Physiol-08B15 Describe the changes that occur with ageing that can affect oxygen delivery to the tissue during moderate exercise.

Background

Ageing = physiological time-dependent process, which results in decrease in cellular function and reserve

Exercise = voluntary physical activity which results in increased metabolic demand

Exercise → body needs to increase oxygen delivery to meet increased oxygen demand

DO_2 = **CO** × (**[Hb]** × 1.34 × **SaO_2** + 0.03 × **PaO_2**)

Baseline DO_2 of young adult ≈ 1L/min
Baseline DO_2 of old age ≈ 400 mL/min
Maximum achievable also reduced with ageing

This is due to reduction in above factors governing DO_2

Changes in ageing which reduce DO_2

(1) impaired ability to increase CO

- ↓autonomic system → ↓sympathetic response to exercise
- ↓maximum HR achievable – fibrosis of SA node, ↓responsiveness of adrenergic receptors
- ↓maximum contractility – fibrosis of cardiac myocytes ± ischaemic injury
- ↓ventricular compliance – fibrosis → diastolic dysfunction
- ↑afterload – e.g. from stenotic valvulopathy, arteriosclerosis
- ↓blood volume with ageing → ↓preload

As a result of ↓HR and ↓SV → ↓maximum achievable cardiac output → ↓maximum O_2 delivery

(2) reduction in PaO_2 and maximal minute ventilation

PaO_2 roughly = 100 – age/3
Maximum MV ≈ 100 L/min at 20 y.o. → 30 L/min in elderly

With ageing:

- ↑lung compliance → ↑closing capacity [FRC = CC when supine (44 y.o.) and erect (66 y.o.)] → ↑basal atelectasis → ↑shunt fraction → ↓PaO_2
- destruction of alveoli ± thickening of alveoli membrane → ↓gas diffusion and ↑V/Q mismatch
- ↓chest wall compliance (e.g. arthritic rib joints) and ↓thoracic volume (e.g. kyphoscoliosis) → ↑work of breathing

(3) reduction in [Hb]

With ageing → may develop chronic diseases ± bone marrow infiltration ± malnutrition (deficiency of haematinics) → anaemia → ↓O_2 carrying capacity of blood → ↓DO_2

Examiner's comments – 14% of candidates passed this question.

Oxygen delivery is the product of cardiac output and arterial oxygen content. Oxygen delivery during exercise is increased by raising cardiac output globally and locally, and increasing oxygen extraction. Linking these changes to aging is the key to answering this question. Cardiac output and respiratory changes with aging both needed discussion to gain a pass mark.

Key points:
• Cardiac output
-contractility decrease, heart rate decrease responsiveness, stroke volum decrease etc, ventricular compliance decrease, and cardiac work increase with aging.
These factors reduce the ability to increase cardiac output to match exercising tissue demand.

• Respiratory – PaO2 decrease, work of breathing increase with a decrease in chest wall compliance, closing capacity encroaches on FRC,and diffusion capacity decrease from increace alveolar membrane thickness and decrease functional surface area. The increase V/Q mismatch that results reduces the ability to oxygenate blood when extraction increases.

Additional marks were awarded for mentioning decrease in blood flow with atherosclerosis, increase pulmonary resistance and heart strain, anaemia decrease O2 content, moderate exercise is below anaerobic threshold, and valvular defects can affect cardiac output. Common errors included focusing on either cardiac or respiratory changes; listing aging and exercise physiological changes without linking the important factors of the two together; describing anaerobic metabolism of tissues; stating that FRC reduces with increasing age; not differentiating between the decrease chest wall compliance and increase lung compliance that happens with aging.