

Work of breathing

The components of breathing work are **stretching of the elastic structures of the chest and lungs** (elastic work), **movement of their inflexible structures** (viscous work) and then also **respiratory muscle work** when air flows through the airways. During normal, calm breathing, almost all muscle contraction occurs only during inhalation. Exhalation is a passive process caused by the elastic contraction of the lungs. It follows that work is needed mainly to breathe.

The work of breathing can be divided into the work needed to expand the lungs against elastic forces (compliance), the work needed to overcome the viscosity of the lungs (resistance) and the work needed to overcome airway resistance.

Work can be expressed as the product of the change in volume and pressure and can be calculated from the relaxation pressure curve.

Pressure work relaxation curve

- **area ABCA** = elastic work for inhalation
 - difference in relaxation pressure curves of the overall respiratory system and the lungs themselves
- **ABDEA area** = actual elastic work required to increase lung volume
 - the elastic work needed to expand the entire respiratory system is lower than the elastic work needed to expand just the lungs themselves
 - this is due to part of the work being done by chest wall elastic energy (AFGBA)

Dynamic pressure-volume diagram

During inhalation, the inspiratory muscles overcome the elastic forces, during exhalation, the elastic forces of the lungs are the driving force. The colored areas in the diagram represent the inspiratory and expiratory work of breathing, which is done against the flow resistance of the airways (+ the frictional resistances of the lungs and chest).

- hatched area = work against the elastic forces of the lungs and chest
 - inspiratory work = $W_{Rinsp} + W_{elast}$
 - expiratory work = $W_{Rexp} - W_{elast}$

If effortful breathing is greater than W_{elast} , active energy must also be expended for exhalation.

Components of breath work

- Inelastic work
 - viscous drag = 7%
 - airway resistance = 28%
- Elastic work = 65%

Most of the work is done by the respiratory muscles, normally only a small percentage of the total work of breathing is needed to overcome viscosity and slightly more is needed to overcome airway resistance. During heavy breathing, when air flows through the airways at high speed, a greater proportion of the total work is used to overcome this resistance. Breathing work during calm breathing equals approximately 0.3–0.8 kg. m./min. Of course, this value is influenced by various factors, such as the health status of the individual or physical exertion that increases the work of breathing. Nevertheless, even during physical exertion, breathing work takes up only a small part of the total energy consumption by the organism (approx. less than 3%). Diseases such as emphysema, asthma, congestive heart failure with dyspnoea and ortopnoia increase the work of breathing. Compliance and viscosity are increased in diseases causing pulmonary fibrosis. The resistance of the airways is increased mainly when they are obstructed. In asthma, expiratory work is higher than inspiratory work.

Links

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- Mechanics of Breathing

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