SPRINTING

INTRODUCTION

Sprinting is running over a short distance at the top-most speed of the body for a limited period of time while maintaining control.

Sprinting is used in many sports, mostly in athletics that involves short races e.g., 100 meters, 200 meters, and 400 meters. It involves these short races because muscles cannot supply enough energy for long races. Sprinting cannot be maintained for more than 30-35 seconds due to the depletion of phosphocreatine stores in the muscles, and perhaps secondarily to excessive **metabolic acidosis** as a result of **anaerobic glycolysis.**

Sprinter's sprinting potential is determined by; muscular strength, adrenaline use, anaerobic respiration capacity, rate of breathing (lung volume) footsteps, leg length, and proportion of **fast-twitch muscles**-are those muscles where the neuron, the component of the nervous system that regulates an individual group of muscle fibers within a muscle structure, is "firing," or directing the fibers to move 10 times more quickly than those in the adjacent fibers. During sprinting the entire body of the sprinter will be used to achieve maximum speed- **the legs** are the primary source of muscle power, with the **arm motion** an important thrust and counterbalance to the leg action.

SPRINTING METABOLISM ACTIVITIES

The energy demand increases in proportion to exercise intensity, and energy supply is often a critical factor for performance. During sprinting, anaerobic processes provide an extensive part of ATP regeneration, and accumulation of metabolic end products (i.e., H^+ and inorganic phosphate) may disturb cellular metabolism and muscle contraction.

Anaerobic processes dominate during the all-out exercise of a duration of less than 1-2 min, but also have an essential role at submaximal work rates, where muscle lactate may reach critical high levels. Aerobic energy release is mainly limited by the rate at which ATP can be produced in relation to the amount of oxygen available ($VO_{2\ max}$). In contrast, anaerobic processes have high power and are instead limited by the amount of ATP that can be

produced. The capacity of anaerobic process can be determined by the muscle store of high-energy phosphates and the maximal capacity of lactate/protons that can be produced. Anaerobic glycolysis leads to production of equal amounts of lactate and hydrogen ions.

During sprinting, muscles use both aerobic metabolism and anaerobic metabolism which releases equal amounts of lactate and H^+. H^+ produced will be buffered and only a small amount will be available in the cytosol, resulting in the decrease of muscle pH. The decrease in muscle's pH interferes with biochemical and physiological processes which may lead to fatigue. Buffering of protons will attenuate the change in pH and is the first line of defense against

potential negative effects of lactic acid formation. Some of the formed lactate will be released to blood or be oxidized within the muscle. The efflux of lactate from muscle and oxidation of lactate will be accompanied with a similar amount of H^+ removal. Both increases in muscle buffer capacity and enhanced removal of lactate/protons will increase the capacity of glycolytic ATP production.

Phosphocreatine (PCr) can be depleted almost completely during exhaustive exercise, providing an equimolar amount of ATP (about 70 mmol per kg dry muscle [dm]) in humans. Anaerobic glycolysis (i.e., glycogen to lactate) gives 1.5 mmol ATP per mmol of lactate.

ATP resynthesis

Substrate-level phosphorylation

PCr + ADP + H+ → ATP + creatine

2 ADP → ATP + AMP

$Glycogen_n$[a] + 3 ADP + 3 Pi → $glycogen_n$[a]+1 + 2 lactate + 3 ATP

Oxidative phosphorylation

Glucose + 6 O_2 + 36 ADP → 6 CO_2 + 6 H_2O + 36 ATP[b,c]

Palmitate + 23 O_2 + 130 ADP → 16 CO_2 + 16 H_2O + 130 ATP[b,c]

The contribution of anaerobic glycolysis (i.e., lactate formation) to anaerobic ATP production during sprinting at VO_{2max} is 74% of total anaerobic ATP production, with the remaining part covered by PCr depletion. Although there is extensive anaerobic energy utilization during sprinting, with concomitant depletion of PCr stores and high lactate levels in muscle and blood, the major part (84 %) of the energy demand is covered by aerobic processes.

ATP utilization

ATP + H_2O → ADP + Pi + H+ ($\Delta G^{\circ\prime} = -6.3$ kcal mol^{-1})

REGULATION OF METABOLISM

During sprinting PCr is a remarkable fuel source because only one metabolic reaction is required to provide ATP.

Creatine phosphokinase catalyzes metabolic breakdown of PCr to ATP.

PCr + ADP + H+ → ATP + creatine

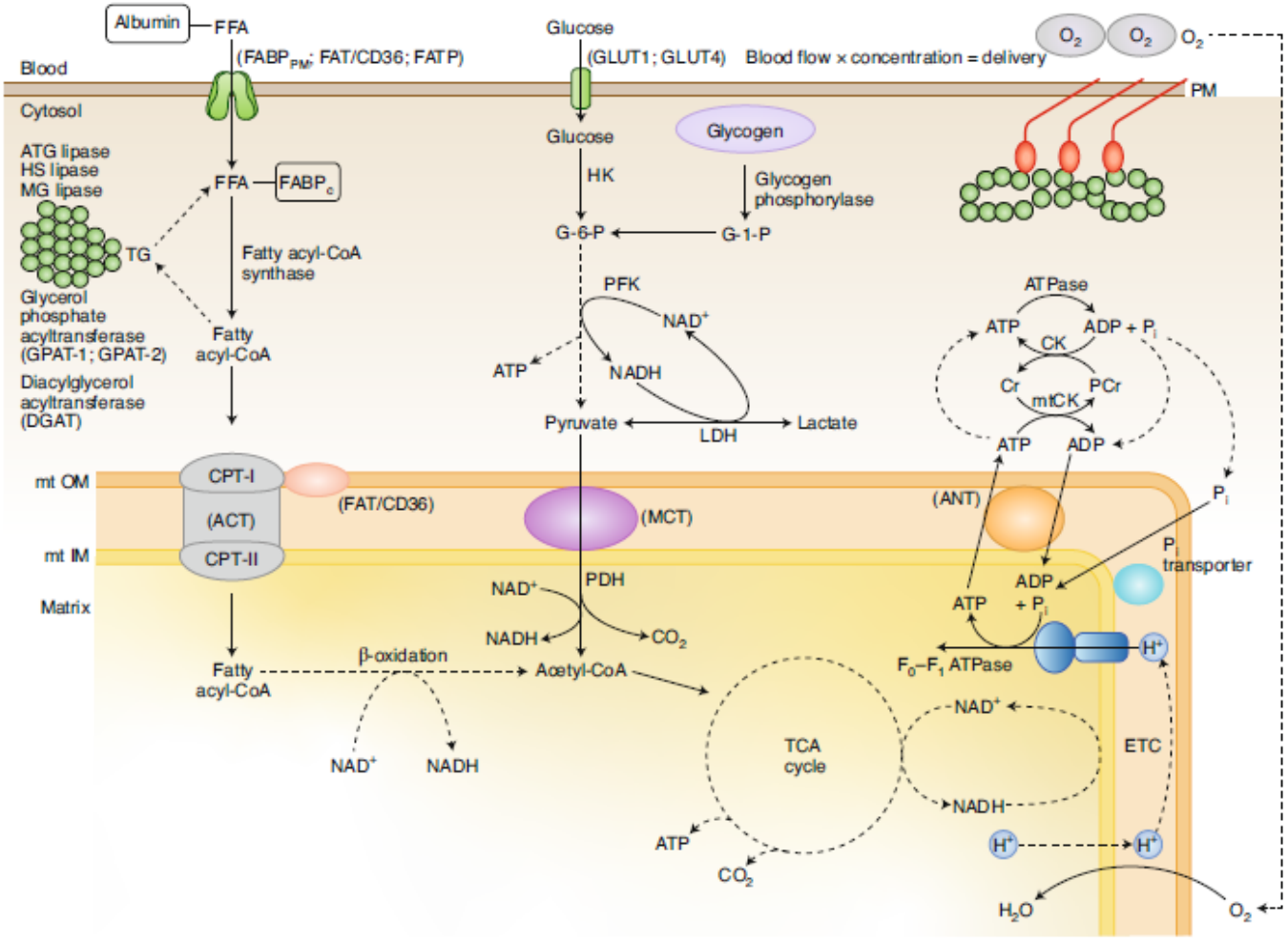
When muscle contraction begins, and ATP is broken down and the concentration of free ADP increases, the reaction direction changes, left to right and ATP is regenerated in several milliseconds.

$$2\ ADP \rightarrow ATP + AMP$$

During muscle contraction Ca^{2+} enters the cytoplasm, together with cellular Ca2+ activates phosphorylase kinase, thereby transforming glycogen phosphorylase from its less active form “b” to a more active form, glycogen phosphorylase “a” through covalent regulation.

An increase in ADP and AMP activates mainly phosphorylase “a”, which breaks down glycogen; the products are then combined with Pi producing glucose-1-phosphate, glucose-6-phosphate, and fructose-6-phosphate in the glycolytic pathway.

An increase in AMP, ADP, and Pi, and F-6-P activates phosphofructokinase, and flux through the reactions continue with the production of 3 ATP and lactate formation. (Image from, https://doi.org/10.1038/s42255-020-0251-4)



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