Exercise In The Heat

- During exercise, adequate levels of blood flow to the muscles is achieved by vasoconstriction of visceral arteries. When exercising in the heat the body needs to balance blood flow between muscles (for oxygen) and the periphery (to release heat).

- During exercise in the heat, blood flow to the periphery increases for heat dissipation through the skin. Less blood is returned to the heart so a smaller blood volume is pumped out (lower cardiac output). To compensate, the heart must beat faster to maintain necessary blood volume flow to exercising muscles and the periphery.

- Exercise in the heat results in greater dependence on anaerobic metabolism (production of energy without oxygen) which leads to earlier onset of lactic acid from an earlier depletion of glycogen stores. The early appearance of lactic acid combined with the reduced blood circulation to muscles is responsible for early fatigue during exercise in the heat.

- A fit person with a higher oxygen uptake ability (VO_2max*) will work with a lower core temperature than a less fit person who will have a higher core temperature and greater sweat output at the same workload.

- The ability of the body to dissipate heat during exercise in hot weather depends on evaporative cooling (sweat rate). As sweat loss continues, the body has a smaller amount of blood volume to contribute to the sweat output, therefore, over time blood flow to the skin is reduced, sweat output is decreased and the ability to dissipate heat is inhibited. For these reasons, the importance of maintaining hydration levels is emphasized for exercise in hot temperatures.

* ***VO_2 max*** = highest achievable rate of oxygen consumption, aerobic capacity

Effects of Fluid Loss

- A loss of fluids makes cardiovascular functions more difficult and the body's strength to perform work will decrease

- The longer the exercise and the greater the volume that is lost, the harder it becomes to dissipate heat, which can lead to dangerous outcomes when exercising in hot temperatures

- Dehydration (of minimum 5%) prior to exercise in heat increases core temperature, increases heart rate and decreases sweat rate – making exercise more difficult and adaptation to the hot environment more difficult

- An elevated heart rate causes more muscle contractions in the core of the body and is the cause of the temperature increase. Also, as the body requires more blood within the core, less blood flows out to the periphery and less heat is dissipated through the skin

- Water loss, as little as 1% of body mass, will increased core temperatures
  Water loss of 4-5% of body mass significantly impair work capabilities

- Without the dissipation of heat caused my working muscles, the body will suffer from several forms of heat illness:
  1) heat cramps: cramping of muscles used in exercise, due to loss of water and minerals
  2) Heat exhaustion: fatigue, breathlessness, hypotension (low blood pressure), dizziness, fainting, and weak rapid pulse because the cardiovascular system can no longer meet the body's needs
  3) Heat Stroke: the body's core temperature exceeds 40°C, the body's cooling system and sweating stops, rapid pulse and respiration can lead to unconsciousness

The amount of water lost by an acclimatized person may be up to 3 litres per hour during intense exercise.

Heat Acclimatization

An improved tolerance to exercise in heat after repeated bouts of exercise in a hot environment

Heat Acclimation : An improved tolerance to exercise in heat , accomplished in an artificially controlled environmental chamber

- After several days of heat exposure a tolerance to heat illness is developed and a reduction of heat stress symptoms progresses
- Partial acclimatization can be seen after 4 days of heat exposure, but full acclimatization will not be achieved until 14 consecutive days of exercising in the heat
- Acclimatization is achieved when exercise is sufficient to raise the body's core temperature and stimulate moderate to heavy sweating
- Exercise should performed at least 1 hour /day at, minimally, mild to moderate exercise intensities (>40% VO2max*). It is recommended to gradually increase exercise durations and intensities in the heat to avoid heat illness in initial exercise exposure to hot temperatures
- The first 5-6 days results in improved control of cardiovascular function, including expanded plasma volume, reduced heart rate, and balance of blood flow to skin and active muscle.
  *The ability of the body to acclimatize after only a few days of exercise in the heat has important practical benefits for competitive athletes travelling to warmer climates.
- The 5 to 10 days after initial exposure show improvements in sweating mechanisms: sweat rate, earlier onset of sweating, and decreases in core temperature
- After 10 days of acclimatization, capacity for sweating will double, and a more even distribution of sweat will be achieved over the skin surface.
- Once acclimatized, individuals have significant functional improvements to exercising in the heat.. Sweat rate will increase during exercise because the heat gradient from the body to the skin becomes more efficient and facilitates heat loss. With more efficient release of heat, less blood is needed at the periphery (skin) and more can be used at the muscles. This allows the muscles to use oxygen longer for metabolism (prolongs aerobic metabolism) and slows the rate of glycogen use and prolongs the production of lactate and therefore also prolongs fatigue. The body will also have a lower sweat rate following exercise, proving greater efficiency for recovery.
- An acclimatized person will exercise with a lower skin and core temprature, and lower heart rate. Sweating is onset at a lower core temperature , before too high of a temperature is reached. Once cooling mechanisms are initiated the body will be able to maintain a cooler core temperature for longer. A lower core temperature allows for blood distribution to flow to the working muscles (whereas an unacclimatized person will need more blood flow to the skin for heat dissipation). A reduction in cardiovascular strain is noticeable after several days of heat exposure by lowered heart rates during exercise. Effectiveness of cardiac output is achieved so that blood pressure remains stable. In these ways, acclimatization allows for more efficient work output by the body before fatigue and lower levels of perceived exertion.

Heat exposure without exercise also induces a heat acclimatization response that is reflected by an improved ability to dissipate heat, but for maximal responses athletes must exercise in the heat.

In order for acclimatization responses to occur, the individual must be fully hydrated during exercise.

- The concentration of sweat changes with acclimatization. Exercise in the heat trains the body to produce greater outputs and expand fluid volume decreasing the amount of NaCl (salt) lost through the sweat. Acclimatized individuals have more diluted sweat because they are losing fewer electrolytes. Excess dietary water and electrolytes do not speed the process of heat acclimatization. When dehydration or salt deficits exist, however, cardiovascular and thermoregulatory responses may be negatively affected, and the theoretical risk of heat illness increases.

An unacclimatized person will have a higher heart rate, dehydrate quicker, and through sweating will lose blood plasma volume and electrolytes

PHYSIOLOGICAL ADJUSTMENTS TO EXERCISE IN HEAT:

ACCLIMATIZATION RESPONSE	EFFECT	DAYS OF ACCLIMATIZATION
Improved blood flow to skin	Transports metabolic heat from deep tissues to the body's periphery	3-6
Improved effectiveness of cardiac output	Circulation betweeen the skin and muscles is balanced to meet demands of thermoregulation (blood flow to skin) and metabolism (blood flow to muscles) Stable blood pressure during exercise	3-6
Earlier onset of sweating	Evaporative cooling begins earlier in exercise	5-10
Effective distribution of sweat over skin surface	Greater ability for evaporative cooling	3-6
Increased sweat output	Greater ability for evaporative cooling	8-14
Lowered salt concentration of sweat	Dilute sweat conserves electrolytes	4-10
Decreased heart rate	Greater ability to perform physical work	3-6