Ventilation during Exercise

- During exercise, increase in metabolic rate is directly proportional to the increase in ventilation which occur to preserve the acid- base equilibrium by keeping the partial pressure of carbon dioxide constant.
- Augmentation of ventilation is the result after arousal of various receptors i.e.
  a) mechanoreceptors in the respective limbs under exercises
  b) chemoreceptors of arterial wall
  (c) thermal receptors

  where, (a) and (b) receptors enable to sense the oscillations of breaths related to partial pressure of carbon dioxide while (c) receptors get activated due to rise in temperature of body as the metabolic increases.

- The brain can anticipate changes in the metabolism function during exercise due to corresponding changes occur in output from the area of motor cortex related to exercising limbs and respiratory neurons.
- The alteration in the level of lactic acid and potassium level in the muscles of exercising limbs may be regarded as another mechanism stimulate the breathing while performing exercises.
- While performing exercises, the demands of neural drive to be efficiently active are determined by rising level of ventilation level which in turn estimated the increased mechanical power of muscles.
- Muscle power can be calculated by multiplying the shortening of muscles distance with pressure.
- During exercise, the diaphragmatic muscles act as a “flow generator” and signifies that mechanical power of muscles specifically is the expression of velocity with which the shortening of muscles occurs rather than pressure.
- In contrast, muscles of abdomen and rib cage act as “pressure generator” and generate the pressure needed to create motion in abdomen and rib cage respectively.
- On the other hand, the muscles of expiration give active participation in breathing and perform their action in well – coordinated manner with the muscles of inspiration related to rib cage e.g. in the course of expiration abdominal muscles contract but rib cage muscles gradually relax and vice -versa.

- ❖ This process has following effects:
  - (a) It prevents the distortion of rib cage.
  - (b) It unloaded the diaphragm so that it can act as a flow generator.
  - (c) It decreases the volume of abdomen below the level of rest.
- ❖ These effects responsible for the end expiratory volume of lungs during exercises leads to the optimization of breathing process.
- ❖ In moderate type of exercises, metabolic essentials show corresponding increase with arterial haem – gas tensions, acid- base equilibrium and alveolar ventilation are maintained their value nearest to its values at rest. The regulatory mechanism of ventilation regulates breathing pattern so precisely with the aim to minimized the work of respiratory muscles.
- ❖ In heavy exercises and maximum level of exercises, muscles of respiration generate pressure in greater amount but below to their maximum limit and consumed oxygen for breathing is nearly equal to 10 percent of the total in normal healthy individuals.
- ❖ *In the course of submaximal exercises:*
  - at steady state (i.e. all aerobic activities which can be accounted as submaximal exercises since they don't require you to surpass your maximum aerobic capacity), ventilation increment is proportional to rise in volume of oxygen expenditure and volume of carbon dioxide production.
  - The strict regulation mechanism of ventilation to rate of metabolism in the body ensures the maintenance of relatively internal state related to arterial partial pressure of carbon dioxide, oxygen and pH value.
  - Instead of taking deep interest in valuable regulation mechanism by which ventilation compromised with the changes occur in metabolism with time during activities or exercises, physiologists are unable to find out the mysterious facts up to today's time.
  - Increment in ventilation during the course of submaximal exercises consists of three phases.
    - a) <u>PHASE-I:</u> It is represented as instant increment in ventilation at the onset of exercise with a constant time up to few seconds.
    - b) <u>PHASE-II</u>: It is represented as slow exponential increase in ventilation with constant time up to 60 seconds. It is slightly faster phase during the course of submaximal exercises.

c) PHASE-III: It is represented as steady state of ventilation by the 180 seconds of activity or exercise.

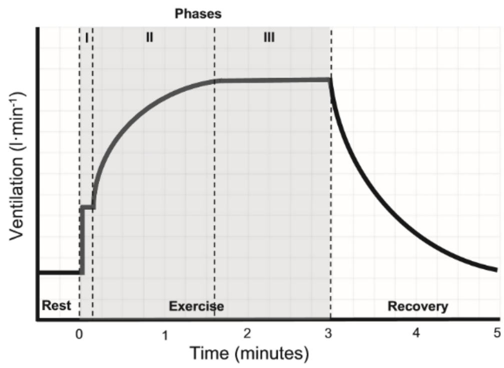

Fig. 1. The ventilatory response to submaximal constant-load exercise (shaded area), beginning at 0 min. The response is characterized by three phases: phase I, an immediate increase in ventilation at exercise onset (fast component), phase II, an exponential increase in ventilation (slow component) until phase III, steady state.

- But during the course of heavy exercises (i.e. activities require you to surpass your maximum aerobic capacity or anaerobic threshold value), PHASE-III can be reached and continuity is maintained until exhaustion or cessation of volitional exercises.
- Moreover, in trained athletes, muscles of inspiration respiration can generate pressure to their maximum value while muscles of expiration generate pressure up to the level where dynamic compression of the conducting airways can estimate the limitation of expiratory flow.
- In older subjects, a most frequent phenomena occur due to age- decay like loss of elasticity in lungs recoils especially in COPD patients or in its severe conditions as a common feature in both conditions i.e. at rest and during exercises can leads to dynamic hyperinflation.
- During this condition, expiratory volume become limited and to overcome this limitation, end-expiratory volume rise to allow the further flow. But in higher operated cases of lung volumes, muscles of inspiration face the load created by chest wall and lung instead of its shortness and lesser capability of generating pressure resulted in consumption of oxygen in same conditions.

Table no.1: Action of groups of muscles during respiration related to the type of exercises or activities performed by the individuals

Groups of Muscles	Rest	Light	Moderate	Hard	Very Hard	Maximal
Diaphragm	• Act as Pressure generator • Inspiratory muscles participate	• Act as Flow generator				
Rib cage muscles	• Act as Pressure generator • Inspiratory muscles participate	• Act as Pressure generator • Inspiratory muscles participate	• Act as Pressure generator • Inspiratory muscles participate	Max. inspiration pressure (approx.)	Max. inspiration pressure (approx.)	Max. inspiration pressure (approx.)
Abdominal muscles	Not participate	Act as Pressure generator (Expiratory muscles participate)	• Act as Pressure generator • Expiratory muscles participate	Max. expiration pressure (approx.)	Max. expiration pressure (approx.)	Max. expiration pressure (approx.)
Features		• EILV increased • EELV decreased • Contraction of respiratory muscles give positive circulatory effects	• EILV increased • EELV decreased • Contraction of respiratory muscles give positive circulatory effects	• Expiratory flow limitation • EELV increased • Blood flow/O2 supply to respiratory muscles increased • Fatigue of respiratory muscle • Contraction of respiratory muscles give negative circulatory effects	• Expiratory flow limitation • EELV increased • Blood flow/O2 supply to respiratory muscles increased • Fatigue of respiratory muscle • Contraction of respiratory muscles give negative circulatory effects	• Expiratory flow limitation • EELV increased • Blood flow/O2 supply to respiratory muscles increased • Fatigue of respiratory muscle • Contraction of respiratory muscles give negative circulatory effects

				• Metaboreflex	• Metaboreflex	• Metaboreflex

EILV i.e. end-inspiratory lung volume

EELV i.e. end-expiratory lung volume decreased

C. ***Respiratory quotient:***

- Respiratory Quotient (RQ): It can be defined as the relationship between volume of oxygen expenditure and volume of carbon dioxide production. It can be denoted as V ˙CO2 / V ˙O2.
- RQ value varies from 0.70 to in the form of functional substrate which is burned to produce energy in aerobic mechanism of respiration.

D. ***Dead space:***

- Dead space can be described as those area of lungs that get ventilated but not undergo perfusion.
- The volume of dead space can be calculated by the sum up of two separated areas of lungs.
  - (a) First component is the area of nose, pharynx, and conduction airways, which do not participate in diffusion of gases and are known as anatomic airway.
  - (b) Second component is well – ventilated area of alveoli with minimum blood flow known as alveolar volume of dead space.
- In mechanical type of ventilation, the endotracheal tube, connectors and humidification apparatus increases dead space and add as mechanical dead space with actual dead space related to components of lungs.
- The Physiological volume of dead space consists of airway dead space (mechanical and anatomical) and alveolar dead space.
- The mean value of volume of dead space related to airway is 2.3 mL/kg but this amount can vary with body and jaw/neck positions.
- Volume of dead space in alveoli increases potentially in COPD, embolism and in ARDS.

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