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EFFECT OF EXERCISE ON RESPIRATION

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Introduction: Muscular exercise leads to a lot of changes on different systems of the body. Degree of changes depends upon the severity of exercise.

Effect on pulmonary ventilation: The amount of air that enters and leaves the lungs each is termed 'Pulmonary ventilation'. It is estimated as a product of tidal volume and respiratory rate, which is around 6 litre/minute in a normal adult human who has a tidal volume of 500 mL and respiratory rate of 12/minute. Exercise, although depends on the degree of severity, increases both the rate as well as the force of respiration, resulting in increased pulmonary ventilation. With moderate exercise, respiratory rate increases to about 30/minute and tidal volume increases to about 2,000 mL., causing an increase pulmonary ventilation to about 60 L/minute. In case of severe muscular exercise, pulmonary ventilation can rise even further, up to around 100 L/minute, in order to supply enough nutrients and oxygen in line with the increased demand for body metabolic needs.

Several factors play an essential role in regulation of pulmonary ventilation during exercise.

1. Body temperature
2. Acidosis
3. Chemoreceptors
4. Proprioceptors
5. Higher centres of the brain

1. **Acidosis:** Because of increased metabolism during exercise, blood pH decreases slightly and acidosis sets in, which activates respiratory centre of the subject resulting in increased pulmonary ventilation.
2. **Body Temperature*:*** Body temperature also enhances the muscular activity, which activates medullary respiratory centre of the body and enhances pulmonary ventilation.
3. **Chemoreceptors:** Chemoreceptors are activated by exercise. The chemoreceptors sense hypoxia and hypercapnea and send impulses to the medullary respiratory centre, which in turn enhances the rate as well as the force of respiration.
4. **Proprioceptors:** Proprioceptors, which are activated during exercise, send impulses to cerebral cortex through the somatic afferent nerves. Cerebral cortex, in turn causes hyperventilation by sending impulses to the medullary respiratory centre.
5. **Higher Centres of the brain:** Both the rate and depth of respiration increases particularly during the onset of exercise. However, the thought or anticipation of exercise

itself can enhance the rate and force of respiration. It is a psychic phenomenon where the higher centres of brain such as Sylvian cortex and motor cortex of brain are stimulated. These higher brain centres in turn enhances the pulmonary ventilation by activating the medullary respiratory centre.

Diffusing capacity for oxygen: During exercise, pulmonary ventilation increases due to increased respiration and enhanced blood flow through the pulmonary capillaries. Due to this, the diffusing capacity of a gas across the respiratory membrane (RM) involving alveolar wall and pulmonary vessel walls enhances. Therefore, the diffusing lung capacity of a gas across the RM mainly explains the conductance of gas transfer between the lungs and RBC. This parameter, which is also known as transfer factor, is mainly influenced by the density of the gas, size of the molecules and the temperature of the medium. Normally, the diffusing capacity for oxygen across RM is about 21 mL/ minute under resting conditions. During exercise in moderation, this can readily increase to 45-50 mL/minute. Carbon monoxide diffusing lung capacity (DL_{CO}) is a clinically used pulmonary function test for predicting the diffusing lung capacity for oxygen, and therefore a proxy test to measure oxygen diffusing capacity across the RM because CO is hundreds of time more diffusible across RM and has greater affinity for Haemoglobin. DL_{CO} is a measure of the quantity of CO transferred each minute from alveolar space to RBC in pulmonary capillaries. The reference range predicted value for DL_{CO} is 80-120% in men, whereas DL_{CO} in women is around 70-120%. DL_{CO} is enhanced particularly during exercise, but may not increase adequately if the area of the RM decreases or the thickness of the RM increases. Some of the conditions where DL_{CO} decrease includes anemia, cigarette smoking, decreased lung volume, heart failure, interstitial lung disease and pulmonary vascular disease (i.e. pulmonary emboli and pulmonary hypertension), emphysema and interstitial lung fibrosis. DL_{CO} is measured by the conducting the pulmonary function test in the following way,

a. Flow tube mouth piece is kept in patient's mouth.
b. Patient will then be allowed to breathe normal air.
c. Afterwards, the patient will exhale the air out of lungs all the way up to residual volume.
d. When the subject starts to inhale again, a test gas containing trace amounts of CO, oxygen and N_2 will be introduced, and the patient is allowed to inhale to the fullest lung capacity.
e. Then the patient will be asked to hold the breath for a total 10 seconds.
f. Then the patient will be asked to exhale the air in the lungs all the way back to the residual volume.
g. Afterwards, the collected air samples will be analysed.

Water is essential for human or animal body because water assists in regulation of the temperature, remove wastes and lubricants your joints. Water is very important for people who are suffering from COPD. In COPD condition water assists to thin mucus in order to make it easier to cough. Even though, diffusion plays an important role regarding the function of alveolar membrane thickness, the predominant factor is normally the capillary blood

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volume. Generally the capillary blood volume influences both the surface available for exchange and volume of blood and availability of haemoglobin for the acceptance of carbon monoxide.

Consumption of oxygen: Oxygen consumed by the tissues, particularly the skeletal muscles is greatly enhanced during exercise. Because of vasodilatation in muscles during exercise, more amount of blood flows through the muscles and more amount of oxygen diffuses into the muscles from blood. The amount of oxygen utilized by the muscles is directly proportional to the amount of oxygen available.

Oxygen debt: Oxygen debt is the extra amount of oxygen required by the muscles during recovery from severe muscular exercise. After a period of severe muscular exercise, amount of oxygen consumed is greatly increased. Oxygen required is more than the quantity available to the muscle. Oxygen is required not only for the activity of the muscles but also for reversal of some metabolic processes such as:

1. Resynthesis of glucose from lactic acid, accumulated during exercise.
2. Regeneration of ATP and creatinine phosphate
3. Replenishment of the amount of oxygen dissociated from haemoglobin and myoglobin.

Thus, for the above reversal phenomena, an extra amount of oxygen must be made available in the body after severe muscular exercise. Oxygen debt is about six times more than the amount of oxygen consumed under resting conditions.

VO_2 Max: VO_2 max is the amount of oxygen consumed under maximal aerobic metabolism. It is the product of maximal cardiac output and maximal amount of oxygen consumed by the muscle. In a normal active and healthy male, the VO_2 max is 35 to 40 mL/kg. body weight/minute. In females, it is 30 to 35 mL/kg. body weight/minute. During exercise, VO_2 max increases by 50%.

Respiratory quotient: Respiratory quotient is the molar ratio of carbon dioxide production to oxygen consumption. Respiratory quotient in resting condition is 1.0 and during exercise it increases to 1.5 to 2. However, at the end of exercise, the respiratory quotient reduces to 0.5.

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