EXERCISES – BIOLOGICAL SIGNALS

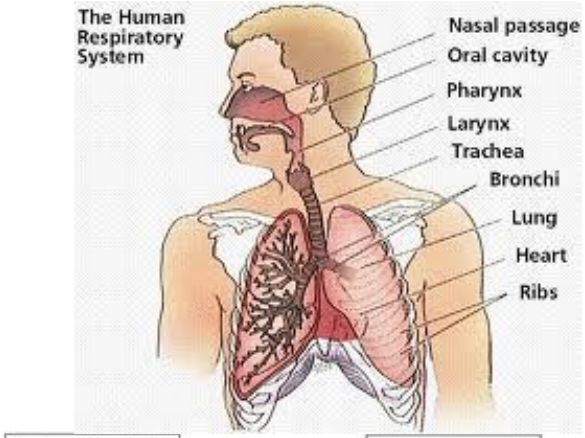
Exercise 5 - SS 2014 – Michel Kana

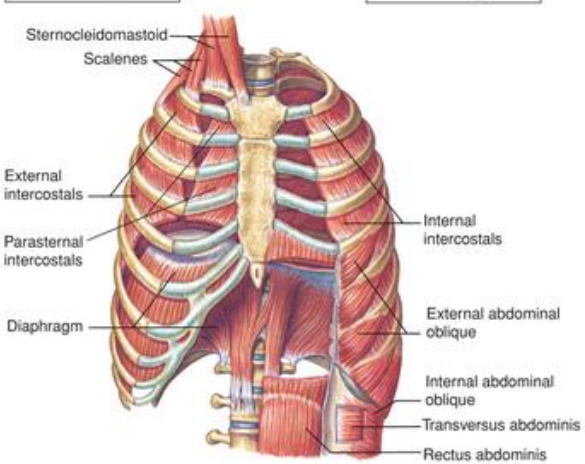
What will we do today?

1. **The physiology of Respiration**
2. **Structure of the Respiration Signal**
3. **Respiration measurement with BIOPAC**
4. **Summary**

The physiology of Respiration

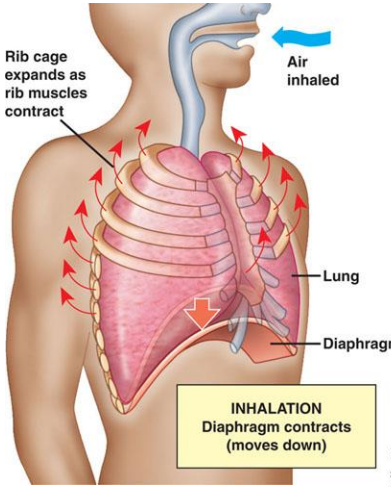
- The respiration system consists of structures involved in ventilation and gas exchange
  - Airways that lead air from the external environment to the exchange surface of lungs
  - Alveoli that form an exchange surface where oxygen moves to blood and carbon dioxide moves from blood.
  - Bones and muscles of the thorax and the abdomen that assist in ventilation.
- The primary functions of the respiration system include
  - Gas exchange
  - Homeostatic regulation of body pH
  - Protection from inhaled pathogens
  - Vocalization

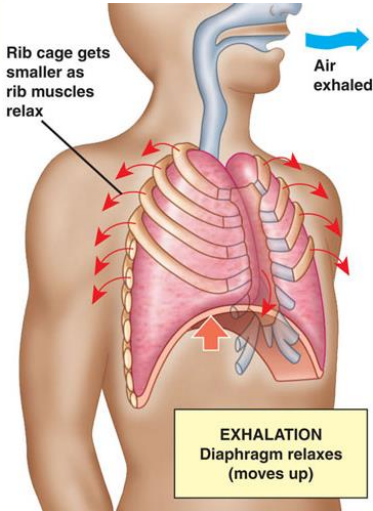




The physiology of Respiration

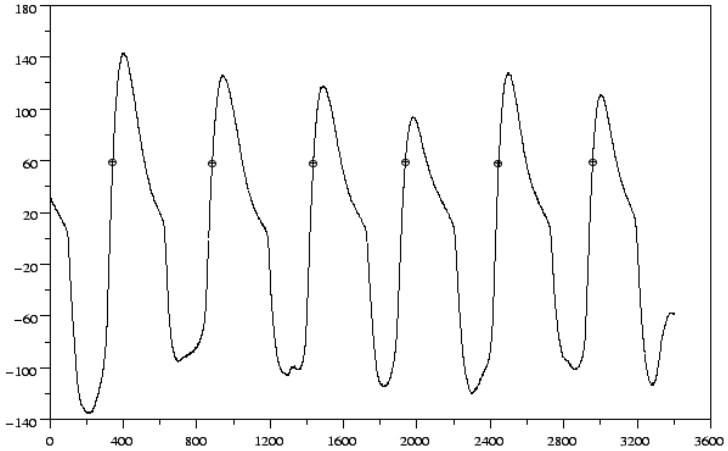
- **Breathing** is an active process that uses muscle contraction to create a pressure gradient.
  - When the diaphragm contracts, it drops down toward the abdomen about 1.5 cm, increasing thoracic volume.
  - When costal and scalene muscles contract, they pull the ribs upward and out, increasing thoracic volume.
- The basic rhythm of breathing is established by inspiratory and expiratory respiratory centers in the **medulla**.
- The air moved during breathing is divided into four lung volumes.
  - **Tidal volume** is the volume of air that moves during a single inspiration or expiration (ca. 500 mL).
  - **Inspiratory reserved volume** is the additional volume of air that can be inhaled after tidal volume is reached during inspiration (ca. 3000 mL).
  - **Expiratory reserved volume** is the additional volume air that can be exhaled after the tidal volume is reached during expiration (ca. 1100 mL).
  - **Residual volume** if the volume of air that remains in the lungs after a maximal exhalation (ca. 1200 mL).





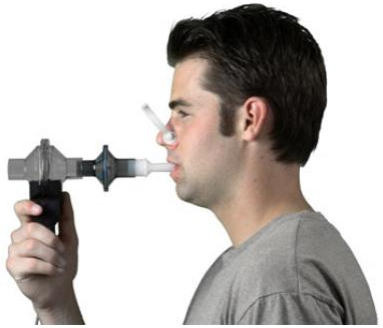
Structure of the Respiration Signal

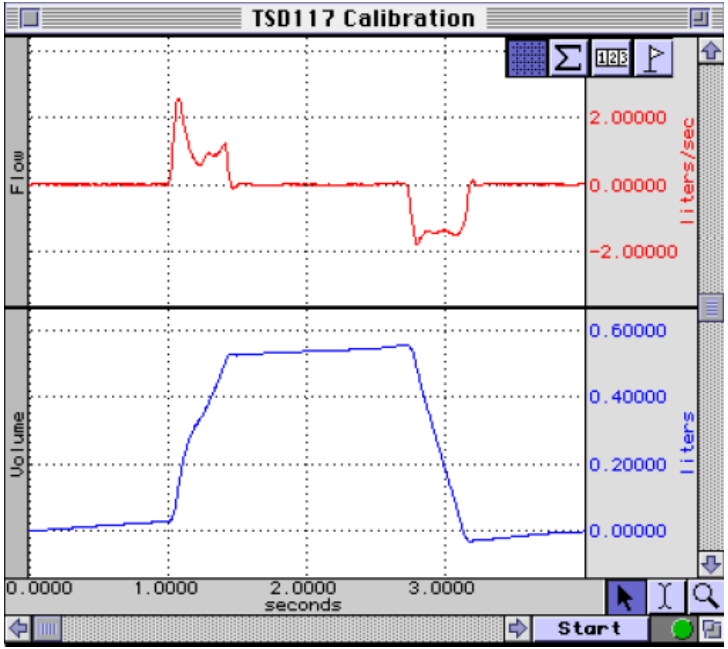
- Respiration creates change in thoracic or abdominal circumference.
- The measurement of the thoracic or abdominal circumference as a voltage is called **respiration signal.**
- The respiration signal contains various information:
  - The **respiration rate**: number of inhalation/exhalation cycles per minute (ca. 12-14).
  - The **tidal volume**: estimated from the amplitude of the respiration signal during quiet breathing. Calibration is required.
  - The **inspiratory reserved volume**: estimated from the amplitude of the respiration signal during forced inhalation.
  - The **expiratory reserved volume**: estimated from the amplitude of the respiration signal during forced exhalation.
  - The inspiration and Expiration duration



Structure of the Air Flow Signal

- Respiration creates bi-directional airflow.
- The measurement of airflow as a voltage is called **airflow signal.**
- Volume measurements are obtained by integrating the airflow signal.





Exercice 1: Respiration measurement with BIOPAC

- **Biopac MP35 measurement system**
  - Respiration is recorded using the Biopac SS5LB transducer plugged in the first channel.
  - Air flow is measured with a Biopac SS11LA transducer plugged in the second channel.
  - Air temperature is measured with a Biopac SS6L transducer plugged in the third channel.
- **Biopac Student Lab PRO software**
  - The acquisition is set up at a sampling rate of *200 Hz*.
  - Analog Channel CH1 have the preset *Respiration (SS5BL)*
  - Analog Channel CH2 should have should the preset *Airflow (SS11L)*
  - Analog Channel CH3 should have should the preset *Temperature (deg C)*
  - Calculation Channel C1 should have the preset *Respiration Rate* (from CH1)
  - Calculation Channel C2 should have the preset *Lung Volume* (from CH2)
- **Respiration parameters calculation**
  - Estimate the breathing rate, the mean tidal volume, the mean inspiration and expiration duration

Exercice 2: Respiratory volume estimation

- **Procedure**
  - Subject is instrumented for Respiration measurement with Biopac.
  - Subject should perform a normal inhalation, followed by a forced inhalation to maximal lung volume during 60 sec.
  - Subject should perform a normal exhalation, followed by a forced exhalation to minimal lung volume during 60 sec.
- **Evaluation**
  - Calculate the tidal volume during forced exhalation and forced inhalation.
  - Compare the obtained values with tidal volume during quiet breathing and estimate the expiratory and inspiratory reserved volumes.

Exercice 3: Respiratory patterns

- **Procedure**
  - Subject is instrumented for Respiration measurement with Biopac.
  - Subject should perform 6 cycles deep breathing during 60 sec.
  - Subject should then perform 60 cycles hyperventilation during 60 sec.
  - Subject should then record a couple of respiration cycles during cough and yawning.
- **Evaluation**
  - Calculate the mean tidal volume, mean inspiration and expiration durations for each experiment.
  - Compare the values between experiments.

Exercice 4: Breathe holding

- **Procedure**
  - Subject is instrumented for Respiration and pulse measurement with Biopac.
  - Subject should record 60 sec of quiet breathing followed by 10-30 sec breathe holding.
  - Subject should resume 60 sec of quiet breathing.
- **Evaluation**
  - Calculate the mean heart rate, respiration rate, mean tidal volume, mean inspiration and expiration durations for each of the three phase.
  - Compare and discuss the values.