Science of Exercise

Initially, Mary Ann had a normal Vo2 Max for her age and gender. This VO2 max was enough for a sedentary lifestyle and her body was in a stable internal body environment, and was in homeostasis. Her new training programme was an overload to her body, which tends to respond and adapt under stress in order to achieve a new homeostatic state. The specificity principle says that only stimulated systems or muscles adapt. As Mary Ann has been running swimming and cycling for months, great endurance exercises during a relevant period of time. It caused an adaptation in her cardiovascular system and consequently, an increase in her VO2max.

This improvement is early a consequence of her well planned training, but the magnitude of the improvement varies greatly from person to person principle of individuality. It means another sedentary 21 year-old female with the same initial VO2max that follows the same training likely to improve to a different degree. Finally, it is worth to remember that this improvement in VO2max is largely reversible and once the training ceases it can return to the previous later after a few months without training.

Oasis the memum Oxygen (o2) a person can use measured in meg min-1, and it reflects the adaptation to exercise, especially endurance training. It is a great indicator of the cards and health levels in general. High Vamos means the person can perform more intensity exercise for long periods (1 hour or more) or do her/his daily tasks without getting tired.

Stroke volume is the volume of blood pumped from the left ventricle per heartbeat. As an indicative value, the stroke volume of a healthy 70 kg man is 70 mL. But this value does not change because of training. High VO2max implies a healthy and big heart.

$$VO_2 = (Cardiac\ \ Output) \times (a\text{-}v)O_2\ \ difference$$

The maximum Heart Rate (HR) does not increase with training. It decreases with age and, during a given exercise or rest, it is lower for trained people. So, since the HR does not increase, an increase in maximum cardiac output reflects an increase in stroke volume (SV).
Maximal cardiac output = HR x SV

Finally, (a-v)o2 difference is the difference between arterial O2 concentration and venous o2 concentration. It should be high (for high VO2max) and it measures the amount of O2 absorbed by mitochondria, within cells. The arterial O2 concentration is affected by the lungs ability to transfer o2 from the air to the blood. A high VO2max implies efficient and big lungs.

The venous O2 concentration should be low, meaning the mitochondria were able to absorb most of the available o2 from the blood. The efficient usage of available o2 by mitochondria also implies good blood flow in the muscles, efficient vasodilation and vasoconstriction, good vascularization and developed capillaries to deliver oxygenated blood where it is needed.

More o2 absorbed means more ATP (energy) consumed. Since the ATP storage in the muscles is very low, more ATP consumed demands and develops the ability of more ATP production. More ATP production requires more O2 and implies more and bigger mitochondria to produce and store enough ATP. We have more mitochondria in muscles type I (the slow muscles).

ATP can be produced without oxygen from carbohydrates, but much less ATP is produced compared to the aerobic way. This is why we get tired quickly during an extreme effort or during vigorous intensity exercises. There are also fewer mitochondria and capillaries in fast muscles type I.

The aerobic way is much more efficient but slower at producing ATP, so it is the preferred way for moderate intensity exercise. Another characteristic is it also uses fats which is an excellent energy source, as shown below.

Glucose (sugar 6o2-> 30 ATP 6CO2 + 6H2O

Palmitic (fats)+ 23 o2->108 ATP + 16 CO2

All these adaptations on the heart lungs, arteries, capillaries, mitochondria and blood management happened in Mary Ann’s body as a consequence of her endurance training allowing this increase in VO2max from 38 to 52 ml/kg/min.