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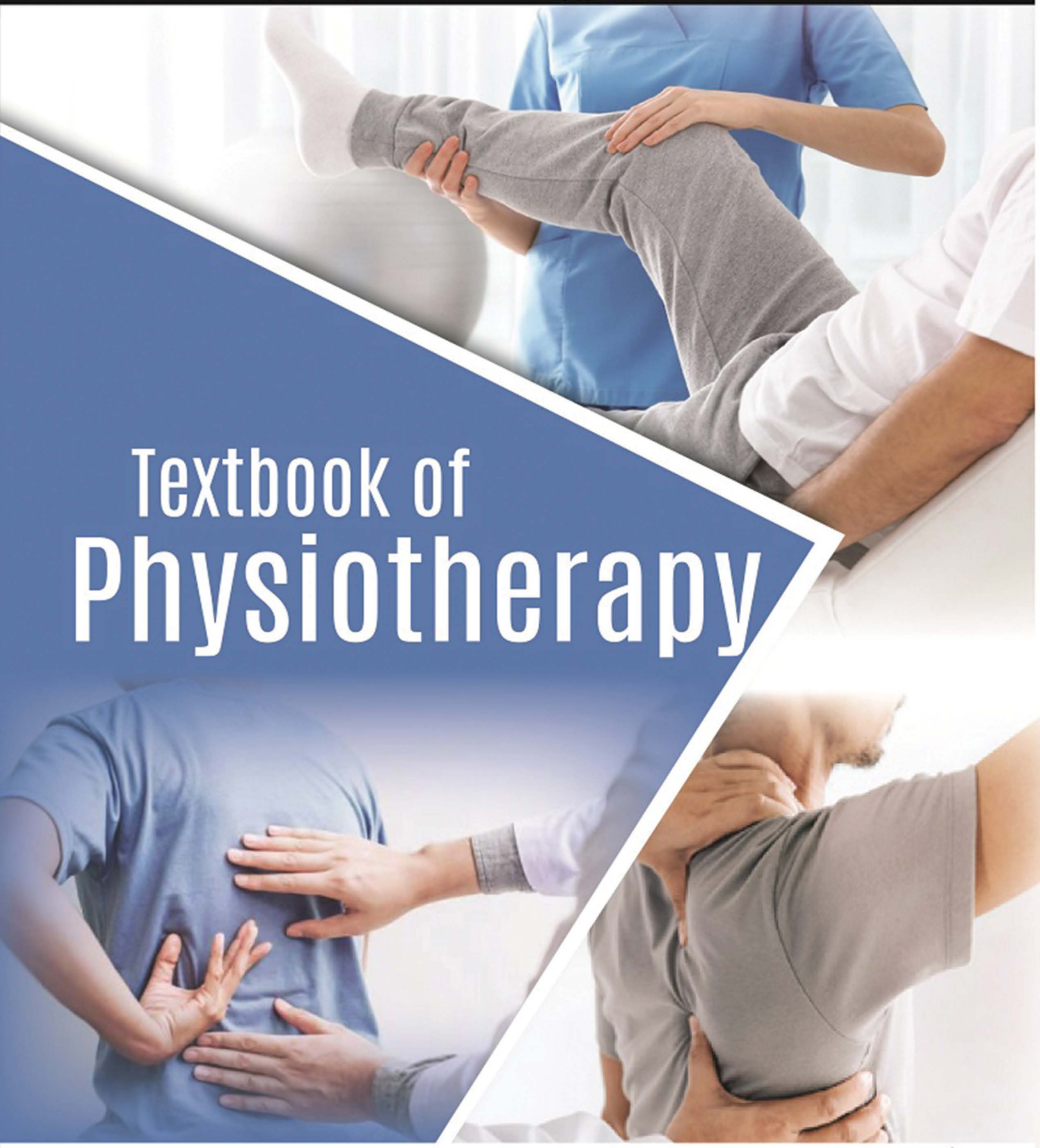

Textbook of Physiotherapy

Basanta Kumar Nanda

JAYPEE

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CHAPTER 4

Normal Human Locomotion, Walking Aids, and Gait Training

NORMAL HUMAN LOCOMOTION

Normal human locomotion is the series of rhythmic alternating movements of the trunk and extremities, resulting in a forward progression of center of gravity. It is a cyclic motion of the body, called the *gait cycle*, which is measured from heel strike to heel strike of the same limb. The gait cycle consists of the following phases such as, stance phase and swing phase as shown in **Figure 4.1A**. There is also a period of double support, that occurs twice throughout one gait cycle. The relative contribution of different phases in the gait cycle are:

1. Stance phase: 60% of the gait cycle.
2. Swing phase: 40% of the gait cycle.
3. Double support: 20% of the gait cycle.

Biomechanics of normal gait: This has two components such as:

1. **Kinetics:** It is defined as the forces acting on the body, that are responsible for the movement. The factors are:
   - Forces acting on the foot by the supporting surface (Ground reaction force).
   - Forces acting in the joints.
   - Forces produced by the contracting muscles.
   - Moments produced by the muscles crossing the joints.
   - Mechanical power generated/ absorbed by the muscles.
   - Energy pattern of the body while walking.
2. **Kinematics:** This is the term used to describe movements, without considering the internal or external forces that caused such movements. It includes:
   - Positions of body segment.
   - Velocity of body segments.
   - Acceleration of body segments.

The kinematics and kinetic factors of normal gait are discussed below:

- **Stance phase**: This is the period, when the limb is in contact with the ground. This phase constitutes 60% of the gait cycle having components such as:
  - *Heel strike/Initial contact:* Occurs when the foot contacts the ground.
    - » Kinematics: *Hip:* 20 degrees flexed.
      Knee: Extended
      Ankle: Plantigrade
    - » Kinetics:
      Hip: Single joint hip extensors and abductors contract vigorously to stabilize pelvis and trunk over femur.
      Knee: Low-amplitude contractions in hamstrings resist knee hyperextension.
      Ankle: Pretibial muscles, i.e., tibialis anterior, EDL, EHL contract eccentrically to decelerate foot lowering, and draw tibia forward following initial contact.
  - *Foot flat/Loading response:* Occurs after initial contact, until elevation of the opposite limb. The weight of the body gets transferred to the supporting limb in this phase.
    - » Kinematics:
      Hip: 20 degrees flexed.
      Knee: 20 degrees flexed.
      Ankle: 5 degrees plantar flexed.
    - » Kinetics:
      Hip: Same as initial contact.
      Knee: Quadriceps contract eccentrically to stabilize the knee and to counteract the flexion moment.

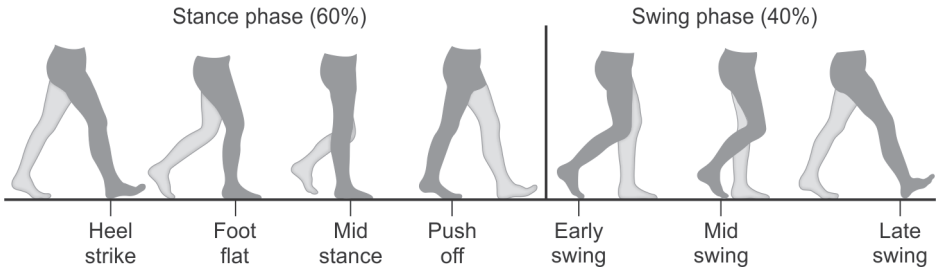

Fig. 4.1A: The gait cycle.

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Ankle: Tibialis anterior contract eccentrically to control plantar flexion moment.

– *Mid stance:* This is the period of single limb support when whole body weight is borne on one limb.
  » Kinematics:
  Hip: Neutral extension.
  Knee: Appears fully extended.
  Ankle: 5 degrees dorsiflexed.
  » Kinetics:
  Hip: Residual hamstring activity assists for hip extension at the beginning, and low-level abductor activity stabilizes the pelvis.
  Knee: Quadriceps contract eccentrically to stabilize the knee in slight flexion (close to full extension).
  Ankle: Plantar flexors of ankle undergo eccentric contraction to allow controlled forward progression of tibia.
– *Push off: Heel off and toe off:*
  » *Heel off/Terminal stance:* Begins when the supporting heel rises from the ground.
  » Kinematics:
  Hip: 20 degrees extended.
  Knee: Appears extended.
  Ankle: 10 degrees dorsiflexed
  » Kinetics:
  Hip: Low amplitude tensor fascia lata activity.
  Knee: Quadriceps contract eccentrically to stabilize the knee in slight flexion (close to full extension).
  Ankle: Plantar flexors of ankle undergo eccentric contraction to allow controlled forward progression of the tibia.
– *Toe off/Preswing:* It starts from initial contact of opposite limb to just before the elevation of ipsilateral limb.
  » Kinematics:
  Hip: 10 degrees extended.
  Knee: 40 degrees flexed.
  Ankle: 15 degrees plantar flexed.
  » Kinetics:
  Hip: Rectus femoris assists with early thigh advancement.
  Knee: Rectus femoris modulates the rate of knee flexion.
  Ankle: Calf muscle activity cease in early pre swing. Stored elastic energy in tendo Achilles contributes to rapid plantar flexion as limb unloads.

❖ **Swing phase**: This is the period of time, when the foot is off the ground and limb advances forward. This phase constitutes 40% of the gait cycle, having components such as:

– *Early swing (acceleration):* It starts from the elevation of a limb to point of maximal knee flexion.
  » Kinematics:
  Hip: 15 degrees flexed.
  Knee: 60 degrees flexed.
  Ankle: 5 degrees plantar flexed.
  » Kinetics:
  Hip: Iliacus, adductor longus, gracilis, sartorius advances the thigh producing hip flexion.
  Knee: Biceps femoris (short head), gracilis, and sartorius contribute to knee flexion.
  Ankle: Activity in pretibial muscles produces the required motion in the ankle.
– *Mid swing:* It starts following knee flexion to the point where tibia is vertical.
  » Kinematics:
  Hip: 25 degrees flexed.
  Knee: 25 degrees flexed.
  Ankle: Neutral.
  » Kinetics:
  Hip: Increasing hamstring activity at end of the phase, restrains further thigh advancement.
  Knee: Activity in hamstrings modulates the rate of knee extension and thigh advancement.
  Ankle: Ankle dorsiflexors contract to ensure foot clearance, by maintaining the ankle in the neutral position.
– *Terminal swing/Late swing:* It starts from the point where tibia is vertical to just prior to initial contact.
  » Kinematics:
  Hip: 20 degrees flexed.
  Knee: Appears fully extended.
  Ankle: Neutral.
  » Kinetics:
  Hip: Hamstrings continue to control thigh posture and decelerate the limb for heel strike.
  Knee: Hamstrings continue activity and vasti become active to prepare the limb for heel strike.
  Ankle: Activity in pretibial muscles, maintain ankle in neutral position.

Parameters of normal gait: The temporal (time taken for the event) and spatial (distance covered in space) parameters of gait are important parameters, that that help the clinician identify normal and pathological gaits, and to provide gait training.

The temporal parameters are:

❖ **Stance time:** Time taken for the stance phase.
❖ **Swing time:** Time taken for the swing phase.
❖ **Time for double support:** This is the time in one gait cycle, when both feet are supported on the ground.
❖ **Step time:** This is the time, that elapses from heel strike of one leg to the next heel strike of the opposite leg.
❖ **Stride time:** The time taken between two corresponding heel strikes in the same leg.
❖ **Cadence:** The number of steps taken in one minute. The normal value of cadence is: 80-130 steps per minute with an average value of 110 steps/ min in adult female and 116 steps/min in adult males.

The spatial parameters are:

❖ **Step length:** The distance from heel strike of one limb to corresponding next heel strike of the other limb. The

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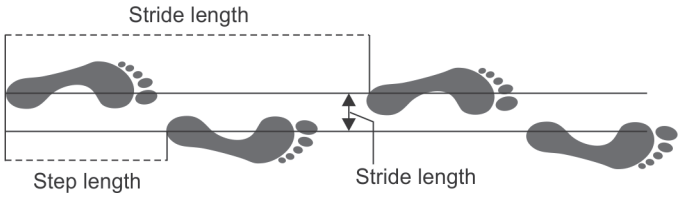

Fig. 4.1B: Spatial parameters of gait.

normal step length in adult female is about 65 cms and in adult male is about 75 cms.

- **Stride length:** This is the distance between two consecutive heel strikes of of the same leg. The average value of stride length for adult female is: 1.28 meter and for adult male is 1.46 meter,
- **Stride width/width of the walking base:** This is the transverse distance between centres of right and left heels during normal walking. The normal value being: 5-10 centimeters.
- **Degree of toe out:** This is the angle between the line of progression (line joining the centres of heels on the same side) and long axis of the foot. The normal value is about 10 degrees.

The spatial parameters of gait are shown in **Figure 4.1B**.

Characteristics of normal gait:

1. **Upward displacement of centre of gravity:** The centre of gravity of human body moves in a sinusoidal path in sagittal plane, with maximum upward displacement occurring during mid stance and maximum downward displacement occurring during double support. The amount of displacement is about 5 cm.
2. **Horizontal displacement of centre of gravity:** The centre of gravity which remains at the centre of the body during double support, gets displaces from side to side (i.e. from one limb to other at mid stance phases). The maximum displacement in the horizontal plane from right to left is about 5 cm.
3. **Pelvic dip/rotation of pelvis in coronal plane:** During normal walking, the pelvis dips by about 5 degrees on the swing phase side, which is counteracted by contraction of gluteus medius of the stance limbs with a reverse action, so that pelvis rotates about the same degrees over the femur of the stance limb, to assist effective ground clearance of the swing side limb.
4. **Knee flexion during stance phase:** Shortly after heel strike, flexion of the knee begins and continues, during the early part of the stance phase, until approximately 20 degrees of knee flexion is reached. This knee flexion, helps to smooth out the path of the center of gravity, by preventing its upward displacement.
5. **Width of the walking base:** The distance between the mid points of successive heel contacts of each limb, called width of the walking base normally has a value of 5-10 cm. Such narrow walking base helps to minimize the lateral displacement of center of gravity during normal walking.
6. **Cadence:** The number of steps taken in a minute, which normally ranges from 80-130 steps/min. If the cadence increases, walking turns into running.

Determinants of gait: The determinants of gait are supposed to represent the adjustments made by pelvis , hip , knee and ankle/foot, that helps to minimize the movements of body's center of gravity, resulting in an energy efficient gait. These determinants help for the followings:

- Minimizes the vertical and lateral displacement of body's center of gravity.
- Decreases energy expenditure.
- Makes the gait more efficient.

The six determinants of gait are:

1. **Rotation of pelvis in transverse plane:** The pelvis rotates in transverse plane upto an angle of 8 degrees total, i.e 4 degrees in a forward direction over the swing limb, and 4 degrees in a backward direction over the stance limb.
2. **Lateral pelvic tilt (drop of pelvis in the frontal plane):** The pelvis that tilts laterally by an angle of 5 degrees on the swing side, is controlled by contraction of gluteus medius on the supported side, there by helping in the prevention of too much upward displacement of body's center of gravity.
3. **Knee flexion during stance phase:** It occurs to prevent excessive upward displacement of the body's ceter of gravity, as the body is carried forward over the stance limb.
4. **Knee, ankle and foot interactions:** The combined movements of knee, ankle anf foot prevent the abrupt changes in the vertical displacement of the center of gravity from downward to upward direction.
5. **Physiological valgus of knee:** This reduces the width of the walking base, due to which minimal lateral displacement of the pelvis is required, to shift the COG, from one lower extremity to another over the base of support.
6. **Lateral displacement of the pelvis:** The pelvis that displaces laterally over the stance limbs can be kept to a minimum by a narrow walking base. By keeping the walking base narrow, little lateral movement of the pelvis is required to preserve balance.

GAIT ANALYSIS

When, a person is not able to walk normally, or has difficulty in walking, either due to neuromuscular/musculoskeletal diseases/disorders, then in this case the walking pattern (gait) of the person should be analyzed and some appropriate exercises, walking aids and orthotic devices should be provided to make walking (gait) energy efficient.

The methods of gait analysis are as follows:

Visual/observational gait analysis: This is the simplest form of gait analysis made by the unaided human eye. This, of course, neglects the remarkable abilities of the human brain to process the data received by the eye. Visual gait analysis is, in reality, the most complicated and versatile form of analysis available. Many clinicians include the observation of a subject's gait as part of their clinical examination. Visual gait analysis is entirely subjective and the quality of the analysis depends on the skill of the person performing it.

The limitations of this method are:

- It is transitory, giving no permanent record.
- The eye cannot observe high-speed events.

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- It is only possible to observe movements, not forces.
- It depends entirely on the skill of the individual observer.
- It is subjective and it can be difficult to avoid assessor bias if the patient is undergoing treatment.
- Subjects may act differently when they know they are being watched (Hawthorne effect).
- A clinic or laboratory environment may be very different than the real world.

Gait analysis in gait laboratory that incorporates videography, force plates, etc., to gather kinematic and kinetic data.

- **Methods for kinematic analysis:**
  - *Videography:* This has provided one of the most useful enhancements to gait analysis in the clinical setting during recent years. Gait examination by video recording is not an objective method, since it does not provide quantitative data in the form of numbers. This helps to overcome two of the limitations of visual gait analysis such as—the lack of a permanent record and the difficulty of observing high-speed events. Two-dimensional (2D) and three-dimensional (3D) video-based motion analysis systems are available for gait analysis; however, their use is limited due to challenges with providing accurate data. It has the following advantages:
    - » It can be used as a record for future reference.
    - » The patient can be demonstrated about his/her gait pattern by showing the video of his walking.
  - *Electrogoniometry:* Electrogoniometers provide an affordable means of measuring joint motion during walking. Early electrogoniometer designs included two rigid links connected by a potentiometer that converted movement into an electrical signal that was proportional to the degree of movement. Recently, designs use a flexible shaft and two small end blocks that are affixed to the proximal and distal segments of the joint.
  - *Optical motion analysis systems:* These are computerized motion analysis systems, where markers are placed on body segments such as the hip, knee, and ankle that are tracked by automated systems **(Fig. 4.1C)**. Motion analysis systems primarily use either active [light emitting diodes (LED)] or passive markers (that requires an external source of illumination) for tracking motion.
  - *Electromagnetic motion analysis systems:* The challenges with optical tracking systems is that T-motion analysis cameras need to be able to "see" the markers to track their position and subsequently calculate kinematic data. This alternative motion analysis technology employs electromagnetic tracking capabilities to determine the 3D coordinates of location and angulation of each sensor.
- **Kinetic analysis of gait:**
  - *Force plate analysis:* This method focuses on analysis of the forces involved in gait, which include ground (floor) reaction forces (GRFs), joint torques, center of pressure (COP), center of mass (COM), mechanical energy, moments of force, power, work, joint reaction forces, and intrinsic foot pressure. The analysis usually starts with the forces being applied to the foot, which is determined by a force plates embedded in the floor. These plates contain load transducers that measure the COP, COM, and GRFs during gait.
  - *Plantar pressure measurement systems:* Pressure measurement systems may be used with force plates. Plantar pressure measurements are used most commonly in gait analysis to determine the pressure distribution under the foot such as—foot-to-ground contact, foot to- shoe contact, and shoe-to-ground contact.



Fig. 4.1C: Shows automated motion analysis with markers attached to body in gait laboratory.

Energy cost analysis (measurement of energy consumption) during gait: Energy expenditure is an important consideration in gait analyses, particularly in neurological conditions where muscular resources may be low. There are three general approaches in determining energy costs which are as follows:

- Physiological cost of energy expenditure.
- Mechanical energy analysis.
- Heart rate data.
- **Physiological cost of energy expenditure:** It is the measurement of oxygen uptake/maximum oxygen consumption volume of oxygen (VO_2 max), during walking, through open loop Spirometry, in which exhaled air is sampled and analyzed for its oxygen content. Physiological cost analysis methods are most useful in comparing the energy cost of walking with normal values, which helps for determining the effects of energy costs of interventions such as use of orthoses, prosthesis, and walking aids.
- **Mechanical energy cost analysis:** There are two methods of measurement of mechanical energy costs such as:
  - *Estimation of energy expenditure from the kinematic data:* The mass of the moving part and the COM are used to calculate the potential energy and translational and rotational kinetic energy levels of each body part

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through basic equations of motion and anthropometric constants for masses of body parts. The difference between values obtained at each time increment indicates energy cost.

– *The kinetic approach:* In this energy changes in body parts between subsequent instants in time are calculated from—the product of forces on each end of the joint and the velocity of the point of application, and from the muscle power, which are the product of each muscle moment and the angular velocity of the body part.

❖ **Energy expenditure from heart rate data:** This focuses on the measurement of heart rate during ambulation. The physiological cost index, which determines the relative costs of walking per unit distance walked, calculated as the difference between walking heart rate and the resting heart rate divided by average speed, is a method of calculation of energy expenditure from heart rate.

The total heart beat index provides an alternative approach for determining the relative energy efficiency of walking. It is calculated by dividing the total (cumulative) number of heartbeats during exercise by the total distance traveled in a given time period

WALKING AIDS

Walking aids are the assistive devices provided to individuals with sensory and motor deficits to facilitate locomotion. These are useful to assist people who have difficulty in walking or people who cannot walk independently. These include crutches, sticks, rollators, and walking frames.

Crutches

These are devices, which are provided to patients to reduce weight bearing on one or both legs and to give support where strength, endurance, and balance are inadequate to support and move the body.

There are various types of crutches used in clinics, such as:

Axillary Crutches

These are either made of wood or aluminum, consisting of an axillary pad, a hand piece, and double uprights joined distally by a single leg and a rubber ferrule that covers the base of the device. The length of the crutch and position of the hand piece is adjustable as per the need of the individual **(Fig. 4.2)**. The axillary pad should rest 5 cm beneath the apex of the axilla and the hand grip should be so aligned that, the elbow remains in approximately 15 degrees of flexion when weight is not fully taken. As weight is fully taken by the crutch, the elbow goes into extension, so that weight is transmitted down the arm to the hand piece (weight of body should not be transmitted to the crutch through the axillary pad to avoid complications like crutch palsy, where the radial nerve is compressed at the axilla, producing wrist drop). These crutches when used help to maintain standing balance with lateral stability.

Measurement of axillary crutch: It can be measured either with the patient in a lying position or standing, as follows.

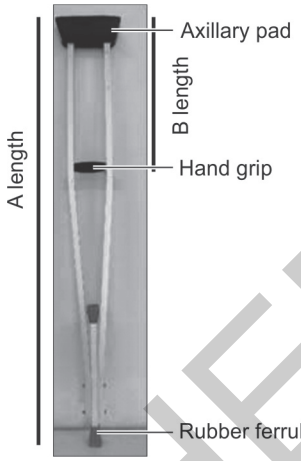

Fig. 4.2: Axillary crutch showing "A" and" B" lengths.

The measurements done in standing position comes out to be most accurate and is commonly performed.

❖ ***Measurement in supine lying:***
  – *Length of the crutch:*
    » A length with shoes off: Measurement is taken with an inch tape from apex of axilla to the lower margin of medial malleolus.
    » A length with shoes on: Measurement is taken with an inch tape, from a point 5 cm vertically down from the apex of the axilla (from the anterior axillary fold) to a point 20 cm lateral to the heel of the shoes.
  – *Length from axillary pad to hand grip -B length:* With the elbow flexed to 15 degrees, measurement is taken from a point 5 cm below the apex of the axilla to the ulnar styloid process.

❖ ***Measurement in standing:*** Patient standing with support in front of a wall. Before standing, a general estimate of the length of the crutch can also be obtained by subtracting 16 inches from the patient's height.
  – *Length of the crutch (A length):* 2" below the apex of the axilla to a point 2" lateral and 6" anterior to the feet.
  – *Location of the hand grip from axillary pad (B length):* With the shoulder relaxed, the hand grip should be adjusted to provide 20-30 degrees of elbow flexion.

Preparation for Crutch Walking

❖ **Preparation of upper limbs:** Muscles of crutch walking such as scapula depressor, shoulder extensors and adductors and elbow extensors, wrist extensors must be assessed and strengthened before the patient starts walking. The hand grip must also be tested to see that the patient has sufficient power and mobility to grasp the hand piece. If the patient is found to have weaker grip, grip strength must be increased, before the patient is made to use the crutch.

❖ **Preparation of lower limbs:** The strength and mobility of both legs should be assessed and muscles, if weak should be strengthened. Main attention should be given to the hip abductors and extensor, the knee extensors, and the ankle plantar flexors.

❖ **Development of balance with crutches:** Patient's standing balance with the crutches must be assessed, and balance

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training with crutches should be given before he/she is made to walk with the crutches.

- **Demonstration:** The physiotherapist should demonstrate appropriate crutch walking pattern/types of crutch gait to the patient, such as:
  - *Non-weight bearing crutch gait/3 point crutch gait:* This gait is generally used for unilateral lower limb amputees, acute fractures in one lower limb, joint replacement in one knee or hip and patients after surgery for fractures in lower limb, where weight bearing is not permitted. The patient is made to stand with a triangular base, i.e., crutches either in front or behind the weight bearing leg. The crutches serve as two points and the normal limb that bears load acts as the third point. While walking, the patient should take both the crutches with affected leg without the affected leg while touching the ground, followed by the normal/weight bearing leg **(Fig. 4.3)**.
  - *Partial weight bearing crutch gait:* This is a modification of the three point pattern. During forward progression of the involved lower extremity, weight is borne partially on both crutches and on the affected leg. In this, both the crutches and the affected leg are taken forward and put down together. Weight is then taken through the crutches and the affected leg, while the unaffected leg is brought through **(Fig. 4.4)**.
  - *4-point crutch gait:* This gait pattern is used when there is a lack of coordination, poor balance, and muscle weakness in both lower extremities. In this gait pattern, one crutch is advanced and then the opposite leg is advanced. For example, the left crutch is moved forward, then the right leg, followed by the right crutch, and then the left leg **(Fig. 4.5)**.
  - *2-point crutch gait:* This gait pattern is similar to the four point gait. However, it is less stable as only two points of floor contact are maintained and the use of such gait requires better balance. This pattern more closely simulates normal gait, i.e., lower extremity along with opposite upper extremity move together along with the crutch. That means left lower extremity and right upper extremity with the crutch moves as one point, and right lower extremity and left upper extremity with the crutch move as another point , making the two point gait pattern **(Fig. 4.6)**.
  - *Swing to gait:* This gait is commonly used for patients of spinal cord injury, who have bilateral lower extremity involvement. This gait involves forward movements of both crutches simultaneously, shifting weight to the hands and swinging the lower extremities to the crutches, not crossing the crutch line **(Fig. 4.7)**.
  - *Swing through gait:* In this gait which is also used for patients with spinal cord injury, the crutches are moved forward together, weight is shifted onto the hands and the lower extremities are swung beyond the crutches **(Fig. 4.8)**.

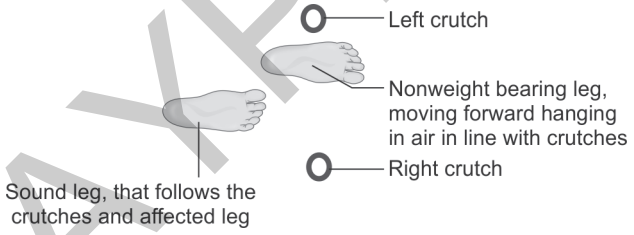

Fig. 4.3: Three point/non-weight bearing crutch gait.

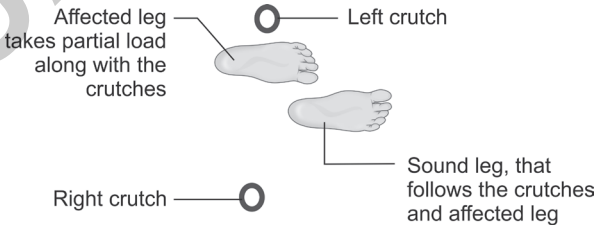

Fig. 4.4: Partial weight bearing crutch gait.

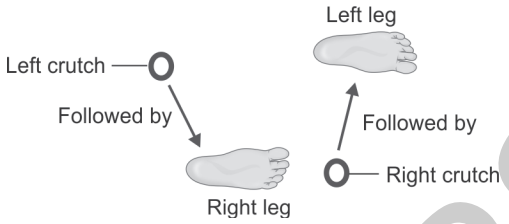

Fig. 4.5: 4-point crutch gait.

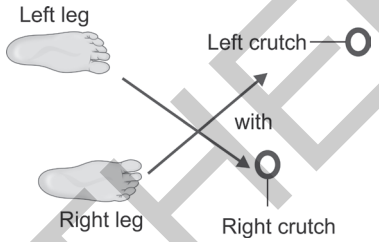

Fig. 4.6: 2-point crutch gait.

Elbow Crutch

It is also called as *Lofstrand* and *Canadian* crutch. It is usually made of aluminum. It consists of a single upright, forearm cuff, handgrip, and rubber ferrule **(Fig. 4.9)**. It can be adjusted both proximally to alter the position of the forearm cuff and distally to alter the height of the crutch. It is available with push button mechanism to alter the length. Forearm cuffs

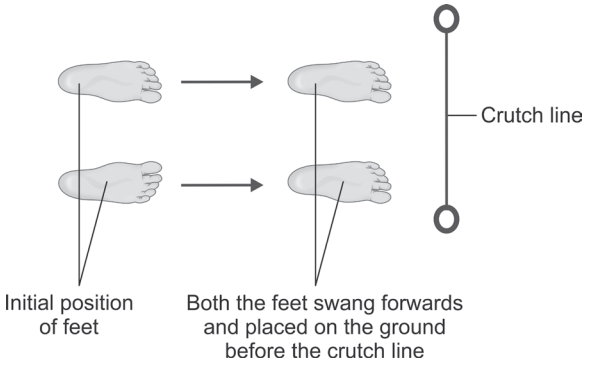

Fig. 4.7: Swing to crutch gait.

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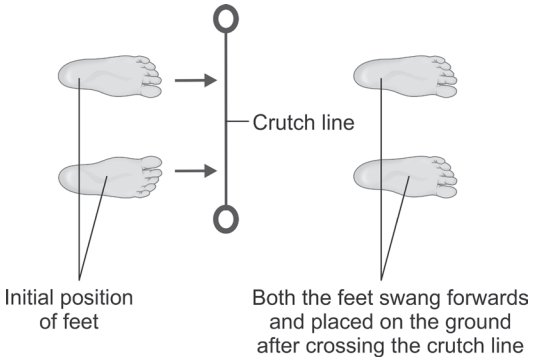

Fig. 4.8: Swing through crutch gait.

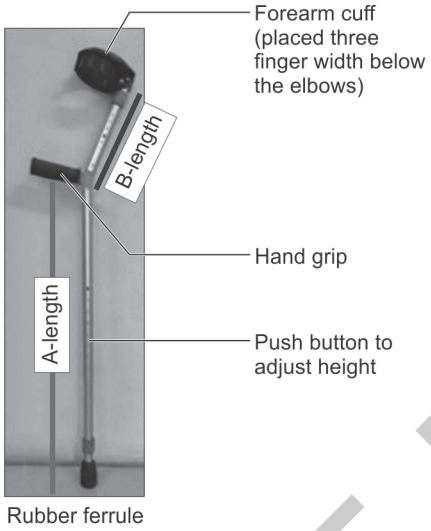

Fig. 4.9: The elbow crutch.

allow the use of hands without disengaging the crutch. The crutch is easily adjustable and allows functional stair climbing activity. It is more cosmetic than other crutches. This crutch has the disadvantage of providing less lateral support due to the absence of an axillary pad. These crutches are suitable for patients with good balance and strong arms.

Measurement of elbow crutch: As per the measurement of axillary crutch, standing is also a method of choice to measure the length of the elbow crutch for the patient. However, for those having difficulty in standing, supine measurement can also be performed.

- **In supine lying (with shoes on):** To get the length of the lower part of the crutch, i.e., from the handgrip to the lower end of the crutch (A-length), measurement is taken from the ulnar styloid process to a point of 20 cm lateral to the heel of the shoe, with the elbow flexed to 15 degrees. To get the length of the upper part of the crutch, i.e., forearm cuff to hand grip (B-length), measurement is taken from a point 1–1.5 inches below the elbow to the ulnar styloid process.

In standing:

Length of the lower part of the crutch from hand grip to the floor (A length): Patient standing tall with the back against the wall, shoulders back with the elbows flexed at 20-30 degrees. Measurement is taken in an inch tape from the floor up to the deep crease between the palm of the patient's hand and wrist and 1 inch is added to this length.

or

From a supported standing position, the distal end of the crutch should be positioned at a point 2 inches lateral and 6 inches anterior to the foot. With the shoulders relaxed, the height should then be adjusted to provide 20–30 degrees of elbow flexion.

- **Length of the upper part of the crutch (forearm cuff to hand grip-B length):** Measurement is taken from a point 1–1.5 inches below the elbow to the ulnar styloid process (the forearm cuff should be positioned over the proximal third of forearm, which is 1–1.5 inches below the elbow).

Gutter Crutch

This crutch is made of metal with padded forearm support and strap. It has an adjustable hand piece and rubber ferrule **(Fig. 4.10)**. It is used for patients who require support on the forearm due to deformities and pain in hands, such as Rheumatoid arthritis where, weight cannot be taken through the hands.

Measurements of Gutter Crunch:

- **Measurement of forearm support:** Measured from 3 inches below the elbow to the wrist.
- **Measurement of the vertical upright:** In supine lying, with shoes on—measurement is taken from the point of flexed elbow to 20 cm lateral to the heel of the shoe.

Walking Sticks/Tripod/Quadripod

Sticks may be made up of either wood or metal with curved or straight handpiece. Metal made sticks are adjustable while the wooden ones are nonadjustable. Tripod or quadripod sticks made of metal with three or four prolonged bases and gives more stable support than the simple walking stick **(Figs. 4.11A to C)**.

- ***Measurement of the walking stick:*** The stick or center of the broad based stick such as tripod/quadripod stick



Fig. 4.10: The gutter crutch.

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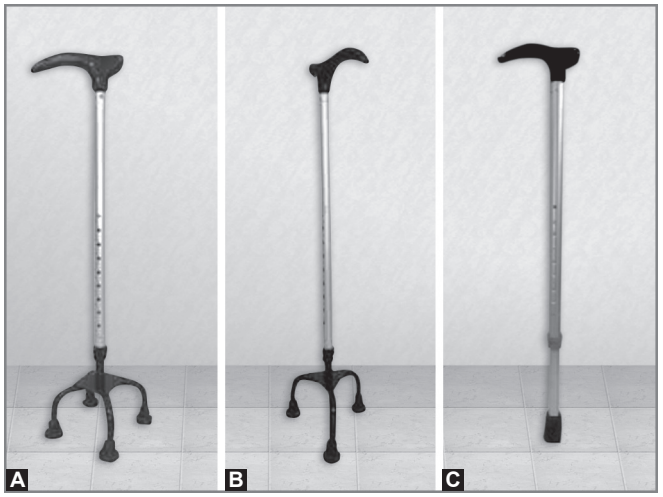


Figs. 4.11A to C: (A) Quadripod; (B) Tripod; (C) Walking stick.

is usually placed approximately 6 inches from the lateral border of the toes. The top of the stick/handgrip should remain at the level of greater trochanter and the elbow should be flexed to about 20–30 degrees.

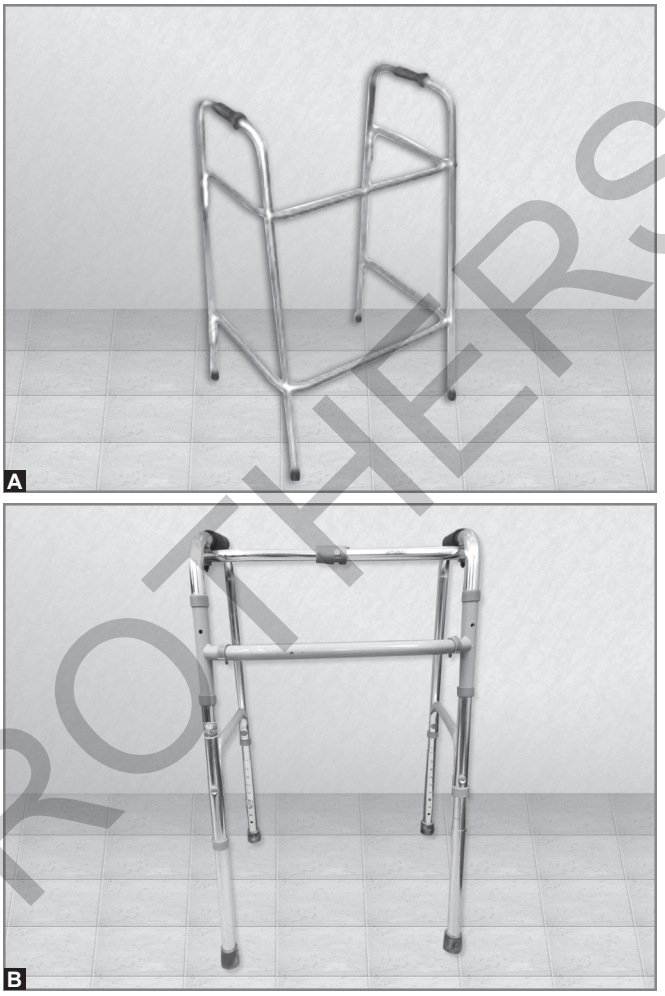
- ***Uses of sticks:*** Sticks allow more weight to be taken through the legs than crutches, and used as a progression from crutch walking. The stick should be used on the strong side and move with the weak side, i.e., one stick may be used on the unaffected side, so that the stick and affected leg are placed forward together, taking some of the weight through the stick. Using the walking stick on the opposite side to the injury allows to shift weight more to the stronger side.
- **Gait training with walking stick:** While walking, the stick should be held in the hand opposite to the affected limb. For ambulation over ground on level surfaces, the stick and the involved extremity are simultaneously advanced. The stick should remain relatively close to the body and should not be placed ahead of the toes of the involved extremity to prevent lateral and anterior trunk bending.

Walking Frames

They are light weight frames with four supporting bases (**Figs. 4.12A and B)**, which can be adjustable in height. Patient lifts the frame forward then leans on it and takes steps. Frames with wheels such as rollator frames which can be pushed are used for individuals with better trunk stability. The *reciprocal frame* where each side moves independently are useful for ataxic patients.

The walker/Rollator frame may be either anterior opening type or posterior opening type (most commonly used). The anterior opening type is usually attached with a seat over the posterior bar of the walker/Rollator **(Figs. 4.13 A and B)**. The anterior opening type is selected for very weak patients with poor endurance, who fatigue very easily, as the seat attached with the posterior bar is used to make the patient rest on it when signs of fatigue are noticed.

- ***Measurement of walker:*** With the elbows flexed to 20–30 degrees, the handgrip or handle of the walker should come to approximately the level of greater trochanter of the femur.
  - *Gait training with conventional walker/walking frame:*



Figs. 4.12 A and B: (A) Simple walking frame; (B) Reciprocal walker.

The patient should remain as vertical a posture as possible. The walker should be picked up and placed down on all four legs simultaneously to achieve maximum stability. The patient should be cautioned not to step too close to the front crossbar, as it will reduce the base of support and may result in a fall. As needed, the patient may be taught non-weight bearing/partial weight bearing/full weight bearing gait patterns with the walker as follows:

» Full weight bearing gait training with walker: The walker is picked up and moved forward about an arm's length, followed by the forward movement of first leg. Subsequently, the second leg is moved forward and past the first. The cycle is repeated resulting in forward movement of the body.

» Partial weight bearing gait training with walker: The walker is picked up and moved forward about an arm's length. The involved partial weight bearing leg is moved forward, transferring part of the body weight onto this limb, and part of the body weight is transferred through the upper extremities to the walker. Subsequently, the normal leg is moved forward past the affected leg. The cycle should be repeated, resulting in partial weight bearing gait with the walker.

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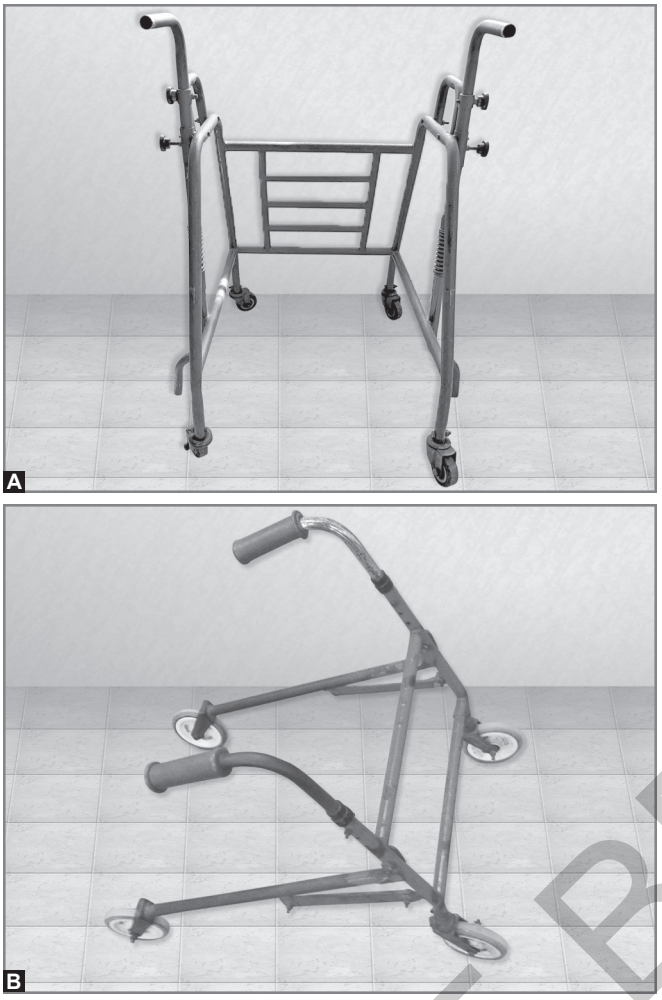

Figs. 4.13 A and B: (A) Anterior opening type walker rollator; (B) Posterior opening type walker rollator.

» Non-weight bearing gait training with walker: The walker is picked up and moved forward about an arm's length. Weight is then transferred through the upper extremities to the walker. The involved non-weight bearing leg is held anterior to the patient's body without making contact with the floor. Subsequently the uninvolved leg is moved forward and the cycle is repeated resulting in non-weight bearing gait with the walker.

Pathological gaits: The therapist/clinician should be able to identify pathological gaits, which will help him to evaluate the abnormal patterns and train normal walking as much as possible:

The common pathological gaits are:

- **High steppage gait:** Found in patients with foot drop, where the subject moves with excessive hip and knee flexion to clear the ground.
- **Lurching gait/lateral trunk bending:** This is found in subjects with hip abductor weakness on one side, this is also called as Trendelenburg gait.
- **Posterior trunk bending/posterior lurching gait:** This occurs in patients with gluteus maximus weakness where the patient bends backward while walking.
- **Circumduction gait:** This gait is found in patients with hemiplegia/hemiparesis, where the individual hikes and rotates the pelvis to clear the ground.
- **Waddling gait:** This occurs due to weakness of bilateral hip abductors where the subject lurches on both sides while walking.
- **Vaulting gait:** This gait is seen in individuals with shortening of one lower limb where the subject raises the heel on the shortened side to clear the ground on opposite side.
- **Antalgic gait:** This is found in individuals with painful joints where the individual tries to reduce the single stance period on the affected leg to avoid weight bearing on that side.
- **Scissoring gait:** This is found in individuals with spasticity of hip adductors and medial hamstrings commonly seen in spastic diplegic cerebral palsy. Both hips remain adducted while walking.
- **Hand to knee gait:** This is found in individuals with weak quadriceps where he/she leans forward and pushes the affected thigh posteriorly with own hand during single leg stance.
- **Anterior trunk bending gait:** This is seen in patients with weak quadriceps where the individual bends the trunk forward to bring the line of gravity more and more in front of the knee joint to create an extension torque during single leg stance.
- **Crouch gait:** Here the subject walks with hips and knees flexion and ankle dorsiflexion. This is commonly seen in spastic diplegic cerebral palsy.
- **Jump knee gait:** The individual walks with both hips and knees flexion and ankle plantar flexion as if he/she is going to jump. This is also seen in spastic cerebral palsy.

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- Motor control and Motor learning have been described to fulfill the needs of the students.
- Special techniques applicable to Neurological conditions, Musculoskeletal conditions (Manual therapy) have been included to highlight on various treatment methods available to Physiotherapists.
- The Author has tried to make the chapters simple by putting illustrative pictures, and the book can serve as a handbook, where the students will get everything contained in one.

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