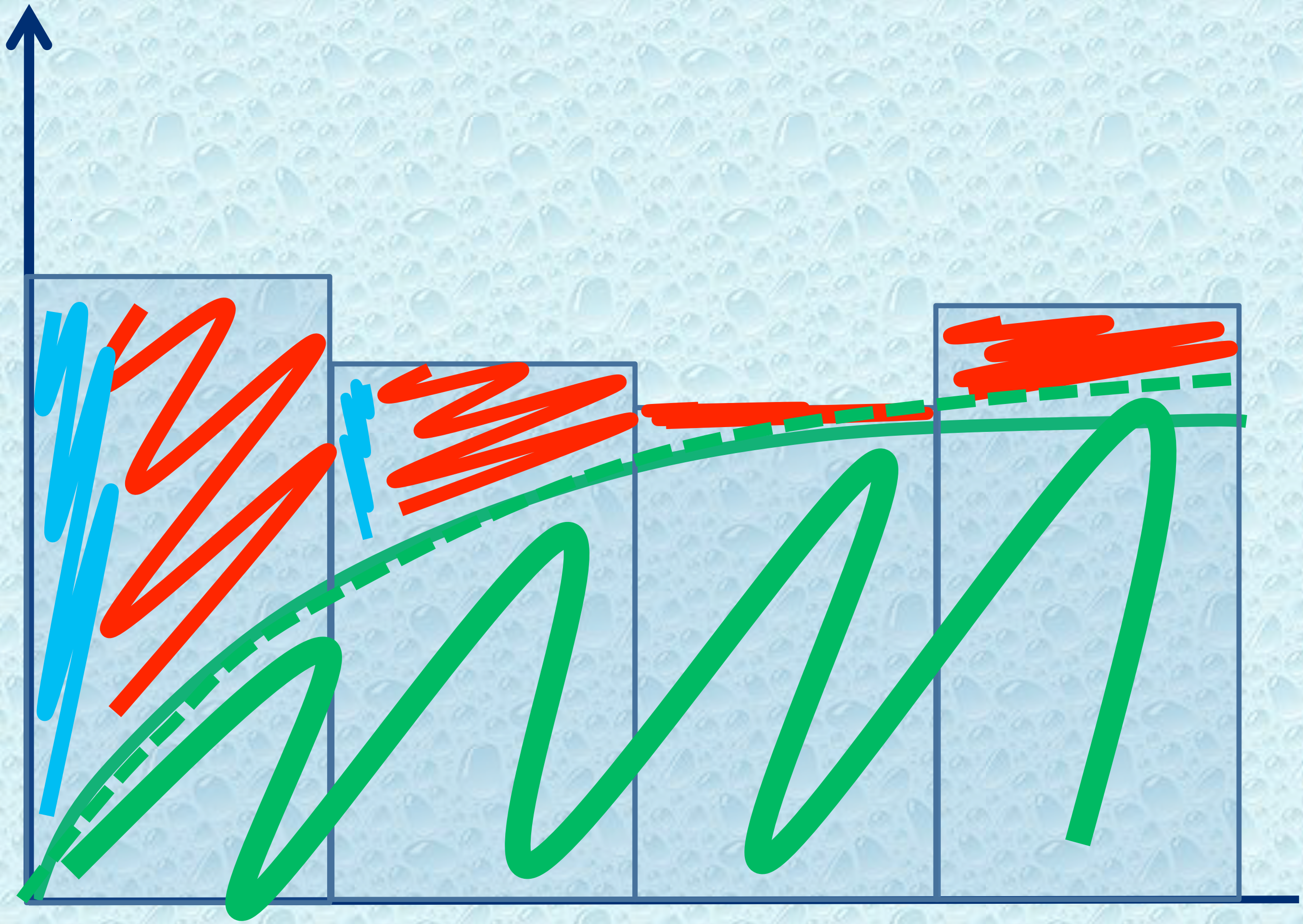
400 m – *decreasing* intensity the second quarter



DISTRIBUTION called 1 – 4 – 3 – 2

ENERGY SUPPLY TO COVER EACH QUARTER

decreasing intensity the second quarter – used in 200 m



DISTRIBUTION called 1 – 4 – 2 – 3

Final 400 free – Olympics Rio

		I° 100	II° 100	III° 100	IV° 100
1° HORTON	3.41.55	54.06	<u>57.13</u>	56.82	53.54
2° SUN	3.41.68	54.52	<u>57.15</u>	56.39	53.62
3° DETTI	3.43.49	54.67	<u>57.17</u>	56.98	54.67
4° DWYER	3.44.01	53.93	<u>57.24</u>	56.92	55.92
6° GUY	3.44.68	53.70	56.53	<u>57.56</u>	56.89

Sebastiano RANFAGNI – 200 back
World Champs Shanghai 2011

		I° 50	II° 50	III° 50	IV° 50
SEMIFINAL	1.57.96	27.64	30.01	30.90	29.41
FINAL	1.57.49	27.73	30.50	30.44	28.82

BEST DISTRIBUTION of the effort: 1 – 4 – 3 – 2

Reduce the effort in the second quarter in 400 (and 200 meters?) competitions is, likely, the key to finish faster the race.

In this respect, the second quarter of the race should be slower of:

0,5 – 0,8 s for 200 m

1,2 – 1.7 s for 400 m

in comparison with the mean time of the quarter calculated on the expected time

For example:

We expected a time of 4.08.0 for a 400 m free for a given swimmer

The second 100 m, according this approach, should be covered in about 1.03.5 to have enough reserve of anaerobic energy in the last part

TRAINING CATEGORIES IN ITALY SINCE 1989

LA RESISTENZA AEROBICA

A1 Intensità molto blande.

A2 Intensità inferiori a quella di soglia anaerobica.

LA POTENZA AEROBICA

B1 Intensità intorno alla soglia anaerobica.

B2 Intesità intorno al massimo consumo di ossigeno (VO2 max).

LE ATTIVITÀ ANAEROBICHE

C1 Tolleranza al lattato.

C2 Picco di lattato.

C3 Esercizi di velocità.

I RITMI DI GARA

D Andature ai ritmi di gara.

Bonifazi Marco
Del Bianco Roberto
Morini Stefano
Parigiani Marco
Pasquali Sergio
Rosso Corrado

Federazione Italiana Nuoto, 1989

Aerobic training

A. Aerobic endurance training

A_1 (warm up, warm down, exercises)
A_2 (endurance volume training)

B. Aerobic power training

B_1 (anaerobic threshold training)
B_2 (VO2 max or aerobic overload training)

Anaerobic training

C_1 Lactate tolerance

C_2 Lactate peak

C_3 Speed drills

Aerobic training

The term “aerobic” describes a condition in which total energy for muscle metabolism is fully delivered from aerobic mechanism. In that condition, during an exercise at costant intensity, blood lactate is costant.

The higher intensity which respect this condition is called ***anaerobic threshold.***

Over the anaerobic threshold energy for muscle metabolism is mixed (aerobic and anaerobic) and lactate rises in the blood during exercise.

ANAEROBIC MUSCLE FIBERS
(few mitochondria)

glucose → **ATP**

↓

piruvate

↓

LACTATE

↓

BLOOD **LACTATE**

↓

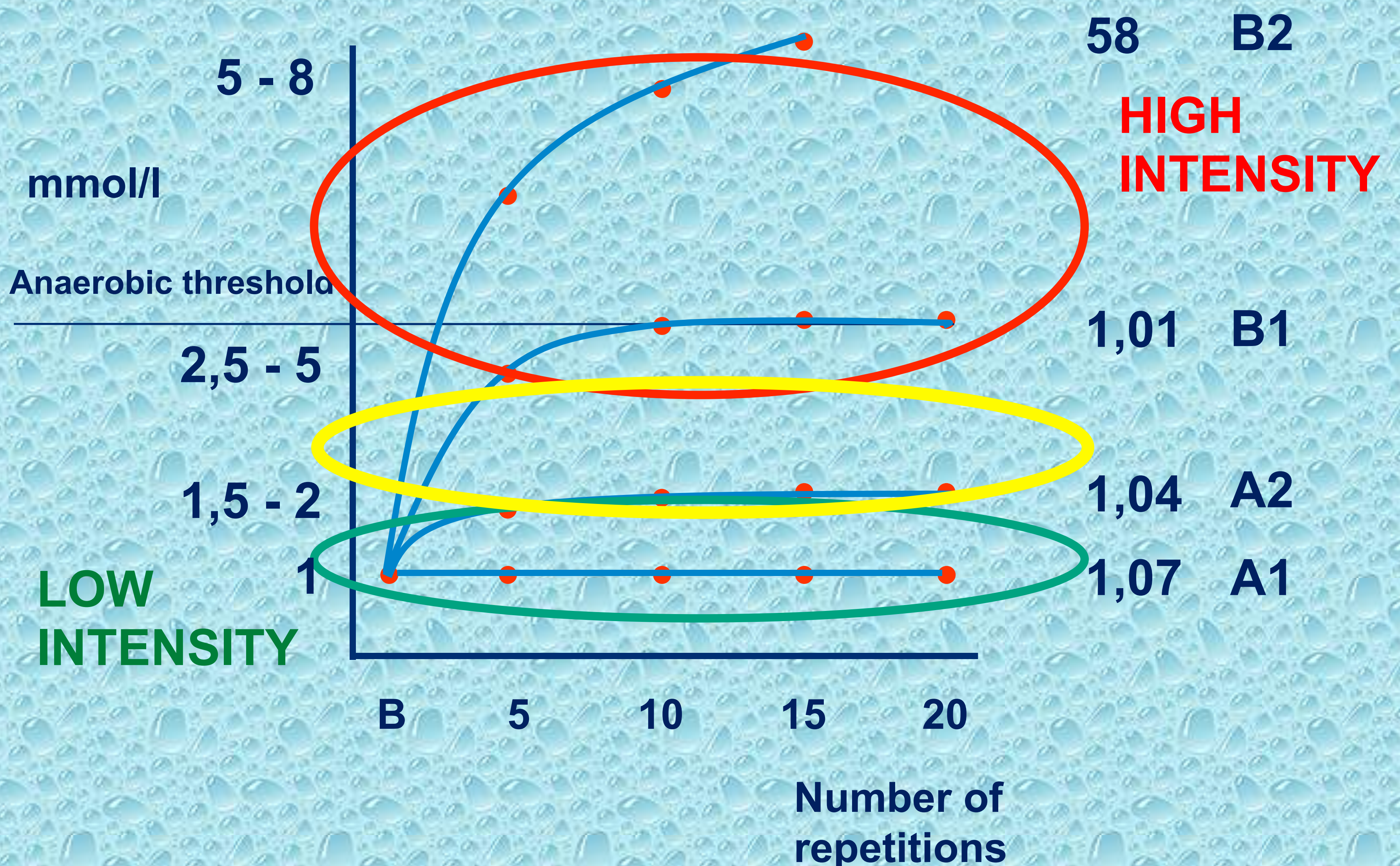
LACTATE

↓

piruvate → **Krebs cycle** → **ATP**

AEROBIC MUSCLE FIBERS
(many mitochondria)

Blood lactate during 20x100 series at different pace (every 100 meters)



AEROBIC ENDURANCE TRAINING
(A_2 type)

AMOUNT: 70 - 80% of total work

SET VOLUME: 1000 - 4000m

DISTANCES: 50 - 1500m with 5 - 20 s of rest

FREQUENCY: DAILY

Low rate of glycogen consumption

AEROBIC ENDURANCE TRAINING

Physiological parameters indicating a correct intensity:

1. Lactate: lower than 2.0 mmol/l (middle and long-distance swimmers) and 2.5 mmol/l (sprinters) during work and constant over the time (steady-state) at constant speed.

2. Heart rate: usually lower than 150 b/min. However, heart rate value is subjective and should be compared with lactate.

3. Breath rate: no or minimal alteration of ventilation

AEROBIC ENDURANCE TRAINING
control of intensity

CORRECT INTENSITY (according LACTATE values):

Less than 2.0 (for distance swimmers) or 2.5 mmol/l (for sprinters) at the end of the work

Intensity can be evaluated with a single blood sample collected immediately after the end of the set

Set must be performed at constant speed

AEROBIC POWER TRAINING (B_1 type)

(usually called anaerobic threshold training)

AMOUNT: 10 - 20% of total work

SET VOLUME: 1500 - 3000m

DISTANCES: 50 - 800m with 10 - 30 s of rest

FREQUENCY: 1 - 3 TIMES per WEEK

High rate of glycogen consumption for long time

AEROBIC POWER TRAINING (B_1 type)

(usually called anaerobic threshold training)

Physiological parameters indicating a correct intensity:

1. Lactate: constant during work at constant speed: less than 1 mmol/l of variation every 10 min of work (steady state). Usually it ranges between 3 - 5 mmol/l at the end of the set.

2. Heart rate: between 150 and 180 b/min. Heart rate value is extremely subjective and should be compared with lactate.

3. Breath rate: increase

AEROBIC POWER TRAINING (B_1 type)

control of intensity

CORRECT INTENSITY (according LACTATE values):

less than 1 mmol/l of increase every 10 min of work

Intensity can be evaluated with two blood sample:

I. at the half of the set, and
II. immediately after the end

Set must be must be lasting 20 min of effective work or more and performed at constant speed

AEROBIC POWER TRAINING (B_2 type)

(usually called VO2 max or aerobic overload training)

AMOUNT: 5 - 10% of total work

SET VOLUME: 800 - 2400m

DISTANCES: 100 - 400m (usually broken in 50 and 100m with 5 - 10 sec of rest) with 45 - 90 s of rest

FREQUENCY: 1 - 4 TIMES per WEEK

High rate of glycogen consumption for shorter time

AEROBIC POWER TRAINING (B_2 type)

(usually called VO2 max or aerobic overload training)

Physiological parameters indicating a correct intensity:

1. Lactate: increase progressively during work. Usually 5 - 8 mmol/l at the end of the set, but it is depending from the duration of the work.

2. Heart rate: usually higher than for B_1 type (5 - 10 b/min). The difference can not be detected manually.

3. Breath rate: marked increase

AEROBIC POWER TRAINING (B_2 type)
control of intensity

CORRECT INTENSITY (according LACTATE values):

more than 1 mmol/l of increase every 10 min (or less) of effective work, final value between 5 and 8 mmol/l

Intensity can be evaluated with two blood sample:

I. at the half of the set, and
II. immediately after the end

Set should be performed at constant speed

AEROBIC PACE

SET	AEROBIC ENDURANCE	ANAEROBIC THRESHOLD	VO2 MAX
50	104-108	108-112	112-116
100	100-102	104-106	108-110
200	98-99	102-103	106-107
400	97-98	101-102	105-106
over 400	96	**100**	104

100 is the swimming speed value corresponding to the mean velocity during a 3000 m performed as fast as possible

Anaerobic training- C_1
(lactate tolerance)

SET VOLUME: 400 - 1000 m

4 - 8 x 100 with 1'-3' of rest
2 - 4 x (4 x 50 with 5") with 2'-4' of rest

FREQUENCY: one time every 1 – 3 weeks

Usually lactate control
during or at the end of the set is not necessary

Anaerobic training- C_2 (lactate peak)

SET VOLUME: up to 400 m

3 - 5 x 75 with 1’ - 3’ of rest

4 - 6 x 50 with 1’ - 2’ of rest

FREQUENCY: one time every 1 – 3 weeks

Usually lactate control
during or at the end of the set is not necessary

Anaerobic training- C_3
(speed drills)

SET VOLUME: up to 400 m

20 - 30 x 50 (12,5 as fast as possible – 37,5 slow)
with 20˝ of rest

FREQUENCY: 2 times per week

Usually lactate control
during or at the end of the set is not necessary

D – Race Pace training

Set of repetitions (fractions of race distance) at actual or desired race speed

Duration of rest among repetitions and the lenght of each repetition affect energy metabolism during the set and therefore its metabolic stress

The aim of race pace training should be to swim the highest volume at race speed by avoiding excessive stress and the risk of underperformance

Estimated contribution % of energy sources

distance broken with 15-20 s of rest

	1 x 400 4'00"	2 x 200 1'59"	4 x 100 59"	8 x 50 29"	16 x 25 14"
Lactate	**16**	**12**	**8**	**4**	**2**
% aerobic	75	75	75	75	75
% lactic	20	17	11	-	-
% alactic	5	8	14	25	25
Work category	Race	Lactate tolerance	VO_2 max	Anaerobic threshold	Aerobic endurance

Training categories and race pace

with appropriate interval of rest

race distance	25m set	50m set	100m set	200m set
200	Anaerobic threshold	VO_2 max	Lactate tolerance	-
400	Aerobic endurance	Anaerobic threshold	VO_2 max	Lactate tolerance
800/1500	Aerobic endurance	Aerobic endurance	Anaerobic threshold	VO_2 max

Trainability

The ability to be trained.

The responsiveness to the training stimulus at different stage of growth and maturation

Training models for adults are based on trainability of metabolic systems and technical efficiency at race pace

Training for adults

Each training set must have:

- **Intensity** (swimming speed) at a defined metabolic regime monitoring swimming tecnique
- **Appropriate volume**, to stress energy systems, recovery and motor control
- **Adequate structure** (i.e., lenght of repetitions, interval of rest) correlated with previous aims
- **Appropriate frequency** during cycles, to generate overload and supercompensation

Puberty

The process of physical changes throught the individual becomes capable to sexual reprodution

On average, puberty begins:

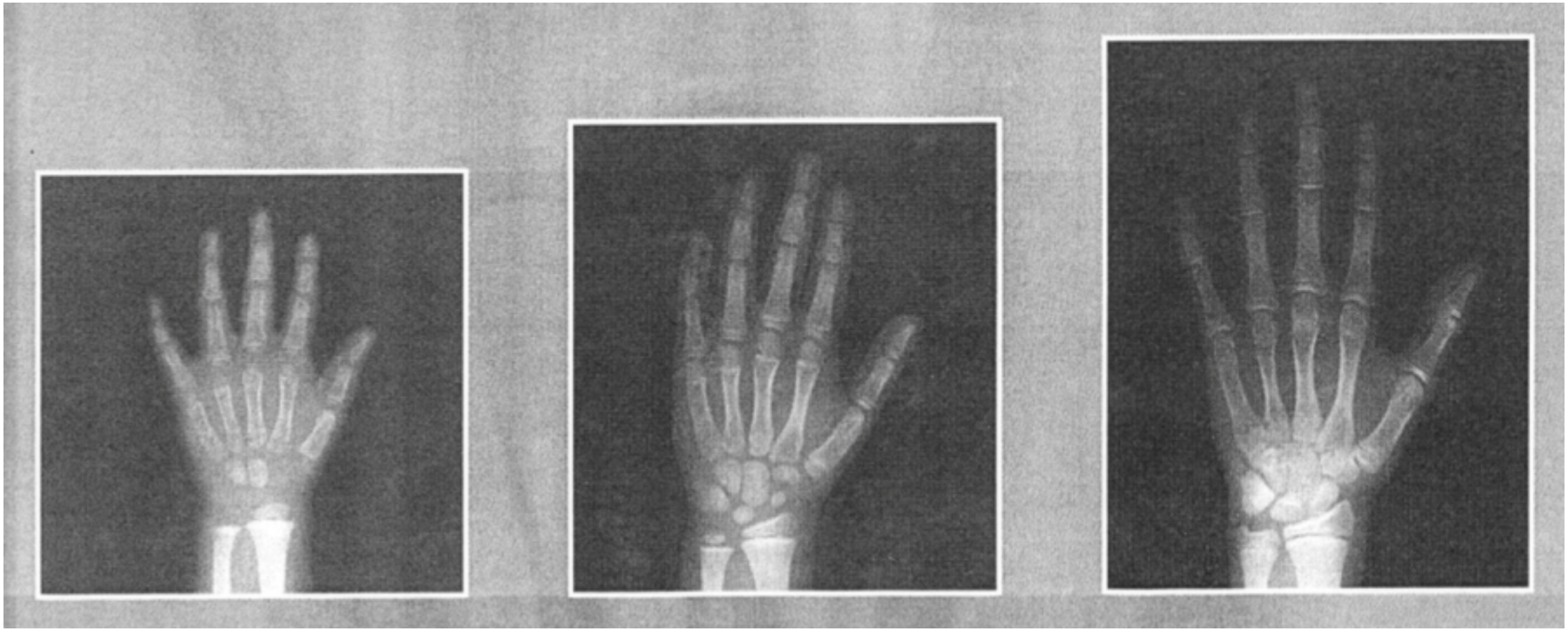
Girls around ages 10–11 ending around 14-17

Boys around ages 11–13 ending around 16-18

Puberty is a process lasting some years

Children's participation in sports is based on chronological age, but young athletes may also have 3 to 4 years of difference in biological age!

Assessment of Maturation
Skeletal Maturity



Tanner et al. (2002). Assessment of skeletal maturity and prediction of adult height (TW3 Method). Saunders

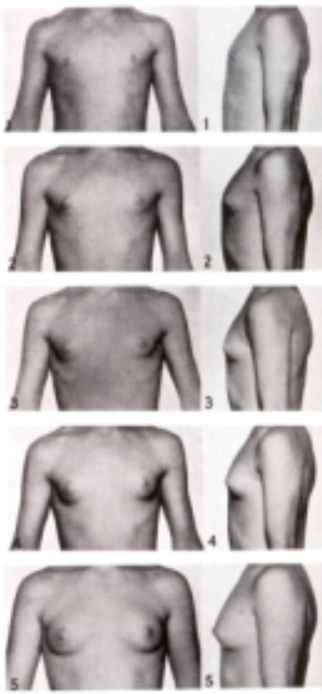
Assessment of Maturation

INSTITUTE OF YOUTH SPORT

Loughborough University

TANNER STAGES:
FEMALE BREAST DEVELOPMENT

The pictures on this page show different stages of development of the breasts. A girl passes through each of the five stages shown by these pictures. Please look at each of the pictures and read the sentences next to the picture. Then choose the picture closest to your stage of development and mark an **A** on the picture. Then choose the picture that is next closest to your stage of development and mark a **B** on the picture.



Stage 1
The nipple is raised a little in this stage. The rest of the breast is still flat.

Stage 2
This is the breast bud stage. In this stage the nipple is little more raised. The breast is a small mound. The areola (darker, coloured middle part) is larger.

Stage 3
The areola and the breast are both larger than in stage 2, but the areola does not stick above the breast.

Stage 4
The areola and the nipple make up a mound that sticks up above the shape of the breast. (Note: this stage may not happen at all for some girls. Some girls develop from stage 3 to stage 5 with no stage 4).

Stage 5
This is the mature adult stage. The breasts are fully developed. Only the nipple stands out in this stage. The areola has flattened into the general shape of the breast.

Once you have completed the form, fold it and put it in the envelope provided and seal the envelope.

Your results are completely private and will be treated in complete confidence. No one will know who has filled out the form, as your name will not be on it.

INSTITUTE OF YOUTH SPORT

Loughborough University

TANNER STAGES:
FEMALE PUBIC HAIR DEVELOPMENT

The pictures on this page show different stages of development of female pubic hair. A girl passes through each of the five stages shown by these pictures. Please look at each of the pictures and read the sentences next to the picture. Then choose the picture closest to your stage of development and mark an **A** on the picture. Then choose the picture that is next closest to your stage of development and mark a **B** on the picture.

Stage 1
(no picture)

Stage 1
There is no pubic hair at all.

Stage 2
There is a little soft hair. Most of the hair is along the slit or lips. This hair may be straight or a little curly.

Stage 3
The hair is darker in this stage. It is coarser and more curled. It has spread out and thinly covers a larger area.

Stage 4
The hair is now as dark as that of an adult woman. However, the area it covers is not as large as that of an adult woman. The hair has not spread out to touch the thighs.

Stage 5
The hair is now like that of an adult woman. It also covers the same area as that of an adult woman. The hair usually forms a triangular (V) pattern as it spreads out to touch the thighs.

Once you have completed the form, fold it and put it in the envelope provided and seal the envelope.

Your results are completely private and will be treated in complete confidence. No one will know who has filled out the form, as your name will not be on it.

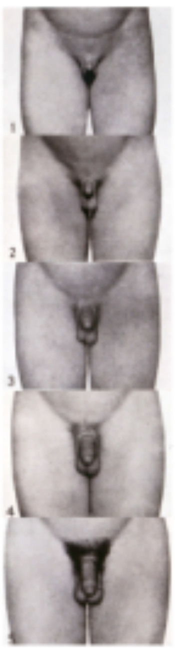
Assessment of Maturation

INSTITUTE OF YOUTH SPORT

Loughborough University

TANNER STAGES: MALE GENITAL DEVELOPMENT

The pictures on this page show different stages of development of the <u>genitals</u> of boys (i.e. the testes and scrotum, and penis). A boy passes through each of the five stages shown by these pictures. Please look at each of the pictures and read the sentences next to the picture. Then choose the picture closest to your stage of development and mark an **A** on the picture. Then choose the picture that is next closest to your stage of development and mark a **B** on the picture. In choosing the right picture, look only at the size and shape of the genitals not at the pubic hair.



Stage 1
The testes, scrotum and penis are about the same size and shape as they have always been since you were a child.

Stage 2
The testes and scrotum have become a little larger. The feel of the skin of the scrotum has changed and it is slightly darker. The scrotum, the sack holding the testes, has lowered a bit.

Stage 3
The penis has grown a little in length. The testes and scrotum have grown bigger and dropped lower than in stage 2.

Stage 4
The penis has grown larger and is wider. The glans (the head of the penis) is bigger than before. The testes have grown bigger and are darker.

Stage 5
The penis, scrotum and testes are the size and shape of that of an adult male.

Once you have completed the form, fold it and put it in the envelope provided and seal the envelope.

Your results are completely private and will be treated in complete confidence. No one will know who has filled out the form, as your name will not be on it.

INSTITUTE OF YOUTH SPORT

Loughborough University

TANNER STAGES: MALE PUBIC HAIR DEVELOPMENT

The pictures on this page show different stages of development of <u>male pubic hair.</u> A boy passes through each of the five stages shown by these pictures. Please look at each of the pictures and read the sentences next to the picture. Then choose the picture closest to your stage of development and mark an **A** on the picture. Then choose the picture that is next closest to your stage of development and mark a **B** on the picture. In choosing the right picture, look only at the pubic hair and not at the size of the testes, scrotum and penis.

Stage 1
(No picture)

Stage 1
There is no pubic hair at all.

Stage 2
There is a little soft hair. Most of the hair is at the base of the penis. This hair may be straight or a little curly.

Stage 3
The hair is darker in this stage. It is coarser and more curled. It has spread out and thinly covers the area around the penis.

Stage 4
The hair is now as dark as that of an adult man. However, the area it covers is not as large as that of an adult man. The hair has not spread out to touch the thighs.

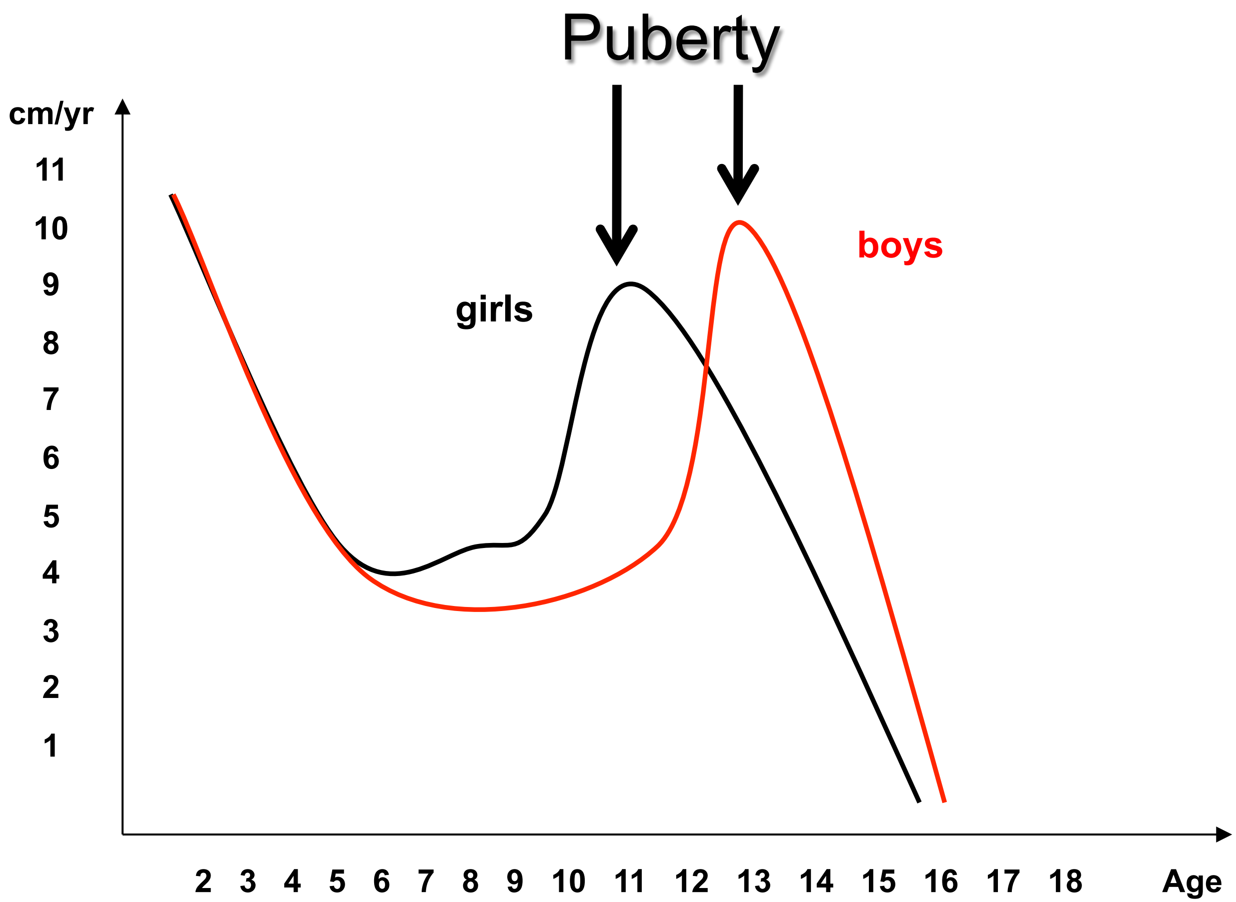
Stage 5
The hair has spread out to touch the thighs. The hair is now like that of an adult man. It also covers the same area as that of an adult man and has the shape of a triangle (V).

Once you have completed the form, fold it and put it in the envelope provided and seal the envelope.

Your results are completely private and will be treated in complete confidence. No one will know who has filled out the form, as your name will not be on it.

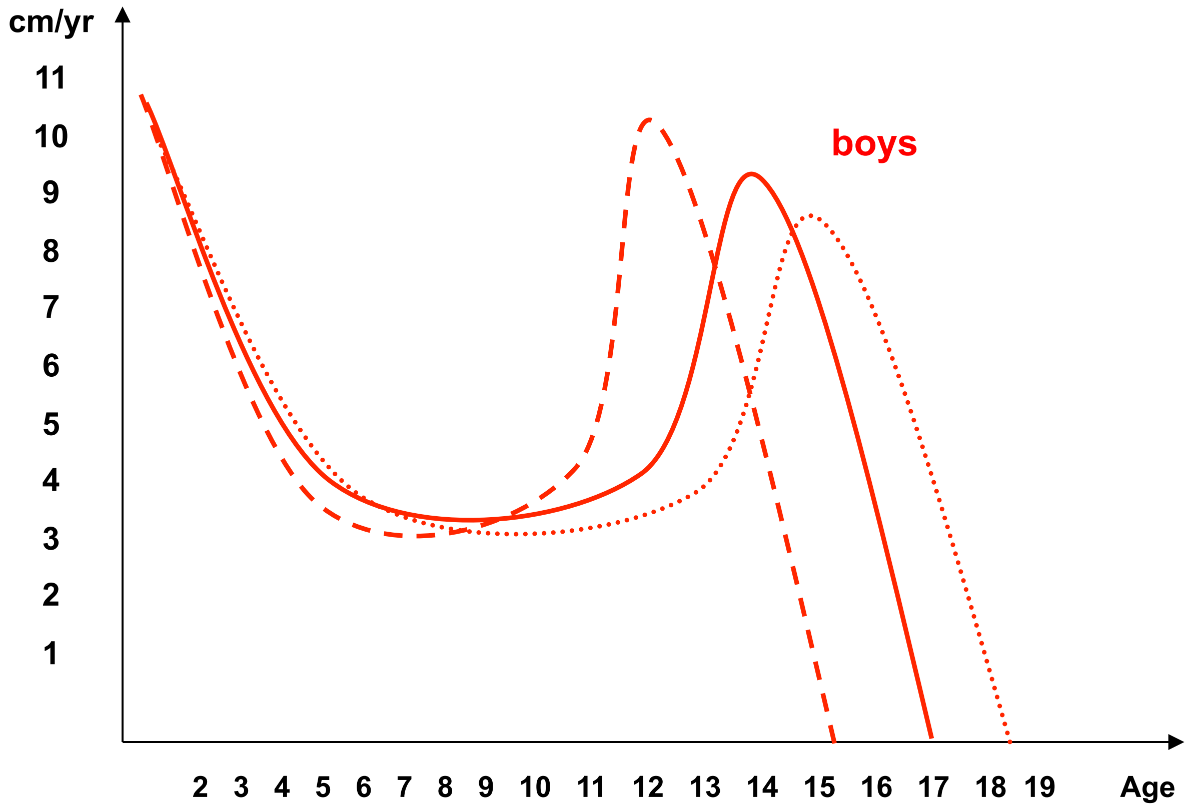
Assessment of Maturation

Height Velocity & Gender Differences



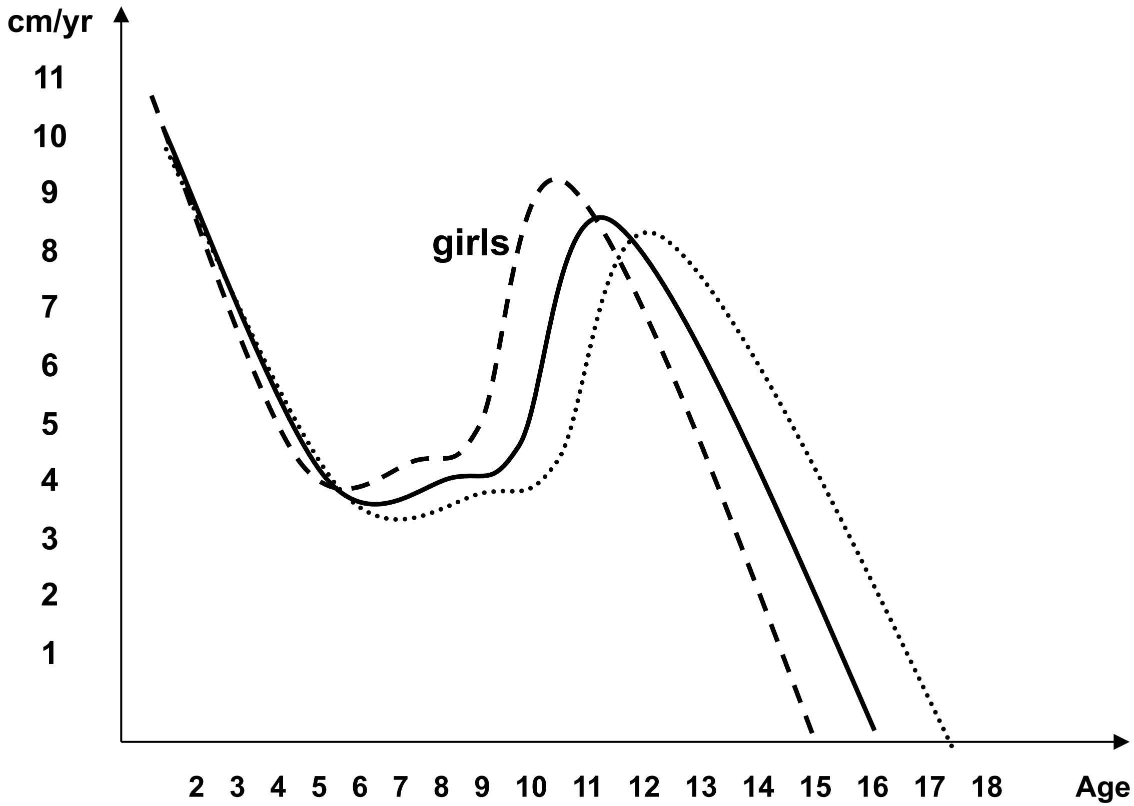
Assessment of Maturation

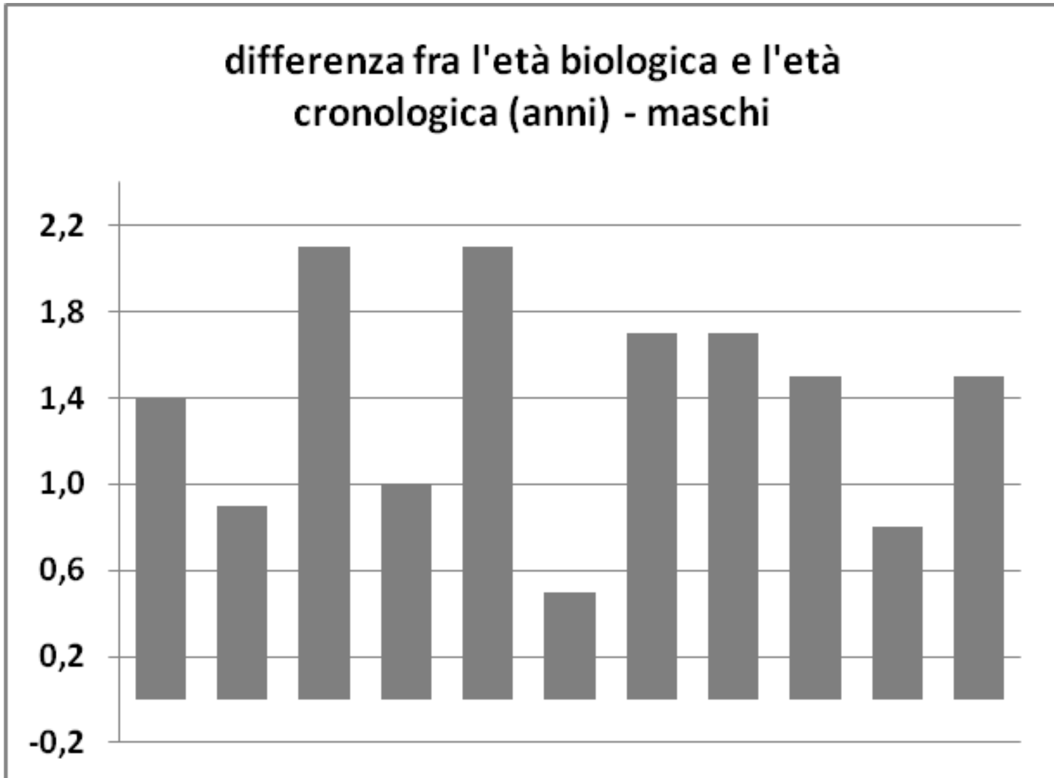
Height Velocity - Early, Average, Late Development



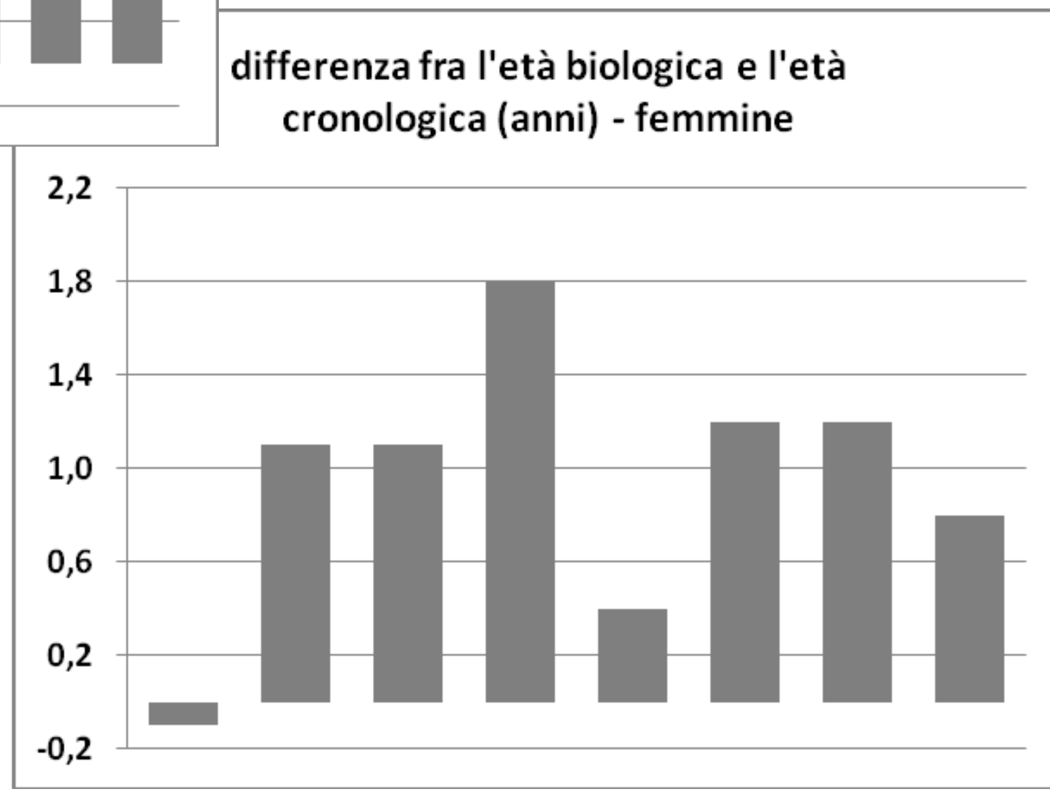
Assessment of Maturation

Height Velocity – Early, Average, Late Development





We have assessed, with echographic tecnique, biological age, according skeletal maturity, in our best young swimmers (13-15 yrs)



Biological age is older than chronological age, on average 0.9 yrs in females and 1.4 yrs in males

Trainability and puberty

The simplest and most effective indicator of trainability of young athletes is body size

As long as height and body mass are far from adult values, the trainability of metabolic systems is poor

Trainability and puberty

THE QUESTION IS:

“stimulate the energy systems of a swimmer at puberty, will make him stronger when he is adult?”

THE ANSWER IS: **MOST LIKELY <u>NO</u>**

Training at puberty should not have the aim to induce adaptations of metabolic systems

A practical example…

A 12-13 year-old girl improves his best time on the 400-meter freestyle in one year:

from 5.20.0 to 4.40.0

Such improvement can be achieved by:

- ✓ *Increase in VO_2 max, and/or*
- ✓ *Increase in anaerobic energy supply, and/or*
- ✓ *Decrease in energy cost*

A practical example…

$$V = \sqrt[3]{\frac{Power * ep * eg}{k}}$$

Time	5.20.0	4.40.0	4.40.0	4.40.0
k	30	30	30	25
ep	0,35	0,35	0,35	0,43
F_d (N)	46,9	61,2	61,2	51,0
VO_2 max (ml/kg/min)	39,8	60,7	39,8	39,8
Lactate (mM)	7	7	37	7
EC (kJ/m)	0,61	0,80	0,80	0,54

A practical example…

Very likely, the improvement from 5.20.0 to 4.40.0 could be achieved by the sum of*:*

- ✓ *5% increase of VO_2 max (about 4 s)*
- ✓ *2 mM increase in blood lactate (about 2 s)*
- ✓ *25% reduction in enerrgy cost (about 34 s)*

Training at puberty

It should be aimed at learning how to perform the training set properly (*pace and distance per stroke costant during the set, correct swimming and gliding tecnique, and so on…*)

The improvement in performance will be mainly for reduction in energy cost for drag reduction and improved propelling efficiency

At puberty, various training set should have technical and learning objectives with:

- **Intensity** (swimming speed) at a defined metabolic regime monitoring swimming tecnique
- **Flexible structure** (i.e., lenght of repetitions, interval of rest) depending on the learning needs
- **Reduced volume**, avoiding to stress energy systems, recovery and motor control
- **An unstructured frequency** during cycles, it is not interesting to enhance adaptations, but ensuring learning

Long-term development of the athlete

FUNdamental | Learning to Train | Training to Train | Training to Compete | Training to Win

5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 +

Chronological age

Biological age +/- 2

Learning to train and training to train…

They are the most important stages to build the athlete in the best way

Robertson & Hamilton, Coventry University 2008

Training should be considered as a chronic stress factor in addition to other stress factors that each individual is subjected daily (physiological, psychological, social)


Stress factors related to training
(mechanical, metabolic, psychological)

↓

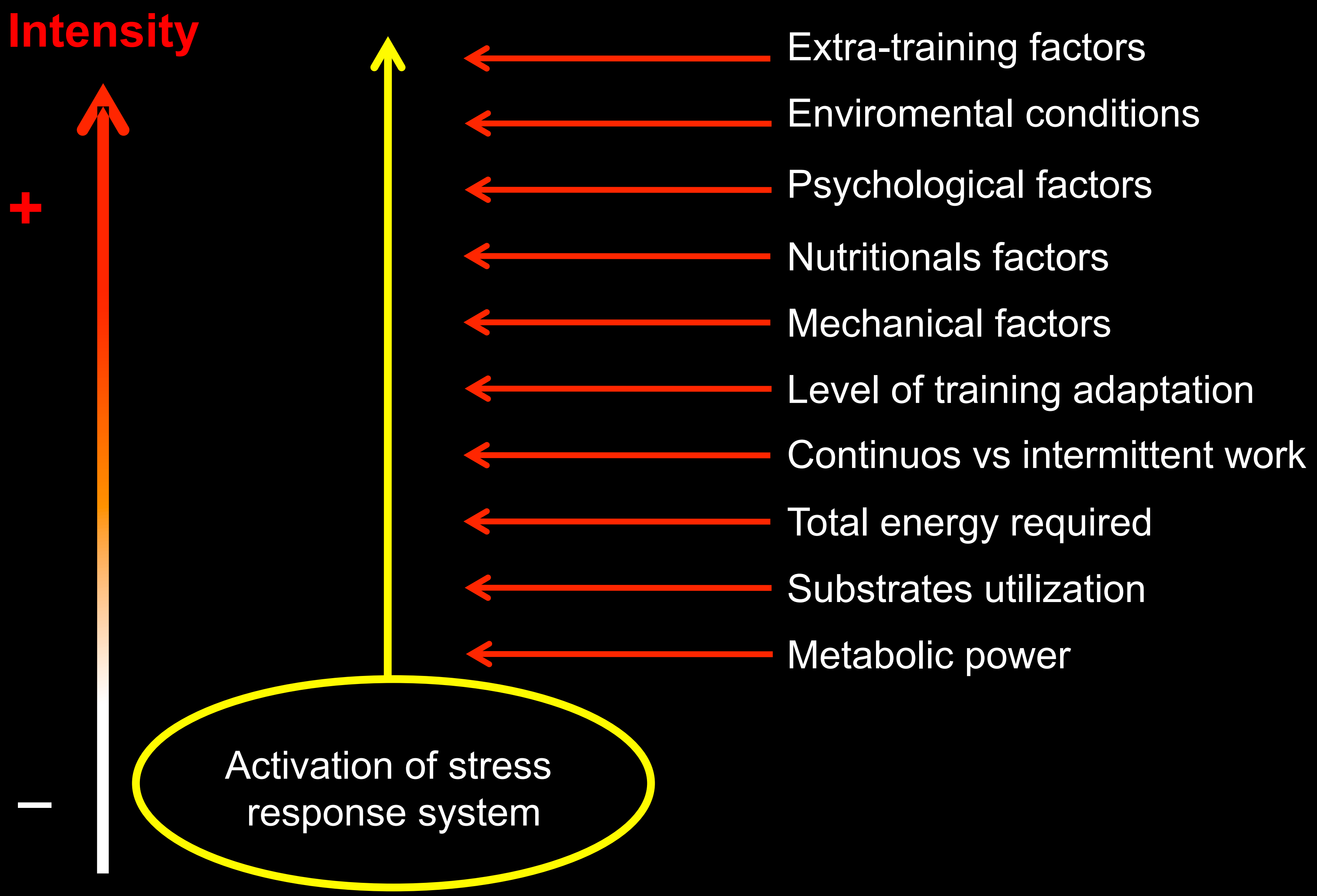
CRH release from hypotalamus

↓

ACTH release from pituitary

↓

Cortisol release from adrenal gland



Intensity
+
–
Extra-training factors
Enviromental conditions
Psychological factors
Nutritionals factors
Mechanical factors
Level of training adaptation
Continuos vs intermittent work
Total energy required
Substrates utilization
Metabolic power
Activation of stress
response system

Total stress (training plus non-training stress) within the available reserve of stress tolerance will result in **adaptation** with improved performance

Total stress (training plus non-training stress) above the available reserve of stress tolerance will result in **maladaptation** with decreased performance

Usually, it is possible to assess if a training cycle (lasting from 2-3 to 6 months) is adaptive or maladaptive only after the end of the cycle

Negative effects of prolonged cortisol elevation on motor system

Most parts of the motor system show the presence of cortisol receptors that render their circuits susceptible to the influence of stress hormones

Stress and cortisol modulate temporal and spatial aspects of motor performance

Skilled movements seem to be most prone to stress-induced disturbances

Metz, Rev Neurosci 2007

Some markers of maladaptation related to performance on standard exercise test

- decreased performance
- inability to meet previously attained performance standard
- need to prolong recovery
- loss of coordination
- decreased efficiency (stroke length in swimming)
- decreased amplitude of movements
- reappearance of technical faults already corrected
- reduced capacity of differentiation and correcting faults

PREVENTION OF MALADAPTATION

1. Matching stress and recovery
2. Structure of the training programme
3. Control of training intensity

Recovery includes:

✓adequate caloric and fluid intake in the diet

✓adequate rest (passive recovery during daytime)

✓sufficient time of sleep

✓reduction of non-training stressors

✓relaxation techniques (massage, saunas, counselling...)

PREVENTION OF MALADAPTATION

1. Matching stress and recovery
2. <u>Structure of the training programme</u>
3. Control of training intensity

A well planned training programme will assist in the administration of correct workload and adequate periods of regeneration to avoid excessive fatigue

Organisation of training in different periods allows:

- ✓ monitoring the improvements in performance
- ✓ to detect sign of impending overeaching
- ✓ a systematic prescription of workload and recovery

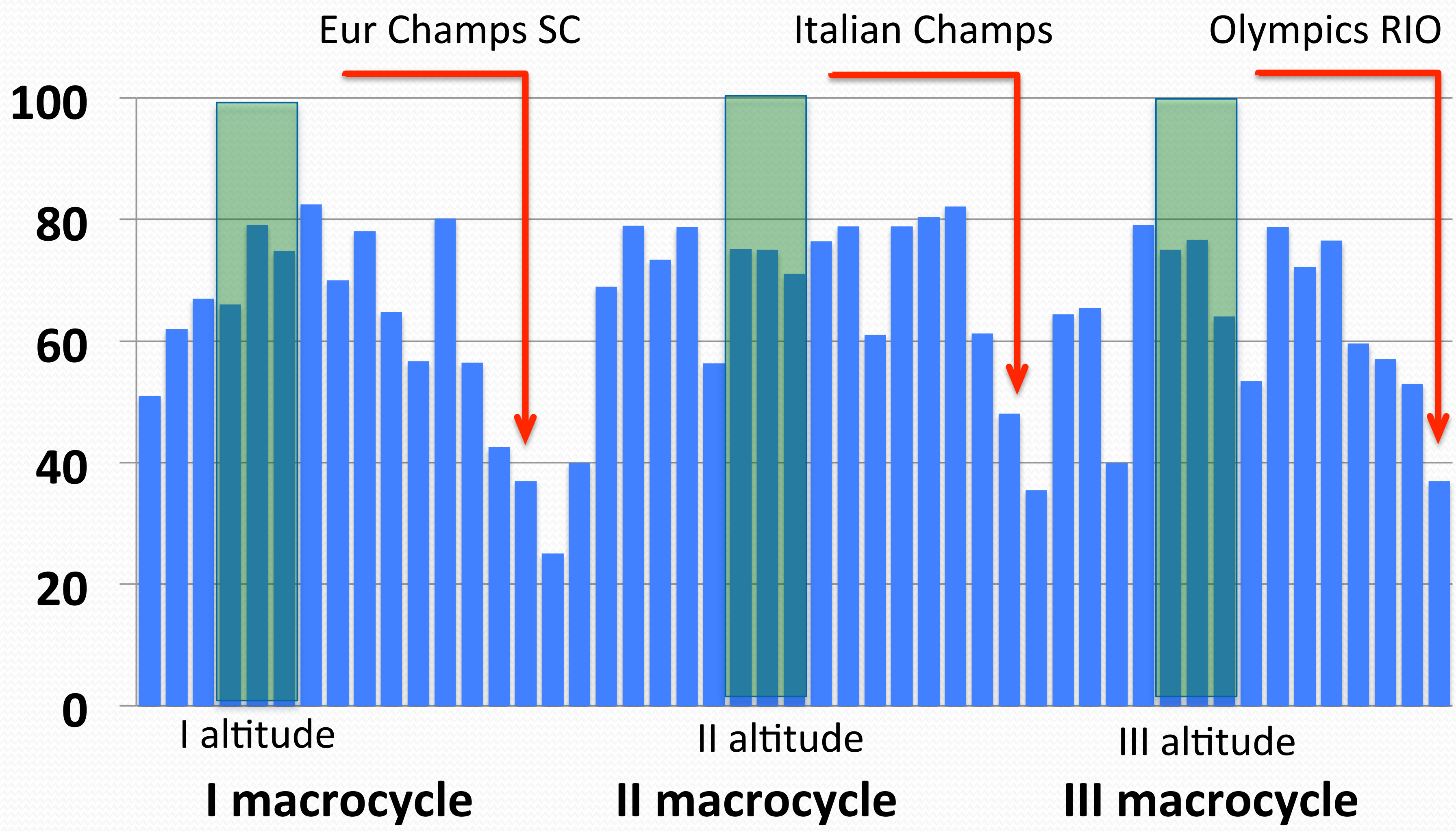
Structure of the macrocycle

period	I	II	III	IV
type	recovery	general	specific	tapering
duration (weeks)	1 - 3	3 - 6	3 - 6	1 - 3

The total duration of the macrocycle is 10 - 18 weeks

Each period is divided in microcycle lasting 3 - 4 days

Coach Morini – Weekly Training Volume **2015-2016** (km)



About 3200 km in total

8% with fins

7% with paddles

10% only arms with pull

8% only arms with paddles and pull

10% only legs

Work load distribution

- about 75-80% in A (aerobic at low intensity)
- about 15-20% in B (aerobic high intensity)
- about 5% in C (anaerobic and speed)

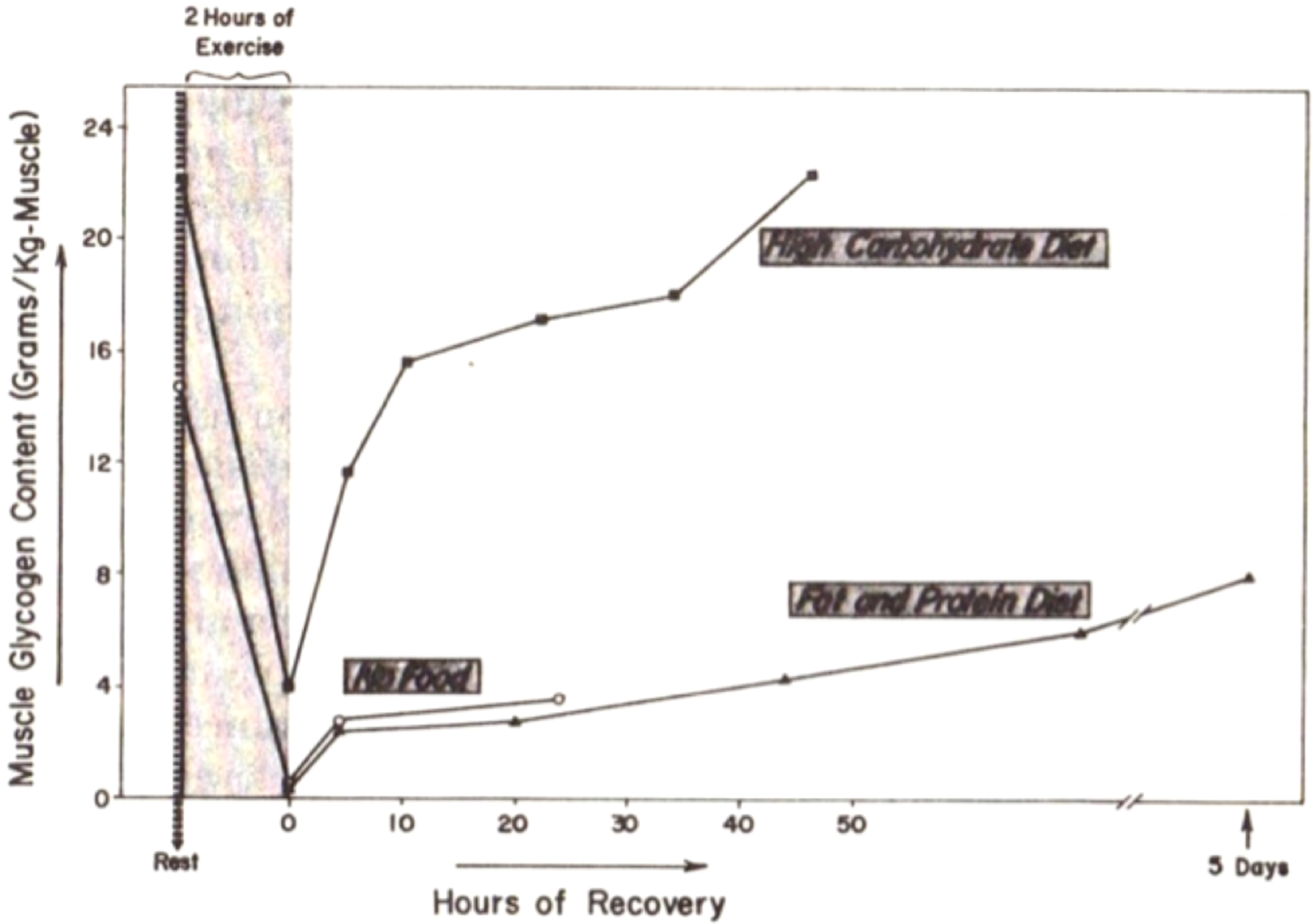
about 10% of the total (more then 300 km in the year) at pace race of 1500 m

PREVENTION OF MALADAPTATION

1. Matching stress and recovery

2. Structure of the training programme

3. <u>Control of training intensity</u>

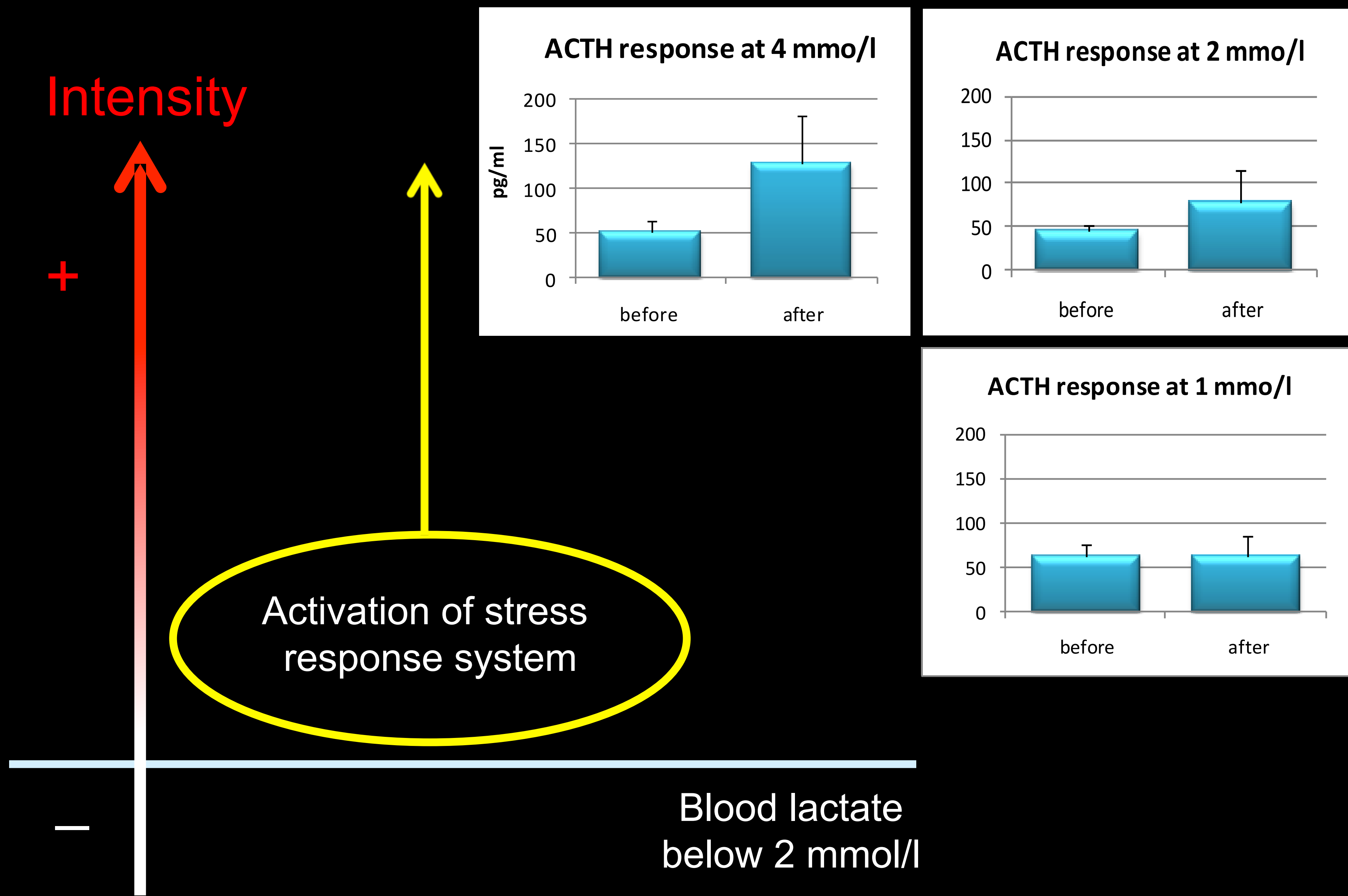


2 Hours of Exercise
Muscle Glycogen Content (Grams/Kg-Muscle)
24
20
16
12
8
4
0
High Carbohydrate Diet
Fat and Protein Diet
No Food
0
10
20
30
40
50
Rest
5 Days
Hours of Recovery

Metabolic stress factor during training

Among metabolic factors, a very important stressor in swimming training is the high rate of glycogen consumption during high intensity aerobic training

Training intensity (lactate)	Energy substrates
at **4 mmol/l** blood value	muscle glycogen
at **2 mmol/l** blood value	muscle glycogen and fats
at **1 mmol/l** blood value	mainly fats



Bonifazi et al, unpublished

Prevention of maladaptation by monitoring training intensity under aerobic conditions (lactate less than 2 mmol/l)

USEFULNESS OF LACTATE DETERMINATION

1. EVALUATION OF AEROBIC CONDITION
2. INDICATION OF TRAINING PACE
3. CONTROL OF INTENSITY OF TRAINING (ESPECIALLY IN THE AEROBIC FIELD)
4. INDICATION OF ANAEROBIC CONDITION

SOME FACTORS AFFECTING LACTATE AT SUBMAXIMAL WORKLOAD

(independently from aerobic and technical level)

- water temperature (above 32° or under 24°)
- site of sampling (arterial, venous or capillary)
- time of sampling (from the end of effort)
- bicarbonate ingestion

amount of glycogen stores (the most important)

when glycogen stores are reduced lactate is lower at the same sub-maximal intensity

EVALUATION OF AEROBIC CONDITION
(for middle and long-distance swimmers)

5 x 300 m with 1 min of rest

- first repetition: 85 % of the swimming speed on 400 m
- other repetitions: 5 - 8 seconds faster than the previous
- sample for lactate determination after each repetition

Gregorio Paltrinieri 12/01/2015 (50 m)

5 x 300 m with 1’ of rest

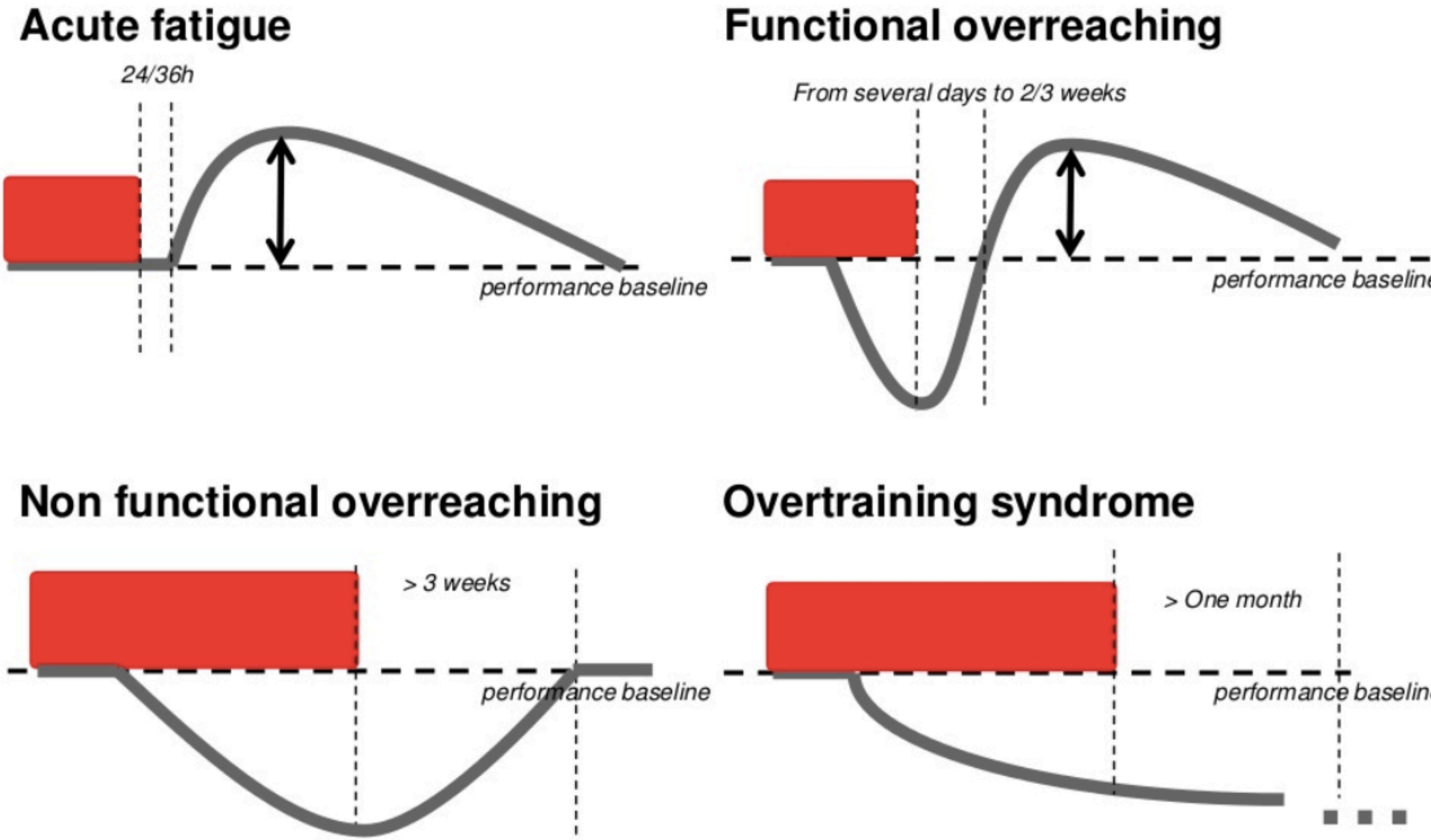
				mmol/l	HR	Sf	Ds
I	3	31	4	0,6	126	30,0	2,72
II	3	21	8	1,0	132	35,0	2,45
III	3	11	7	1,7	138	39,0	2.31
IV	3	03	7	3.0	150	40,5	2.32
V	2	56	1	7.3	160	43,7	2.25

Gregorio Paltrinieri 12/01/2015 (50 m)

Pace for aerobic endurance (A2), anaerobic threshold (B1) and VO_2 max (aerobic overload) (B2)

Set	A2 (1,5 mmol/l)	B1 (3 mmol/l)	B2 (6 mmol/l)
50 m	30.2	28.9	27.7
100 m	1.02.4	1.00.1	57.9
200 m	2.06.8	2.02.6	1.58.4
300 m	3.11.3	3.05.1	2.58.9
400 m	4.15.7	4.07.5	3.59.4
every 50 m	32.2	31.2	30.2

% of total volume: 75-85% 15-20%


Acute fatigue
24/36h
performance baseline
Functional overreaching
From several days to 2/3 weeks
performance baseline
Non functional overreaching
> 3 weeks
performance baseline
Overtraining syndrome
> One month
performance baseline

Le Meur, 2015

date	**Paltrinieri** 14.39.67	**Jaeger** 14.41.20	**Detti** 14.53.93
Nov 2015		15.19.59	
Dec	*14.08.06*		14.53.39
Jan 2016		15.06.24	
Feb			
Mar	14.40.61	15.14.68	14.48.86
Apr	14.42.91		14.46.48
May	14.34.04	14.59.13	14.48.75
Jun		15.28.34	
Jul	14.51.62	14.47.61	
Aug (RIO)	**14.34.57**	**14.39.48**	**14.40.86**