MED437
KING SAUD UNIVERSITY

437
PHYSIOLOGY TEAM

# Low & High altitude

- Color index:
  - Red: important
  - Green: doctor's notes
  - Grey: extra information
  - Pink: found only in female's slides
  - Blue: found only in male's slides
  - Yellow: numbers

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Physiology 437 team work

Editing file

# objectives:

## By the end of the lecture you will be able to:

1-Describe the effects of exposure to low and high barometric pressures on the body.

2- Describe the body acclimatization to low barometric pressure.

3-Define decompression sickness and explain how it can be avoided.

4-Understand the effects of high nitrogen pressure, and nitrogen narcosis.

# Effect of increased  barometric pressure (Deep sea diving)

ted-ed
4:00

- When human descend below the sea, the pressure around them increased.
- To prevent the lungs from collapse air must be supplied also under high pressure.
- This exposes the blood in the lungs to extremely high alveolar gas pressure (hyperbarism).
- Under certain limits these high pressures cause tremendous alterations in the physiology of the body.

# Effect of increased  barometric pressure (Deep sea diving)

- The surrounding pressure increases by 1 atmosphere for every 10 meter (33 feet) of depth in sea water.
- Therefore at a depth of 31 meter (100 feet) in the ocean the diver is exposed to a pressure of 4 atmospheres .1 atm “from air “ + 3 atm “ 1 for each 10 M” = 4 .
- These problems confront SCUBA (self contained underwater breathing apparatus..)

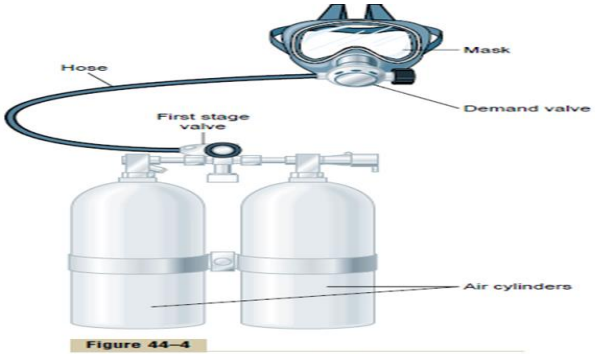


Figure 44–4
Open-circuit demand type of SCUBA apparatus.

# Effect of increased barometric pressure (Deep sea diving)

- **Effect of depth on the volume of the gases**:

At depth there is compression of gases to smaller and smaller volumes. i.e 1L (sea level )→1/2 L at 33 feet and so on. **Boyle's law** "The absolute pressure exerted by a given mass of an ideal gas is inversely proportional to the volume it occupies".

- **Effect of depth on density of gases**

There is increase in the density of gas and hence increased work of breathing.

- **Nitrogen effect at high nitrogen pressure**

Nitrogen will has 2 principle effects:

* Nitrogen narcosis (anesthetic effect)

* Decompression thickness. النيتروجين أكثر عنصر من عناصر التنفس يتأثر بقانون هنري الي هو لما يزداد ضغط الغاز تزداد ميوعته.

Henry' law : " the amount of dissolved gas is proportional to its partial pressure in the gas phase".

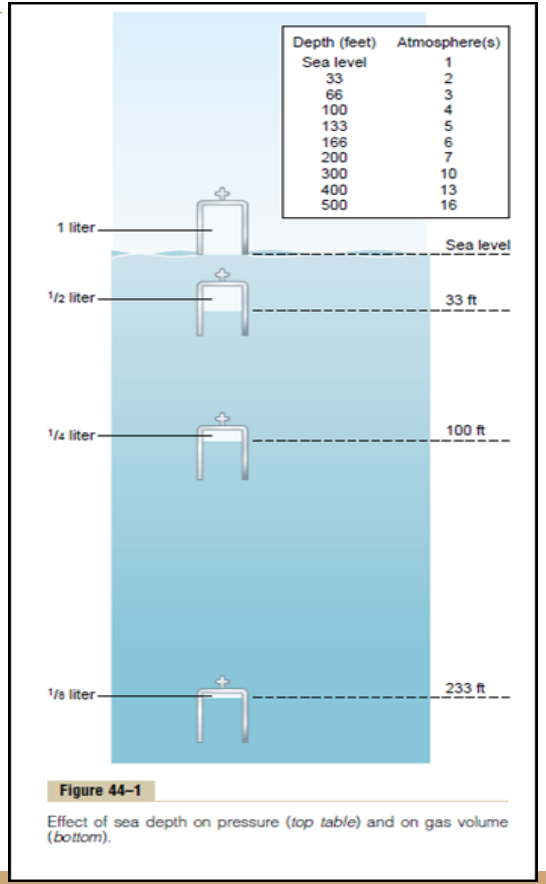



**Figure 44–1**

Effect of sea depth on pressure (*top table*) and on gas volume (*bottom*).

# Nitrogen Narcosis

- Nitrogen like most other anesthetic gases, dissolve freely in the fats of the body including the membranes and other lipid structures of the neurons.
- This leads to alteration of the electrical conductance of the membranes:
  - reduces their excitability
  - and subsequent narcosis develops.

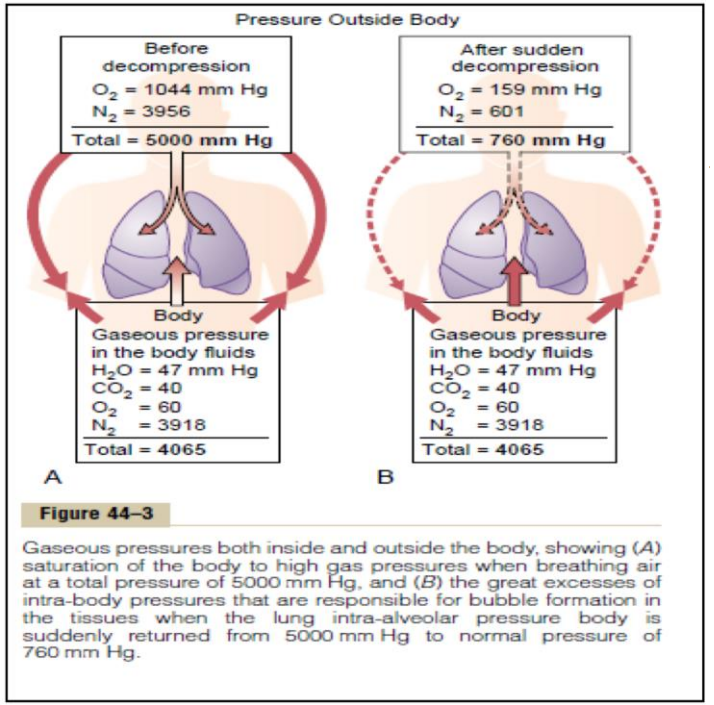



**Figure 44–3**

Gaseous pressures both inside and outside the body, showing (*A*) saturation of the body to high gas pressures when breathing air at a total pressure of 5000 mm Hg, and (*B*) the great excesses of intra-body pressures that are responsible for bubble formation in the tissues when the lung intra-alveolar pressure body is suddenly returned from 5000 mm Hg to normal pressure of 760 mm Hg.

At 120 feet:
the diver loses many of his cares.

At 150 feet:
there is a feeling of euphoria and drowsiness and impaired performance.

At higher pressure:
loss of coordination and finally coma might develop.

# Decompression Sickness

الفيديو السابق شرح هذي النقطة

- **Other names:** Bends, Compressed Air Sickness, Caisson Disease, Diver's Paralysis, Dysbarism.
- It is a syndrome caused by a decrease in the ambient (surrounding) pressure which occur in animal and men when the tissues of the body contain an excess of physically inert (does not undergo chemical reactions) gas.
- **During descent,** the high partial pressure of nitrogen (encountered when breathing compressed air at depth) forces this gas into solution in body tissue particularly in fat (it has a high $N_2$ solubility).
- **On ascending,** this inert gas comes out of physical solution forming a gaseous phase (bubbles), leading to symptoms and signs.
    - **During slow ascent,** $N_2$ is slowly removed from the tissues since the partial pressure there is higher than that in the arterial blood and alveolar gas.الطريقة الصحيحة عشان تتجنب الدي اس
    - **If decompression is rapid,** bubbles of gaseous nitrogen are released, in tissues and blood, causing the symptoms of decompression sickness (the bends or caisson disease).

# Symptoms & signs of decompression sickness (DS)

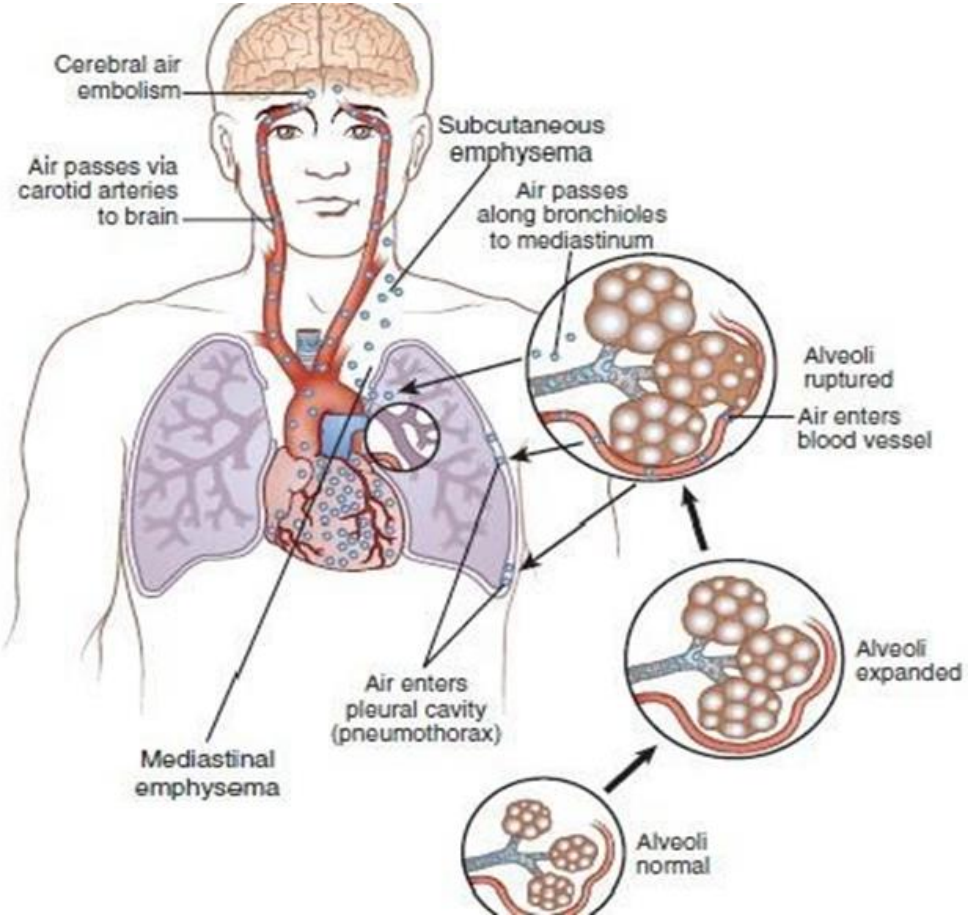
**Mild** symptoms:

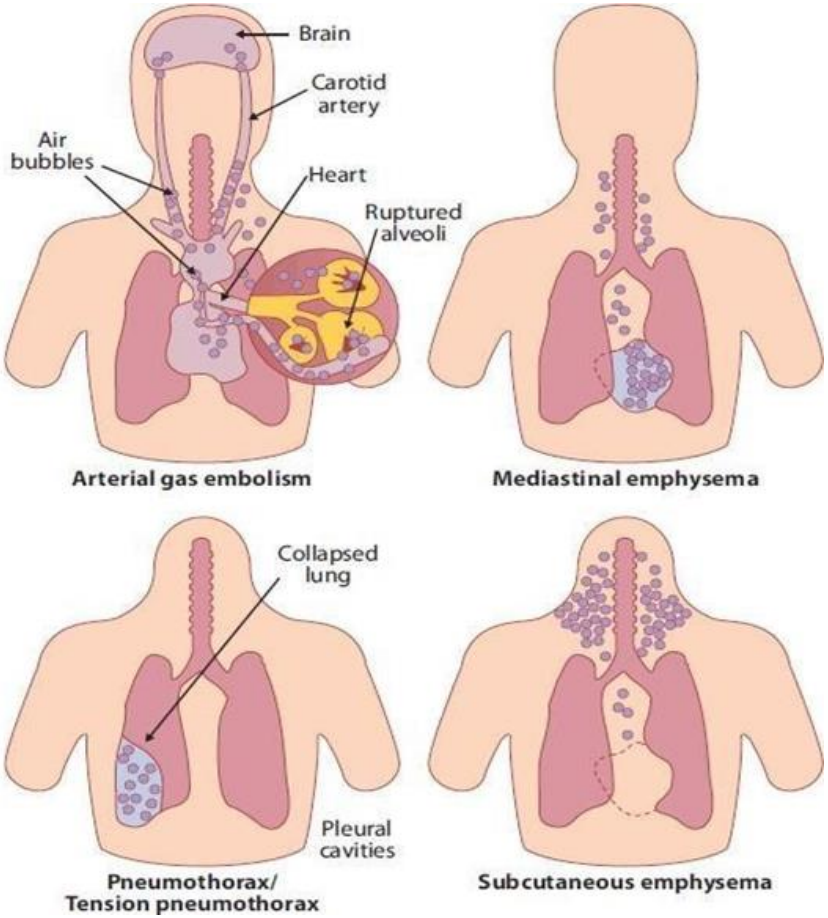
- **fatigue** or **drowsiness** after decompression.
- Locally there is skin **itch**.

**Severe** symptoms:

- **bubbles** in the tissues cause severe pains particularly around the **joints**.
- **Neurological** symptoms include **paresthesia** -تنميل-, **itching**, **paralysis**, and **inner ear disturbances.**
- Thoracic pains: **dyspnea**, **substernal pain**, **cyanosis**, and **cough**.
- Bubbles in the coronary arteries may cause **myocardial damage "the bubbles will block the blood vessels".**
- Decompression sickness shock, capillaries become permeable to plasma and **hypovolemia** rapidly develop.
- **Edema** may be prominent and **shock** is also usually complicated by pulmonary edema..

أحد الشباب سأل الدكتور قال ماذا عن الأسماك وخصوصا الحوت -لأنه يتنفس بالرئة مثلنا -؟ وأجاب الدكتور أنه ما عنده خلفية بذا الموضوع .في الفيديو هنا
مراجعة لكل الكلام الي في السلايدات فوق والجواب على السؤال جميل المقطع قايق


Cerebral air embolism
Subcutaneous emphysema
Air passes via carotid arteries to brain
Air passes along bronchioles to mediastinum
Alveoli ruptured
Air enters blood vessel
Alveoli expanded
Air enters pleural cavity (pneumothorax)
Mediastinal emphysema
Alveoli normal


Brain
Carotid artery
Air bubbles
Heart
Ruptured alveoli
Arterial gas embolism
Mediastinal emphysema
Collapsed lung
Pleural cavities
Pneumothorax/ Tension pneumothorax
Subcutaneous emphysema

# Treatment of decompression symptoms

- **Rapid** recompression(نرجع نضغطه مرة ثانية😊)in a pressure chamber followed by **slower** decompression.
- This **reduces** the volume of the bubbles and forces them back into solution.
- In a very deep dives, the risk of decompression sickness can be **reduced** if a helium-$O_2$ mixture is breathed during the dive.
- Also it is important to **reduce** the oxygen concentration in the gaseous mixture to avoid oxygen toxicity that would cause seizures .

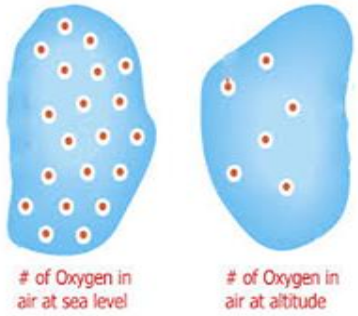
Helium is **more** desirable than nitrogen in deep dives because it has:

- 1/4 - 1/5 the **narcotic effect** of nitrogen on CNS.
- 1/7 the molecular **weight** of nitrogen.
- **low** density leading to **decreased** airway resistance of diver.
- Helium is about 1/2 as soluble as nitrogen in body fluids. This **reduces** the quantity of bubbles that can form in tissues when the diver is decompressed after diving.
- Diffuses out of the tissues during decompression several times **as rapidly as** does nitrogen, thus **reducing** the problem of decompression sickness.

# Effects of low oxygen pressure on the body ( Aviation-ascend to high altitude)

- At the sea level the barometric pressure is 760 mmHg.
- At 10,000 feet is 523 mmHg
- At 50,000 feet 87 mmHg.

This decrease in barometric pressure is the basic cause of all the hypoxia problems in high altitude in physiology. لأن هذا يعني نقص في تركيز الاوكسجين وبالتالي هيبوكسيا.




# Alveolar PO2 at different altitudes

•As the barometric pressure decreases, the oxygen partial pressure decreases proportionally, remaining less than 21% of the total barometric pressure.

• At sea level $PO_2$= 159 mmHg.

•At 20,000 feet $PO_2$= 40 mmHg.

•At 50,000 feet $PO_2$= only 18 mmHg.

•Even at high altitude $CO_2$ is continuously excreted from the pulmonary blood into the alveoli. Also, water vaporizes into the inspired air from the respiratory surfaces.

•Therefore, these two gases dilute the oxygen in the alveoli, thus reducing the oxygen concentration and therefore hypoxia develops.

# Effects of acute hypoxia

• **Some of the important acute effects of hypoxia beginning at an altitude of approximately 12,000 feet, are:**

• Some of the important acute effects of hypoxia beginning at an altitude of approximately 12,000 feet, are: Drowsiness, lassitude, mental and muscle fatigue, sometimes headache, occasionally nausea and sometimes euphoria (happiness).

• All these progress to a stage of twitching or convulsions above 18,000.

• Above 23,000 feet the un acclimatized person can enter into coma.

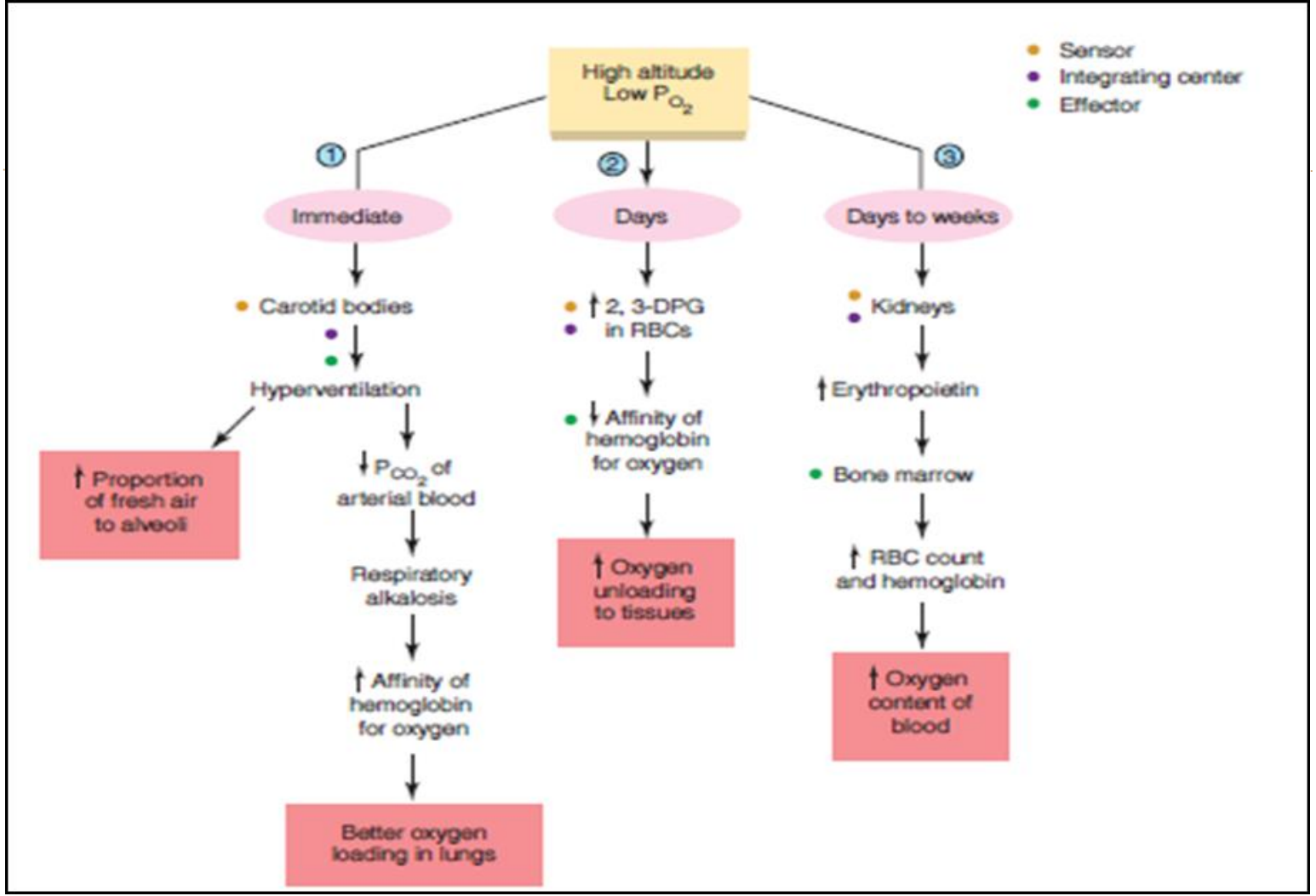
One of the most important effects of hypoxia is decreased mental proficiency, which decreases judgment, memory, and performance of discrete motor movements.

# Acclimatization to low $PO_2$

- A person remaining at high altitudes for days , weeks or years becomes more and more acclimatized to low PO2.
- So that it causes fewer deleterious effects on the body and it becomes possible for the person to work harder without hypoxic effects or to ascend to still higher altitude.

# Principle means of acclimatization

1. **Increased** pulmonary ventilation.
2. **Increased** red blood cells.(if there is decrease in O2 the kidney will respond by producing **Erythropoietin** which will go to the bone marrow and synthesize RBCs + Hb, so more O2 will be carried on Hb and more O2 will be transferred to the tissue).
3. **Increased** diffusing capacity of the lungs.
4. **Increased** vascularity of the tissues.
5. **Increased** ability of the cells to utilize oxygen despite the low PO2 through increased number of mitochondria and oxidative enzymes activity.


Sensor
Integrating center
Effector
High altitude
Low $P_{O_2}$
1
2
3
Immediate
Days
Days to weeks
Carotid bodies
Hyperventilation
↑ Proportion of fresh air to alveoli
↓ $P_{CO_2}$ of arterial blood
Respiratory alkalosis
↑ Affinity of hemoglobin for oxygen
Better oxygen loading in lungs
↑ 2, 3-DPG in RBCs
↓ Affinity of hemoglobin for oxygen
↑ Oxygen unloading to tissues
Kidneys
↑ Erythropoietin
Bone marrow
↑ RBC count and hemoglobin
↑ Oxygen content of blood

## Female’s team:

Leader: Alanoud Salman Alotaiby

Members:

1. Renad AlMogren
2. Sarah AlFlaij
3. Reem ALQarni

## Male’s team:

Leader: Abdulhakim AlOnaiq

Members:

1- Mohammed Alhassan

2- Saad alhaddab

3- Anas Alsawida