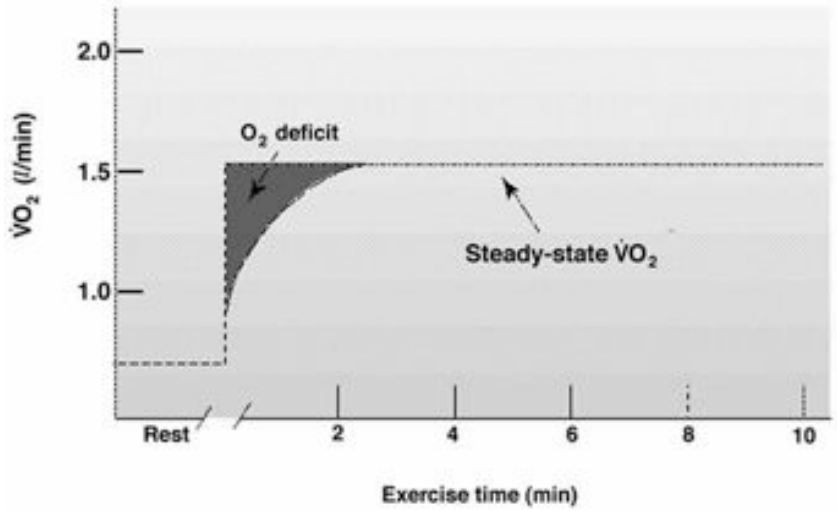
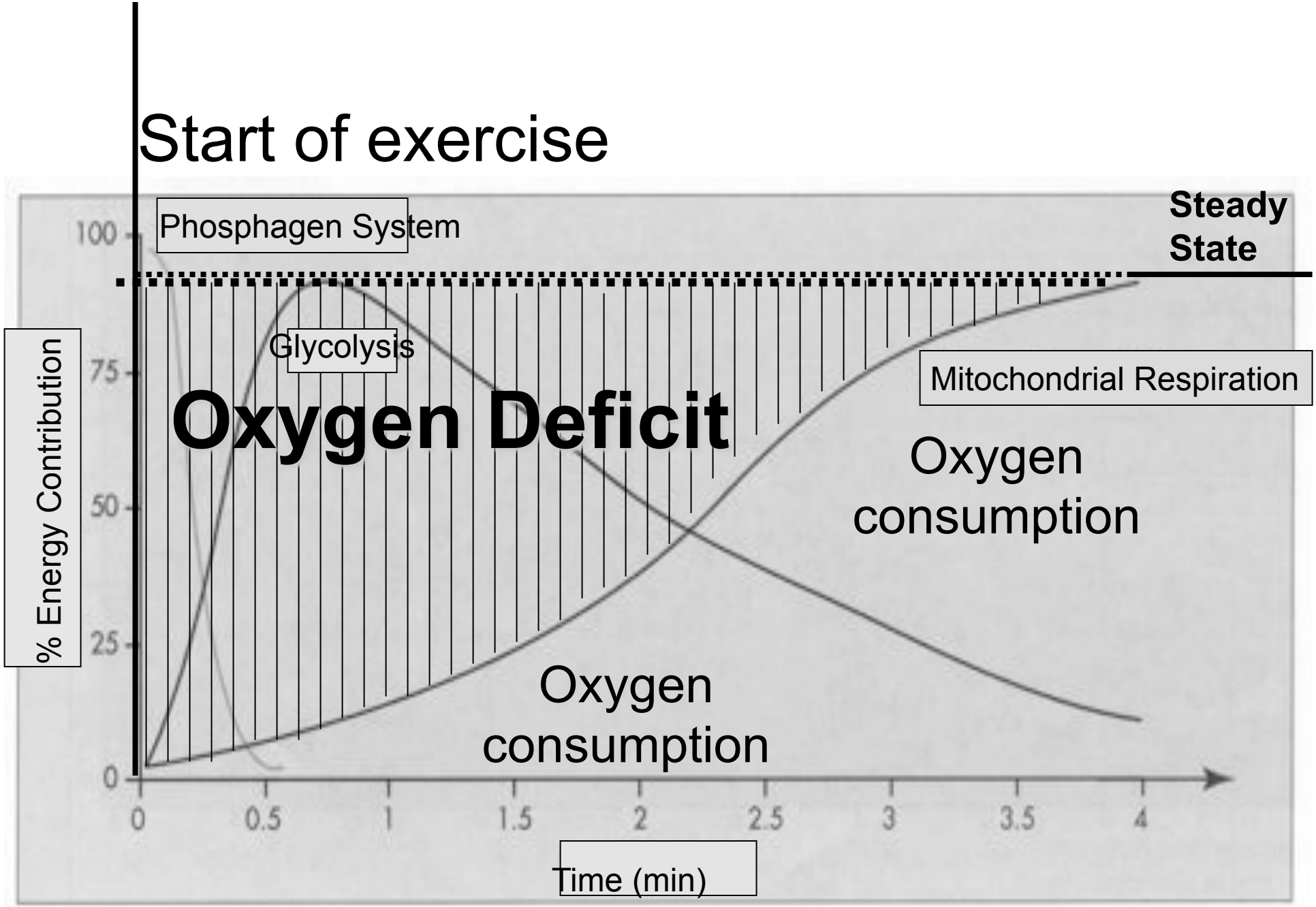
Maximal Accumulated Oxygen Deficit

- Considered by many to be the gold standard of anaerobic capacity determination

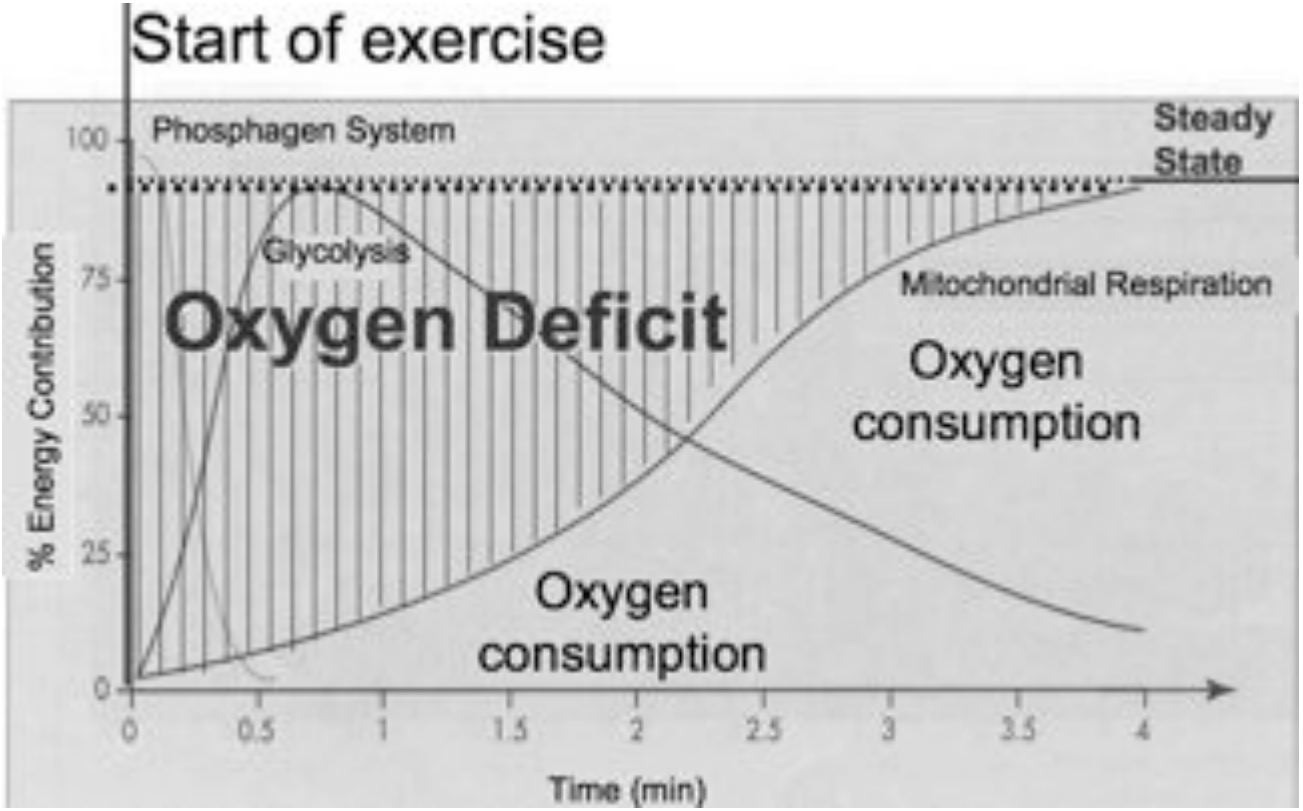
First we must understand oxygen deficit!




Start of exercise
Phosphagen System
Steady State
Glycolysis
Oxygen Deficit
Mitochondrial Respiration
Oxygen consumption
Oxygen consumption
% Energy Contribution
100
75
50
25
0
0
0.5
1
1.5
2
2.5
3
3.5
4
Time (min)

What is oxygen deficit?

Deficit (O_2) met by the phosphagen and glycolytic energy systems to meet the O_2 demand (workload) of the exercise.



Concept of MAOD

During moderate intensity exercise, a linear relationship exists betwe exercise intensity and oxygen demand.

Rate of anaerobic contribution is taken as the max O_2 demand minus max O_2 uptake.

Concept of MAOD

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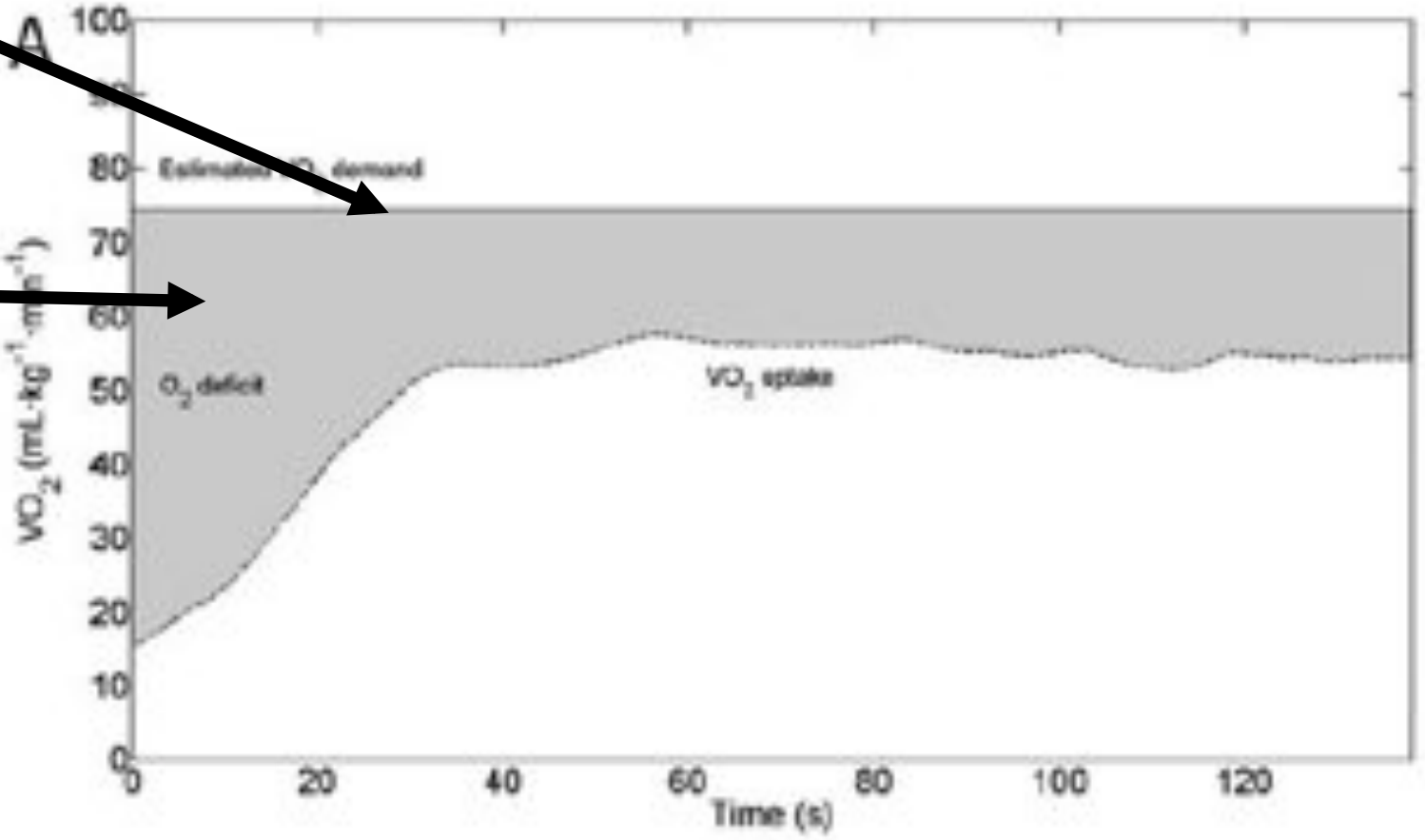
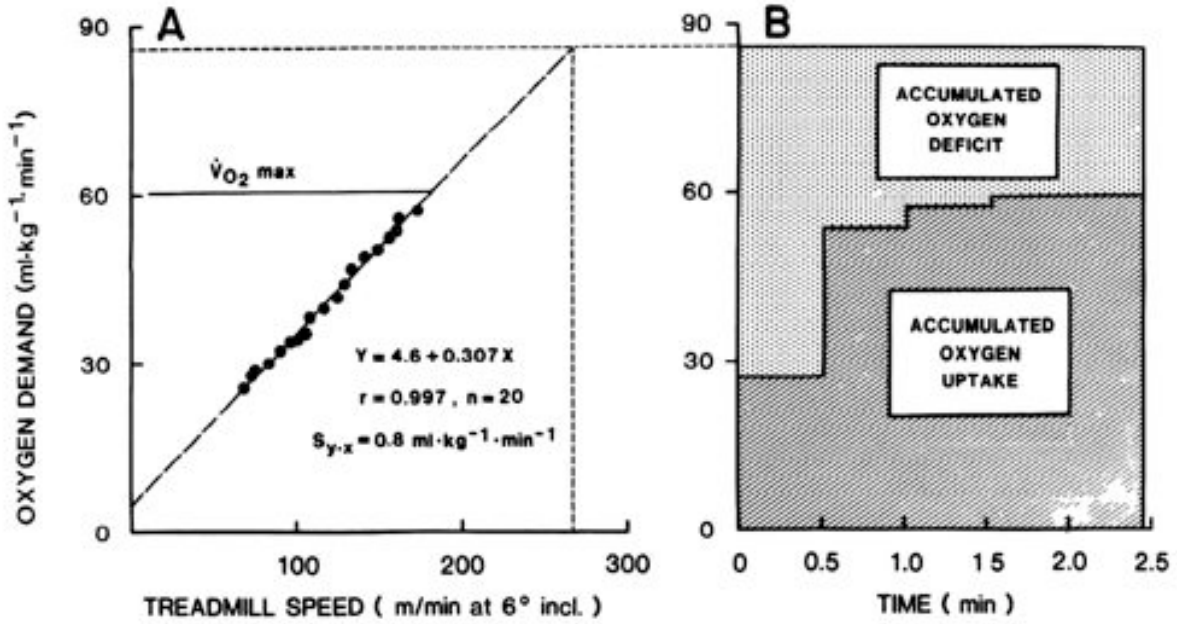


Assumptions of MAOD

Mechanical efficiency is identical in supra- and submaximal exercise

The rate of total energy release increases linearly with the exercise intensity

O2 demand is constant during this type of supramaximal exercise



MAOD Testing Procedures

VO2 – power output relationship

- Originally 10 stages at 10 min per stage
- Modified to fewer stages at 40-70% VO2max with 4 min per stage

Duration of the test:

- Long enough to allow max anaerobic energy release
- Short enough to minimize aerobic energy production

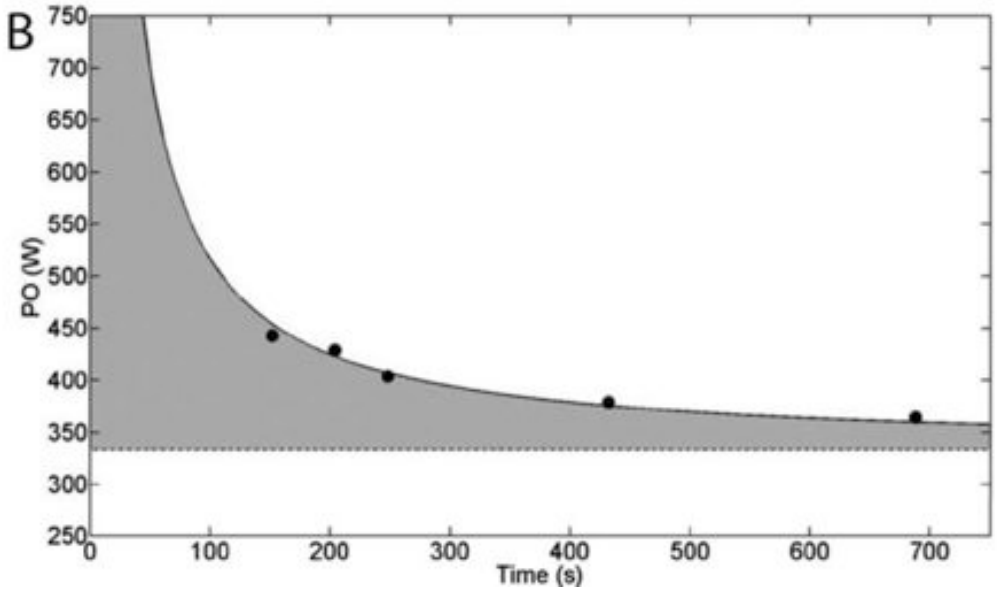
Quiz!

- What is oxygen deficit?
- What is maximal accumulated oxygen deficit?
- What assumptions are made using MAOD?

Critical Power Concept

The highest work rate that can be sustained while maintaining a physiological steady state

Occurs close to maximal lactate steady state



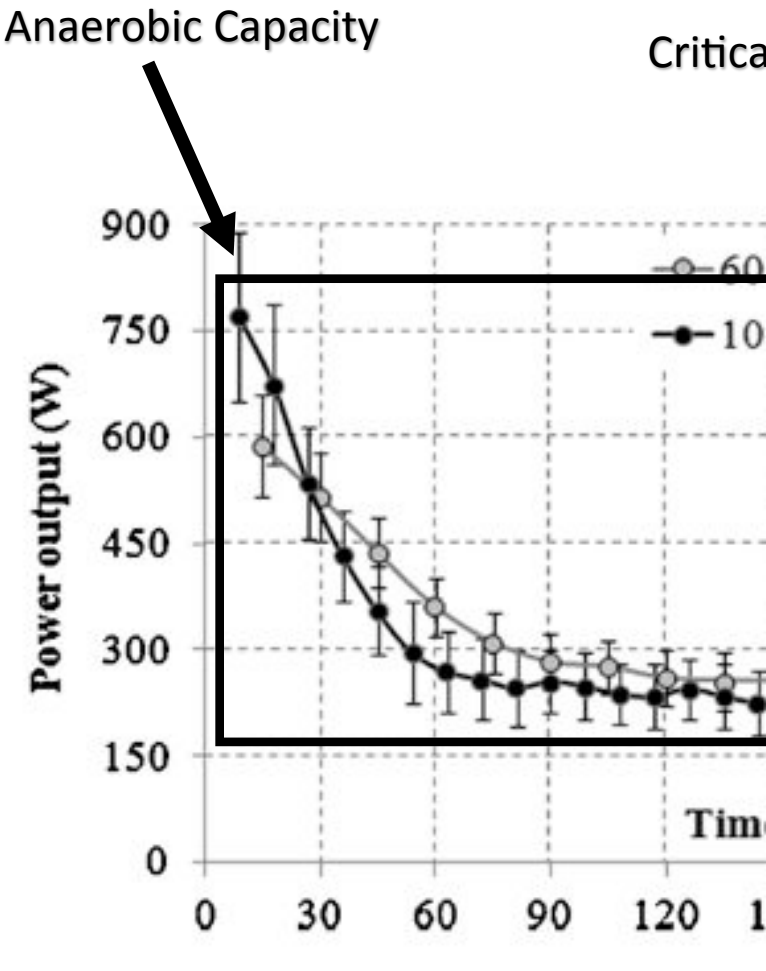
Critical Power Protocol

4 or more all-out 3 min cycle tests at 70-105% max power output

CP defined as max power output to be sustained during last 30 seconds of the test

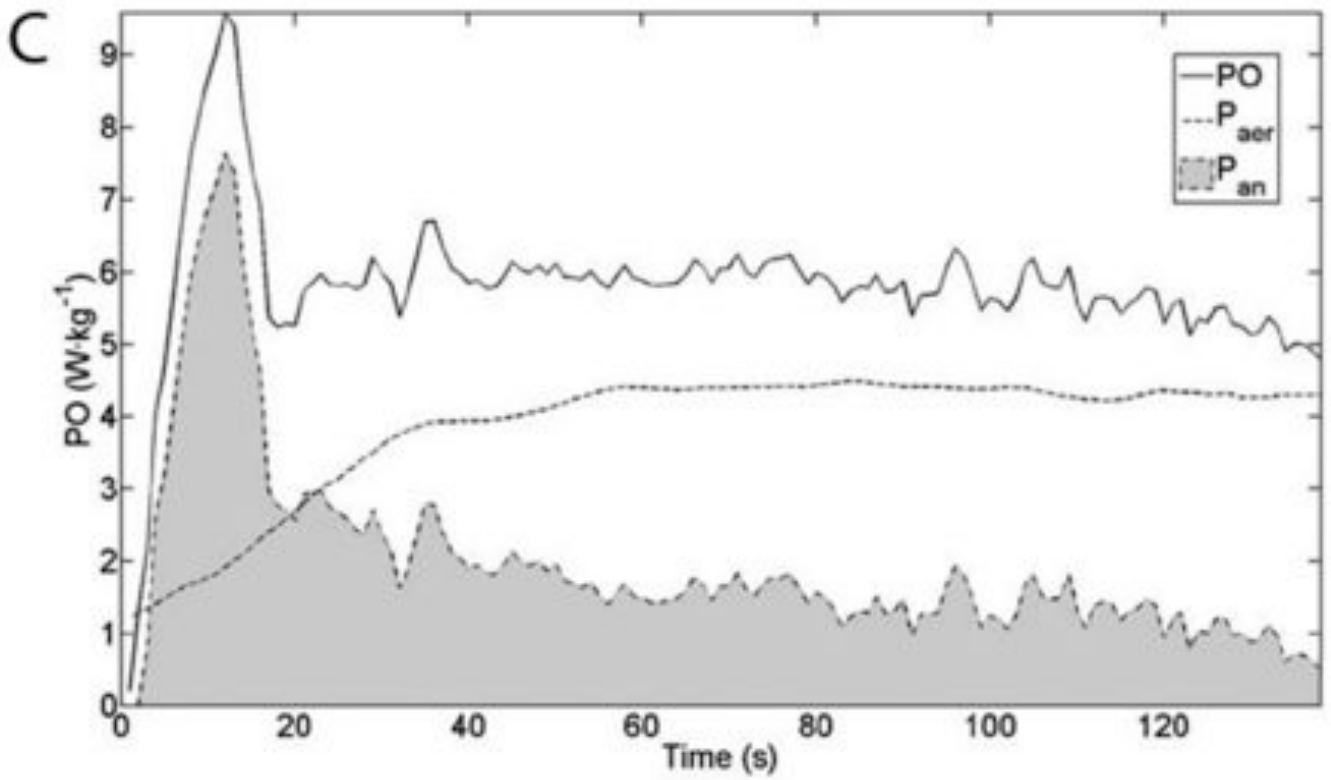
- Performed at constant 60 or 100 rpm

Accumulated work above CP = anaerobic capacity



Gross Efficiency Concept

Calculates anaerobic power by subtracting calculated aerobic power output from total power output produced.



Gross Efficiency Protocol

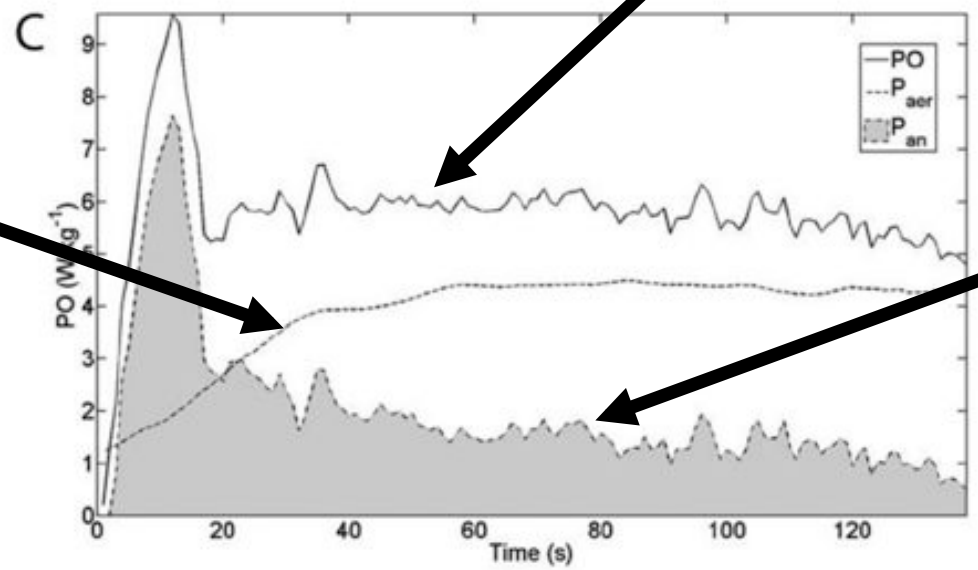
10 submaximal exercise bouts at intensities between 30 and 90% VO_2max for 4 minutes each

Anaerobic capacity is calculated by subtracting anaerobic energy from total power output

Power output

obic energy

Anaerobic En



Quiz!

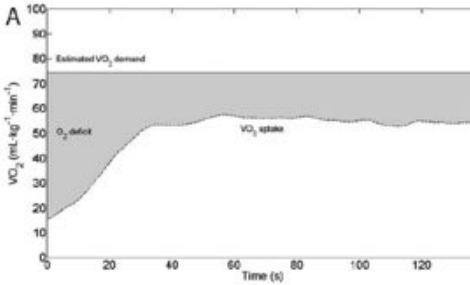
- What is critical power?
- How is anaerobic capacity determined using the CP method?
- How is anaerobic capacity determined using the gross efficiency method?

Anaerobic Capacity Determination Summary

ate

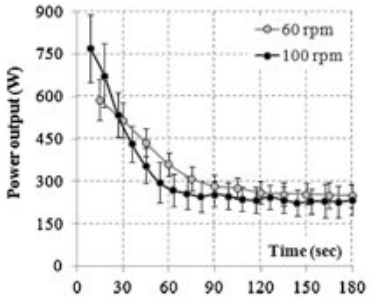
igher = more glycolytic contribution

ILSS = anaerobic capacity



OD

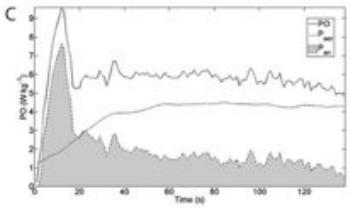
naerobic capacity = max O_2 demand – max O_2 consumed



naerobic capacity = energy generated above CP

ss efficiency

naerobic capacity = peak power output – aerobic energy



Is there a difference between each method?

Units

- MAOD = O2 equivalent
- CP + GE = mechanical units (joules/watts)

Is there a difference between each method?

U

vatts)

BE CONSISTENT!!

Validity

- No direct measurement
- All result in similar anaerobic capacity estimates

Anaerobic Power Measurements

- Anaerobic power measurements focus on strength, speed, and maximal mechanical power

  - Wingate anaerobic test
  - Vertical Jump
  - Margaria Kalamen

Wingate Anaerobic Test

Most popular anaerobic power test

Developed at the Wingate Institute, Israel in 1974

Named after Orde Wingate

Wingate Anaerobic Test Protocol

Consists of pedaling with maximal (all-out) effort for 30 seconds

Typically 7.5-9% body weight is used as resistance

Traditional (flying start) – no weight on the flywheel till test start

Stationary start – weight on flywheel at start

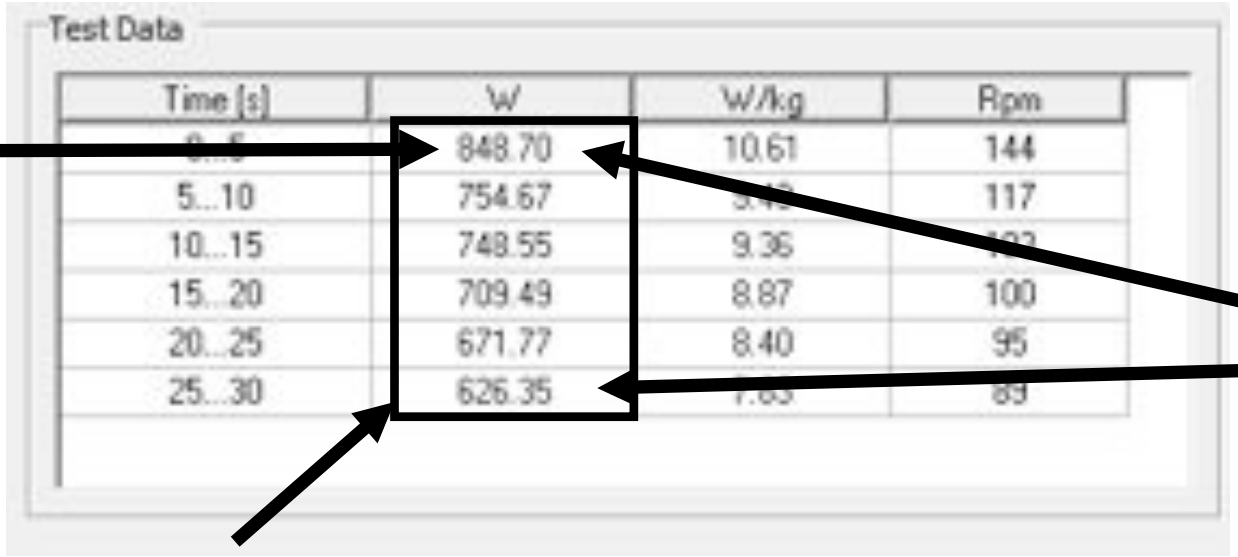
Never stand!

Interpreting Wingate Test Results

Peak power = highest power (watts) in any 5 sec

Mean power = average power over entire 30 sec.

Fatigue index = rate of power decrease from point of peak power to end of test (%)



power

Fatigu
Index

Mean power

Limitations of Wingate Anaerobic Power Interpretations

1) Limited to cycling exercise
2) Is 30 seconds enough to determine anaerobic capacity?
3) Some energy is contributed from mitochondrial respiration
4) Flying vs stationary start data cannot be directly compared
5) Motivational factors (i.e. music, verbal encouragement etc.)

Quiz!

/hat is the focus of anaerobic power measurements?

/hat is the difference between traditional (flying) and stationary tart Wingate tests?

st at least 3 limitations to determining anaerobic power with the /ingate test.

an you ever stand during a Wingate test?

Vertical Jump Test

Jumping ability related to phosphagen ATP production

"Sort of" correlated with fast-twitch muscle fibers in vastus lateralis

- r= 0.48

Is vertical jump useless?

30 second vertical jump test: cheap alternative to Wingate

- Peak jump
- Mean jump
- Fatigue index

Highly correlated with Wingate

Margaria Kalamen Stair Test

Running up stairs (two at a time)

Test typically lasts 2-10 seconds

Absolute, relative, and anaerobic power calculated from:

- Subject weight
- Height of the stairs
- Time between stairs

Highly correlated with Wingate peak power

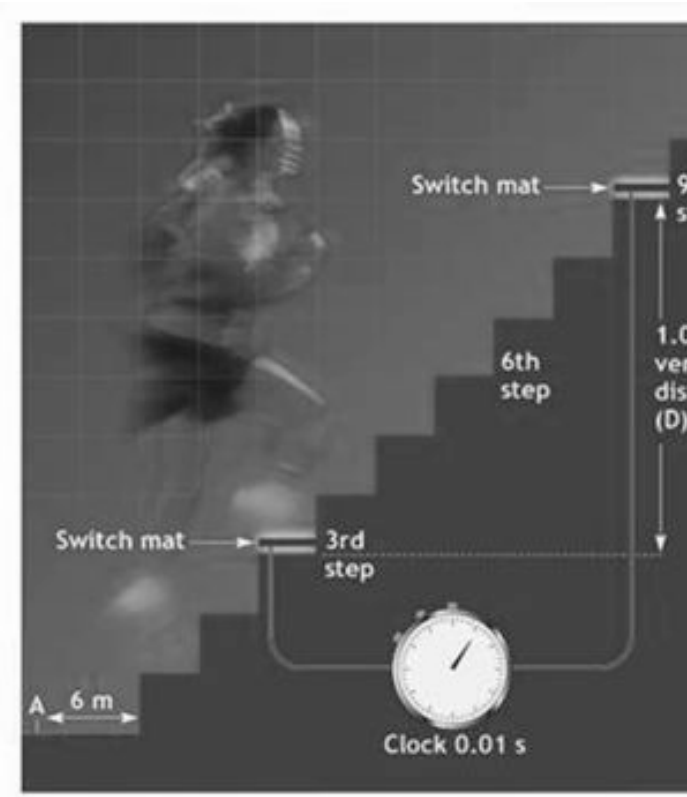


Figure 11.3. Stair-sprinting power test. The subject begins at point A and runs as fast as possibl
stairs, taking three steps at a time. Electric switch mats placed on the steps record the time need
distance between stairs 3 and 9 to the nearest 0.01 second. Power output equals the product of th
mass (*F*) and vertical distance covered (*D*), divided by the time (*T*).

Which anaerobic power test to choose?

- Things to consider:
  1. Goal of the test
  2. Average power vs instantaneous power
     (Glycolytic vs phosphagen system)
  3. Muscles being used
  4. Practicality of the measurement

Quiz!

- What are some things you should consider when deciding on an anaerobic power test?
- If you did not have access to a Wingate system, what type of anaerobic power test would you choose to best determine glycolyt energy?

Quiz!

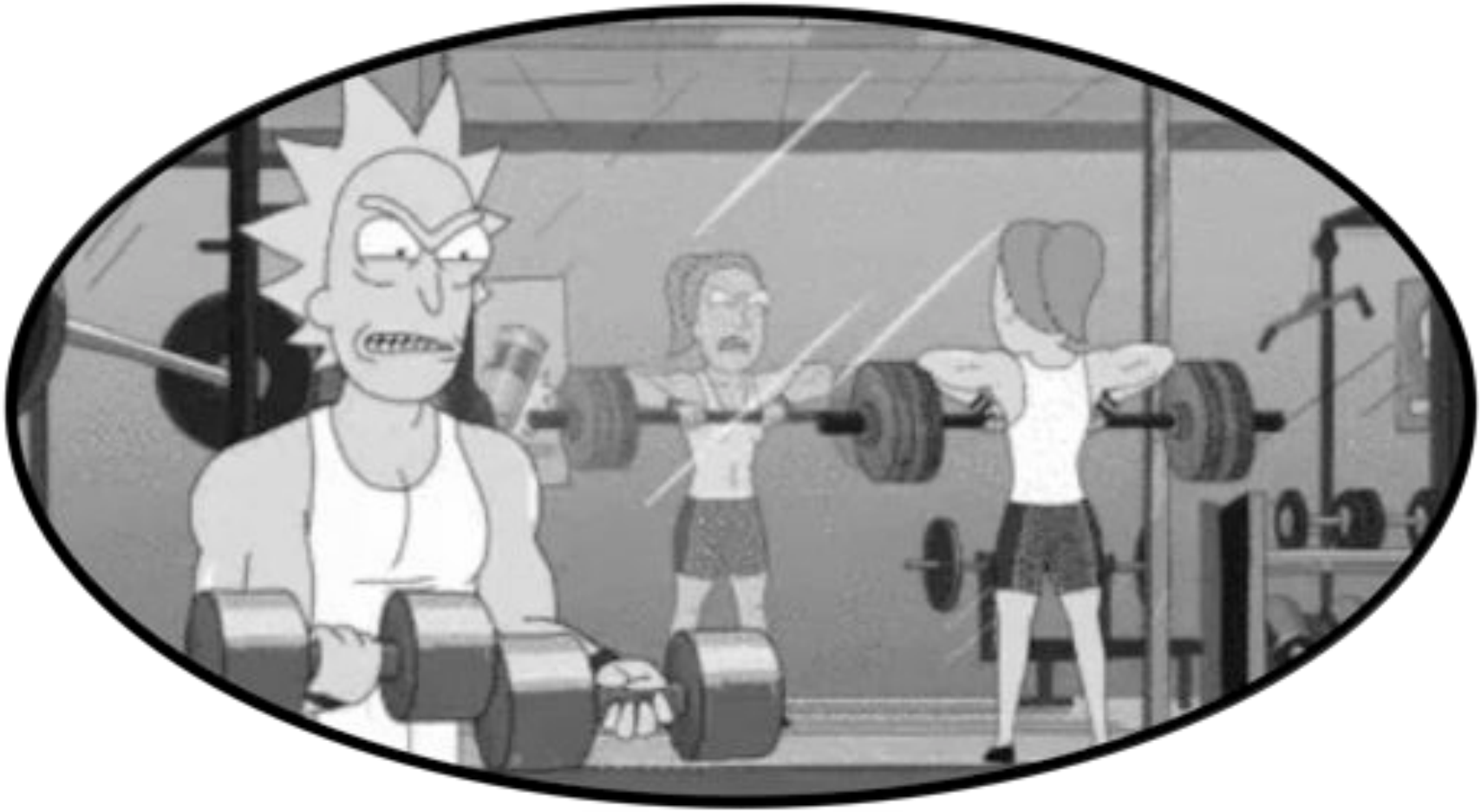
What is the primary difference in how anaerobic capacity is reported between lactate, MAOD, CP, and GE?

Which method is considered by many as the gold standard of anaerobic capacity determination?

What is the primary focus of anaerobic power measurements?

What is the difference between a traditional (flying) and stationary start for a Wingate test?

Can you train your anaerobic energy systems?



Phosphagen System Training Adaptations

Strength training can increase ATP and PCr storage capacity by up to 20%

No change with sprint training

Research is no well defined

Increase ATPas and creatine kinase enzyme

Glycolytic System Training Adaptations

Glycolytic flux = ↑ ATP production rate

↓

↑ Glycolytic enzymes (PFK, LDH)

↓

h intensity interval and sprint training

↓

sec max effort with alternating 2-3 min rest

Glycolytic System Training Adaptations

↑ Blood and muscle buffering capacity

- Results from increased lactate production
- Lactate buffers H+ ions

Improvements shown via sprint training and HIIT

Glycolytic System Training Adaptations

↑ Faster lactate removal

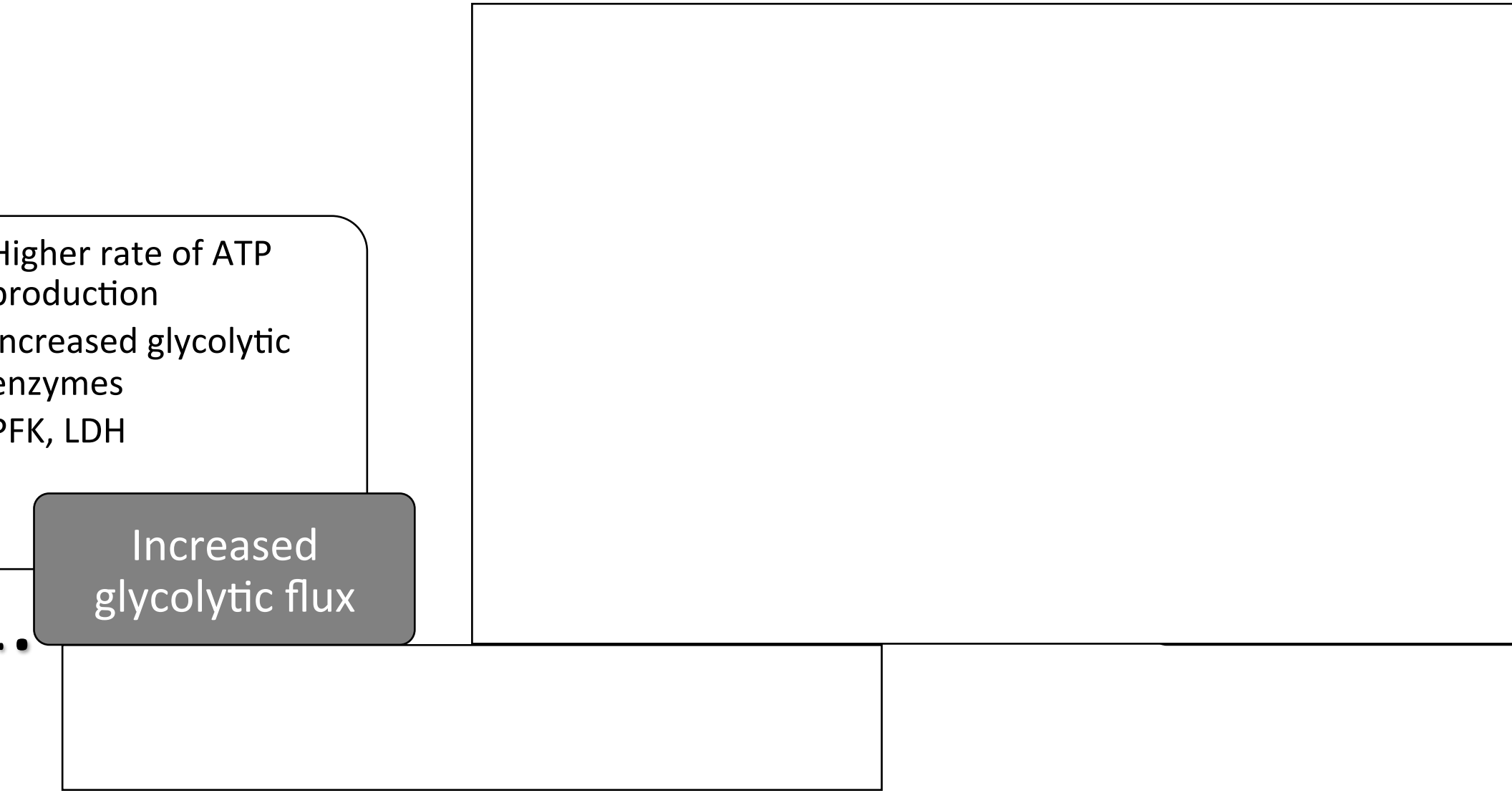
ncreased number and efficiency of monocarboxylate
ransporters (lactate transporters)

- Converted to pyruvate in inactive muscles to be used in TCA cycle
- Fuel for gluconeogenesis in liver and kidneys

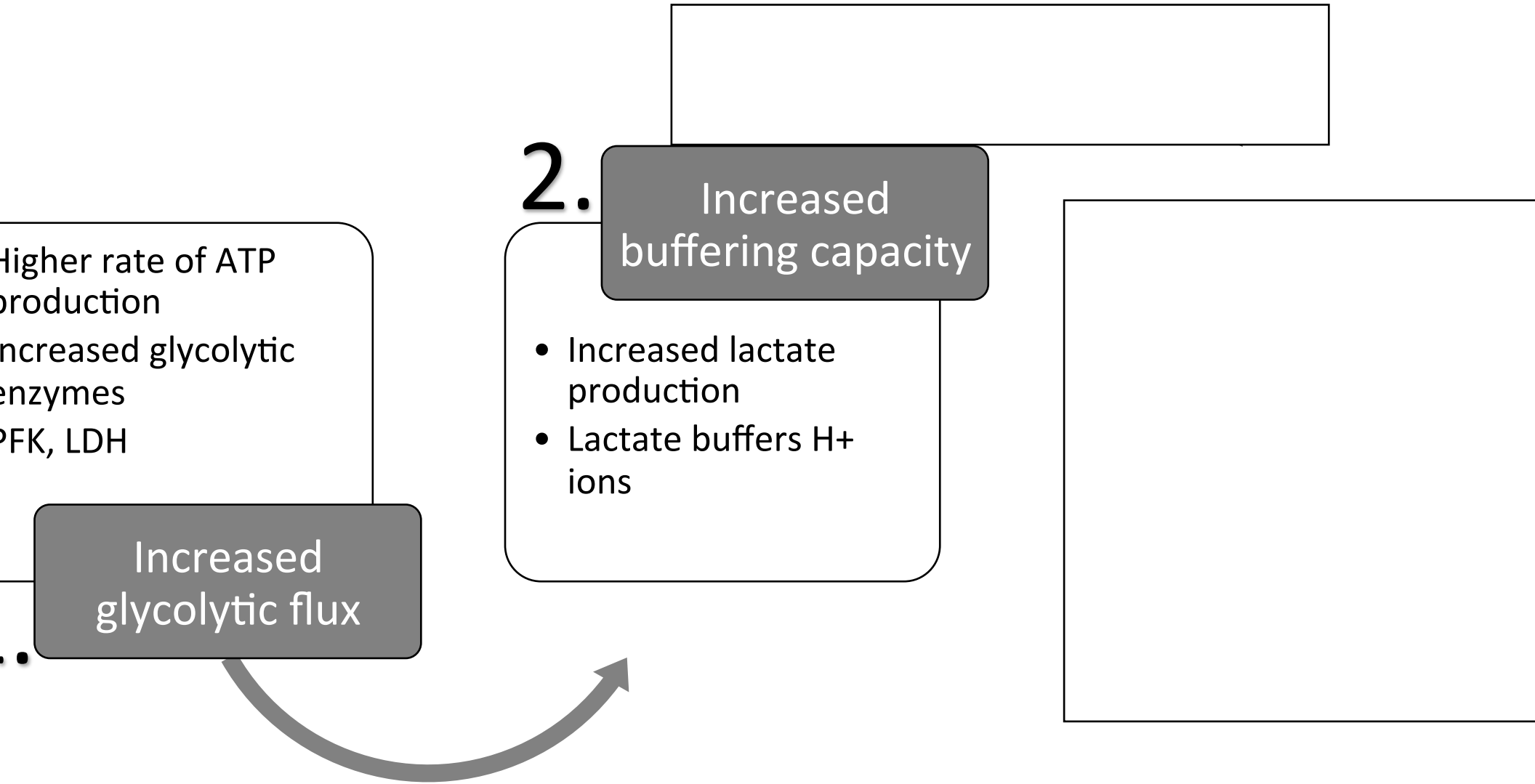
Quiz!

- What phosphagenic adaptations have been shown to occur with strength training?
- What enzymes related to the phosphagen system are increased with both strength and sprint training?
- What are the 3 main training adaptations observed in the glycolytic system?

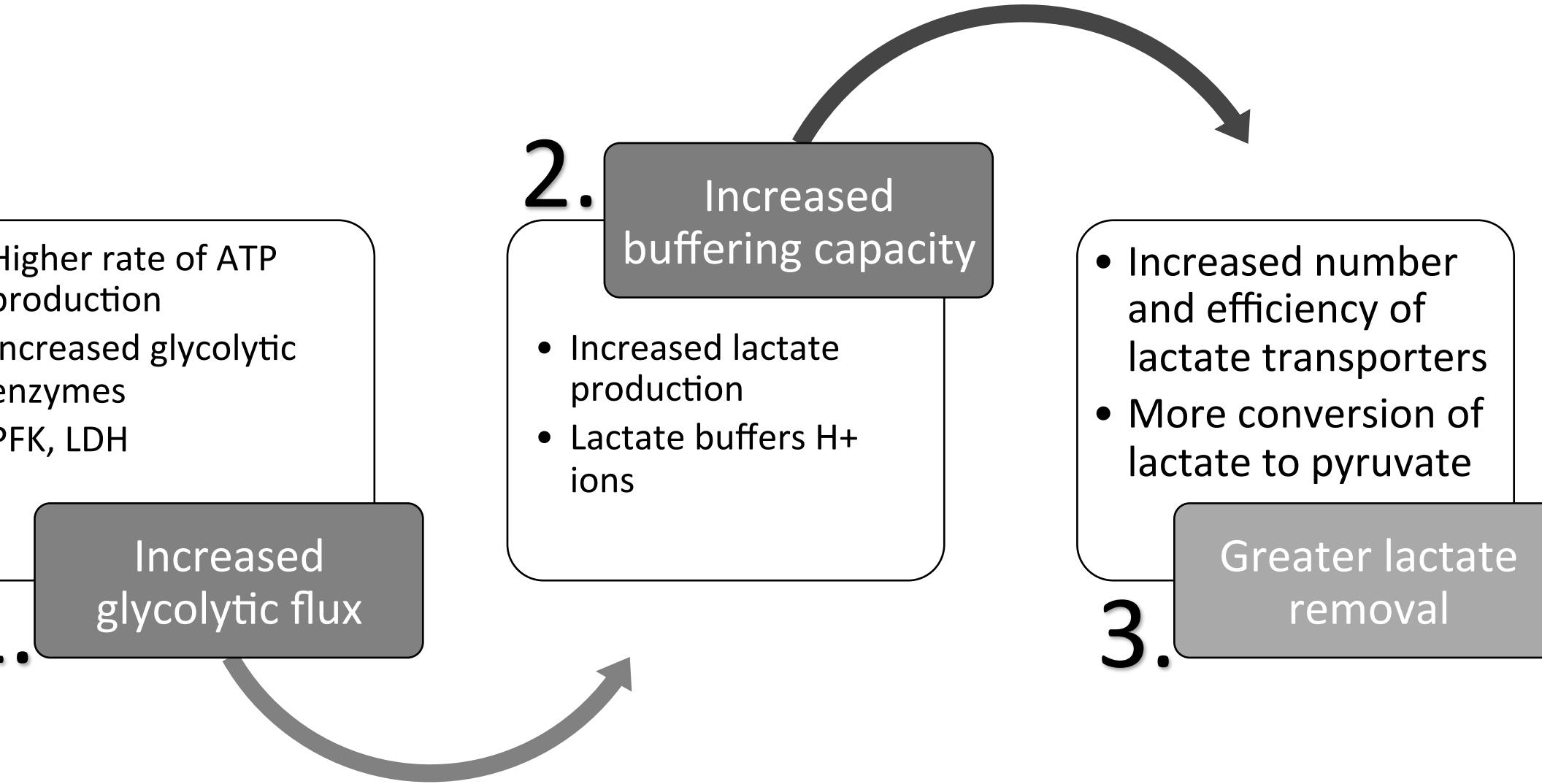
Glycolytic System Training Adaptations



Glycolytic System Training Adaptations



Glycolytic System Training Adaptations



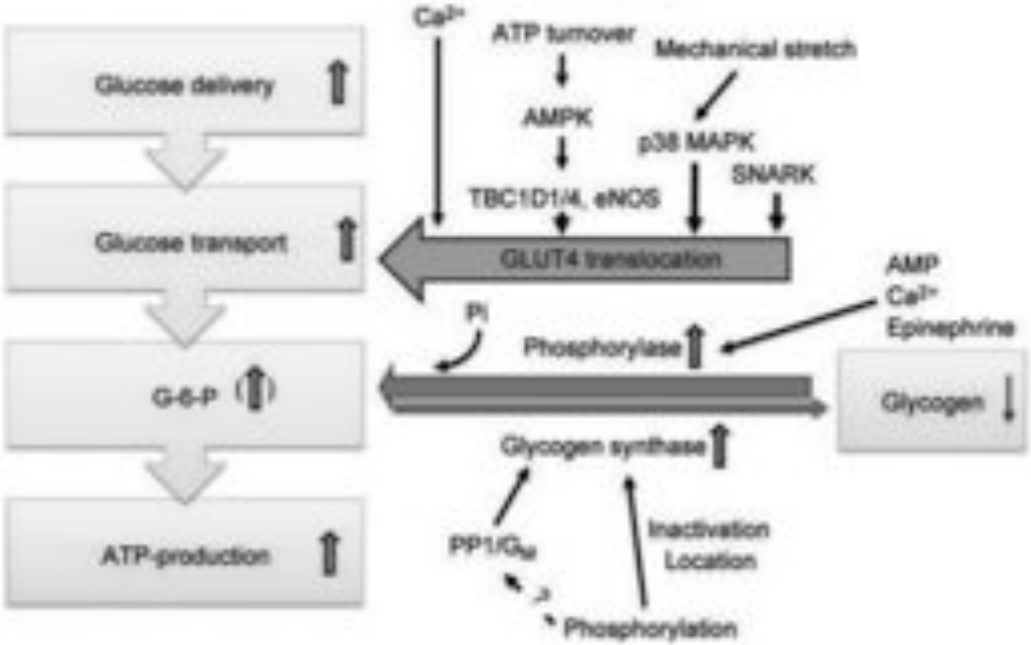


Figure 1. Glucose utilization in the working muscle is increased through increased delivery and uptake of plasma glucose and increased glycogenolysis

Transport of glucose across the sarcolemma and T-tubular membranes is determined by the amount of contraction- and insulin-responsive glucose transporter 4 (GLUT4) proteins in the outer membrane. This magnitude of glucose transport response with contraction correlates with work intensity with evidence suggesting the involvement of kinases like AMPK, p38 MAPK and SNARK whereas Ca^{2+} activated proteins are probably required but likely to be insufficient to stimulate glucose transport. Allosteric and covalent regulation increases both glycogen mobilization by glycogen phosphorylase (GP) and resynthesis by glycogen synthase (GS) simultaneously during exercise by altering enzyme activity and/or location. GP may also be regulated by the availability of its substrates glycogen and inorganic phosphate (Pi). Depending on the work intensity and duration, glucose-6-phosphate (G-6-P), an important allosteric inhibitor of GP and stimulator of GS, may increase.