Rewarding Learning

A2 LEVEL
FACT FILE

Sports Science and the Active Leisure Industry

Unit A2 2:
The Application of Science to Sports Performance
- **The Respiratory System – Structure, Function and Adaptations**

FACT FILE

sports science
and the active leisure industry

Learning Outcomes

Students should be able to:

- Describe and compare the respiratory structures and the mechanics of inspiration and expiration at rest and during exercise;
- Identify, relate and evaluate lung volumes and capacities to pre-and post-training values;
- Discuss the process of gaseous exchange across the respiratory surfaces and the associated adaptations.

Course Outline

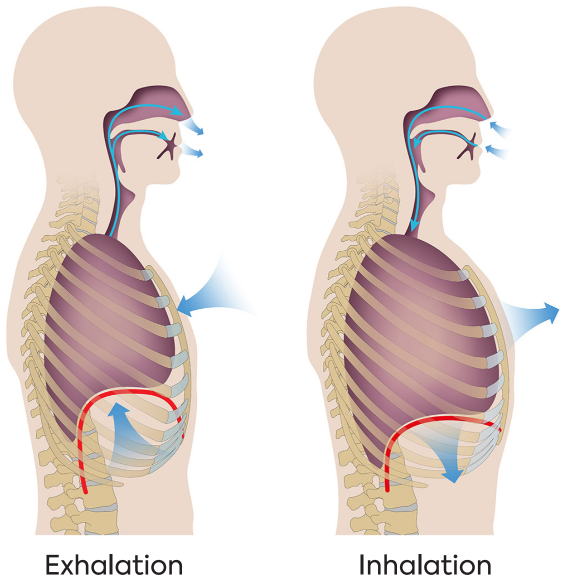
Respiratory System

The respiratory system combines with the cardiovascular system to ensure efficient transportation of oxygen and carbon dioxide in and out of our bodies. This involves four separate processes:

- Pulmonary ventilation: (breathing) the movement of air into and out of the lungs.
- Pulmonary diffusion: the exchange of O_2 and CO_2 between the lungs and the blood.
- Transport of O_2 and CO_2 in the blood.
- Capillary gaseous exchange of O_2 and CO_2.

By understanding the mechanisms of ventilation and what each stage is attempting to achieve, you will be better able to understand the responses and adaptations that can be made.

The movements of the chest during breathing



Inhalation

The primary respiratory muscles – the intercostal muscles and the diaphragm contract causing the chest cavity to increase in volume, which in turn causes the pressure in the lungs to drop. A ‘pressure gradient’ is created between the low-pressure in the lungs and the relatively high-pressure of the atmosphere outside. This causes the air, containing oxygen, to ‘move down the gradient’ and into the lungs.

Exhalation

Relaxation of the intercostal muscles and diaphragm and the elastic recoil of the stretched lungs return the thorax to its previous state. This causes an increase in pressure within the lungs. As a result, a new pressure gradient is created from the lungs to the atmosphere. Air moves down this new gradient, out of the lungs and into the atmosphere. At rest, exhalation is largely passive.

The onset of physical activity is accompanied by a two-phase increase in ventilation. An immediate significant increase occurs, followed by a more gradual increase in the depth and rate of breathing.

Breathing at rest	Breathing during exercise
Largely passive	Largely active
Exhalation is almost entirely passive	Exhalation is more active
Breathing is shallow	Breathing is deeper
Breathing is slow	Breathing is faster
Smaller percentage of exhaled air is CO_2	Greater percentage of exhaled air is CO_2
Primary respiratory muscles only	Primary and secondary muscles used

The table below shows the difference between ventilation at rest and during different intensities of exercise.

Activity level	Ventilation rate
Rest	Approximately 6 litres per minute
Steady-state aerobic exercise	Approximately 80-100 litres per minute in young adult males
Steady-state aerobic exercise	Approximately 50-80 litres per minute in young adult females
Maximal aerobic exercise	In excess of 120-140 litres per minute

Gaseous Exchange

Within the alveoli, an exchange of gases takes place between the alveoli and the blood.

Blood arriving in the alveoli has a higher carbon dioxide concentration produced by the body's cells during respiration. However, the air in the alveoli has a much lower concentration of carbon dioxide, meaning there is a concentration gradient which allows carbon dioxide to diffuse out of the blood and into the alveolar air.

Similarly, blood arriving in the alveoli has a lower oxygen concentration (as it has been used for respiration by the body's cells), while the air in the alveoli has a higher oxygen concentration. Therefore, oxygen moves into the blood by diffusion and combines with the haemoglobin in red blood cells to form oxyhaemoglobin.

Adaptations of the alveoli

To maximise the efficiency of gaseous exchange, the alveoli have several adaptations:

- They are folded, providing a much greater surface area for gas exchange to occur.
- The walls of the alveoli are only one cell thick. This makes the exchange surface very thin - shortening the distance across which gases have to diffuse.
- Each alveolus is surrounded by blood capillaries which ensure a good blood supply. This is important as the blood is constantly taking oxygen away and bringing in more carbon dioxide, helping to maintain the maximum concentration gradient between the blood and the air in the alveoli.
- Each alveolus is ventilated, removing waste carbon dioxide and replenishing oxygen levels in the alveolar air. This also helps to maintain the maximum concentration gradient between the blood and the air in the alveoli.

An aerobic training regime can:

- Increase surface area of the alveoli.
- Strengthen the respiratory muscles and restrict fatigue, often experienced at the end of intense and prolonged activity.
- Provide small increases in lung volumes – for example, vital capacity (the amount of air that can be forcibly expelled following maximum inspiration) increases slightly, as does tidal volume during maximal exercise.

However, such measurements are not used as indicators of aerobic fitness since there is no correlation between lung volume and athletic ability.

Additional work

Calculate respiratory rates for clients:

- at rest;
- standing up;
- moving during exercise at a moderate intensity; and
- moving during exercise at a high intensity.

What is the difference in respiration rate over a 30 second period in each case? Explain these differences.

References

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3. Roscoe, D., Davis, B. and Roscoe, J. (2009) *A2 Revised P.E. for Edexcel*. Widnes, Jan Roscoe Publications.

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