FUNCTIONAL ANATOMY AND BIOMECHANICS OF MOVEMENT **Joanna Abbatt**

NAADA RECORDINGS 5 and 6 **October 2020**

RECORDING 5

KNEE JOINT – condyloid joint

- large surface area, very complex mechanics
- hinge joint, pivot joint
- supports and transfers weight from hip to foot
- largest joint in body

Landmarks: distal end of femur, lateral and medial condyles, lateral and medial epicondyles, patellar surface, patella, head of fibula, tibial tuberosity, tibial plateau
- 3 bones, tibia, femur and patella

Articulations:
Tibio femoral joint – actual knee joint,
Superior tibio-fibular –gliding joint, rotates
Patellofemoral joint – patella, sesamoid bone, connected to femur by ligaments and to tibial tuberosity by the strong patellar ligament

Mechanical axis, plumb line through femoral head, tibial tuberosity, and middle of ankle,

Ligaments/Cartilage
intracapsular – inside deepest synovial layer of capsule
Meniscus – 2 C shaped discs made of fibrocartliage, needs synovial fluid, partly vascularized,

- slightly mobile and help to lubricate joint in movement

next layer – between inner synovial layer and outer fibrous layer of capsule
- ACL, anterior cruciate ligament – front of tibial plateau moving up, back and laterally to attach to back of lateral femoral condyle and posterior joint capsule
- limits movements front of tibia on femur and internal rotation of tibia
- PCL, posterior cruciate ligament, back of tibial plateau moving up, forward and medial to attach to medial femoral condyle and posterior joint capsule, not as long as ACL
- limits movements to back of tibia on femur, and external rotation of tibia

next layer, extracapsular – outside fibrous layer of joint capsule

- MCL – tibial and femoral condyles, joins outside of joint capsule, which is connected with medial meniscus
- LCL – head of fibula and lateral femoral condyle, does not connect with joint capsule, can feel it just above head of fibula when in lotus position
- In hyperextension more stable as all ligaments act together and are taut, don't need muscular action, in flexion less stable as ligaments on slack

- muscle tendons reinforce capsule as well as other ligaments

Muscles play active role as “active” ligaments – TFL, sartorius, semi-tendinosus, and gracilis (gluteus max too.)
Position of rest for knee is flexion about 20 degrees
Closed packed position: full extension with lateral rotation tibia

Joint mechanics
Osteokinematics
- flexion, extension
- knee flexed to 90 degrees there is internal and external rotation, 40 – 80 degrees, no rotation when knee extended
- if knee facing different due to hip joint or patellar tracking

Variations
genu valgus – knock knees
- knee joint angles inward of line of gravity and foot angles outward of line of gravity passing through hip joint
- increased compression on lateral knee joint – lateral meniscus, increased tensile force on medial knee joint

genu varus – bow legs
- knee joint angles outward of line of gravity, foot angles inward of line of gravity passing through hip joint
- increased compression on medial knee joint –medial meniscus, increased tensile force on lateral knee joint

genu recurvatum – hyperextended knees or double jointed knees
- ligamentous laxity of hip and knee
- femur continues to rotate internally when knees shin/foot faces front
- posterior joint capsule is on stretch and anterior joint capsule and patellar ligament of knee is slack, vasti may be too short to contract effectively, i.e patella, not pulled up, stress on ACL

Head of femur angled so that more abducted at rest = genu varus, more common in men
Head of femur angled more adducted at rest = genu valgus, more common in women
Valgus stress, tendency to valgus – ACL, joint laxity, hyperextension knee, shape of tibial plateau, estrogen, poor biomechanics

Capsule
contains patella, femur and tibia, contains synovial fluid and is very slack anteriorly allowing for good flexion, thicker posteriorly helping limit hyperextension

Bursae – about 20 around knee, to reduce friction between muscle, tendon and bone

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UPPER EXTREMITY

Cervical spine and thoracic spine affect shoulder girdle

Core transfers forces from shoulder and hips back to centre - whole kinetic chain

Core strengthen vs stabilization

Whole kinetic chain necessary to assess with shoulder

- Lack of stability of lower quadrant can affect upper body, shoulder has to work harder if not stable down below
- Lumbopelvic control can affect shoulder

Increase proprioception before pain comes
Strengthen muscles through full ROM, need control
Gradual modulation of effort – tendons need gradual change, dynamics, phrasing, movement qualities affect muscle

SHOULDER COMPLEX

Most injuries occur overhead or weight bearing…

Function: mobile base for movement of arms, flexible for ROM of arm and hand, strong, stable fixed point for certain actions, eg. Lifting, resisting

- shoulder joint formed by 4 bones, 2 clavicles, 2 shoulder blades (scapulae)
- only connection between shoulder girdle and spine with muscles
- incomplete girdle compared to pelvic girdle, only joint with trunk is in front at top of the sternum, between manubrium and clavicle
- very mobile, shoulder girdle moves freely on thorax, each side can move independently from other side

Landmarks: sternum, manubrium, humerus, radius, ulna, antecubital crease, axilla, sternoclavicular joint, acromio-clavicular joint, coracoid process, acromion process, angles of scapula, inferior angle of scapula, superior angle, borders of scapula, glenoid fossa, glenohumeral joint

Glenohumeral joint – primary joint of shoulder
Acromioclavicular joint
Sternoclavicular joint
Scapulothoracic joint – not real joint, interfacing of 2 bones

clavicle – S shaped from above, flat, elongated bone, articulates with manubrium and acromion, straight across in neutral position

Scapula – flat, triangular bone, 3 borders and 3 angles,

- separated from rib cage by layer of muscles

Movements of shoulder girdle:

- clavicle circumduction, elevation/depression, protraction/retraction
- scapula rotates around clavicle – in horizontal plane – medial borders open out
- in sagittal plane - inferior angle moves away from or toward ribcage
- in coronal plane - inferior angle swings up and medial or up and lateral

Movements of clavicle and scapula together called **scapular:**
– elevation, depression, abduction, adduction, upward or lateral rotation, downward rotation or medial rotation, retraction, protraction
(forward tilt, return from forward tilt)

- add movement of arm with shoulder allows for even greater mobility

SC joint: sterno-clavicular joint, shallow saddle joint, articular disc between clavicle and sternum

Osteokinematics: protraction, retraction, elevation, depression, and small amount of rotation,

AC joint – acromio-clavicular joint, joint surfaces both very flat, acromion and lateral end of scapula articulate, fibrous disc

Close packed positions: avoid creating laxity of ligaments
GH joint – full abduction and external rotation
SC joint – full or maximum rotation of clavicle, arm in full elevation
AC joint – arm is abduction to 90 degrees

GH joint and scapula: range of motion
Flexion 180 degrees, Abduction 180 degrees
Extension 45 degrees,
Adduction 45 degrees,

Shoulder Girdle Muscles - trapezius, levator scapulae, rhomboids, pectoralis minor, subclavius, serratus anterior, sterno-cleido-mastoid

Scapular motion and shoulder girdle muscles:
adduction: middle trapezius, rhomboids
abduction: anterior serratus, pectoralis minor
elevation: upper trapezius, levator scapula, rhomboids

depression: lower trapezius, pectoralis minor
medial/downward rotation: levator scapulae, rhomboids, pectoralis minor
lateral/upward rotation: trapezius – upper and lower, anterior serratus
retraction – especially middle trap, and lower trap, rhomboids, pectoralis minor
protraction – anterior serratus

Coordination of shoulder girdle muscles:

Muscles work in sync – force couple
Eg. Serratus anterior and lower trap and upper trap pull in different directions to create upward rotation of scapula

Trapezius and serratus anterior – important stabilizers of scapula, work together to laterally/upwardly rotate the scapula

Downward rotation – rhomboids, levator scapulae, pectoralis minor

ASSESSMENT - start anatomical position
Normal postural alignment:
Shoulders level, plumbline sideview bissects acromion
Humerus no more than 1/3head in front of acromion
Palms face body
Scapula – vertebral bodies 2" away from spine, parallel to spine, flat against thorax, between T2 and T7
Head alignment, T spine and chest

Brachial plexus - primary nerve source for upper extremity is brachial plexus, formed by nerve roots from spinal nerves C5-T1.
Nerve roots innervate arm, pass between clavicle and rib cage
We need strength, power, endurance of all these muscles to maintain antigravity erect posture – neck, low back, shoulder joint
Spinal influence
Timing whole body

Glenohumeral joint/Shoulder joint
- main joint of shoulder, ball and socket joint, head of humerus about 2/3 sphere, head of humerus larger than glenoid cavity, cavity shallow, not stable, glenoid cavity is lateral and mostly anterosuperior
- glenoid labrum, fibrocartilaginous ring helps to seal joint, deepens joint
- capsule of GH joint attaches to scapula, outside glenoid cavity, twice the size of humeral head
- capsule very loose with folds, weakest inferiorly due to less muscle attachments and no ligaments
- ligaments reinforce joint capsule, both internally and externally, preventing external rotation at shoulder

- strongest ligament to reinforce capsule is *coracohumeral* ligament, then *glenohumeral* ligaments, 3, superior, middle and inferior, form a Z, going from glenoid cavity to lesser tubercle of humerus and anatomical neck, anteriorly placed
- capsule also reinforced by rotator cuff muscles (supraspinatus, infraspinatus, teres minor, subscapularis), capsule weakest antero-inferiorly, therefore often dislocation of humeral head anteromedial – think about any posture where gravity pulling us down to floor weight bearing, eg. chaturanga

Movements
- in reference from anatomical position
flexion, extension, abduction, adduction, horizontal abduction/extension, horizontal adduction/flexion, internal rotation, external rotation

scapulohumeral rhythm = 2:1, 2 degrees of glenohumeral to 1degree scapula

Rotator cuff muscles: (reinforcement to joint capsule)
SITS– supraspinatus, infraspinatus, teres minor, subscapularis
-long head of biceps enters joint capsule, sometimes considered to part of reinforcing cuff of glenohumeral joint, can help in flexion and if humerus is laterally rotated help in abduction

Muscles of Shoulder
Deltoid, Teres major, Latissimus dorsi, Pectoralis major, Coracobrachialis, Biceps brachii, Triceps

Common to have faulty movement patterns due to following factors:
Timing
Lengthened /shortened muscles
Overactive or insufficient muscles
Capsular, ligament
Forward head and shoulders
Scapula elevated/abducted/ depressed
Short pectoralis minor, lengthened middle and lower trapezius
Overused upper trapezius, levator scapulae, scalenes, pectoralis major, latissimus dorsi

Limited vascularity in shoulder
With aging increased tendon trauma, decreased joint spaces = increased shoulder pain as age

Good shoulder mechanics need:
- ROM glenohumeral joint
- rotator cuff strength and motor control
- extrinsic muscles shoulder
- scapulothoracic muscles
- trunk musculature
- BREATHING

ELBOW/WRIST
2 bones, radius and ulna
- ulna and humerus involved with elbow joint and radius with wrist
- modified hinge joint of humerus and ulna is elbow joint, flexion and extension
- pronation and supination, not real elbow movements
- in supination (ulna and radius parallel to each other) – crossed over - pronation
- wrist an elaborate hinge joint between radius/ulna and three carpal bones of hand, scaphoid, lunate and triquetrum – flexion, extension, adduction, abduction

Landmarks –always go from anatomical position to locate radius, lateral, and ulna, medial, elbow crease, antecubital crease
-wrist flexors (anterior)
-wrist extensors (posterior)
common flexor tendon at medial epicondyle
common extensor tendon at lateral epicondyle

- in movement of elbow, head of radius slides on capitulum and trochlear notch of ulna slides on trochlea
- in flexion, extreme snug, gliding fit and in extension also to prevent elbow from extending beyond 180 degrees

joint capsule
-taut in front, especially lateral and loose in back to help flexion
-joint between radius and ulna, radioulnar shares ligaments and synovial cavities of elbow joint

Movements
Flexion/extension
pronation /supination in radioulnar joint
-carrying angle, axis of trochlea directed obliquely superior-laterally

Close packed position: extension
Loose packed position: 70 degrees flexion, 10 degrees supination
Muscles
Brachialis
Brachioradialis
Biceps brachii
Triceps brachii
Anconeus

Pronation/supination
Changes in relationship between radius and ulna, not humerus
Palm faces posterior in pronation and radius crosses over ulna, in supination radius and ulna parallel and palm faces anterior, neutral position in between the two

-bend elbow easier to see not to confuse with internal/external rotation
-articular disc at base between radius and ulna provides strong support during pronation and supination

4 flexors = biceps brachii, brachialis, brachioradialis, pronator teres, assists primarily pronator
2 extensors = triceps brachii, anconeus assists
2 supinators = supinator, biceps brachii
2 pronators = pronator teres, pronator quadratus

Movements of wrist
flexion, extension in sagittal plane, abduction, adduction in frontal plane

Muscles of wrist:
Flexors: flexor carpi radialis, palmaris longus, flexor carpi ulnaris
Extensors: extensor carpi radialis longus, extensor carpi radialis brevis, extensor carpi ulnaris
Adductor of wrist: ulna deviation, ulna side muscles extensors and flexors, flexor carpi ulnaris, extensor carpi ulnaris
Abductor of wrist: radial deviation, radial side muscles, flexor carpi radialis, extensor carpi radialis longus, extensor carpi radialis brevis

problems in wrist – all muscles above or higher up the chain somewhere, check amount of pronation/supination of forearm, keep wrist neutral when possible, radial or ulnar deviation, line up with third finger or adjust if needed

HAND
- very complex structure - biomechanically
- important sensory organ for perception of surroundings, expressions of emotion, motor behaviours
- 19 bones, 19 articulations with 29 muscles
wrist - 8 carpal bones
hand - 5 metacarpals, 14 phalanges - 2 in thumb, 3 in other fingers, digits 1-5
IP joint in thumb, PIP and DIP joints in fingers
palmar surface, dorsal surface, radial surface,
- fingers – extension, flexion, adduction, abduction,
- thumb and little finger – opposition, circumduction(thumb)
- arches in hand - *proximal transverse arch, distal transverse arch, longitudinal arch*

Movements of thumb and hand
extension, flexion, abduction, adduction
thumb due to orientation - opposition, reposition
thumb - circumduction

Extrinsic and intrinsic muscles of hand
Huge amount of hand movements, many muscles of hand come from humerus or forearm: flexors and extensors
Fingers: small muscles, lumbricals, interossei,
Thumb: whole set of muscles
Little finger: whole set of muscles

Carpal tunnel syndrome - 9 extrinsic flexor tendons of digits travel with median nerve through carpal tunnel, hand activities that require prolonged and extreme wrist positions can irritate these tendons, swelling of synovial membranes increases pressure on median nerve = pain, atrophy, muscular weakness

Primary nerve source for upper extremity is brachial plexus, formed by nerve roots from spinal nerves C5-T1.

Interconnectedness of whole body in movement
Hard to dissect into parts, one part affects the other
Full kinetic chain
Joint stability necessary in yoga practice, strength in joints
Tight people need flexibility while hypermobile people need to be careful of overstretch in capsule and ligaments
Assessing the individual is always the best path