CHAPTER-5 (Part-A)

Muscular system

Core Resources

Tortora and Grabowski- Principles of Anatomy and Physiology

Chapters 7, 8, 11

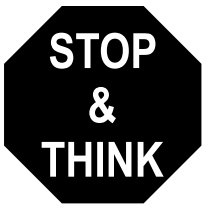
Introduction

In this section we shall be introducing you to the muscular and skeletal systems, collectively known as the musculoskeletal system.

The musculoskeletal system is comprised of: Skeletal muscle, joints, ligaments and tendons. Also present is cartilage and bone which are types of connective tissue (see chapter on **histology**).

Skeletal muscles attach to bone by means of a tendon, whereas ligaments attach bone to bone in the region of joints. The structure of skeletal muscle has already been described (see chapter on **histology**), but it is important to remember that it is under voluntary control as opposed to smooth or cardiac muscle whose control is effected by the autonomic nervous system.

Learning outcomes



The student should be able to:

- Describe how muscles contract
- Understand how muscles effect movement
- Know the locations, including the origin and insertion of the muscles listed
- Describe the composition of a typical long bone
- Know the locations of the bones listed

Muscle tissue

Pleas refer back to your **histology** notes for the structure of muscle fibres

Skeletal muscle tissue

Through the alternating contraction and relaxation of muscle tissue, it functions to generate body movements, to stabilise the body's position, moving substances within the body, regulating organ volume and to create heat.

Structure

- The bulk of the muscle is referred to as the **belly** of the muscle, and is attached to the bones by means of the **tendons**.
- The external sheath surrounding the muscle, known as the **epimysium**, extends beyond the belly to form the tendon. This epimysium is made up of tough regular connective tissue.
- Immediately deep to this layer, lies the **perimysium**, which extends deep into the belly of the muscle, and surrounds groups of 10- 100 muscle fibres, dividing the muscle into muscle bundles called **fascicles**.
- The **endomysium**, is a thin sheet of areolar connective tissue, which further divides the fascicles into individual muscle fibres (a single muscle cell).
- The deep fascia, epimysium, perimysium and endomysium converge together at the ends of the muscle to form the tendons, attaching the muscles to the bone.

Actin and myosin

- Actin and myosin represent the two contractile proteins of the muscle.
- The thick myosin filament is made up of approximately 300 molecules of 'double headed golf club shaped proteins, which are twisted together. The 'heads of the golf clubs' represent the heads or cross-bridges of the myosin, which extend towards the thin actin filaments surrounding the thick myosin filament.
- The thin filament is made up of a helix of actin, along with some troponin and tropomyosin proteins. The actin contains myosin-binding sites, which are the sites of attachment for the cross-bridges. The troponin and tropomyosin cover the binding sites of the actin, until muscle contraction is required.

The Neuromuscular Junction

The neuromuscular junction is the point of synapse between a somatic motor neuron and a skeletal muscle fibre.

A neuromuscular junction is made up of:

- An axon terminal with synaptic end bulbs, which houses synaptic vesicles containing the neurotransmitter, acetylcholine (ACh).
- The motor end plate containing receptor sites for acetylcholine.
- Between these two structures is a gap called the synaptic cleft.

Sequence of muscle contraction

1. An action potential triggers the rupture of the synaptic vesicles, and subsequent release acetylcholine (ACh) into the synaptic cleft. ACh diffuses across the synaptic cleft and binds with the receptor sites on the sarcolemma.
2. This triggers the release of sodium ions into the muscle cell, changing the fibre to become positive, and thus stimulating an action potential, which propagates along the sarcolemma and through the T tubules for a collective and synchronised muscle contraction.
3. This triggers the release of calcium ions from the sarcoplastic reticulum into the myofilaments.
4. The calcium ions bind to the troponin and tropomyosin. This alters the three dimensional shape of the actin-troponin-tropomyosin complex, revealing active sites on the actin to which myosin will attach.
5. The calcium ions also act upon myosin, activating it. The myosin hydrolyses ATP into ADP plus a phosphate group, to energise the myosin head, moving it towards the newly exposed binding sites on the actin.
6. The energised myosin head (still holding the ADP and phosphate group) attaches to the myosin-binding site on the actin.
7. Phosphate is released, and this triggers the power stroke of contraction. The power stroke is the rotation of the myosin head, and the release of the ADP molecule.
8. As the myosin head rotates, it generates a force, which results in the sliding of the actin past the myosin towards the M-line thereby contracting the sarcomere and the muscle fibre. As the filaments slide the mysosin heads detach from one site and attach to the next. As many as 100 such attachments per second can occur.
9. After the power stroke, the myosin head remains attached to the actin, until it binds with another ATP molecule.
10. When the stimulus of the action potential stops, the calcium ions are taken back in by the sarcoplasmic reticulum. As the level of calcium ions drop troponin and tropomyosin move back to their initial positions, blocking the myosin binding sites, and the filaments also return to their original positions (so long as the myosin has bound with an ATP molecule).

As ATP is the ‘energy of life’, you can now understand why death causes rigor mortis: As myosin head cannot detach without the ATP molecule.

The Muscles of the body:
It is important to realise that muscles manipulate movement through a system of leverage. They **always pull** and **never push**, the bones from the site of insertion towards the site of origin.

Origin The attachment of the muscle tendon to the stationary bone. (usually proximal)

Insertion The attachment of the other muscle tendon to the movable bone. (usually distal)

Agonist The prime mover, or contractor

Antagonist The muscle which stretches to accommodate to the effects of the agonist.

Fixator Stabilises the proximal joints for the operation of weight bearing.

Neutralizer Neutralises undesired movements.

At this stage, you shall progress to learning the major muscles of the body. Below are outlined the muscles, which should be learned. It is necessary to be able to identify these muscles, and the directions of movement, which they produce. In certain muscles you will also be instructed to learn the sites of origin and insertion.

The muscles of facial expression:

Orbicularis oculi
Orbicularis oris
Frontalis
Zygomaticus major
Zygomaticus minor
Risorius
Buccinator
Temporalis
Platysma

The muscles of the eye (extraocular muscles):

Superior rectus - elevates
Inferior rectus - depresses
Lateral rectus - abducts
Medial rectus - adducts

Superior oblique – rotates to the right (note the loop through which it passes)
Inferior oblique - rotates to the left
Note that these muscles exit with the optic nerve. Take note of the direction in which the muscle pulls the eye.

The muscles of mastication:

Temporalis
Masseter
Medial pterygoid
Lateral pterygoid

The lateral and anterior neck muscles:

Sternocleidomastoid
Trapezius
Levator scapulae
Note the hyoid bone, and the suprahyoid and infrahyoid muscles.

Deep muscles of the back and posterior neck:

Splenius
Erector spinae muscles (just learn the group)
Transversospinalis group (just learn the group)
Intertransversarii
Interspinalis
Suboccipital muscles

Muscles of the thorax:

The diaphragm (learn origin and insertion)
External intercostals (learn origin and insertion)
Internal intercostals (learn origin and insertion)
Innermost intercostals muscles
Psoas major and minor
Iliacus

Muscles of the anterior abdominal wall:

Transverse abdominus
Rectus abdominus (your six pack!)
Internal oblique
External oblique

Learn all the origins and insertions of this group.
Note also, the linea alba.

Muscles of the pelvis:

Observe the difference between the pelvic floor and the pelvic wall. Note how the muscles originate or insert into the pelvic girdle

Muscles of the perineum:

Learn the boundaries of the perineum, and be able to differentiate between the urogenital and the anal triangles. It is not necessary to learn these muscles.

Muscles of scapular stabilisation:

Trapezius
Rhomboid major
Rhomboid minor
Levator scapulae
Serratus anterior
Pectoralis minor

Learn all origins and insertions

Muscles of the musculotendinous cuff / rotator cuff : (SITS muscles)

Supraspinatus
Infraspinatus
Teres minor
Subscapularis
Learn all origins and insertions.

Study the clinical relevance of the subacromonial bursa.

Muscles of the shoulder joint:

Deltoid (Learn origin and insertion)
Pectoralis major (Learn origin and insertion)
Latissimus dorsi (Learn origin and insertion)
Teres major
Biceps brachii (Learn origin and insertion)
Triceps brachii (Learn origin and insertion)

Muscles of the elbow and radioulnar joints:

Biceps brachii (learn origin and insertion)
Brachialis
Brachioradialis
Pronator teres
Triceps brachii (learn origin and insertion)

Observe the flexors on the wrist and hand joint. Note how the muscles terminate at the phalanges as tendons. Note, also the *extensor* and *flexor retinaculum* which holds the flexor tendons against the wrist bones like a cuff. The flexor retinaculum is frequently cut in patients suffering from Carpal Tunnel Syndrome (CTS).

Please take note of the locations of the *thenar* and *hypothenar eminences*.

Muscles of the gluteal region:

Gluteus maximus (learn origin and insertion)
Gluteus medius (learn origin and insertion)
Gluteus minimus
Tensor fascia latae (learn origin and insertion)
Piriformis

Muscles of the posterior thigh:

Semimembranosus (learn origin and insertion)
Semitendinosus (learn origin and insertion)
Biceps femoris (learn origin and insertion)

Muscles of the medial thigh:

Adductor brevis (learn origin and insertion)
Adductor longus (learn origin and insertion)
Adductor magnus (learn origin and insertion)
Gracilis (learn origin and insertion)

Muscles of the anterior thigh:

Sartorius (learn origin and insertion)
Rectus femoris (learn origin and insertion)
Vastus lateralis (learn origin and insertion)
Vastus intermedius (learn origin and insertion)
Vastus medialis (learn origin and insertion)

Muscles of the anterior leg:

Tibialis anterior
Peroneus longus
Note the retinaculum surrounding the ankles of the feet.

Muscles of the posterior leg:

Gastrocnemius
Soleus
Plantaris
Popliteus