Gait analysis:

Human gait depends on a complex interplay of major parts of the nervous, musculoskeletal and cardiorespiratory systems.

- The individual gait pattern is influenced by age, personality, mood and sociocultural factors.
- The preferred walking speed in older adults is a sensitive marker of general health and survival.
- Safe walking requires intact cognition and executive control.
- Gait disorders lead to a loss of personal freedom, falls and injuries and result in a marked reduction in the quality of life.

Definitions

- **Gait** - the manner or style of walking.

- **GaitAnalysis** -
  An analysis of each component of the three phases of ambulation is an es sential part of the diagnosis of various neurologic disorders and the asses sment of patient progress during rehabilitation and recovery from the effe cts of neurologic disease, a musculoskeletal injury or disease process, or amputation of a lower limb.

- **Gait speed**
  - The time it takes to walk a specified distance, usually 6 m or less. Slower speeds correlate with an increased risk of mortality in geriatric patients.[2]
  - Normal walking speed primarily involves the lower extremities, with the arms and trunk providing stability and balance.
  - Faster speeds - body depends on the upper extremities and trunk for propulsion, balance and stability with the lower limb joints producing greater ranges of motion.

- **Gait cycle** is a repetitive pattern involving steps and strides

- **Step** is one single step

- **Stride** is a whole gait cycle.

- **Step time -** time between heel strike of one leg and heel strike of the contralateral leg.

- **Step width** - the mediolateral space between the two feet.

The demarcation between walking and running occurs when periods of double support during the stance phase of the gait cycle (both feet are simultaneously in contact with the ground) give way to two periods of double float at the beginning and the end of the swing phase of gait (neither foot is touching the ground)

The Gait Cycle

The sequences for walking that occur may be summarized as follows:

1. Registration and activation of the gait command within the central nervous system.
2. Transmission of the gait systems to the peripheral nervous system.
3. Contraction of muscles.
4. Generation of several forces.
5. Regulation of joint forces and moments across synovial joints and skeletal segments.
6. Generation of ground reaction forces.

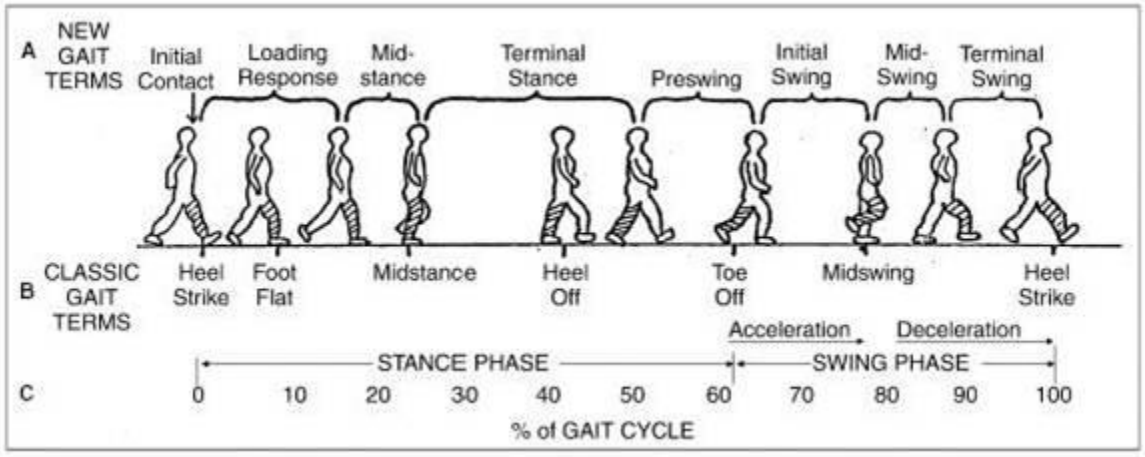
The normal forward step consists of two phases: stance phase; swing phase,

- The Stance phase occupies 60% of the gait cycle, during which one leg and foot are bearing most or all of the bodyweight
- The Swing phase occupies only 40% of it[4], during which the foot is not touching the walking surface and the bodyweight is borne by the other leg and foot.
- In a complete two-step cycle both feet are in contact with the floor at the same time for about 25 per cent of the time. This part of the cycle is called the double-support phase.Gait cycle phases: the stance phase and the swing phase and involves a combination of open and close chain activities.

Phases of the Gait Cycle (8 phase model):

1. Initial Contact
2. Loading Response
3. Midstance

4. Terminal Stance
5. Pre swing
6. Initial Swing
7. Mid Swing
8. Late Swing.



Heel Strike (or initial contact) -

Short period, begins the moment the foot touches the ground and is the first phase of double support.

Involves:

- 30° flexion of the hip: full extension in the knee: ankle moves from dorsiflexion to a neutral (supinated 5°) position then into plantar flexion.
- After this, knee flexion (5°) begins and increases, just as the plantar flexion of the heel increased.
- Plantar flexion is allowed by eccentric contraction of the tibialis anterior
- Extension of the knee is caused by a contraction of the quadriceps
- Flexion is caused by a contraction of the hamstrings,
- Flexion of the hip is caused by the contraction of the rectus femoris.

Foot Flat (or loading response phase)

- Body absorbs the impact of the foot by rolling in pronation.
- Hip moves slowly into extension, caused by a contraction of the adductor magnus and gluteus maximus muscles.
- Knee flexes to 15° to 20° of flexion.

- Ankle plantarflexion increases to 10-15°.

Midstance

- Hip moves from 10° of flexion to extension by contraction of the gluteus medius muscle.
- Knee reaches maximal flexion and then begins to extend.
- Ankle becomes supinated and dorsiflexed (5°), which is caused by some contraction of the triceps surae muscles.
- During this phase, the body is supported by one single leg.
- At this moment the body begins to move from force absorption at impact to force propulsion forward.

Heel Off

- Begins when the heel leaves the floor.
- Bodyweight is divided over the metatarsal heads.
- 10-13° of hip hyperextension, which then goes into flexion.
- Knee becomes flexed (0-5°)
- Ankle supinates and plantar flexes.

Toe Off/pre-swing

- Hip becomes less extended.
- Knee is flexed 35-40°
- Plantar flexion of the ankle increases to 20°.
- The toes leave the ground.

Early Swing

- Hip extends to 10° and then flexes due to contraction of the iliopsoas muscle 20° with lateral rotation.
- Knee flexes to 40-60°
- Ankle goes from 20° of plantar flexion to dorsiflexion, to end in a neutral position.

Mid Swing

- Hip flexes to 30° (by contraction of the adductors) and the ankle becomes dorsiflexed due to a contraction of the tibialis anterior muscle.
- Knee flexes 60° but then extends approximately 30° due to the contraction of the sartorius muscle. (caused by the quadriceps muscles).

Late Swing/declaration

- Hip flexion of 25-30°
- Locked extension of the knee
- Neutral position of the ankle.

Gait Cycle - Anatomical Considerations

- Pelvic region - anterior-posterior displacement, which alternates from left to right. Facilitates anterior movement of the leg (each side anterior-posterior displacement of 4-5°).
- Frontal plane - varus movement in the: foot between heel-strike and foot-flat and between heel-off and toe-off; hip, in lateral movements (when the abductors are too weak, aTrendelenburg gaitcan be observed). Valgus movement between foot-flat and heel off in the feet.
- A disorder in any segment of the body can have consequences on the individual's gait pattern.

Gait Disorders

Gait disorders - altered gait pattern due to deformities, weakness or other impairments eg loss of motor control or pain . Prevalence increases with age and the number of people affected will substantially increase in the coming decades due to the expected demographic changes.

- Lead to a loss of personal freedom and to reduced quality of life.
- Precursors of falls and therefore of potentially severe injuries in elderly person

Gait Descriptions

- Antalgic gait a limp adopted so as to avoid pain on weight-bearing structures, characterized by a very short stance phase.
- Ataxic gait an unsteady, uncoordinated walk, with a wide base and the feet thrown out, coming down first on the heel and then on the toes with a

double tap.This gait is associated with cerebellar disturbances and can be seen in patients with longstanding alcohol dependency. People with 'Sensory'Disturbances may present with a sensory ataxic gait. Presentation is a wide base of support, high steps, and slapping of feet on the floor in order to gain some sensory feedback. They may also need to rely on observation of foot placement and will often look at the floor during mobility due to a lack of proprioception.

- Equine gait a walk accomplished mainly by flexing the hip joint; seen in crossed leg palsy.
- Parkinsonian Gait (seen in parkinson's disease and other neurologic conditions that affect the basal ganglia). Rigidity of joints results in reduced arm swing for balance. A stooped posture and flexed knees are a common presentation. Bradykinesia causes small steps that are shuffling in presentation. There may be occurrences of freezing or short rapid bursts of steps known as ‘festination’ and turning can be difficult.
- Trendelenburg gait, the gait characteristic of paralysis of the gluteus medius muscle, marked by a listing of the trunk toward the affected side at each step.
- Hemiplegic gait a gait involving flexion of the hip because of foot-drop and circumduction of the leg.
- Steppage gait the gait in foot-drop in which the advancing leg is lifted high in order that the toes may clear the ground. It is due to paralysis of the anterior tibial and fibular muscles, and is seen in lesions of the lower motor neuron, such as multiple neuritis, lesions of the anterior motor horn cells, and lesions of the cauda equina.
- Stuttering gait a walking disorder characterized by hesitancy that resembles stuttering; seen in some hysterical or schizophrenic patients as well as in patients with neurologic damage.
- Tabetic gait an ataxic gait in which the feet slap the ground; in daylight the patient can avoid some unsteadiness by watching his feet.
- Waddling gait exaggerated alternation of lateral trunk movements with an exaggerated elevation of the hip, suggesting the gait of a duck; characteristic of muscular dystrophy.
- Diplegic Gait (Spastic gait). Spasticity is normally associated with both lower limbs. Contractures of the adductor muscles can create a ‘scissor’ type gait with a narrowed base of support. Spasticity in the lower half of the legs results in plantarflexed ankles presenting in ‘tiptoe’ walking and often toe dragging. Excessive hip and knee flexion is required to overcome this

- Neuropathic Gaits. High stepping gait to gain floor clearance often due to foot drop

Causes of gait disorders

They include neurological, orthopedic, medical and psychiatric conditions and multifactorial etiology becomes more common with advancing age, making classification and management more complex. Any gait disorder should be thoroughly investigated in order to improve patient mobility and independence, to prevent falls and to detect the underlying causes as early as possible. Thorough clinical observation of gait, careful history taking focussed on gait and falls and physical, neurological and orthopedic examinations are basic steps in the categorization of gait disorders and serve as a guide for ancillary investigations and therapeutic interventions.

Musculoskeletal Causes

Pathological gait patterns resulting from musculoskeletal are often caused by soft tissue imbalance, joint alignment or bony abnormalities affect the gait pattern as a result.

Hip Pathology

- **Arthritis** is a common cause of pathological gait. An arthritic hip has reduced range of movement during swing phase which causes an exaggeration of movement in the opposite limb 'hip hiking[15][20].
- **Excessive Hip Flexion** can significantly alter gait pattern most commonly due to; • Hip flexion contractures • IT band contractures, • Hip flexor spasticity, • Compensation for excessive knee flexion and ankle DF, • Hip pain • Compensation for excess ankle plantar flexion in mid swing. The deviation of stance phase will occur mainly on the affected side. The result is forward tilt of the trunk and increased demand on the hip extensors or increased lordosis of the spine with anterior pelvic tilt. A person with reduced spinal mobility will adopt a forward flexion position in order to alter their centre of gravity permanently during gait.
- **Hip Abductor Weakness**. The abductor muscles stabilise the pelvis to allow the opposite leg to lift during the swing phase. Weak abductor muscles will cause the hip to drop towards the side of the leg swinging forward. This is also known as Trendelenburg gait[18]

- **Hip Adductor Contracture.** During swing phase the leg crosses midline due to the weak adductor muscles, this is known as 'scissor gait'[18]
- **Weak Hip Extensors** will cause a person to take a smaller step to lessen the hip flexion required for initial contact, resulting in a lesser force of contraction required from the extensors. Overall gait will be slower to allow time for limb stabilisation. Compensation is increased posterior trunk positioning to maintain alignment of the pelvis in relation to the trunk[18]
- **Hip Flexor Weakness** results in a smaller step length due to the weakness of the muscle to create the forward motion. Gait will likely be slower and may result in decreased floor clearance of the toes and create a drag

Knee Pathologies

- **Weak Quadriceps**. The quadriceps role is to eccentrically control the knee during flexion through the stance phase. If these muscles are weak the hip extensors will compensate by bringing the limb back into a more extended position, reducing the amount of flexion at the knee during stance phase. Alternatively heel strike will occur earlier increasing the ankle of plantar flexion at the ankle, preventing the forward movement of the tibia, to help stabilise the knee joint.
- **Severe Quadriceps Weakness** or instability at the knee joint will present in hyperextension during the initial contact to stance phase. The knee joint will 'snap' back into hyperextension as the bodyweight moves forwards over the limb
- **Knee Flexion Contraction** will cause a limping type gait pattern. The knee is restricted in extension, meaning heel strike is limited and step length reduced. To compensate the person is likely to 'toe walk' during stance phase. Knee flexion contractures of more than 30 degrees will be obvious during normal paced gait. Contractures less then this will be more evident with increased speeds.

Ankle Pathologies

- **Ankle Dorsiflexion Weakness** results in a lack of heel strike and decreased floor clearance. This leads to an increased step height and prolonged swing phase.
- **Calf Tightening or Contractures** due to a period of immobilisation or trauma will cause reduced heel strike due to restricted dorsiflexion. The compensated gait result will be 'toe walking' on stance phase, reduced step

length, and excessive knee and hip flexion during swing phase to ensure floor clearance.

Foot Pathologies

- **Hallux Rigidus** results in a lack of dorsiflexion of the great toe. The MPJ uses the windlass effect to raise the arch and stiffen the foot during dorsiflexion of the hallux. This stiffness increases the efficiency of the propulsion portion of the gait cycle. To be efficient in creating stiffness, the hallux should be able to dorsiflex at least 65 degrees.

Leg length discrepancy

Leg length discrepancy can be as a result of an asymmetrical pelvic, tibia, or femur length or for other reasons such as scoliosis or contractures. The gait pattern will present as a pelvic dip to the shortened side during the stance phase with possible 'toe walking' on that limb. The opposite leg is likely to increase its knee and hip flexion to reduce its length.

Antalgic Gait

- Antalgic gait due to **knee pain** presents with decreased weight bearing on the affected side. The knee remains in flexion and possible toe weight-bearing occurs during stance phase[15]
- Antalgic gait due to **ankle pain** may present with a reduced stride length and decreased weight bearing on the affected limb. If the problem is pain in the forefoot then toe-off will be avoided and heel weight-bearing used. If the pain is more in the heel, toe weight-bearing is more likely. General ankle pain may result in weight-bearing on the lateral border[15][18].
- Antalgic gait due to **hip pain** results in a reduced stance phase on that side. The trunk is propelled quickly forwards with the opposite shoulder lifted in an attempt to even the weight distribution over the limb and reduce weight-bearing. Swing phase is also reduced

Gait Analysis

- The analysis of the gait cycle is important in the biomechanical mobility examination to gain information about lower limb dysfunction in dynamic movement and loading.
- When analyzing the gait cycle, it is best to examine one joint at a time.

- Objective and subjective methods can be used.

Subjective

- Different gait patterns - We might ask the individual to walk normally, on insides and outsides of feet, in a straight line, running (all the time looking to compare sides and understanding of "normal").
- Ask/observe the type of footwear the patient uses (a systematic review suggests shoes affect velocity, step time, and step length in younger children's gait[32]).

An objective approach is quantitative and parameters like time, distance, and muscle activity will be measured. Other objective methods to assess the gait cycle that use equipment include:[33][31]

- Video Analysis and Treadmill
- Electronic and Computerized Apparatus
- Electronic Pedometers
- Satellite Positioning System

Qualitative methods to assess and analyse gait include:

- Rancho Los Amigos Hospital Rating List
- Ten Meter Walking Test
- 6 Minute Walk Test
- 2 Minute Walk Test
- Dynamic Gait Index
- Emory Functional Ambulation Profile
- Timed Up and Go Test· This test is statistically associated with falling in men, but not in women.
- Functional Ambulation Categories
- Tinetti-Test

Sports medicine

Sports medicine is a branch of healthcare. It deals with the diagnosis, treatment and prevention of Injuries related to participation in sports and/or exercise.

Scope of sports medicine

In the field of physical education and sports, the fields of various sub-disciplines of sports medicine are utilize. Without the knowledge of scope of sports medicine, it is

difficult to carry a sportsperson performance at apex level. There are following scope of sports medicine:

a) Sports and first aid

b) Human anatomy and physiology

c) Female and sports

d) Study of optimal load for different age groups

e) Scientific promotion of games and sports

f) Sports injury rehabilitation

g) Fitness for games and sports.

Aims of sports medicine

a) To provide information to athletes about injuries.

b) To provide knowledge about the causes of injuries.

c) To provide means or treatment for sports injuries and for rehabilitation of injuries.

d) To provide knowledge about the preventive measures of sports injuries.

e) To aware the sports person & athlete about the different kinds of injury in respect of different games.

f) To concentrate on the causes of injury

Concept of Sports medicine

- Bio-mechanics related to sports
- Effect of attitude on endurance performance
- Psychological aspect performance

- Nutrition & metabolism in relation to competition & performance
- Recommendations of FISM(the International Federation of Sports Medicine at world level)
- Cardio-respiratory function in relation to performance
- Exercise in Cardio-Vascular disease prevention & rehabilitation

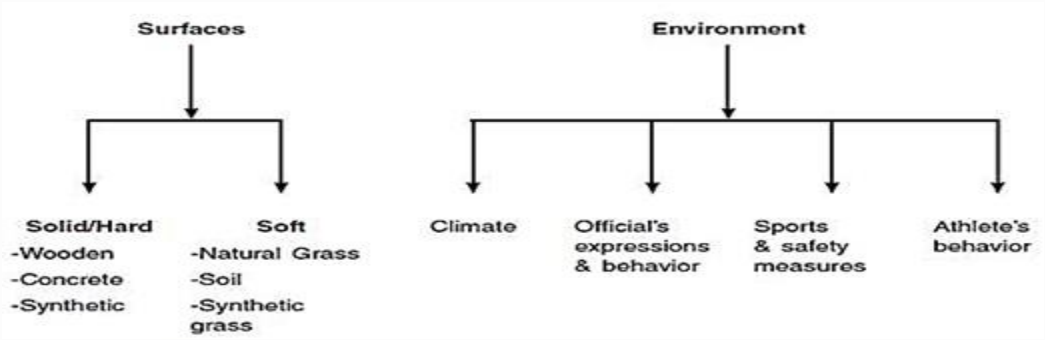
Prevention of Sports Injuries :

- Pre-participation of medical check up
- Proper conditioning
- Avoid dehydration
- Protective Sports equipment & Gears
- Adequate & effectively maintained facilities
- Sports person's psychological conditions & environment
- Adequate rehabilitation/Injury management
- Proper use of right techniques
- Balanced diet & adequate rest
- Use of proper skills
- Warming up & cooling down

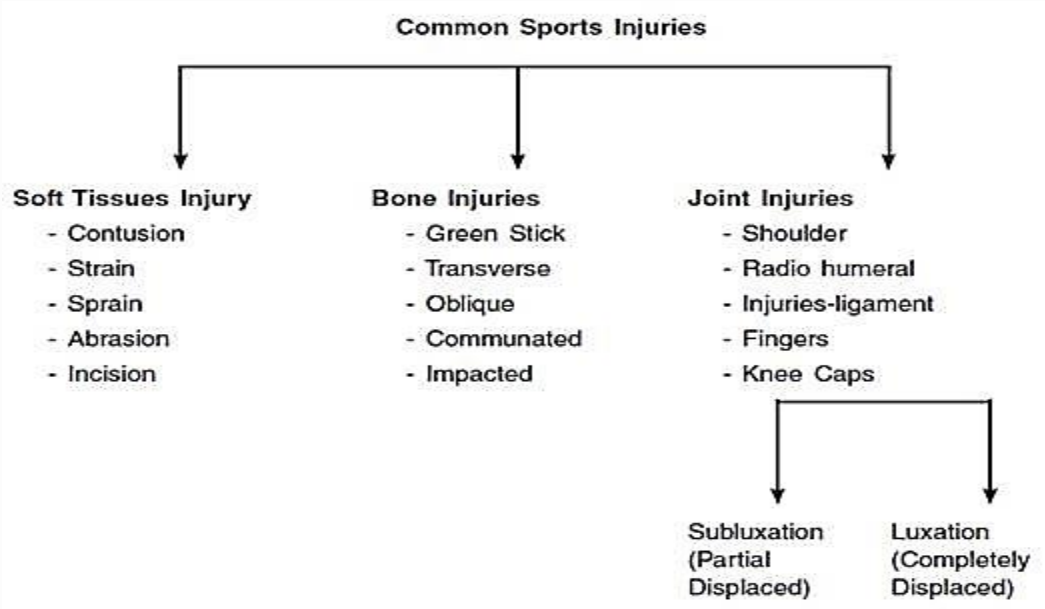
Impact of surface on athletes

There are two types of surfaces used in any indoor or outdoor games. These are natural and artificial surfaces. Natural surfaces is the surfaces that are prepared through proper combination of natural elements like soil and grass. On the other hand, artificial surfaces are more like carpets which are made from artificial components like rubber, synthetic fiber etc. These surfaces impact performance of athletes differently. In many contact games like football, cricket, running and Kabaddi natural surfaces are preferred because they provide more familiarity, grip and avoid severe injuries. On the other hand, artificial surfaces provide more opportunities for practice because their use need not be stopped for maintenance. Also, with innovation in technology, artificial surfaces are becoming more user friendly. Risks of injuries are reducing in artificial surfaces also nowadays.

Impact of Surfaces and Environment on Athletes



SportsInjury

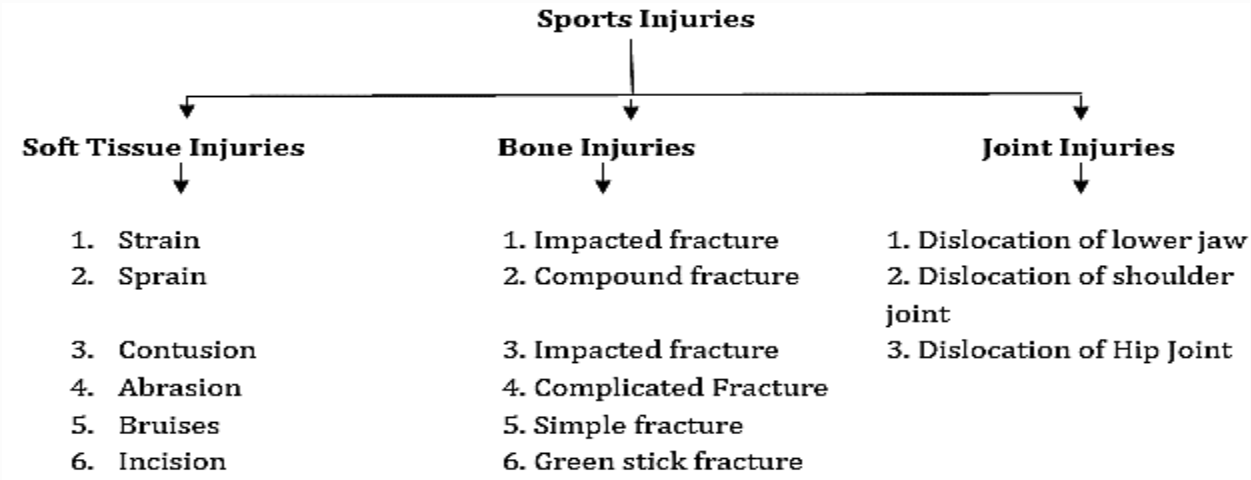


Intrinsic Risk Factor	Extrinsic Risk Factor	
Physical Preparation Lack of proper training Fitness label Improper warming up & cooling Down Over use of muscles Muscles imbalance **Individual variables:-** a. Gender and Age b. Nutrition c. Fatigue d. Posture deformities	**Coaching** a. Poor techniques b. Lack of knowledge • Skill • Rules & Regulations • Surrounding • Environment • Equipment • Facilities	**Environmental** Factors a. Climate b. Playing Surface c. Preventive surfaces d. Medical facilities

Climatic conditions affect the performance

Environmental conditions, such as excessively high or low temperatures, have the potential to have a negative impact on an athlete ‘s well-being. An athlete ‘ability to use a number of thermoregulation techniques helps in regulating body temperature.

Sports injuries are those which are common in the field of games and sports. During training, competition or practice, any player can be injured. Perhaps there will not be any player who has not been injured during his career.



Strain is also a muscle injury. A strain is caused by twisting or pulling a muscle or tendon. A sudden strain is caused by a recent injury, lifting heavy objects or rods in wrong way and over stressing the muscles. Chronic strain is usually caused by moving the muscles and tendons in repetition.

Sprain is a ligament injury. It may occur due to overstretching or tearing of ligaments. Many things can cause sprain. Falling, twisting, or getting hit can force a point out of its normal position. This can cause ligaments around the joints to tear. Generally, Sprain occurs at wrist and ankle joints.

Prevention of sprain and strain

a) Conditioning should be performed during the preparatory period.

b) Sports equipments must be of good quality.

c) Play courts should be smooth and clean.

d) The scientific knowledge of games should be must for preventing srain.

e) Player should discontinue during the condition of fatigue.

f) Good officiating is essential for preventing such injury.

g) Players should be careful and alert during practice, training and competition.

A**brasion** is a key injury generally occurs due to friction with certain equipments or a fall over the area where bone is very close to skin. It may be caused by a fall on hard surface. As someone falls or slides on the ground, friction causes layers of the skin to rub off.

Bruises are not clearly seen as upper skin remains undamaged and inner blood vessels are damaged and collect beneath the skin. A fresh bruise may actually be reddish and after a few hours it turns to blue or dark purple.

A **laceration** is a wound that is produced by tearing of soft body tissue.

Contusion is a muscle injury. A direct hit with or without any sports equipment can be the main cause of contusion. Contusion can also be due to minor accidents to the skin such as falling, bumping into something or being hit or kicked. In contusion blood vessels in muscles are broken and sometimes bleeding may occur in the muscles which may cause bruise. Stiffness and swelling are common features at the site of contusion.

Management:

- Cold compression should be used immediately. Ice or cold water should not be used for more than 40 minutes persistently.
- The cold compression should be performed 5 to 6 times daily.
- If there is more swelling at the sight of contusion, the anti-inflammatory medicine should be given.
- If the swelling persists, consult the Doctor immediately.
- For the purpose of rehabilitation, flexibility exercises should be performed.

Causes of sports injuries

To effectively diagnose, rehabilitate and ultimately prevent subsequent injuries, a sport therapist

- Anatomical Factors: These are related to make up of the body. Leg length differences a n d cause injury to ankle, hip and back.

- Age related causes as the body ages, it changes. It is less able to produce force, recovers slower and soft tissues lose the ability to stretch. Therefore, it is more prone to injury.
- Training related cause's Excessive repetitive loading of the tissues is needed for successive adaptation. However, without suitable recovery, tissues never have the chance to adapt and can fail.
- Equipment selection factors These are related to the suitability of equipment. An instance is incorrect footwear, which will not protect the foot and ankle adequately. It also will not distribute forces effectively. Thus it increases the risk of injury.
- Impact and contact causes Impact or contact can be with objects, surfaces or other people. These injuries are common in contact sports like football, rugby, hockey etc. Also they are common in more dangerous sports like motor racing, boxing and skiing.

Joint injuries & its types

A hard blow to a joint, a fall, a forceful throwing, lifting or hitting may cause dislocation. Infact it is dislocation of surface of bones.

Types of dislocation

a) Dislocation of lower jaw: it occurs when the chin strikes to any other object. It may occur if mouth is opened excessively.

b) Dislocation of shoulder joint: dislocation of shoulder joint may occur due to a sudden jerk or a fall over a hard surface. The end of the humerous comes out from

the socket. In face when your shoulder dislocates, a strong force, such as a sudden blow to your shoulder. Pulls the bones in your shoulder out of place.

c) Dislocation of hip joint: By putting maximum strength spontaneously may cause dislocation of hip joint. The end of the femur is displaced from the socket.

d) Dislocation of wrist: A sportsperson who participates in a sports or game in which he may fall, runs the risk of getting a dislocated wrist. A miscalculated landing can also cause a dislocated wrist. Infact, it generally occurs to the person who use his hand to break his fall.

Preventions:

a) Adequate warming-up should be performed prior to any activity.

b) Proper conditioning should be performed during preparatory period.

c) Stretching exercises should be include in warm-up

d) Players should be careful during training and competition.

e) Protective equipment should be used

f) Players should have good anticipation and concentration power

g) Always obey the rules and regulations.

h) Perform regular exercise around your shoulder, hip, and wrist joints etc.

i) Avoid falls or hits as far as possible.

Causes of fracture

Fracture usually occurs due to a high impact on the bone. It can be causes by overuse. The most common causes of fracture are:

a) In such sports event where there is a high impact.

b) Traumatic, forceful and unnatural movements.

c) Prolonged long distance walking or running.

d) Sudden fall on hard surface.

e) Direct strike or hit with any solid sports equipment.

f) Osteoporosis.

Management of Fracture

a) Elevate the extremity and rest while bone heals itself.

b) Apply ice to the affected part for 24 to 48 hrs

c) If pain persists, give painkillers.

d) If there is any need of immobilization to the affected part, use a slint

e) After removal of swelling begin to put partial weight on the affected area.

f) Crutches or walking stick may be used in the beginning. After two weeks start putting normal weight.

g) For 6 to 8 weeks, avoid the activity that caused stress fracture. Then start doing the activity slowly.