FUNCTIONAL ANATOMY AND BIOMECHANICS OF MOVEMENT
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EXTENSORS of the spine

-follow the entire length of the spine from pelvis to head, different layers of muscles – superifical, intermediate and deep

The erector spinae are an intermediate back extensor while the multifidus is a deep back muscle lateral to the posterior spinous processes. It spans from the sacrum to the 2nd cervical vertebra, spanning from 2-4 vertebrae at a time.

ABDOMINALS

- abdominals work with spinal extensors
- fill space between ribcage and pelvis, flexors of trunk, located anteriorly and laterally with attachments on ribs, sternum and pelvis
- abdominals need to work when any motion that involves flexion of the trunk against gravity
- abdominals also perform function of protecting and supporting viscera
- Psoas seen as *flexor, stabilizer and extensor not an abdominal muscle*, much deeper, posterior, part of deep abdominal wall

Psoas major - Fibres oblique anteroinferior

Origin: bodies & transverse processes T12-L5
Insertion : lesser trochanter of femur
Function: hip joint fixed (femur fixed) = if bilateral, flexion of Lumbar spine**,** or increased lordosis EMG studies show paradox
If unilateral = ipsilateral sidebending or contralateral rotation of L spine, pelvis rotates towards same side
- abdominals popping out, bulging

<u>Abdominals:</u>
Transversus Abdominis - deepest layer, fibres horizontal, circular contraction,

Origin: inguinal ligament, the iliac crest, the lumbodorsal fascia and the costal cartilages of the last 6 ribs
Insertion: linea alba, and the pubic crest
Action: compresses the abdominopelvic cavity - research shows connection with multifidus, deep back muscles for stability

Internal obliques - between transversus and external oblique fibres run in various directions but majority are anterosuperior

Origin: inguinal ligament, the iliac crest, and the lumbodorsal fascia
Insertion: linea alba, the pubic crest, and the lower 4 ribs
Action: unilateral – sidebending or ipsilateral rotations of spine and ribcage, bilateral – compression of abdomen and helps flexion of trunk

External obliques = next layer, fibres anteroinferior

Origin: external surface of the lower 8 ribs
Insertion: linea alba and the anterior half of the iliac crest
Action: unilateral = side bending and contralateral rotation of spine and ribcage, bilateral = compression of abdomen and assists in flexion of trunk

Rectus abdominis:
- anterior and superficial, covered by sheath formed by aponeurosis of other abdominals

Origin: pubic crest
Insertion: xiphoid process and the costal cartilages of the 5^{th} through 7^{th} ribs
Action: mainly flexor and also helps in compression abdomen

Muscles of pelvic floor

- tissues that connect the pubic bone in the front of the pelvis to the coccyx in the back - skeletal muscles, under our voluntary control
- deep muscle layer and superficial muscle layer, need to work together with diaphragm and help support contents of pelvis
- 3 major functions: supportive, sphincteric, (eg. continence), sexual
- don't play a supporting role for vertebral column nor produce movement but are close to vertebral column and link in the pelvis
- studies found that surrounding muscles of back, pelvic floor, deep abdominals and respiratory diaphragm help to dissipate forces on spine, cocontraction
- deep muscle group: pelvic diaphragm muscles – levator ani, coccygeus (pubo, ilio, ischio), oburator internus
- superficial muscle group: urogenital diaphragm (perineum)

Structure of the pelvis

3 fused bones – sacrum and 2 innominate bones, each innominate bone begins as three bones which fuse (approximately age 14-16 yrs) at hip joint:
ilium, ischium, pubis
- composed of 3 joints within pelvis itself, 2 sacroiliac joints and one pubic symphysis

- pelvis articulates with 5th lumbar vertebra (lumbo-sacral joint) and with femurs below (femoral joints)

Intrinsic Joints

- *pubic symphysis* – cartilage attaches 2 bones, slightly moveable
- *sacro-iliac joints* – between sacrum and iliac bones, slightly moveable

Extrinsic Joints of Pelvis

- lumbo-sacral joint – most movement flexion and extension
- femoral joints – ball and socket joints, very mobile, socket (acetabulum) in center of each innominate bone orbiting over ball – head of femur.

Sacro-iliac joints

- stability and mobility,
- correlates with hip flexibility as well as spinal flexibility - ligaments, muscles - lumbar spine - flexion/extension/lateroflexion/rotation
- pelvic motion - as a unit - anterior/posterior pelvic tilt, lateral tilt (R/L elevation, 'hip hiking'), transverse rotation
- pelvic motion – intrapelvic – nutation and counternutation, range of motion is only .2 - 8 degrees, ability to move sacrum on ilium or ilium on sacrum, anterior/posterior rotation of innominate is also intrapelvic motion
- hip motion - flexion/extension/abduction/adduction/medial/lateral rotation

Muscles that stabilize and reinforce SI joint: erector spinae, lumbar multifidi, abdominals (all), hip extensor muscles (lateral hamstring, gluteus maximus), latissimus dorsi, iliacus and piriformis

Without adequate stability, the sacroiliac joints may become malaligned or hypermobile and stress is created at the joint.

Movements of pelvis in relationship to lumbar spine and femoral joints

BREATHING

Why do we breathe?
- acquisition of O2 and elimination of CO2

We take air into lungs and expel out
Respiratory system - movement of oxygen and carbon dioxide, elasticity of lungs, postural patterns greatly affect breathing
- exchange of gases between the outside and us

- air that we breathe in and out is mixture of oxygen, carbon dioxide, nitrogen and water Inhale – higher level of oxygen and nitrogen
Exhale – higher level of carbon dioxide and water, more water
Central nervous system controls breathing – many different ways to breathe
Chemistry of whole body better when breathing is efficient
We can voluntarily change our breathing for a while but not forever

Inspiration: ribs elevate, upper thoracic cage increases in diameter anteriorly, while lower ribs increase laterally, required action of muscles
Rib cage upward and outward = contraction of intercostal muscles and expansion all around
Diaphragm flattens down to press on top of abdominal cavity = contraction of diaphragm and abdominals
Want abdominals to work in synchronicity with diaphragm, but not over work

Expiration: opposite, ribs move down, costal cartilages return to normal shape
Elastic recoil of lung tissue, decrease in thoracic cavity
Good way to relieve tension in neck, shoulders and back
important to let all air out, if not, diminished oxygen potential and added tension
Muscles work eccentrically to prolong exhale and thus avoid elastic recoil of lungs
Diaphragm moves up, relaxes, obliques help to keep ribs down

- pause in between inhale/exhale and again after exhale

Muscles involved in breathing:
Intercostals, internal and external, contract in deep forced exhalation
Diaphragm : primary muscle in respiration, large dome

Origin: xiphoid process, inner surface of lower 6 ribs, and the lumbar vertebrae L1-3
Insertion: central tendon of diaphragm
Action: pulls central tendon downward increasing the size of the thoracic cavity and therefore causing inspiration
- R side slightly higher than L due to liver
- Close to psoas, quadratus lumborum, arcuate ligaments at L1, T12

Abdominals:

- in breathing – expiration, they help to depress ribs, compress abdominal contents helping to push up diaphragm, important in yoga in even breathing, transversus abdominis seen as antagonist to diaphragm muscle

Accessory muscles:

- muscles that attach to ribcage, shoulder girdle of spine that help in breathing
- SCM, QL, pectoralis major, pectoralis minor, trapezius, subclavius, scalenes, serratus posterior,

external intercostals, levator costarum, internal intercostals, subcostals, abdominal wall and more
- all muscles involved in inspiration elevate the ribs and those involved in expiration depress the ribs and the sternum
- training of muscles involved in breath

Types of breathing:

- apical/chest breathing,
- abdominal/belly breathing

Effects of various postures on breathing

Phrenic nerve: motor nerve of the diaphragm with sensory branches to the pleura, pericardium, and peritoneum, runs inferiorly next to anterior scalene and enters the thoracic cavity, continues down in ventral region of mediastinum, between the pleura and pericardium, downward to the diaphragm

- the only motor nerve to the diaphragm, vital role in respiration, irritation of phrenic nerve triggers a contraction of diaphragm called hiccups
- supports respiration when breathing is automatic
- with paralysis of both phrenic nerves, respiration kept in upper respiratory tract, abdominal breathing fails and the abdominal organs below the diaphragm no longer move

HIP JOINT

Joint between acetabulum (hip socket) of pelvis and head of femur, femoral joint
Ball and socket joint, most difficult joint to dislocate, very stable
2^{nd} most movable joint in body
Injuries relate to back, knee and ankle/foot
Excessive loading required with great range of motion (ROM)
Support of body weight and locomotion

Bony landmarks
- iliac crest, pubic symphysis, ischial tuberosity, acetabulum (hip socket), greater trochanter of femur, lesser trochanter, neck of femur, shaft of femur, medial and lateral condyles

Find centre of hip joint

Hip joint (coxo-femoral joint)
Acetabulum formed by ischium, ilium and pubis, **concave**
Femoral head 3/5 sphere, **convex**, covered with hyaline cartilage except where ligamentum teres is attached

Labrum – fibrous cartilage ring, attached around acetabulum holds femoral head in place and increases depth of socket, reinforced by ligament

Joint capsule – inner layer composed of synovial membrane, it lines joint capsule of hip, thick strong capsule

Joint also stabilized internally by ligamentum teres – hard to dislocate joint, fat pad protects ligament

Strong reinforcement by broad oblique ligaments:
In erect posture, all ligaments under moderate tension
Extension winds them up and flexion slackens them, all coiled around femoral neck in same direction, clockwise,
- iliofemoral - 'Y' ligament – strongest in body, from top and front of pelvis to front of intertrochanteric line
- ischiofemoral –from lower back of pelvis to top of femoral neck
- pubofemoral – from lower front of superior pubic ramus to front of intertrochanteric line

Bursae

in front of joint capsule, in between greater trochanter and ITB and gluteal muscles

Muscles

many muscles, most oblique on downward spiral from back to front, outside to inside

Fascia/connective tissue – covers each compartment of thigh, ITB essential for stability of hip joint

Nerves

large sciatic nerve between tuberosity of ischium and greater trochanter

Blood vessels

femoral artery in front of hip = strong pulse femoral vein, no pulse

Lymphatics – palpate lymph nodes front of hip joint

Osteokinematics/Movements of hip

Sagittal movement: flexion/extension of thigh on pelvis or pelvis on thigh, with knee extended and flexed

Frontal plane: abduction/adduction of thigh on pelvis or pelvis on thigh - abduction limited if femur neutral
Horizontal plane: internal rotation/external rotation of thigh on pelvis or pelvis on thigh

Movements of femur on pelvis or pelvis on femur

Anteversion/retroversion of pelvis
Anterior tilt/posterior tilt
Lateral flexion/medial flexion– associated with lumbar spine flexion
Medial rotation/lateral rotation, more SI joints than hip joint

Variations in structure – affects ROM

- deep or shallow hip socket
- ligament laxity
- anteversion or retroversion of femur
- coxa vara or valga

Anteversion - neck oriented posteriorly, femoral head anterior to greater trochanter, if large angle external rotation harder, less mobility, greater trochanter runs into back of acetabulum in external rotation
Retroversion - if small angle better fit anatomical position and good articular contact in lateral rotation, greater external rotation, decreased internal rotation

Coxa vara = when angle between femoral neck and shaft is less than 135 degrees, less abduction
Coxa valga = angle is greater than 135 degrees, greater abduction

Coxa vara promotes dislocation as does anteversion of femoral neck

Muscles of posterior hip joint

Gluteus maximus
External rotators – piriformis, quadratus femoris, obturator externus, obturator internus, superior gemellus, inferior gemellus
Hamstrings – semitendinosus, semimembranosus, biceps femoris, long head

Muscles of lateral hip joint

Tensor fascia latae
Gluteus medius
Gluteus minimus

Muscles of anterior, medial hip joint

Sartorius
Rectus femoris
Psoas major, Iliacus

Muscle of medial hip joint

Pectineus
Adductor longus, magnus
Gracilis
Adductor brevis

- finding neutral pelvic alignment may help muscles to function optimally.

Close packed and loose packed positions of joints

The pair of articular surfaces within most joints fits best in only one position, usually in or near the very end range of a motion. Maximal congruency = close packed position. In this position most ligaments and parts of the capsule are pulled taut. A natural stability happens in the joint. No accessory movement is possible

Loose packed = all other positions where the ligaments and capsule relatively slackened, allowing an increase in accessory movements.

Close packed for the hip = full extension, medial rotation
Loose packed for the hip = 30 degrees flexion, 30 degrees abduction, slight lateral rotation

Reciprocal Inhibition

Also called reciprocal innervation – a neuromuscular reflex used to stretch muscles. If one muscle is contracting very strongly, the muscle on the opposite side of the joint is inhibited from contracting. A way to actively stretch muscles.