Understanding Lactate Clearance

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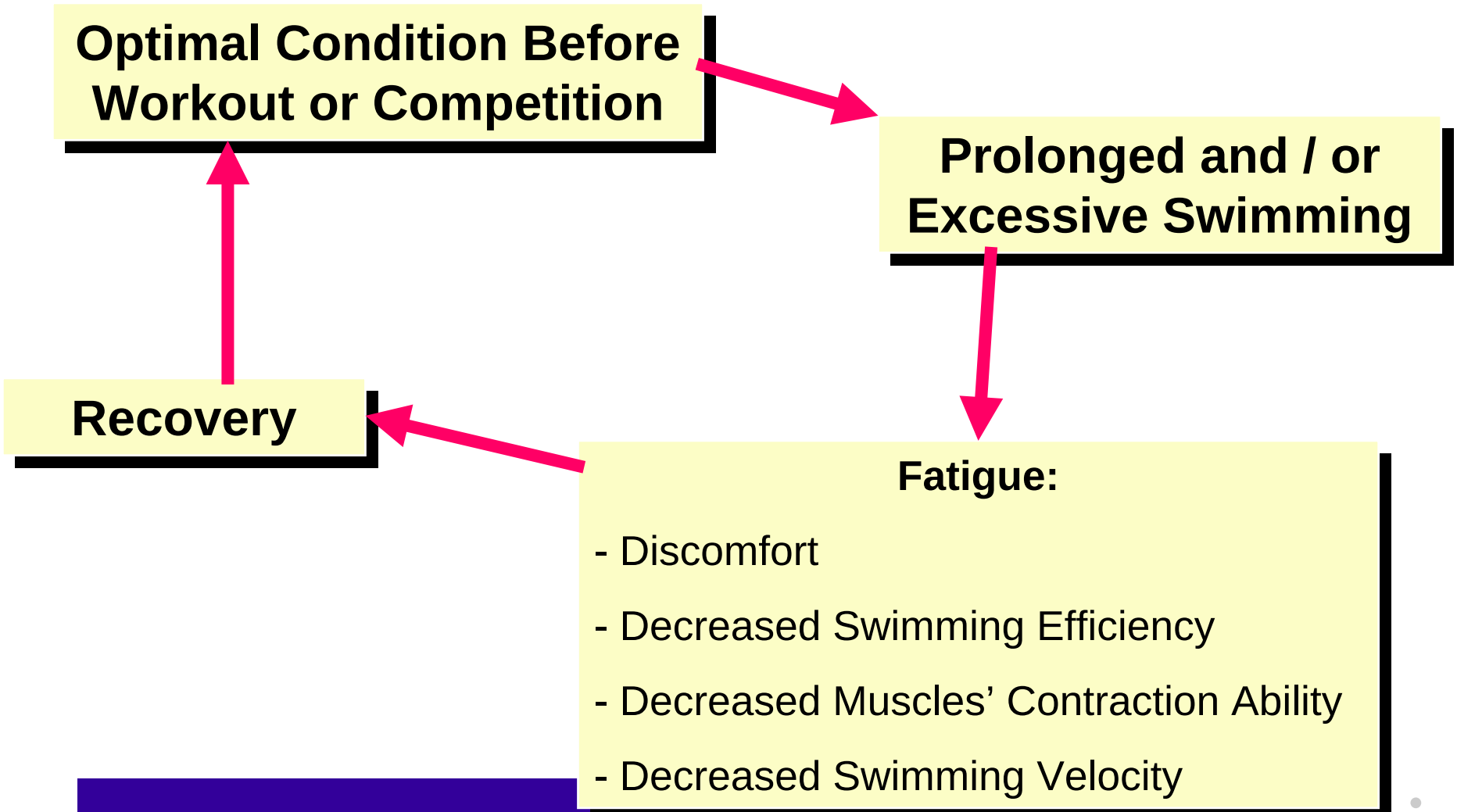
USA Swimming

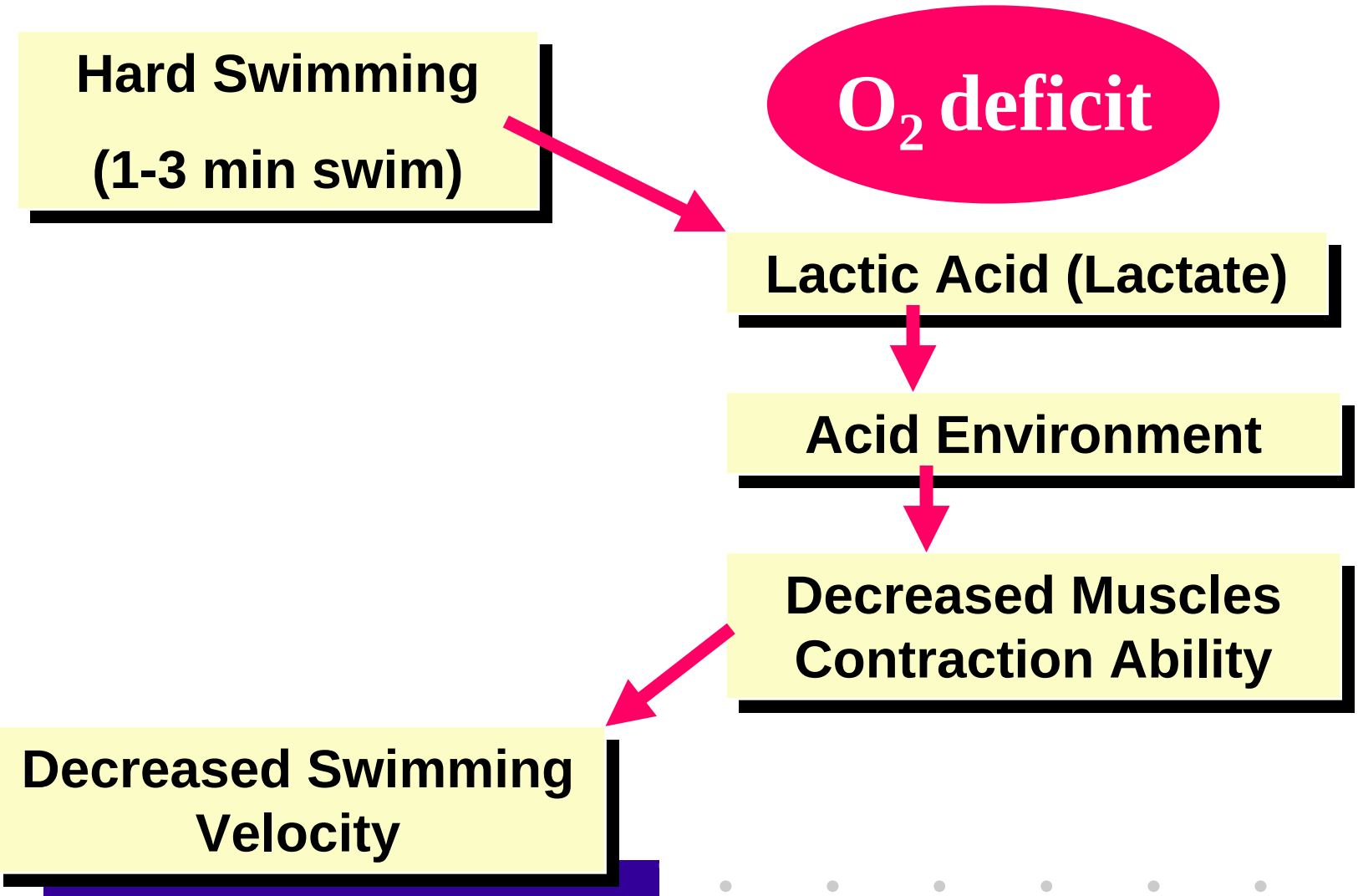
Fatigue in Swimming

- **Fatigue** is a state of discomfort, decreased efficiency, and reduced swimming velocity resulting from prolonged and/or excessive exertion.
- Fatigue requires more or less prolonged time to normalize the functions of various organs.

Fatigue in Swimming



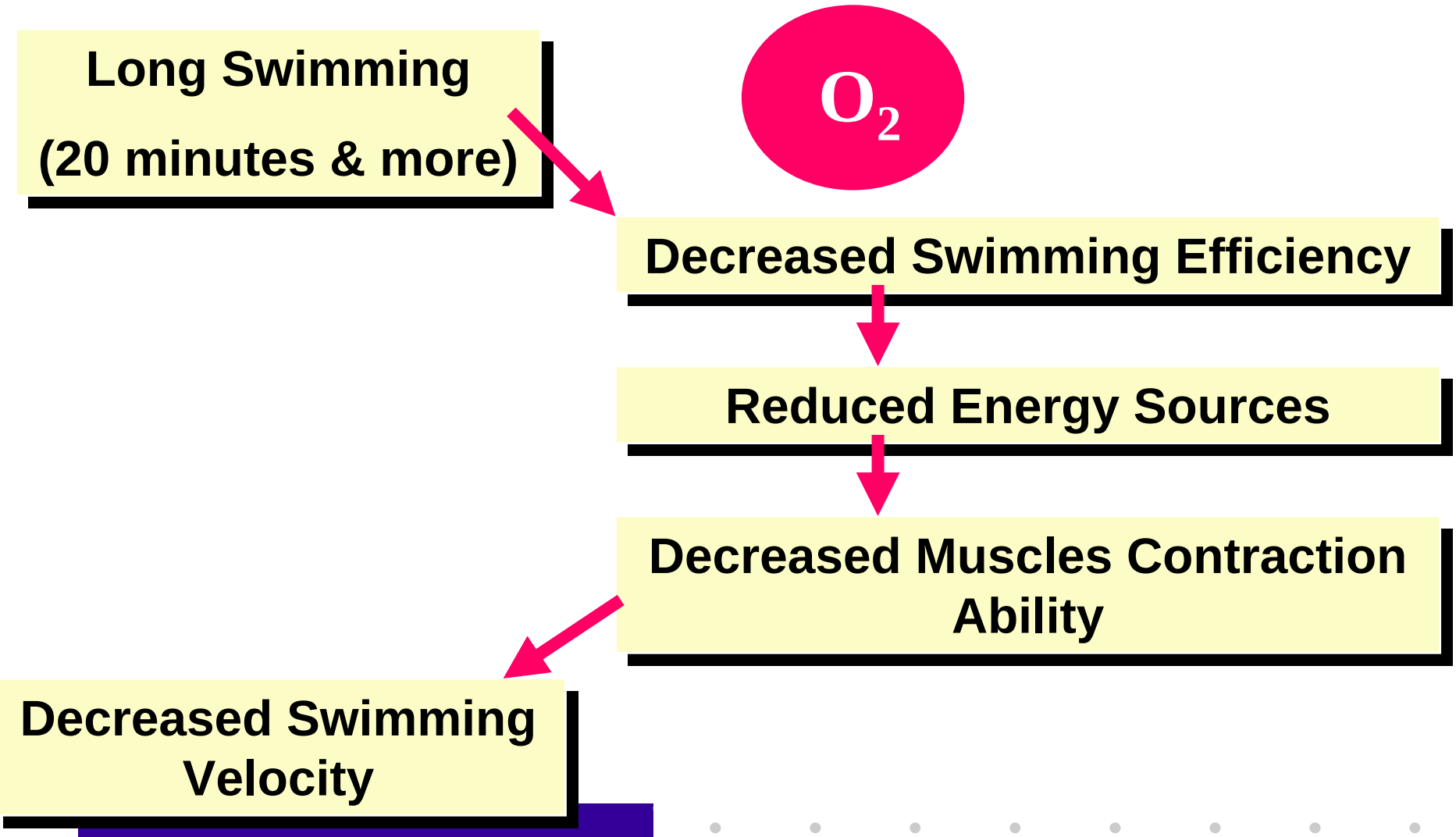
Hard Swimming



Anaerobic Metabolism

- The main energy system for distances lasting from 30 sec to 3 min
- Lactic acid is a by-product of anaerobic glycolysis
- Swimmers produce maximum lactate amounts in distances from 100 to 400 m, when anaerobic glycolysis is the dominant pathway

Fatigue After Long Swimming



Importance of Lactate Clearance

- During competition, swimmers are faced with numerous races: prelims, semifinals and finals
- Lactic acid (or lactate) creates an acid environment in the body, which ultimately affects the ability of muscles to contract
- In order for a swimmer to perform at maximal effort again, lactate must be removed

Types of Recovery

- **Passive Recovery:**

  Athletes recover after competition sitting in the pool. No warm-down swimming, no stretching.

- **Active Recovery:**

  Athletes are swimming warm-down, doing stretching.

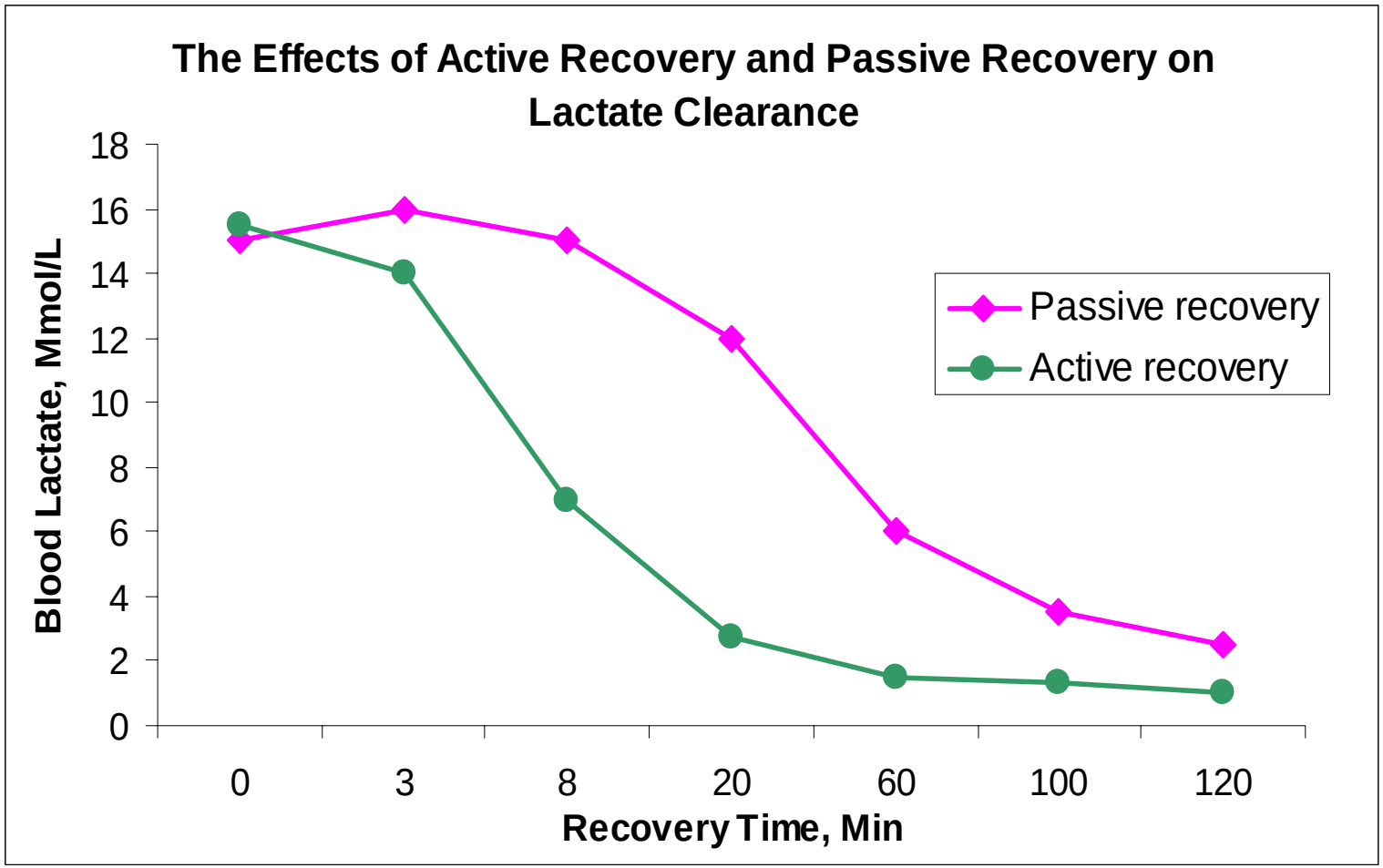
Examples of Passive Recovery

- Sitting on the bench or deck
- Talking to friends or coach
- Listening to music
- Watching races

Examples of Active Recovery

- Cool-down swimming
- Active stretching
- Jogging

Active and Passive Recovery



Effects of Active Recovery

- Elevated blood circulation
- Fast oxygen delivery
- Elevated transition of lactate from muscles to the blood
- Faster lactate clearance
- Faster replenishment of energy sources in muscles
- Increased muscle contraction ability
- Ability to race again at maximum efforts within a short time period

Effects of Passive Recovery

- Slow blood circulation
- Slow oxygen delivery
- Slow transition of lactate from muscles to the blood
- Slow lactate clearance
- Slow replenishment of energy sources in muscles
- Decreased muscle contraction ability
- Inability to race again at maximum efforts within a short time period

Duration of Active Recovery

- The shorter the race distance, the longer the active recovery
- Duration of warm-down after the race for sprinters 25-30 min
- Duration of warm-down after the race for middle distance swimmers 20-25 min
- Duration of warm-down after the race for distance swimmers 15-20 min

Intensity of Active Recovery

- Intensity of warm-down for sprinters 50-55% of maximum 100 swimming velocity
- Intensity of warm-down for middle distance swimmers 55-60% of maximum 100 swimming velocity
- Intensity of warm-down for distance swimmers 60-65% of maximum 100 swimming velocity

Duration of Active Recovery Swimming

400 to 1500 Swimmers	Race Duration	50 to 200 Swimmers
10-15 min	50	20-25 min
15-20 min	100-200	25-30 min
15-20 min	400	20-25 min
10-15 min	800-1500	15-20 min

Types of Skeletal Muscle Fibers

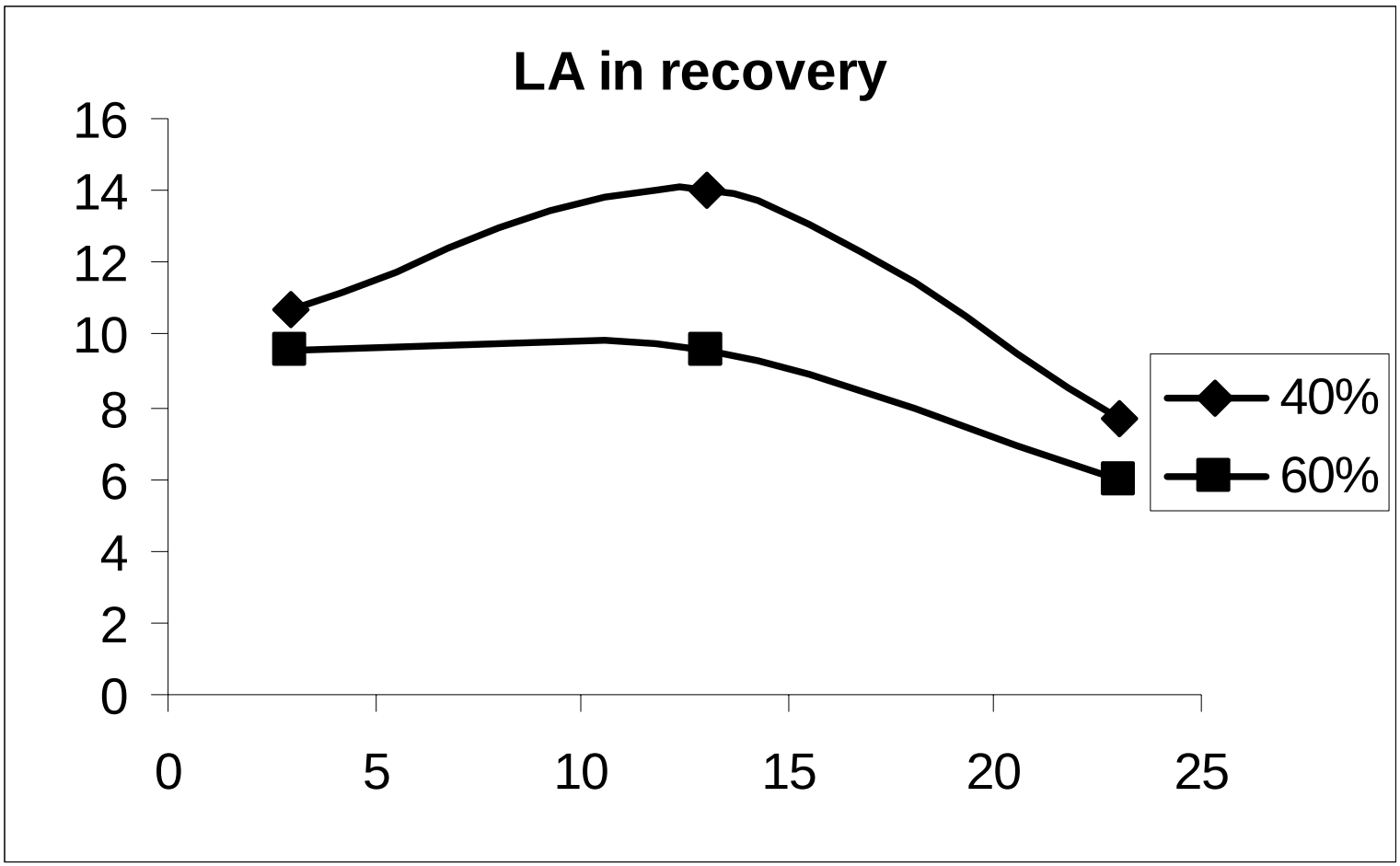
- Skeletal muscles have two categories of fibers:
- fast twitch (white or type I)
- slow twitch (red or type II)

- Fast twitch muscle fibers contract rapidly, but shortly, high peak lactates, and slow lactate clearance
- Slow twitch muscle fibers contract slowly, but longer time, low peak lactates, and fast lactate clearance

Peculiarities of Lactate Clearance

- **Sprinters:**
  - High peak of lactate after the race (10-16 mmol/l)
  - Slow lactate clearance after the race
  - Long warm-down protocol (25-30 min)
  - Low intensity of warm-down protocol

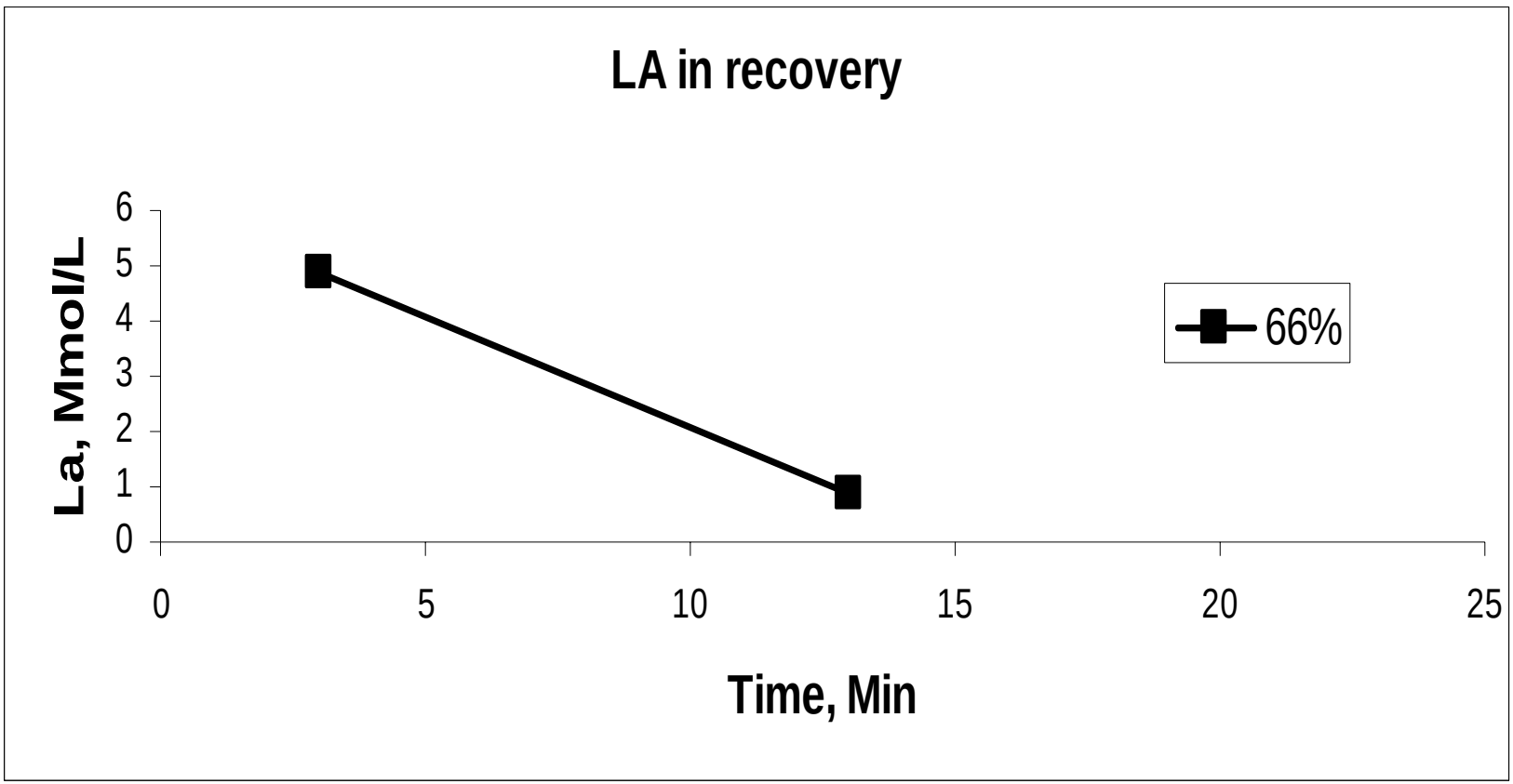
Example of Lactate Clearance (Sprinter)



Peculiarities of Lactate Clearance

- **Distance swimmers:**
  - Low peak of lactate after the race (5-8 mmol/l)
  - Fast lactate clearance after the race
  - Short warm-down protocol (15-20 min)
  - Moderate intensity of warm-down protocol

Example of Lactate Clearance (Distance Swimmer)



Working Capacity

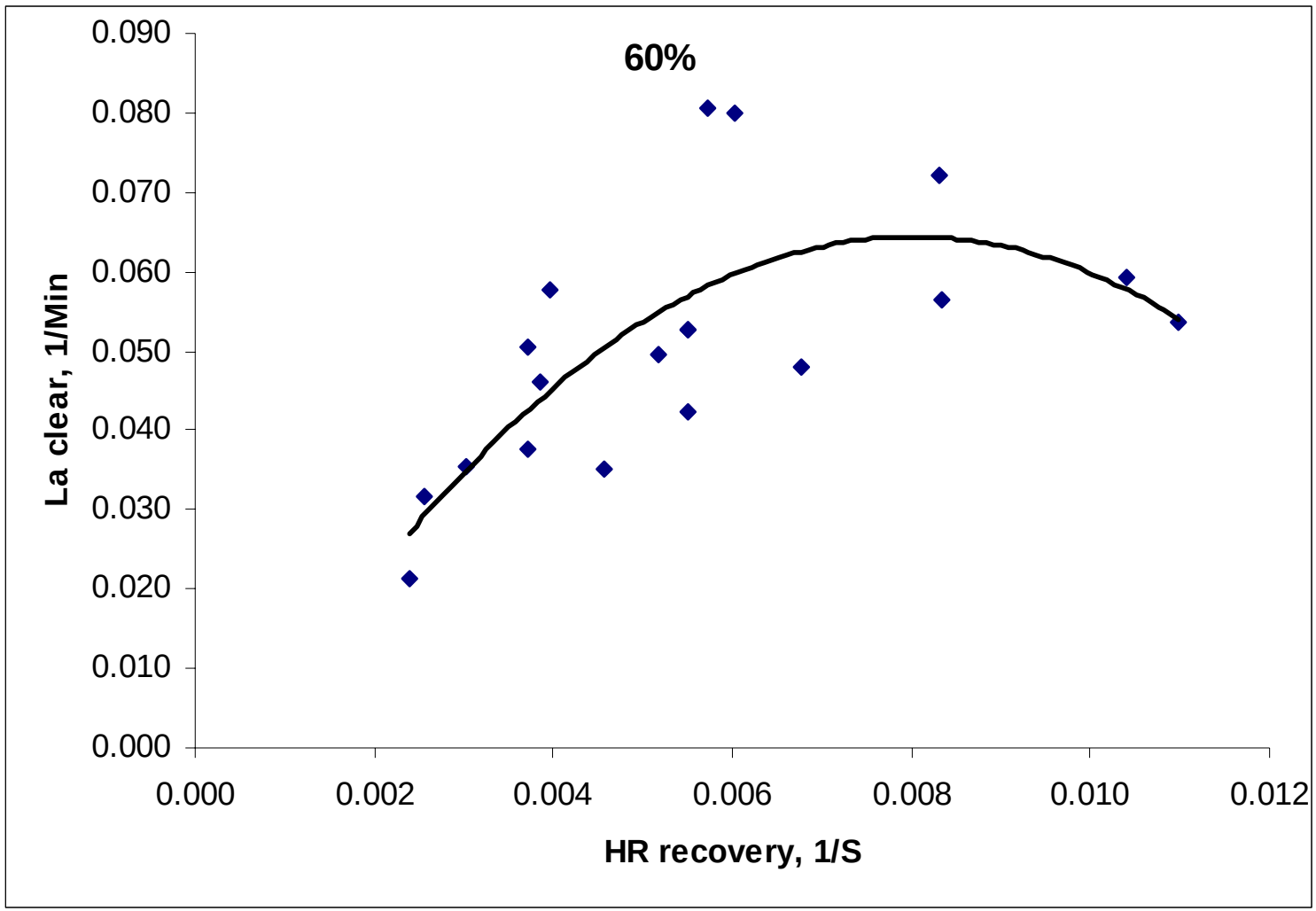
- Lactate clearance depends on working capacity.
- Working capacity can be evaluated as heart rate in recovery after test set or time trial.
- Heart rate is easy to count on the neck or wrist.
- The lower the maximum heart rate and higher the rate of heart rate recovery, the better is the working capacity.

Heart Rate in Recovery

- Decline of heart beats during the first minute of recovery after the race or swimming set:

	Swimmer 1	Swimmer 2
HR1 - from 0-10 sec	31	30
HR2 - from 30-40 sec	27	29
HR3 - from 60-70 sec	24	27

Lactate Clearance - HR Recovery



Calculation of Heart Rate in Recovery

- HR1 - 31 beats/10 sec
- HR2 - 27 beats/10 sec
- HR3 - 24 beats/10 sec

- HR Recovery = 100 – [(HR3/HR1)*100]
- HR Recovery = 100 – [(24/31)*100] = 22.6%

Duration of Post-Race Recovery

- Heart Rate Recovery is 22.6%. This number is put into a formula:

- $Y = 99.15 * X^{-0.4316}$,

- where Y = duration of post-race recovery at 60% swimming velocity (in minutes), and X = Recovery Heart Rate (%). After calculations, we get an optimal duration of post-race recovery of 25.8 min.

Lactate Clearance Feedback

Summer Nationals, Fort Lauderdale, 8/12/2002

Protocol 1 - 151 bpm

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Testing Time - 8/12/2002

Testing Stroke - Fly

Testing Distance - 100 LCM

Result - 0:58.49

Minutes	Lactates
3	9.30
13	8.30
16	6.40

		(after Peak)
Rate of Recovery: First 10 Min -	**10.75 %**	**10.75 %**
Second 10 Min -	**76.31 %**	**76.31 %**
First 20 Min -	**78.85 %**	**78.85 %**

Optimal Duration of Warm-Down:

Down to 2 mmol/L - 19.9 Min

Down to 1 mmol/L - 21.5 Min

Lactate Clearance Feedback

Summer Nationals, Fort Lauderdale, 8/12/2002

Protocol 7 - 143 bpm

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Testing Time - 8/15/2002
Testing Stroke - Free

Testing Distance - 100 LCM

Result - 0:54.66

Minutes	Lactates
3	13.10
13	11.80
30	4.30
38	2.40

		(after Peak)
Rate of Recovery: First 10 Min -	**9.92 %**	**9.92 %**
Second 10 Min -	**37.39 %**	**37.39 %**
First 20 Min -	**43.60 %**	**43.60 %**

Optimal Duration of Warm-Down:

Down to 2 mmol/L - 36.7 Min

Down to 1 mmol/L - 40.9 Min

Lactate Clearance Feedback

02 JEI, L.A., 7/18/2002

Protocol 1 - 126 bpm

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Testing Time - 7/18/2002
Testing Stroke - Free
Testing Distance - 800 LCM
Result - 8:00.82

Minutes	Lactates
3	7.10
13	1.40

		(after Peak)
Rate of Recovery: First 10 Min -	**80.28 %**	**80.28 %**
Second 10 Min -	**407.14 %**	**407.14 %**
First 20 Min -	**160.56 %**	**160.56 %**

Optimal Duration of Warm-Down:

Down to 2 mmol/L - 8.9 Min

Down to 1 mmol/L - 10.7 Min

Lactate Clearance Feedback

02 Summer Nationals, Fort Lauderdale, 8/12/2002

Protocol 1 - 145 bpm

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Testing Time - 8/12/2002

Testing Stroke - IM

Testing Distance - 200 LCM

Result - 2:03.27

Minutes	Lactates
3	13.20
23	12.90
31	7.70

		(after Peak)
Rate of Recovery: First 10 Min -	**1.14 %**	**1.14 %**
Second 10 Min -	**1.15 %**	**1.15 %**
First 20 Min -	**2.27 %**	**2.27 %**

Optimal Duration of Warm-Down:

Down to 2 mmol/L - 36.8 Min

Down to 1 mmol/L - 38.3 Min

Recovery Profile Feedback

#	Date	Result	La Peak	Rec 0-10	Rec 20	Warm-D...	Result	La Peak	Rec 0-10	Rec 20	Warm-D...
1	5/16/2003	200 IM	9.6	21%	67%	22.4	200 IM	10.4	31%	73%	21.8
		0:00.00	Medium	Medium	Medium	High	0:00.00	Medium	Medium	High	High
2	5/18/2003	200 Fly	8.6	35%	60%	26.6	200 Fly	6.9	-1%	53%	23.1
		0:00.00	Low	High	Low	VLow	0:00.00	VLow	VLow	VLow	Medium

Conclusions

- Swimming at high velocity yields high amounts of lactate in the muscles. This has negative effects on the ability of the muscles to contract. In order for a swimmer to perform at maximal effort again, lactate must be removed
- Active recovery (swimming warm-down) is helpful for lactate removal. During passive recovery (i.e. sitting on the bench) lactate removal is very slow
- Duration of post-race recovery should be 25-30 min for sprinters, 20-25 min for middle distance swimmers, and 15-20 min for distance swimmers

Conclusions

- Swimming intensity during warm-down should be light for sprinters (about 50-55% of maximum 100 m swimming velocity), light to moderate for middle distance swimmers (55-60% of maximum 100 m swimming velocity), and moderate for distance swimmers (60-65% of maximum 100 m swimming velocity)
- The post-race recovery protocol should include straight swimming. Warm-down can be substituted with stretching if there is no warm-down pool available. Heart rate during stretching should be low (120-140 beats/min or 20-23 beats/10 sec)
- The warm-down protocols can also be used for workouts after hard swimming sets. A warm-down will help to recover faster before the next workout