JHARKHAND RAI UNIVERSITY

RANCHI

LAB MANUAL

BIOMECHANICS - II

(23A402P)

BPT IV

LIST OF PRACTICAL

BIOMECHANICS - II (23A402P)

S.NO	PRACTICAL
1.	Biomechanics factor analysis of shoulder joint stability
2.	Biomechanics analysis of elbow joint
3.	To identification and understanding different function position of hand and movement adopted for the same.
4.	To study lumbopelvic rhythm and movement in forward bending of spine
5.	To study knee joint kinematics during last 30 degree of movement
6.	To identify gait abnormalities

Practical 1

Aim: Biomechanics factor analysis of shoulder joint stability

Description: Shoulder motion requires the coordinated participation of muscles, tendons, ligaments, and bones across the Shoulder complex and articular surface. The glenohumeral joint is a multiaxial ball and socket variety of synovial joint that functions as a diarthrosis to facilitate a wide range of motion for the upper extremity. Stability across the glenohumeral joint is balanced by both static and dynamic mechanisms. The glenohumeral joint consists of an articulation between the scapula and humerus. The humeral head lies within the glenoid fossa, a cavity that is lined by the glenoid labrum. The shallow nature of the glenoid fossa lends the glenohumeral joint an increased range of motion while providing little stability

Static stability and biomechanics

The articular surface is inclined upward on average 130 degrees with an average retroversion angle of 30 degrees; both measures, however, are highly variable

The glenoid is an inverted pear-shaped concave surface that articulates with 33% of the humeral head in formation of the glenohumeral joint which supports humeral head rotation and gliding

The area of highest contact pressure during normal glenohumeral motion is located posterosuperior on the glenoid. Synovial fluid within the joint permits an adhesion-cohesion relationship or "suction-cup effect".

The glenoid labrum is a fibrocartilaginous rim of tissue that is triangular in cross-section and acts to increase the depth of the glenoid vault. It serves as a passive stabilizer of the joint while providing an insertion for the anterior band of the inferior glenohumeral ligament and long head of the biceps

The glenohumeral capsule functions in multiple planes to provide static stability to the glenohumeral joint and maintain its synovial environment

The anterior band anchors to the anterior labrum and serves as the primary restraint to anterior/inferior translation in the abducted/externally rotated late cocking position.

Static and dynamic Stabilizer of shoulder joint

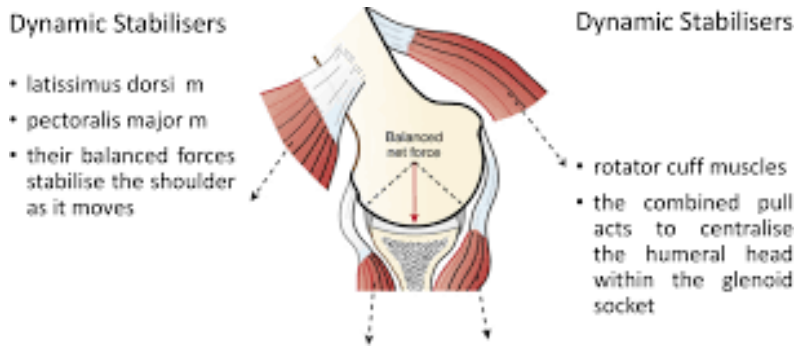
Dynamic stability and biomechanics

The rotator cuff is defined as a collective group of four muscles: subscapularis, supraspinatus, infraspinatus, and teres minor. During abduction, the rotator cuff depresses the humeral head into the glenoid to allow the deltoid muscle to elevate the arm. In a normal shoulder, the rotator cuff also acts to stabilize anterior-posterior translation of the humeral head via compression to the glenoid by the combined antagonistic forces of the subscapularis (anterior) and the infraspinatus/teres minor (posterior).

The supraspinatus abducts and to a lesser extent, externally rotates the humerus while exerting its greatest force at lower abduction angles, peaking between 0°–15°. The contribution of the supraspinatus to resist inferior gravitational translation of the humeral head generated by the body weight of the arm. The subscapularis muscle functions to stabilize the glenohumeral joint anteriorly and facilitates internal rotation and abduction of the humerus

Biceps brachii effects serve to center the humeral head within the glenohumeral joint and act as a fulcrum for arm elevation

Periscapular muscles serve to anchor the scapula allowing it to function as the base of the glenohumeral joint. This muscle group includes the pectoralis minor, serratus anterior, rhomboids, latissimus dorsi, and trapezius. Activation of these muscles during glenohumeral motion contributes to overall stability.



Different muscle acting in different direction to stabilize shoulder joint dynamically

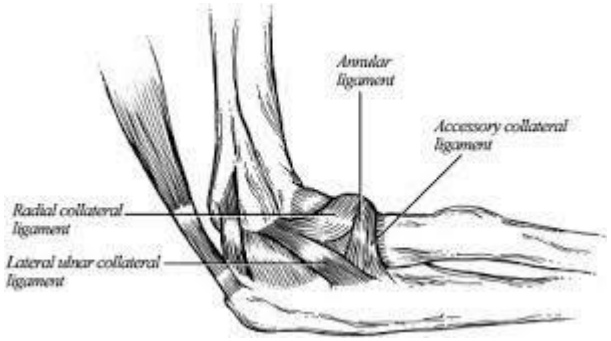
Practical 2

Aim: Biomechanics analysis of elbow joint

The elbow increases the flexibility of the upper limb. It also transmits forces between the arm and the forearm and acts as the axis for the forearm lever system. The elbow is a complex of three joints of humerus, ulna and radius: humeroulnar, humeroradial and proximal radioulnar joints. All three joints are enclosed within the same capsule.

The distal humerus is divided into medial and lateral columns, which are tilted anteriorly approximately 40° from the humeral shaft. The columns form two articulating surfaces at the elbow joint: capitellum and trochlea.

The humeroulnar joint is a hinge joint formed by the hourglass-shaped trochlea articulating with the saddle-shaped trochlea notch of the ulna. This is an inherently stable configuration, and restricts undue relative motion between the articulating surfaces. The humeroradial joint is a ball and socket joint. It is an unconstrained joint formed between capitellum, which is an almost perfect hemisphere, and radial head, which has little contact with the capitellum. The proximal radioulnar joint is a pivot joint formed by articulation between the adjacent surfaces of the radius and ulna. It is a relatively constrained joint.



Elbow joint - Anatomy of ligament

Range of motion

The elbow joint complex allows two types of motion: flexion and extension occur at the humeroulnar and humeroradial joints; and pronation and supination occur at the humeroradial and proximal radioulnar joints, and also require simultaneous motion at the distal radioulnar joint. The two types of motion are independent of each other. The normal range of flexion– extension is 0°–140°, and pronation–supination is 75° pronation – 85° supination. The functional range of flexion–extension is 30°–120°, and pronation–supination is 50° pronation – 50° supination.

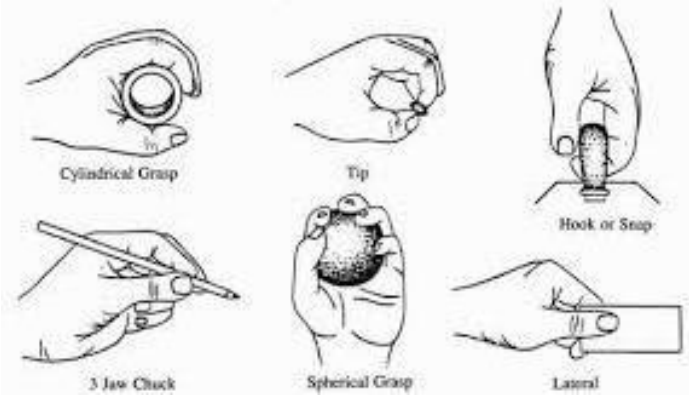
Practical 3

Aim: To identification and understanding different function position of hand and movement adopted for the same.

Description: The hand is made up of a stable wrist with 2 digits, at the minimum, that are able to oppose against each other with some power. Ideally one or both of the digits are capable of motion so grasping can be performed. In its minimal form, one digit can be stable with one digit having motion to move against that stable post. Digits benefit from having sensation and from being pain free so that their usage is facilitated. The hand has 7 maneuvers that make up most hand functions

1. **Terminal pinch/precision pinch:** The precision pinch, otherwise known as the terminal pinch, involves flexion of the interphalangeal (IP) joint of the thumb and the distal IP (DIP) joint of the index finger. The fingernail tips are brought together so that a small item, such as a pen, can be picked up

2. **Opposition pinch:** the oppositional pinch, otherwise known as the subterminal pinch. This pinch is where the pulp of the thumb and index finger are brought together with the IP and DIP joints in extension, which allows for increased forces to be generated through thumb opposition. It also relies on the first dorsal interosseous contracting while, simultaneously, the index profundus flexion is occurring.
3. **Key pinch:** Key pinch maneuvering, in this situation, is when the thumb is adducted to the radial aspect of the index finger's middle phalanx. The key pinch maneuver does require a stable post, which in this situation is really the index finger. It also requires adequate length of the digit and a metacarpal phalangeal joint (MCP), which is capable of resisting thumb adduction
4. **Chuck grip/directional grip:** The chuck grip, otherwise known as the directional grip, allows the index finger, long finger, and thumb to come together to envelop a cylindrical object. A rotational and axial force is usually applied to the object when using this type of grip
5. **Hook grip:** The hook grip requires finger flexion at the IP joints and extension at the MCP joints. This grip is used, for example, when one picks up a suitcase or a briefcase. It does not require thumb function
6. **Power grasp:** In the power grasp position, the fingers are flexed and the thumb is flexed and opposed relative to the other digits such as gripping a club or bat.
7. **Span grasp:** The span grasp maneuver is when the DIP joints and the proximal IP (PIP) joints flex to approximately 30° and the thumb is palmarly abducted such that forces are generated between the thumb and fingers. This maneuver differs from the power grasps maneuver whereby forces are generated between the fingers and the palm. Stability is needed at the thumb, MCP, and IP joints. This type of grip is used, for example, to grab a ball.



Different types of prehension activities

Practical 4

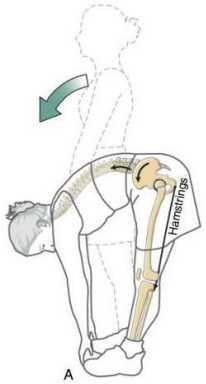
Aim: To study lumbopelvic rhythm and movement in forward bending of spine

Description: The lumbosacral junction is the point of connection between the lumbar spine and the pelvic girdle. The connection is formed by the wedge-shaped intervertebral disc anteriorly and posteriorly by the L5-S1 facet. A coordinated simultaneous activity of lumbar flexion and anterior tilting of the pelvis in the sagittal plane during trunk flexion and extension. When the femur, pelvis, and spine move in a combined coordinated manner, it produces a larger ROM than what might be available to one segment alone. It is an open kinematic chain.

Lumbopelvic Rhythm: The activity of foreword bending over to touch your toes with knees straight depends on the lumbopelvic rhythm. Lumbopelvic rhythm or the hip-spine coordination refers to how the lumbar spine, moves in combination with the pelvis. It is the kinematic relationship between the lumbar spine and hip joints during sagittal plane movement.

The first part of bending forward consists of lumbosacral flexion followed by anterior tilting of the pelvis and hip joint flexion. The muscles in the lower back namely erector spinae, contract eccentrically to control the movement against gravity while the trunk flexes and pelvis tilts anteriorly. The muscles that flex the hip contract concentrically and this motion is balanced by eccentric contraction of muscles that extend the hip.

When returning to the erect posture, this rhythm is reversed. It is initiated by posterior tilting of the pelvis at the hip, followed by extension of the lumbar spine. The hip extensors initiate the posterior rotation of the pelvis until it is in a better position for spinal extensors to concentrically contract without too much stress being put on them. As these muscles contract concentrically, the hip flexors contract eccentrically to help control the movement. The aspect of motion of interest includes timing, as well as magnitude-related characteristics.



Lumbopelvic Rhythm

Practical 5

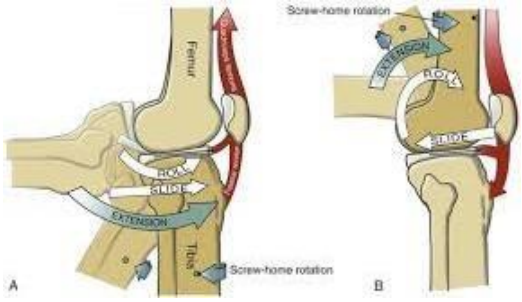
Aim: To study knee joint kinematics during last 30 degree of movement.

Description: The knee joint is one of the largest and most complex joints in the body. It is constructed by 3 bones and an extensive network of ligaments and muscles. It is a bi-condylar type of synovial j9oint, which mainly allows for flexion and extension (and a small degree of medial and lateral rotation). The thigh bone (femur), the shin bone (tibia) and the kneecap (patella) articulate through tibiofemoral and patellofemoral joints. These three bones are covered in articular cartilage which is an extremely hard, smooth substance designed to decrease the friction forces. The medial and lateral condyles of the femur articulate with the tibia to form tibiofemoral joint.

Knee Joint Kinematics: The knees have a "Screw Home" rotation that allows for full knee extension and flexion. There is an observable rotation of the knee during flexion and extension. During the last 30 degrees of knee extension, the tibia (open chain) or femur (closed chain) must externally or internally rotate, respectively, about 10 degrees. That might not seem all that significant, but this rotation is important for healthy movement of the knee.
Whether it is tibial-on-femoral rotation, as in an open chain exercise like in the leg extension machine, or femoral-on-tibial rotation, as in a closed chain exercise like the squat, rotation must occur to achieve full extension and then flexion from full extension.

This is due to factors including:

- The shape of the medial femoral condyle. The condyles on the femur are shaped a bit differently than those elsewhere in the body. The articular surface on the medial femoral condyle has a 30 degree lateral curve. This curvature allows the tibia and femur to follow this curve with tibial-on-femoral rotation as well as femoral-on-tibial rotation.
- The lateral pull of the quadriceps is a factor in the lateral rotation during the later phases of extension. (The quadriceps insert into the tibial tuberosity via the patellar tendon). When contracted, the quadriceps cause an anterior translation of the tibia on the femur.
  This creates a passive tension in the anterior cruciate ligament (ACL) which contributes to external rotation. This passive tension helps stabilize the extended knee by resisting excessive anterior translation of the tibia or excessive posterior translation of the femur. In order to unlock the knee from extension, the popliteus muscle must work to initiate internal or external rotation. The tibia must internally rotate slightly to allow for knee flexion in an open chain, and the femur must externally rotate for knee flexion in a closed chain. This mechanism of rotation contributes to proper movement at the knee.



Knee joint Screw home mechanism

Practical 6

Aim: To identify and analyze gait patterns and gait abnormalities.

Description: A gait deviation is an abnormality in the gait cycle that can affect the trunk, hip, knee, or ankle joint. Gait deviations can stem from increased age and/or certain pathologies. These pathologies can be musculoskeletal or neurological in nature. Gait deviations can have a tremendous impact on patient's quality of life, morbidity, and mortality. The variety of gait deviations calls for different treatments.

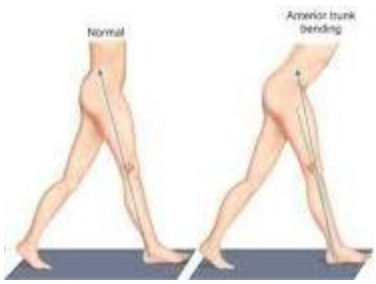
The patient's orthotics, prosthetics, and footwear to assess their wear pattern, and then look into the individual's gait. Knowing the wear pattern will help us in determine a patient's gait style. Certain patterns indicate whether a patient is over pronating or supinating. The gait examination officially begins as soon as the patient enters the clinic. We should look for which phase of the gait cycle is affecting the patient as well as deformities that could be contributing to the patient's abnormal gait cycle. Some of the tests that will be completed during the assessment are the sit-to-stand transfers from a chair, stand-to-sit transfers, balance when sitting compared to standing and the clinician will test for leg length discrepancy. The gait examination should include observation from head to foot along with visualizing the patient's anterior, posterior, and lateral aspect of their body. Some of the common factors to consider while examining gait include a patient's cadence, step length, step height, center of gravity, gait base width, and pelvis/trunk shift.

Musculoskeletal

Antalgic gait. Antalgic gait is due to pain in the lower extremities that results in a limp that is associated with a shortened stance phase relative to the swing phase. This gait deviation, asymmetry, can be caused by issues that originate in the trunk, hip, knee, or ankle.

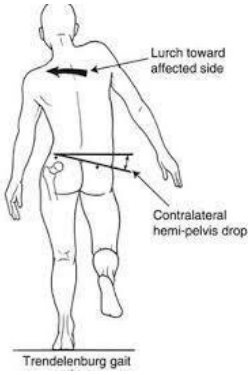
Antalgic Gait

Leg Length Discrepancies. Leg length discrepancies can either be structural of functional. This can cause pelvic drop, decreased hip, knee, and ankle plantarflexion. To compensate, the patient may use vaulting or toe-walking.



Limb Length Discrepancy

Trendelenburg Gait. Trendelenburg gait occurs when the gluteus medius is weak. Gluteus medius weakness can be the result of dysfunctions or diagnoses related to back pain or lumbopelvic pain, chronic hip dysfunctions, or lumbopelvic surgery. The weakness of the involved side causes a contralateral pelvic hip drop during swing phase.

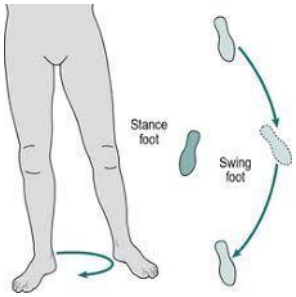


Trendelenburg Gait

Posterior Lurch Gait. Posterior lurch gait is when the trunk leans posteriorly with a hyperextended hip, especially during the loading response due to a weak gluteus maximus. Hence it is also known as gluteus maximus gait.

Posterior Lurch Gait

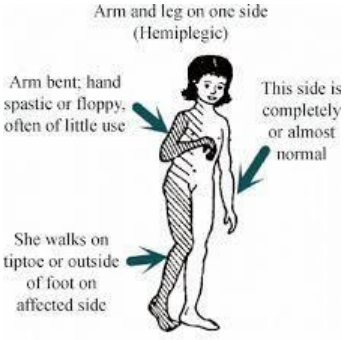
Circumduction of the Hip. Circumduction of the hip during swing phase occurs for several reasons including weak hip flexors, contralateral hip dysfunction, or leg length discrepancy. This is a combination of hip hiking, forward rotation of the pelvis, and abduction of the hip. Hip flexor weakness is caused by L2-L3 nerve compression or possibly upper motor neuron lesion.



Circumduction of the hip

Neurological

Spastic hemiparetic gait. It is characterized by unilateral leg extension and circumduction, in which the paretic leg performs a lateral motion (circumduction) during the swing phase. This is also known as circumductory gait.

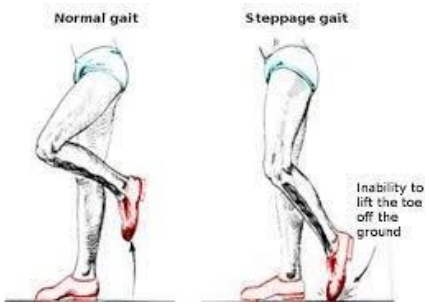


Spastic Hemiparetic Gait

Spastic diplegic gait (scissors gait). It is characterized by bilateral leg extension and adduction, the legs appear to be stiff. When spasticity in the adductors is marked it results in a scissoring gait where the legs cross in the scissors-like pattern.

Spastic Diplegic/ Scissor Gait

Steppage gait. In this gait, the patient must lift the leg higher than usual and the patient is unable to stand or walk on their heel. It is caused by weakness in the ankle dorsiflexors.
This gait is also known as a **slapping gait.**



Steppage/ Slapping Gait

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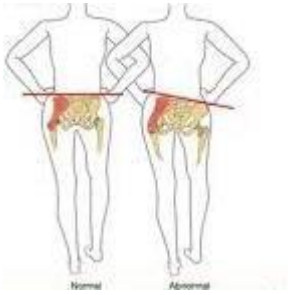
Waddling gait (myopathic gait). In waddling gait weakness in the gluteus medius muscles leads the hip on the swinging side to drop during gait, in an attempt to counteract, the patient bends the trunk towards the other side, resulting in the gait to appear waddling.



Wadding Gait

Parkinsonism gait. Parkinsonism Gait is described as a decrease in stride length and arm swing which will result in a slow shuffling pattern. There will also be an increased in hip flexion of the trunk and knees with partially flexed elbows. An individual with Parkinsonism will have difficulties initiating walking and may freeze mid-strike. They may also present with festination meaning involuntary acceleration.

Parkinsonism Gait

Cerebellar ataxic gait. The gait is broad based, insecure and lacks coordination. Leg movements and step length are irregular and variable.

Cerebellar Ataxia Gait

Sensory Ataxic gait. In this gait the patient's proprioception is disturbed resulting the gait to appear broad-based and insecure. The patient uses visual control to compensate for the disturbed proprioception.

Sensory Ataxia Gait