

TEXT BOOK OF BIOMECHANICS AND EXERCISE THERAPY

by

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DEDICATED TO

My Father **C.SATYAM**

AND

My mother **C.USHA RANI**

ACKNOWLEDGEMENT

First and foremost I want to thank **Almighty** and **My Parents** because of whom I am in this position. Thanks to my brothers **Subash, Suresh** and **Prudhvi** who are always beside me in every deed I do and helped me in completing this book. It is my pleasure and privilege to record my deep sense of gratitude to **Mrs. Sandhya Rani** for giving me opportunity for writing this book.

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CHAPTER 1

MECHANICAL PRINCIPLES

DEFINITIONS:

1. The study of mechanics in the human body is referred to as biomechanics.
2. The study of the effects of internal and external forces on the human body in movement and rest is called biomechanics.
3. Mechanical principles applied to the study of biological functions; the application of mechanical laws to living structures; the study and knowledge of biological function from an application of mechanical principles is called biomechanics.

Axis : It is the line about which movement takes place. An imaginary straight line around which an object rotates is called axis.

Plane : It is the surface which lies at right angles to axis and in which the movement take place. These terms are used to facilitate the description of movement or direction.

Types of axes : They are 3 types of axes.

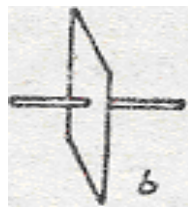
a. Sagittal axis: It lies parallel to sagittal suture of skull, i.e. in a anterior-posterior direction. Movement at this axes occur in a frontal plane.

b. Frontal or transverse axes: It lies parallel to transverse suture of skull. It is horizontal and at right angles to sagittal axes. Movement about frontal axes occurs in a sagittal plane.

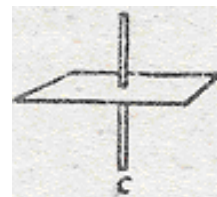
c. Vertical axes: It lies parallel to line of gravity. Movement about this axis is in a horizontal plane.



Sagittal



Frontal



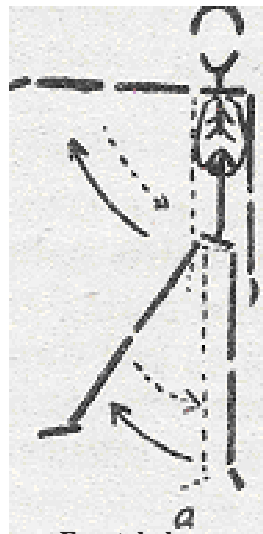
Vertical

Planes: There are three planes.

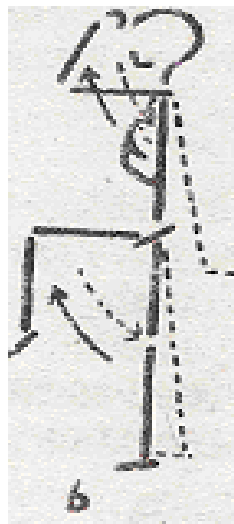
1. Movement in horizontal plane (transverse plane): This plane divides the body into upper and lower halves. Movements in transverse plane occur parallel to ground. For example in rotation of the head, the nose moves parallel to ground. Rotatory movements in a transverse plane occur around a vertical axis of motion. Movement in the horizontal plane is not affected by gravity hence it is stated as gravity free movement. Weak muscles which unable to produce movement against gravity can often succeed in this plane.

2. Movement in frontal plane (coronal plane): the frontal plane divides the body into front and back halves. Movements in the frontal plane occur side to side movements such as bringing the head to each of the shoulders. Rotatory motion in the frontal plane occurs around an anterior posterior axis.

3. Movement in vertical plane (sagittal plane): An anteroposterior vertical plane passing through the body from front to back, dividing it in half. It is the plane that divides the body or body segment into the right and left parts. Movements in this plane include forward and backward motions such as nodding of the head. Rotatory motion in the sagittal plane occurs around a coronal axis.



Frontal plane



Sagittal plane



Transverse plane

KINEMATICS

Kinematics is the area of biomechanics that include description of motion without regard for the forces producing it. They include.

- i. Types of motion.
- ii. Location of motion.
- iii. Direction of motion.
- iv. Magnitude of motion.

(i) Types of motion: four types of motion are there.

a. Rotatory motion: It is the movement of an object around a fixed axis in a curved path. Each point on the object or segment moves through the same angle at same distance. In human body the goal of most muscles appear to rotate a bony lever around a fixed axis.

b. Translatory motion: It is the movement of an object in a straight line. Each point of an object moves through the same distance, at the same time, in parallel paths.

c. Curvilinear motion: Both rotatory and translatory motions combine to produce this motion. It is the most common form of motion produced in human joints Ex: thrown ball, where the ball both moves through space and rotates on its own axis.

d. General plane motion: Here the object is segmented and free to move.

(ii) Location of motion: Motion at a joint may occur in transverse, frontal or sagittal planes.

(iii) Direction of Motion: Movement may occur either in clockwise or anticlockwise direction. Flexion and extension generally occur in sagittal plane around coronal axis. Flexion refers to rotation of one or both bony levers around a joint axis so those ventral surfaces are being approximated. Rotation in the same plane in the opposite direction is termed extension.

Abduction and adduction occur in frontal plane around Antero-posterior axis. Abduction is rotation of one or both segments of a joint around an axis so that the distal segment moves away from the midline of the body. Adduction in same plane but in opposite direction.

Rotation occurs in horizontal plane around vertical axis. Medial rotation refers to rotation toward the body's midline. Lateral rotation refers to the opposite direction.

(iv) Magnitude of Motion can be given either in degrees or radians.

One radian = 57.3°

$1^\circ = 0.01745$ radians

Goniometer is most widely used measure for joint range in degrees.

KINETICS

Kinetics means it is the area of biomechanics concerned with the forces producing motion or maintaining equilibrium. All forces are described as either External or Internal forces. External forces are pushes or pulls on the body arise from sources outside the body. Ex: Gravity. Internal forces are forces act on the body arise from sources within human body Ex: Muscles, bones etc.

Gravity: It is force by which all the bodies are attracted to earth. It is the most consistent force encountered by human body and behaves in a predictable manner.

CENTER OF GRAVITY (COG): It is the point through which the earth's attraction effectively acts regardless of position of body.

The center of gravity (COG) of human body lies approximately at S2, anterior to sacrum.

LINE OF GRAVITY (LOG):- It is the vertical line through centre of gravity. When the human body is in fundamental standing position, the line of gravity (LOG) pass through vertex and a point between the feet, level with transverse tarsal joints.

BASE OF SUPPORT: It is the area which is supported. In human body base of support is the area bounded posteriorly by tips of heels and anteriorly by a line joining the tips of toes.

EQUILIBRIUM: It results when the forces acting upon a body are balanced and the body remains at rest.

Types of equilibrium are

- **Stable equilibrium:** If the forces acting upon a body at rest tend to restore it to its original position after it has been displaced, the body is said to be in stable equilibrium.
- **Unstable equilibrium:** If a body is given an initial displacement and the forces acting upon it increase this initial displacement, the body is said to be in unstable equilibrium.
- **Neutral equilibrium:** If, in spite of displacement of a body, the height and position of its centre of gravity remain the same in relation to the base, the body is said to be in neutral position.

FIXATION AND STABILISATION

- Fixation is the state of immobility
- Stabilization is the state of relative immobility
- Active fixation of joints is obtained by co-combination of muscles.
- Passive fixation is by manual pressure straps, sand bags etc.

FORCE: It is that which alters the state of rest of a body or its uniform motion in a straight line

The force applied to a body is specified by

- a) direction of force
- b) Magnitude of force

Forces are classified as external force, internal force.

External force: It is supplied from a source outside the body, i.e. the force of gravity or the pressure of physiotherapist hand.

Internal force: It is supplied by forces developed within the body i.e. by muscular contraction.

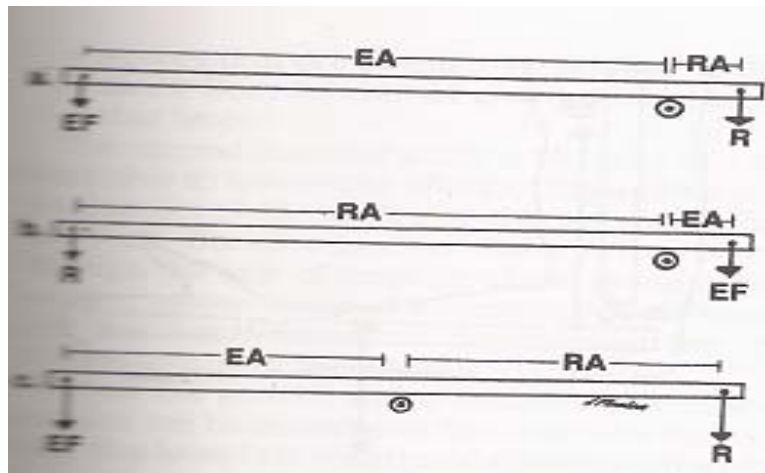
LEVER: It is a rigid bar that rotate around on axis

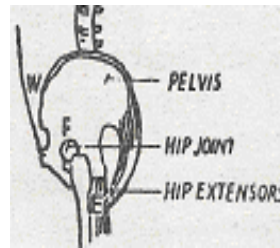
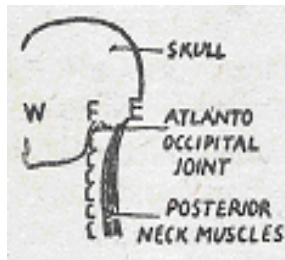
- Forces applied to levers will produce either equilibrium or movement such as rotation or translation.
- There are 3 orders or classes of levers.
- Lever is capable of producing a movement about a fixed point called fulcrum (F).
- Work is done when a force or effort (E), applied at one point on the lever, acts upon another force or weight (W), acting at second point on lever.
- The perpendicular distance from fulcrum to effort (E) is called as effort arm and from fulcrum to weight (W) is called as weight's arm.

1st Order Lever: Here fulcrum is in between the effort and weight; it may be situated centrally, or towards either the effort or the weight, consequently the efforts and the weight arms may be equal, or may exceed the other in length.

Ex: Nodding movements of head.

Skull represents lever atlanto-occipital joints represents fulcrum, the weight is situated anteriorly in the face and the effort is supplied by contraction of posterior neck muscles.

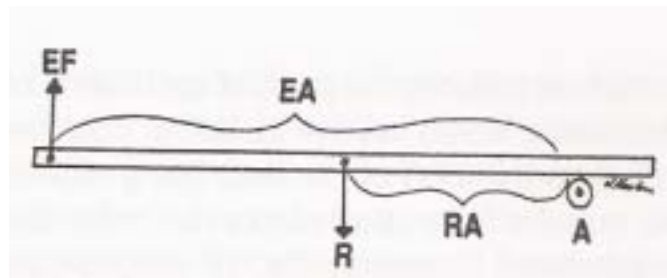




2nd Order Lever: The weight is in between fulcrum and effort, and the effort's arm must therefore always exceed the weight's arm. It helps in taking mechanical advantage, thus known as lever of power.

Ex: Rising of heels to stand on toes

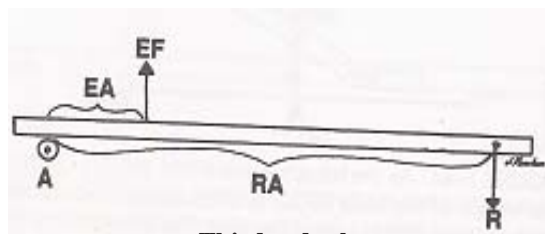
Tarsal and metatarsal bones are stabilized to form lever. Fulcrum is metatarsophalangeal joints weight of the body is transmitted to ankle joint by talus. Effort is applied by combination of calf muscles.



Second order lever

3rd Order Lever: Effort is in between fulcrum and weight, and weight arm must therefore exceed the effort arm. It serves as mechanical disadvantage. It is considered as lever of velocity as it offers more velocity and less stability.

Ex: When lever is forearm, fulcrum is elbow joint effort is supplied by contraction of brachialis muscle and weight is some object held in hand.



Third order lever

MECHANICAL ADVANTAGE: Efficacy of force in relation to lever depends on two factors.

They are

- i) Force exerted (W) or (E)
- ii) Perpendicular distance from fulcrum to the weight's arm or efforts arm.
 - When both weights arm and efforts arm are of equal length no advantage is gained.
 - However if the length of effort arm exceeds weight arm an advantage will be gained by the use of lever. This is known as Mechanical advantage.
 - Here less effort is required to lift a weight.
 - Mechanical advantage is obtained in 1st order lever when fulcrum is nearer to weight than to effort, and in all levers of the 2nd order. It is never obtained in 3rd order lever.
 - It is the ratio of weight to effort
M.A = W/E

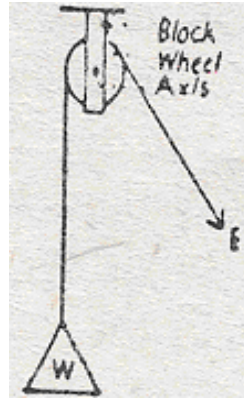
PULLEYS: Pulley is a grooved wheel which rotates about a fixed axis by a rope which passes round it. The axis is supported by a frame work or block.

Types of pulleys

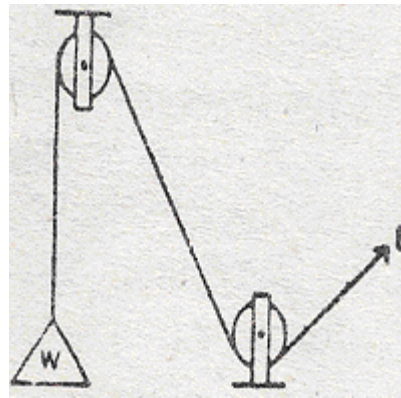
- i) Fixed pulleys
- ii) Movable pulleys

i) Fixed Pulleys: These are used to alter the direction of force. The pulley block is fixed and the rope which passes round the wheel is attached to the weight at one end and the effort is applied at the other.

ii) Movable pulleys: These are used to gain mechanical advantage when lifting heavy weights. Commonly used for lifting the trunk for suspension exercises. The upper pulley is fixed to an overhead support, to which one end of rope is attached. The rope is then wound round the movable pulley, to which the weight is attached, and round the fixed pulley, the effort being applied at the free end.



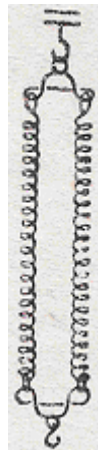
Single Fixed Pulley



Two Fixed Pulley

SPRINGS:

Spiral springs are used either to resist or to assist the force of muscular contraction, or to produce passive movement of joint, consist of a uniform coil of wire which is extensible.



Springs in Parallel



Springs in Series

Springs used in parallel: When a spring of a specific weight is not available two equal springs of half the required weight may be used in parallel to produce the same result.

Springs used in series: The weight of two equal springs arranged in series is same as that of a single spring, but the amount by which they must be extended in order to reach the limit of extension is double that required for a single spring.

ELASTICITY: It is the property of a body which regains its original shape after the application of force.

TYPES OF MUSCLE CONTRACTION:

- Isometric
- Isotonic

Isometric contraction involves the development of force by an increase in intramuscular tension without any change in length of the muscle.

Isotonic contraction increases intramuscular tension accompanied by change in length of the muscle. It may either shorten or lengthen the muscle.

Types of Muscle work:

Work is the product of force and distance through which the force acts

Types are

- Static Muscle work:** Muscles contract isometrically to balance opposing forces and maintain stability. Therefore no work is done.
- Concentric Muscle Work:** the muscles contract isotonicly in shortening to produce movement.
- Eccentric Muscle Work:** the muscles contract isotonicly in lengthening. The muscle attachments are drawn apart.

Range of Muscle Work: The amount of shortening or lengthening of muscle during contraction is about 50 percent of muscles maximum length.

Types of range are

- Inner range – muscle in its shortest position
- Outer range – muscle in fully extended position
- Middle range – muscle is neither fully shortened nor fully extended.

Group Action of Muscles: Integrated activity of many muscle groups is required for production of efficient functional movement. They are

i) Agonists: Group of muscles which contract to provide the force required to produce the movement.

ii) Antagonists: These muscles oppose the action of agonists and relax progressively for permitting the movement.

iii) Synergists: These groups of muscles work with agonists to provide a suitable activity and facilitates the movements

iv) Fixators: These muscles stabilize the bones of origin of the agonists and increases their efficiency for production of movement.

Limb Length Measurements:

- True shortening of leg is measured from the anterior superior iliac spine or upper margin of greater trochanter to lateral malleolus.
- Apparent shortening of leg is measured from umbilicus or xiphisternum to the level of knee joint or the tip of medial malleolus.

CHAPTER 2

GAIT

Gait may be described as a translatory progression of the body as a whole, produced by coordinated, rotatory movements of body segments.

Stages of gait:

I. stance phase: the stance phase begins at the instant that one extremity contacts the ground and continues only as long as some portion of the foot is in contact with the ground.

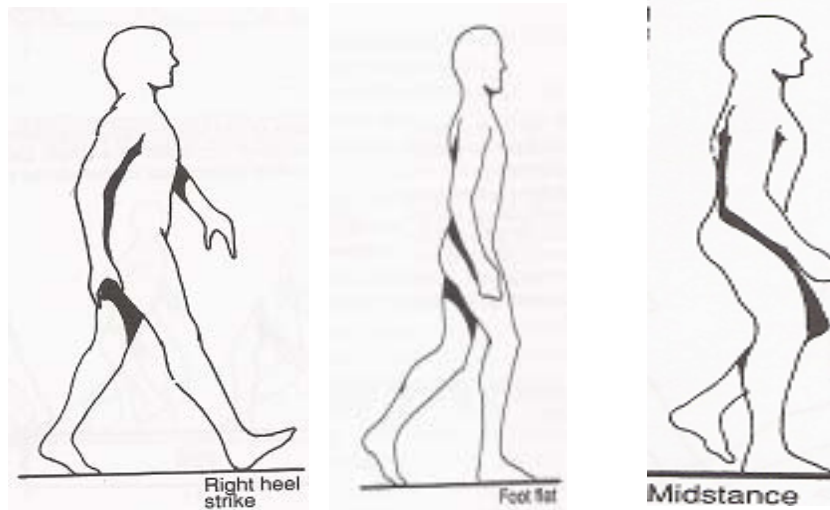
Heel strike: the beginning of the stance phase when the heel contacts the ground.

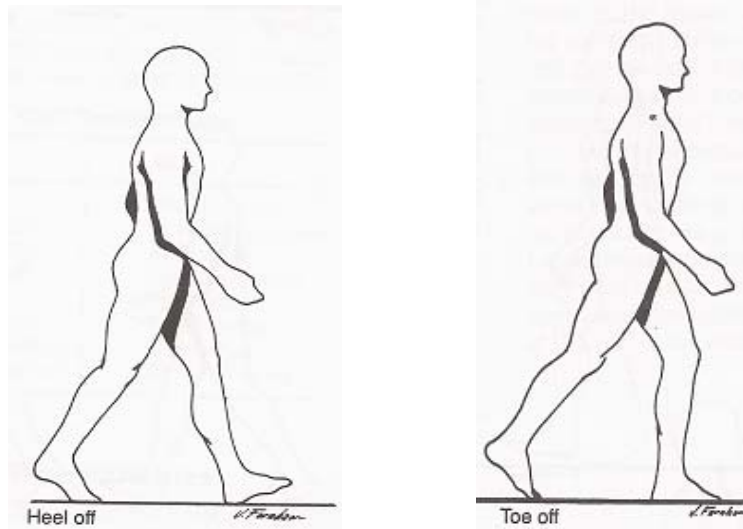
Foot flat: It occurs immediately following heel strike, when sole of the foot contacts the floor.

Mid stance: the point at which the body passes directly over the reference extremity.

Heel off: the point following midstance at which time the heel of the reference extremity leaves the ground.

Toe off: the point following heel off when only the toe of the reference extremity is in contact with the ground.



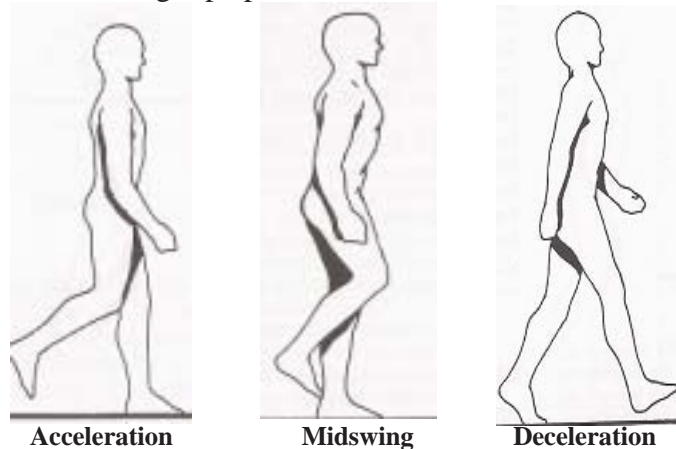


II. Swing phase: the swing phase begins as soon as the toe of one extremity leaves the ground and ceases just before heel strike or contact of the same extremity.

Acceleration: the portion of beginning swing from the moment the toe of the reference extremity leaves the ground to the point when the reference extremity is directly under the body.

Midswing: portion of the swing phase when the reference extremity passes directly below the body. Midswing extends from the end of acceleration to the beginning of deceleration.

Deceleration: the swing portion of the swing phase when the reference extremity is decelerating in preparation for heel strike.



Variables:

Stance time: It is the amount of time that elapses during stance phase of one extremity in a gait cycle.

Single-support time: It is the amount of time that elapses during the period when only one extremity is on supporting surface in the gait cycle.

Double-support time: It is the amount of time that a person spends with both the feet on the ground during one gait cycle.

Stride length: It is the linear distance from the point of heel strike of one lower extremity to the next heel strike of the same extremity.

Step length: It is the linear distance from the point of heel strike of one lower extremity to the next heel strike of the opposite extremity.

Stride duration: It refers to amount of time it takes to accomplish one stride.

Step duration: It refers to the amount of time spent during a single step.

Cadence: It is the number of steps taken by a person per unit of time.

Pathological gaits:

1. Antalgic or painful hip gait: this is the gait of a person with a painful condition in the hip joint. To minimize the pain the person shortens the time duration of the stance phase on the painful side and quickly transfers the weight to the painless leg.

2. Stiff hip gait: when one hip is ankylosed, it is not possible to flex at the hip joint during walking to clear the ground in the swing phase.

3. Unstable hip gait:

The stability of the hip in walking is provided by the bony components of the joint being kept in stable position by the muscles and ligaments around the joint. Any problem in these structures causes instability of hip.

a. Trendelenberg gait: eg. Anatomical disruption on the right side Ex: non union fracture neck of femur. The action of gluteus medius in pulling the pelvis downwards in the stance phase is ineffective or weak due to lack of a stable fulcrum. The pelvis drops on the opposite (i.e. left) side causing instability.

b. Gluteus medius gait: when the right gluteus medius is paralyzed, it is unable to pull down the pelvis on the right due to a functional deficiency of the abductor mechanism in the stance phase.

4. Gluteus maximus gait: when the gluteus maximus muscle is paralyzed, the stabilizing factor is lost and the patient leans backward at the hip to passively extend it and keep the centre of gravity over the stance leg. This causes the backward lurch in the gluteus maximus gait.

5. Quadriceps gait: when quadriceps power is weak or paralyzed; the locking is done by passively pushing the knee backward by the patient putting his hand over the front of the lower thigh. This results in a limp and may even cause genu recurvatum.

6. High stepping gait: when there is a foot drop, the foot slaps on the ground on heel strike and then drops in the swing phase. To get the foot clear the ground, the hip is flexed more and this causes the high stepping gait.

7. Short leg gait: inequality of the legs is obvious when the shortening of one leg is more than 1". It leads to gait with a marked pelvic tilt downwards and an equines deformity at the foot.

8. Scissoring gait: this is characteristic gait of a spastic child with marked bilateral spasm at the hips and equines spasm in the ankle.

CHAPTER 3

INTRODUCTION TO PHYSIOTHERAPY

Physiotherapy (also known as physical therapy) is a health profession concerned with and the assessment, diagnosis and treatment of disease and disability through physical means. It is based upon principles of medical science, and is generally held to be within the sphere of conventional (rather than alternative) medicine.

ROLE OF PHYSIOTHERAPY

1. It provides psychological support for the patient in depression.
2. It is useful in treating psychosomatic conditions.
3. It helps in treating deformities and making the functionally independent.
4. It plays a major role in treating neuro-muscular disorders.
5. It improves the walking abilities.
6. It relieves the pain, spasm etc.

PRINCIPLES OF TREATMENT

1. To relieve pain and spasm.
2. To increase joint range of motion.
3. To reduce the stiffness or contractures.
4. To improve muscle power.
5. To prevent deformities.
6. To relieve from spasticity.
7. To remove the secretions from the lungs.
8. To improve the breathing capacity.
9. To improve the aerobic capacity.
10. Improve gait pattern etc.

Methods and effects:

1. Heat therapy: By heating tissues there will be rise in the temperature and increase in the metabolic activity. As a result of increase in the metabolism there is an increased demand for oxygen and foodstuffs, and an increased output of waste products. There is blood flow to the part. All these physiological effects can be used to relieve the pain and spasm by increasing the circulation and carrying the waste products. e.g. superficial heating modalities are wax bath, Hydrocollateral packs etc. Deep heating modalities are SWD, IFT etc.

2. Cryotherapy: The initial of skin to cooling is vasoconstriction of blood vessels which is useful in reducing the inflammation. Cryotherapy also helps in reducing the spasticity by reducing the nerve conduction velocity of muscle spindles. It also reduces pain by stimulating cold receptors which inhibits pain carrying fibers.
3. Ultra Violet radiation therapy is used to control skin diseases.
4. Breathing exercises and postural drainage are used to reduce secretions and improve breathing capacity.
5. Passive and active exercises are used to increase joint ROM, deformities by preventing adhesion formation and maintaining circulation.
6. Resisted exercises to improve strength: To improve muscle strength resisted exercises can be given with the help springs, pulleys, weights etc.
7. Gait training to improve gait: after any musculoskeletal and neurological deficits the patient tends to develop abnormal gait. To correct this we have teach gait training to the patient by using assistive devices such as crutches, frames, orthotics etc.

These are some of the means of physiotherapy. There are so many other uses which be dealt later in the text.

CHAPTER 4

AN INTRODUCTION TO EXERCISE THERAPY

Exercise therapy is a means of accelerating the patient's recovery from injuries and diseases which have altered his normal way of living.

The aims of exercise therapy

1. To promote activity and minimize the effects of inactivity.
2. To increase the normal range of motion.
3. To strength the weak muscles.
4. To improve the performance in daily activities.

The techniques of exercise therapy

Movement used in treatment may be classified as follows.

I. Active movements

1. Voluntary: (i) assisted
(ii) Free
(iii) Assisted-Resisted
(iv) Resisted
2. Involuntary reflex

II. Passive movements

- a. (i) Relaxed Passive Movements and accessory movements
- b. Passive Manual Mobilization Techniques
 - (i) Mobilizations of joints
 - (ii) Manipulations of joints performed by
 - (iii) Controlled sustained stretching of tightened structures

Posture: movement begins and ends in posture which is classified either as active or passive.

Active movement and posture is achieved by muscular contraction in response to demands which are suitable to the patient's ability.

Passive movement and posture result from the application of external forces when the muscles are unable to contract voluntarily to permit movement or allow support.

The techniques which are most effective for obtaining the aims of treatment are those which

- (i) Demand as much activity as possible.
- (ii) Based on patterns of movement which are the same as those used by the patient for his normal functional activities.

The approach to the patient problem

The problems arising from loss of function are different for each patient therefore treatment must be planned according to the patient need.

Assessment of the patient's condition

1. Functional tests: these are used to assess the patient's needs and abilities with regard to functional activities e.g. mobility, personal care etc.
2. Test of range of motion: it is measured with the help of goniometer.
3. Tests for neuromuscular efficiency: these may be carried out electrically, manually or mechanically.

Electrically: these may be carried out with the help of electro-myography.

Manually: it can be done with manual muscle testing.

Mechanically: these are done with tape measurement.

Static power test: It may be recorded by means of a spring balance capable of registering up to 50 or 100 lbs.

Dynamic power test: the maximum weight which can be lifted once through a prescribed range is called the one repetition maximum (1 R.M).

4. Endurance test.
5. Speed test.
6. Tests for co-ordination.
7. Tests of sensation.
8. Measurement of vital capacity.

GONIOMETRY

The term goniometry is derived from two greek words, gonio, meaning angle, and metron, meaning measure. Therefore, goniometry refers to the measurement of angles, in particular the measurement of angles created by human joints.

Types of goniometry

1. Universal goniometry: These are most commonly used instrument. The body of a universal goniometer resembles a protractor and may form full or half circle. Measurement scales are located on the body (0-180 or 0-360). It consists of two arms stationary or fixed arm and movable arm. Stationary can not be moved. Movable arm is attached to the fulcrum which is the center of the body and it can be moved. It contains a black line extending the length of the arm for measuring the angle.

2. Gravity dependent goniometers: These are sometimes called inclinometers. They use gravity's effect on pointers and fluid levels to measure joint position and motion.

3. Electro goniometers: These are used primarily in research to obtain dynamic joint measurements. It is similar to that of universal goniometer.

4. Visual estimation: Although some examiners make visual estimates of joint position and motion but it is not a recommended position.

5. Pendulum goniometer: It consists of a 360 degree protractor with a weighted pointer hanging from the center of the protractor.

6. Fluid goniometer: It has fluid filled circular chamber containing an air bubble. It is similar to a carpenter's level, but being circular, has a 360 degree scale.

I. UPPER LIMB

Shoulder joint range of motion

1. Flexion

Recommended testing position: supine lying

Normal ROM: 0-180°

Fulcrum : acromial process

Movable arm: middle line of humerus

Fixed arm : midaxillary line of thorax

2. Extension

Recommended testing position: prone lying

Normal ROM: 0-60

Fulcrum : coracoid process

Movable arm: lateral midline of the humerus.

Fixed arm : midaxillary line of thorax

3. Abduction and Adduction

Recommended testing position: supine lying

Normal ROM: 0-180

Fulcrum : acromial process

Movable arm: medial midline of humerus

Fixed arm : parallel to the midline of the anterior aspect of the sternum.

4. Adduction

Normal ROM: 180-0

Rest is same as abduction

5. Medial rotation

Recommended testing position: supine lying, with the arm placed at 90 of abduction

Normal ROM: 0-70

Fulcrum : olecranon process

Movable arm : parallel to ulna

Fixed arm : parallel or perpendicular to the floor

6. Lateral rotation

Normal ROM: 0-90

Rest is same as medial rotation

ELBOW**1. Flexion and Extension**

Recommended testing position: supine lying

Normal ROM: 0-135

Fulcrum : Lateral epicondyle of humerus

Movable arm : lateral midline of the humerus

Fixed arm : midline of the humerus

2. Extension

Normal ROM: 135-0

Rest is same as flexion

FOREARM**1. Supination**

Recommended testing position: sitting with upper arm at the side of the body, elbow flexed to 90 and forearm supported

Normal ROM: 0-80

Fulcrum : lateral to the ulnar styloid process

Movable arm: ventral aspect of the forearm, proximal to styloid process

Fixed arm : anterior midline of humerus

2. Pronation

Recommended testing position: same as supination

Normal ROM: 0-80

Fulcrum : lateral to the ulnar styloid process

Movable arm : dorsal aspect of the forearm, proximal to styloid process of radius

Fixed arm : anterior midline of humerus

WRIST**1. Flexion**

Recommended testing position: sitting next to a supporting surface and hand facing the ground.

Normal ROM: 0-80

Fulcrum : lateral aspect of the wrist over the triquetrum

Movable arm : lateral midline of the fifth metacarpal

Fixed arm : lateral midline of the ulna

2. Extension

Recommended testing position: same as flexion

Normal ROM: 0-70

Fulcrum : at the level of capitate

Movable arm : volar midline of the third metacarpal

Fixed arm : volar midline of the forearm

3. Radial deviation

Recommended testing position: same as flexion

Normal ROM: 0-20

Fulcrum : at the level of capitate

Movable arm : dorsal midline of the third metacarpal

Fixed arm : dorsal midline of the humerus

4. Ulnar deviation:

Normal ROM: 0-30

Rest is same as radial deviation

II. LOWER LIMB

HIP JOINT

1. Flexion

Recommended testing position: supine lying

Normal ROM: 0-120

Fulcrum : lateral aspect of the hip joint

Movable arm: lateral midline of the femur

Fixed arm : lateral midline of the pelvis

2. Extension

Recommended testing position: prone lying

Normal ROM: 0-30

Rest is same as flexion.

3. Abduction

Recommended testing position: supine lying

Normal ROM : 0-45

Fulcrum : anterior superior iliac spine(ASIS) of the extremity being measured

Movable arm : anterior midline of the femur

Fixed arm : horizontal line extending from one ASIS to other ASIS

4. Adduction

Normal ROM: 0-30

Rest is same as abduction

5. Medial rotation and Lateral rotation

Recommended testing position: sitting on a supporting surface

Normal ROM: 0-45

Fulcrum : anterior of the patella

Movable arm: anterior midline of lower leg

Fixed arm : parallel to leg

KNEE JOINT

1. Flexion

Recommended testing position: prone lying

Normal ROM: 0-145

Fulcrum : Lateral epicondyle of the femur

Movable arm : lateral midline of the femur

Fixed arm : lateral midline of the fibula

2. Extension

Normal ROM: 145-0

Rest is same as flexion.

ANKLE JOINT

1. Dorsi flexion

Recommended testing position: sitting or supine

Normal ROM: 0-20

Fulcrum : lateral aspect of lateral malleolus

Movable arm : lateral aspect of fifth metatarsal

Fixed arm : lateral midline of the fibula

2. Plantar flexion

Normal ROM: 0-50

Rest is same as dorsi flexion

3. Inversion

Recommended testing position: sitting with knee flexed to 90 and the lower leg over the edge of supporting surface

Normal ROM: 0-35

Fulcrum : anterior aspect of the ankle midway between the malleoli

Movable arm : anterior midline of the second metatarsal

Fixed arm : anterior midline of the lower leg

4. Eversion

Normal ROM: 0-15

Rest is same as inversion.

CHAPTER 5

STARTING POSITIONS

Sherrington stated that every moment begins in posture and ends in posture. The postures from which movement is initiated are known as starting positions. There are five fundamental starting positions they are STANDING, KNEELING, SITTING, LYING and HANGING. Equilibrium and stability is maintained in these positions by balance of forces acting upon the body.

FUNDAMENTAL POSITIONS

1. STANDING

This is the most difficult of all the fundamental positions to maintain as the whole body must be balanced on a small base of support and by the coordinated work of many muscles. The position may be described as follows.

- (i) The heels are together and on the same line.
- (ii) The knees are together and straight.
- (iii) The hips are extended and laterally rotated slightly.
- (iv) The pelvis is balanced on the femoral heads.
- (v) The spine is stretched to its maximum length.
- (vi) The vertex is thrust upwards, the ears are levels and the eyes look straight forwards.
- (vii) The shoulders are down and back.
- (viii) The arms hang loosely to the sides, palms facing inwards towards the body.

Muscle work: the muscle work required to maintain the position varies with the circumstances. It is reduced considerably when the body segments are in good alignment and perfectly balanced.

1. The intrinsic muscles of the feet working to stabilize the feet.
2. The plantar flexors and dorsiflexors of the ankle working to keep the ankle in neutral.
3. The evertors, working to counterbalance the action of the invertors.
4. The extensors of the knee may work slightly.
5. The extensors of the hip, working to maintain hip extension and to pelvis on the femoral heads.
6. The extensors and flexors of the spine are working to keep the trunk upright.
7. The pre-vertebral neck muscles, working to control excessive extension of the neck.

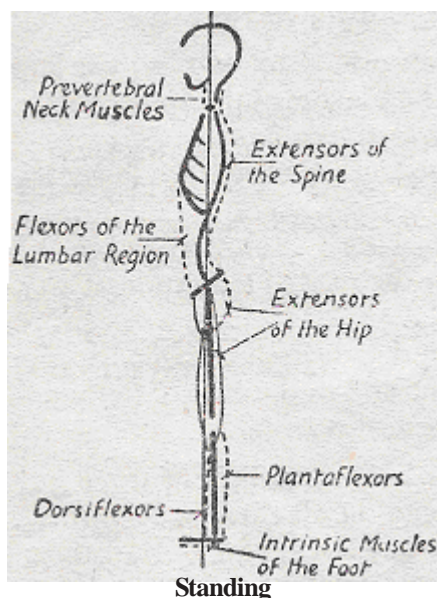
STARTING POSITIONS

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8. The flexors and extensors of atlanto-occipital joint, working reciprocally to balance the head.
9. The retractors of the scapulae, working to draw the scapula backwards.
10. The arms relaxed by the side of the body.

Effects and uses:

As the base of support is small and centre of gravity high standing is a difficult posture so this position should be given only to those who can maintain it. By practice in attaining and holding standing posture reduces fatigue. It is apposition of alertness, joy and efficiency.



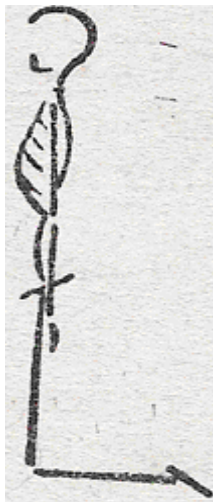
2. KNEELING

The body is supported on the knees which may be together or slightly apart. The lower leg rests on the floor with feet plantar-flexed. The rest of the body is held as in standing.

Muscle work:

The lower leg is relaxed; the body must be stabilized on the knees.

1. There is interplay between the flexors and extensors of the knee, to balance the femora vertically on the knees.
2. The extensors of the hip and the flexors of the lumbar spine work more strongly to maintain the correct angle of pelvic tilt.



Kneeling

3. SITTING

The position is taken on a chair or stool, the thighs are fully supported, the hips and knees to be flexed to a right angle and feet rest on the floor.

Muscle work:

The flexors of the hips work to maintain a right angle at these joints. The muscle work of rest of the body is same as in standing.

Effects and uses:

This is a comfortable, natural and very stable position. Many non-weight bearing knee and foot exercises and lateral and rotatory movements of the spine can be performed in this position.



Sitting

4. LYING

It is easiest of the fundamental positions as the body can be completely supported in the supine position.

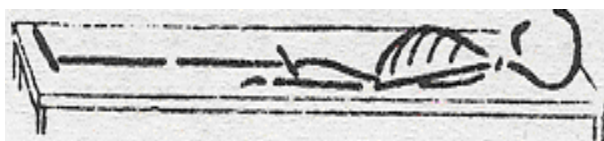
Muscle Work:

There is minimal muscle work in this position. When the lying position is used as the starting position for exercise it is usually taken on a firm surface.

1. Head rotators of both the sides work reciprocally to stabilize the position of the head.
2. The extensors of the hips and flexors of the lumbar spine work to counter balance the hollowing of the back.
3. The medial rotators of the hips work to keep the legs in the neutral position.

Effects and Uses:

This is an easy position so it is a suitable position for many exercises. The spine is relieved of the weight of the head and shoulders therefore it tends to elongate and straighten, hence it is used in treatment of spinal deformities. Breathing is impeded slightly by pressure on the thorax and abdomen, so this position is unsuitable for those suffering from respiratory or heart diseases.



Lying

5. HANGING

The body is suspended by grasping over a horizontal bar, the forearm being pronated, the arm straight. The head is held high. The trunk and legs hang straight with the heels together and ankle plantarflexed.

Muscle Work:

1. The flexors of the fingers work strongly to grasp the bar.
2. All the muscles around the wrist and elbows work to reduce the strain on the joints.
3. The adductors of the shoulders work strongly to lift the body on the arms.
4. The pre vertebral and posterior neck muscles work reciprocally to maintain the position of the head and neck.
5. The flexors of the lumbar spine and extensors of the hips work to correct the tendency to arch the back.
6. The adductors of the hips work to keep the legs together.

Effects and Uses:

As the weight of the shoulders is taken on the spine and weight of the legs exerts traction upon it, it is straightened and elongated. Breathing is difficult in this position. Therefore the position is unsuitable for respiratory or cardiac connections. This position is enjoyed especially by children.



Hanging

CHAPTER 6

PASSIVE MOVEMENT

These movements are produced by an external force during muscular inactivity or when muscular activity is voluntarily reduced as much as possible to permit movement.

Classification

- a. Relaxed Passive Movements, including accessory movements.
- b. Passive Manual Mobilization Techniques
 - (i) Mobilizations of joints
 - (ii) Manipulations of joints
 - (iii) Controlled sustained stretching of tightened structures

Specific Definitions

a. (i) Relaxed Passive Movements

These are movements performed accurately and smoothly by the Physiotherapist. A knowledge of the anatomy of joints is required. The movements are performed in the same range and direction as active movements. The joint is moved through the existing free range and within the limits of pain.

(ii) Accessory movements

These occur as part of any normal joint movement but may be limited or absent in abnormal joint conditions. They consist of gliding or rotational movements which cannot be performed in isolation as a voluntary movement but can be isolated by the physiotherapist.

b. Passive Manual Mobilization Techniques

(i) Mobilizations of joints

These are usually small repetitive rhythmical oscillatory, localized accessory, or functional movements performed by the physiotherapist in various amplitudes within the available range, and under the patient's control. These can be done very gently or quite strongly, and are graded according to the part of the available range in which they are performed.

(ii) Manipulations of joints performed by**a. Physiotherapists**

These are accurately localized, single, quick decisive movements of small amplitude and high velocity completed before the patient can stop it.

b. Surgeon/Physician

The movements are performed under anesthesia by a surgeon, or physician to gain further range. The increase in movement must be maintained by the physiotherapist.

(iii) Controlled sustained stretching of tightened structures

Passive stretching of muscles and other soft tissues can be given to increase range of movement. Movement can be gained by stretching adhesions in these structures or by lengthening of muscle due to inhibition of the tendon protective reflex.

PRINCIPLES OF GIVING RELAXED PASSIVE MOVEMENTS

Relaxation. A brief explanation of what is to happen is given to the patient, who is then taught to relax voluntarily, except in cases of flaccid paralysis when this is unnecessary. The selection of a suitable starting position ensures comfort and support, and the bearing of the physiotherapist will do much to inspire confidence and co-operation in maintaining relaxation through the movement.

Fixation. Where movement is to be limited to a specific joint, the bone which lies proximal to it is fixed by the physiotherapist as close to the joint line as possible to ensure that the movement is localized to that joint; otherwise any decrease in the normal range is readily masked by compensatory movements occurring at other joints in the vicinity.

Support. Full and comfortable support is given to the part to be moved, so that the patient has confidence and will remain relaxed. The physiotherapist grasps the part firmly but comfortably in her hand, or it may be supported by axial suspension in slings. The latter method is particularly useful for the trunk or heavy limbs, as it frees the physiotherapist's hands to assist fixation and to perform the movement. The physiotherapist's stance must be firm and comfortable. When standing, her feet are apart and placed in the line of the movement.

Traction. Many joints allow the articular surfaces to be drawn apart by traction, which is always given in the long axis of a joint, the fixation of the bone proximal to the joint providing an opposing force to a sustained pull on the distal bone.

Traction is thought to facilitate the movement by reducing interarticular friction.

Range. The range of movement is as full as the condition of the joints permits without eliciting pain or spasm in the surrounding muscles. In normal joints slight over pressure can be given to ensure full range, but in flail joints care is needed to avoid taking the movement beyond the normal anatomical limit.

As one reason for giving full-range movement is to maintain the extensibility of muscles which pass over the joint, special consideration must be given to muscles which pass over two or more joints. These muscles must be progressively extended over each joint until they are finally extended to their normal length over all the joints simultaneously, e.g. the Quadriceps is fully extended when the hip joint is extended with the knee flexed.

Speed and Duration. As it is essential that relaxation be maintained throughout the movement, the speed must be uniform, fairly slow and rhythmical. The number of times the movement is performed depends on the purpose for which it is used.

Effects and Uses of Relaxed Passive Movements

(i) Adhesion formation is prevented and the present free range of movement maintained. One passive movement, well given and at frequent intervals, is sufficient for this purpose, but the usual practice is to put the joint through two movements twice daily.

(ii) When active movement is impossible, because of muscular inefficiency, these movements may help to preserve the memory of movement patterns by stimulating the receptors of kinesthetic sense.

(iii) When full-range active movement is impossible the extensibility of muscle is maintained, and adaptive shortening prevented.

(iv) The venous and lymphatic return may be assisted slightly by mechanical pressure and by stretching of the thin-walled vessels which pass across the joint moved. Relatively quick rhythmical and continued passive movements are required to produce this effect. They are used in conjunction with elevation of the part to relieve oedema when the patient is unable or unwilling, to perform sufficient active exercise.

(v) The rhythm of continued passive movements can have a soothing effect and induce further relaxation and sleep. They may be tried in training relaxation and, if successful the movement is made imperceptibly and progressively slower as the patient relaxes.

PRINCIPLES OF GIVING ACCESSORY MOVEMENTS

The basic principles of relaxation and fixation apply to accessory movements as to relaxed passive movements. Full and comfortable support is given and the range of the movement is as full as the condition of the joint permits. They are comparatively small movements.

Effects and Uses of Accessory Movements

Accessory movements contribute to the normal function of the joint in which they take place or that of adjacent joints.

In abnormal joint conditions there may be limitation of these movements due to loss of full active range caused by stiffness of joints from contracture of soft tissue, adhesion formation or muscular inefficiency. Accessory movements are performed by the Physiotherapist to increase lost range of movement and to maintain joint mobility. Hence they form an important part of the treatment of a patient who is unable to perform normal active movement.

PRINCIPLES OF PASSIVE MANUAL MOBILISATIONS AND MANIPULATIONS

These techniques, together with their effects and uses, cover a very wide field which is beyond the scope of this book. Specific reference to books by Maitland, Grieve, Kaltenborn and other authorities on the subject is given in the bibliography.

Manipulations performed by a surgeon or physician are usually given under a general or local anesthetic which eliminates pain and protective spasm, and allows the use of greater force. Even well-established adhesions can be broken down; but when these are numerous, it is usual to regain full range progressively, by a series of manipulations, to avoid excessive trauma and marked exudation. Maximum effort on the part of the patient and the physiotherapist must be exerted after manipulation to maintain the range of movement gained at each session, otherwise fibrous deposits from the inevitable exudation will form new adhesions.

PRINCIPLES OF GIVING CONTROLLED SUSTAINED STRETCHING OF TIGHTENED STRUCTURES

The patient is comfortably supported and as relaxed as possible in an appropriate position. With suitable fixation the part is grasped by the physiotherapist and moved in such a way that a sustained stretch can be applied to the contracted.

structures for a period of time within a functional pattern of movement. Mechanical means can be used, e.g. turnbuckle plaster.

Effects and Uses of Controlled Sustained Stretching

(i) Steady and sustained stretching may be used to overcome spasticity patterns of limbs, e.g. a hemiplegic patient. The slow stretch produces a relaxation and lengthening of the muscle.

(ii) A steady and prolonged passive stretch can overcome the resistance of shortened ligaments, fascia and fibrous sheaths of muscles as, for example, in controlled stretching and progressive spintage of talipes equino varus.

CHAPTER 7

ACTIVE MOVEMENTS

Definition

Movement performed or controlled by the voluntary action of muscles, working in opposition to an external force.

Classification:

Free exercise: the working muscles are subject only to forces of gravity acting upon the part moved or stabilized.

Assisted exercise: when muscle strength or co-ordination is inadequate to perform a movement an external force is applied to compensate for deficiency.

Assisted-resisted exercises: muscles may be strong enough to work against resistance in part of the range and not in others. External forces applied are adapted in every part of the range to the abilities of the muscles.

Resisted exercises: resistance is applied to the working muscles are artificially and systematically increased to develop the power and endurance of muscle.

FREE EXERCISE

Free exercises are those which are performed by the patient's own muscular efforts without the assistance or resistance of any external force, other than that of gravity.

Advantage: helps in maintaining range of motion by the patient itself without relying on others for this purpose.

Disadvantage: they frequently make insufficient demands on neuromuscular system to elicit the maximal response required for redevelopment of weak muscles.

Classification

1. Localized: These exercises are designed primarily to produce some local and specific effect, for example to mobilize a particular joint or to strengthen particular muscle groups.

2. General: These exercises usually involve the use of many joints and muscles all over the body and the effect is wide spread.

The technique of free exercises

1. The starting position is selected and taught to the patient with care.
2. Instruction is given in a manner which will gain the interest and co-operation of the patient.
3. The speed at which exercise is given depends on the effect required.
4. The duration of the exercise depends very largely on the patient's capacity.

The effect and uses of free exercises

1. Relaxation: rhythmical swinging movements assist in relaxation of hypertonic muscles.
2. Joint mobility: normal ROM is maintained by exercises performed in full range.
3. Muscle power and tone: it is increased by tension created by the muscles.
4. Neuromuscular coordination: it is improved by repetition of exercises.
5. Improves confidence of patient.

Assisted exercises

When the force exerted on one of the body levers by muscular action is insufficient for the production or control of movement, an external force may be added to augment it. As the power of muscle increases, the assistance given must decrease.

Technique

1. Starting position and pattern of movement: this must be well known and understood by the patient.
2. Fixation: adequate fixation of the bone origin of prime movers improves their efficiency.
3. Support: the part of the body moved is supported throughout to reduce the load on weakened muscles.
4. Antagonistic muscles: every effort must be made to reduce tension in the antagonistic muscles.
5. Traction: preliminary stretching of the weak muscles to elicit the stretch reflex.
6. Assisting force: the force used to augment the action of the muscles is applied in the direction of the movement.
7. The character of the movement: the movement should be smooth.
8. Repetitions: the number of times the movement is repeated depends on the condition of the patient.
9. The cooperation of the patient is essential during this exercise.

Effects and uses of assisted exercise

1. There will be production of movement which they are incapable of achieving.
2. The memory of the pattern of co-coordinated movement is stimulated by the correct performance.
3. Patient's confidence is increased.

Assisted-resisted exercise

This type of exercise constitutes a combination of assistance and resistance during a single movement.

Resisted exercise

The external force may be applied to the body levers to oppose the force of muscular contraction and there will be increase in muscle power and hypertrophy.

Technique

1. Starting position and pattern of movement: this must be well known and understood by the patient.
2. Fixation: adequate fixation of the bone origin of prime movers improves their efficiency.
3. Support: the part of the body moved is supported throughout to reduce the load on weakened muscles.
5. Traction: preliminary stretching of the weak muscles to elicit the stretch reflex.
6. Resisting force: a variety of means may be employed to supply the force used to resist the contraction of the working muscles, e.g. manual pressure, weights etc.
7. The character of the movement: the movement should be smooth and controlled.
8. Repetitions: the number of times the muscles are thrown into action against a resistance varies according to the condition of the patient.
9. The cooperation of the patient is essential during this exercise.

Resistances: a resisting force other than that provided by gravity and friction may be provided by

1. Physiotherapist
2. The patient
3. weights
4. Pulleys
5. springs
6. Water
7. Substances which are malleable

Effects and uses of resisted exercises

1. Muscle power can only be maintained or increased by contraction.
2. The blood flow to the working muscles is increased.
3. There will be a general rise in blood pressure.
4. Heat, which is produced as the result of strenuous muscular activity.

CHAPTER 8

RELAXATION

MUSCLES which are relatively free from tension and at rest are said to be relaxed. Tension develops in muscles as they work during contraction and this tension is reduced to a variable degree as the muscles come to rest during relaxation.

Muscle Tone

Under ordinary circumstances living muscles are never completely free from tension, as they retain a quality of firmness known as muscle tone even when they are as relaxed as possible.

Muscle tone, which represents a state of preparedness in resting muscles, is now thought to be maintained through the activity of the muscle spindle circuit. The efferent fibres of this small fibre nervous reflex pathway transmit impulses which produce a sustained contraction of the small intrafusal muscle fibres of the muscle spindles, while the large extrafusal fibres concerned in the production of voluntary movement remain relaxed.

Postural Tone

The contraction which persists in the muscles concerned with the maintenance of posture (chiefly the anti-gravity muscles) is called postural tone. Postural tone is maintained and regulated by a reflex mechanism, the fundamental basis of which is the myotatic or stretch reflex, although the higher centers also exert a controlling influence. Any stretching of the muscles by an external force, such as the force of gravity, stimulates sensory receptors situated within the muscles themselves and so gives rise to a discharge of motor impulses to the same muscles. These motor impulses bring about a contraction of a sufficient number of the muscles motor units to increase the tension sufficiently to enable the effects of the force which produced the stretching to be counterbalanced.

As tension in these muscles is increased in response to stretching of their constituent fibres by an external force, and in proportion to the degree of stretching to which they are subjected, it follows that the use of measures tending to reduce or eliminate the effect of this force assists in promoting their relaxation.

The degree and location of postural tone varies with any alteration in posture. It is greater in the upright positions, in which the force of gravity tends to stretch the muscles more strongly, than it is in recumbent positions, in which the effects of the force of gravity upon them is adequately counterbalanced by full support of the body. Those recumbent positions which provide full support for all segments of the body are therefore most suitable for obtaining general relaxation.

Voluntary Movement

Specific muscles contract as they work to initiate or control movement, but at the completion of the movement in question they relax and come to rest. There is a recognized biological principle that activity of living cells tends to be followed by inhibition of that activity. Contraction in any one group of muscles is accompanied by a reciprocal relaxation of the antagonistic group to allow movement to take place smoothly. These facts are of importance during consideration of methods designed to obtain relaxation of a particular group of muscles.

Mental Attitudes

Mental attitudes such as fear, anger and excitement give rise to a general increase in muscular tension which serves a useful purpose by preparing the muscles for rapid or forceful action.

Normally this tension, developed to serve a useful purpose, is relaxed when the need for it no longer exists, but in some cases it persists and becomes habitual which may lead to alterations in normal posture.

Recognition of a state of tension followed by voluntary relaxation of the muscles in which it is present provide a means of helping the patient to economize in nervous energy, and in cases where the tension has resulted in the reduction of the normal range of movement in a joint, an increase in mobility can be achieved.

As fear in one form or another is the most usual cause of persistent tension, the physiotherapist must do her best to reassure the patient and to gain his confidence and co-operation. An atmosphere conducive to rest, both mental and physical, contributes much for success in helping the patient to acquire the art of voluntary relaxation.

Degrees of Relaxation

The degree to which muscular tension can be reduced is very variable and it is better to regard the term 'Relaxation' merely as an indication that some reduction in tension has taken place. It is often possible to estimate the degree of relaxation achieved by gentle passive movement or by palpating the muscles, as for instance during massage, and the fact that a patient falls to sleep during treatment is ample proof that the method of obtaining general relaxation has been successful.

Pathological Tension in Muscles

A marked, persistent increase in muscular tension or tone is a feature of many pathological conditions which affect the nervous system. Lesions of the higher motor centres, and those which interfere with the normal function of the nervous

pathways which connect them with the spinal reflex arc, commonly result in an abnormal state of muscular tension which varies from hypertonicity to spasticity or rigidity. A temporary reduction in this tension in the affected area can be achieved in some cases by suitable means which promote relaxation, and this allows re-education of any functional activity which remains to take place.

TECHNIQUE**GENERAL RELAXATION**

Support, comfort and a restful atmosphere are basic conditions for general relaxation and may prove effective without additional methods.

a. Support

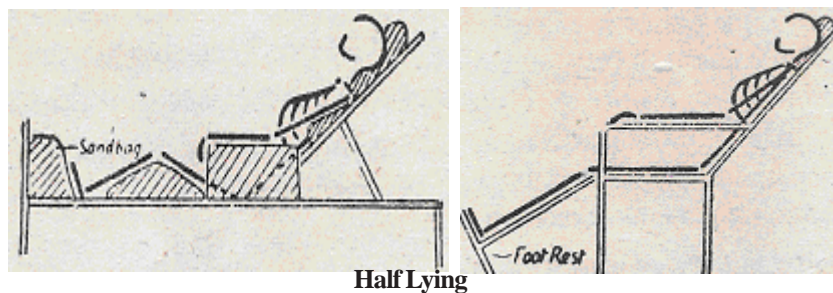
Various forms and modifications of the lying position are used, to achieve full support of the body, the relative suitability of each one varying according to the condition of the patient and to individual preference. The weight of the body is thus effectively counterbalanced by the uniform upward pressure of a reciprocal surface, or by suspension, in a position of semi-flexion which obviates all mechanical tension on muscles or ligaments.

(i) *Lying Supine*. A firm surface is essential, and if resilient also, as in the case of a good spring mattress, it is ideal, as it will mould itself to the body contours and give even press and comfort. At all costs plinths or beds which sag are to be avoided as they cramp the thorax and so throw additional strain on the inspiratory muscles. A head pillow is required which is sufficiently soft to prevent the head from rolling to either side, and to be well moulded to support the neck posteriorly. A small pillow under the knees relieves tension on the Hamstrings and the ilio-femoral ligament, and consequently allows the pelvis to roll backwards so that the lumbar spine is straightened and supported. The feet are held in the mid-position by a sandbag or similar device, and each arm, slightly abducted at the shoulder and flexed at the elbow, rests on a pillow.



Lying

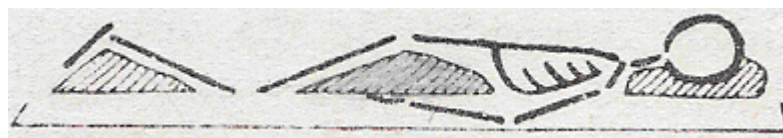
(ii) Half Lying. This is similar to the previous position but breathing is easier as there is less weight on the back and abdominal pressure on the under surface of the Diaphragm is reduced.



Half Lying

An armchair makes quite a good substitute for a plinth or bed, the thighs are fully supported and the feet rest on the floor, or a footstool, or a T footrest.

(iii) Prone Lying. The head is turned to one side and may rest on a small pillow, if more comfortable. A firm pillow under the hips and the lower abdomen prevents hollowing of the back, and for women it should extend higher to avoid too much pressure on the breasts; the lower leg is elevated so that the knees are slightly bent and the toes free. A degree of medial rotation at the hips, causing the heels to fall apart, still further induces relaxation of legs. Many find this position comfortable and use it for sleeping; others dislike it because of the rotated position of the head.



Prone Lying

(iv) Side Lying. The measure of relaxation obtained is governed by the efficiency with which the shoulder and pelvic girdles are stabilized. The arm and leg which are uppermost may be rested on the supporting surface instead of on pillows, but some of the weight then falls on the trunk and this impedes respiration. The head pillow supports the neck and head in alignment with the body, and must not be too high. The majority of people sleep on the side, but few are conscious of the part suitable positioning for relaxation plays in promoting it.



Side Lying

b. comfort

In addition to support and individual preference in positioning, for which some suggestions have already been made, the ingredients of comfort include freedom to breathe deeply, warmth, abdominal quiescence and a mild degree of physical fatigue. Removal of constrictive clothing, such as corsets and belts, is essential and any garters, buttons or suspenders liable to cause pressure must be removed. The room should be warm, but should have a free supply of fresh air; in winter additional warmth can be supplied by light but warm blankets, a covered hot-water bottle at the feet, an electric blanket or by non-luminous infra-red irradiation, but care being taken to avoid over heating, as this leads to restlessness. For home use a warm bath gives the most even and pleasing type of heat, but its soothing effect must not be ruined subsequently by vigorous rubbing with a towel. A light well-balanced meal, rhythmical physical activity of short duration, such as a brisk walk in the open-air, and attention to emptying the bladder before treatment are all conducive to general relaxation.

c. *Restful Atmosphere*

As physical and mental relaxations are interdependent, an effort must be made to secure a state of mental rest. The treatment-room should be as quiet as possible, as many people for whom training in relaxation is prescribed are highly susceptible to the disturbing influence of noise. A few are worried by complete silence, but in general it is the high-pitched intermittent sound produced close at hand which is to be avoided; the continuous low-pitched 'hum' of distant traffic tends to be soothing. Bright lights and strong colours, such as red and bright yellow, are said to be stimulating, whereas a room with low well-diffused light with for instance green and peach furnishings gives a soft and warm glow and provides an ideal setting for relaxation. This is indeed a counsel of perfection, but much can be done with screens and shades used with a little imagination, even in a busy department.

The most difficult and important factor in the creation of a restful atmosphere, and one which determines the ultimate success or failure of the treatment, is the manner and bearing of the physiotherapist. She must inspire confidence, as fear, in one form or another, is at the root of much of the tension which she can help to relieve. Her appearance must be tidy and her dress suitable; she must be punctual and move calmly without hurry or hesitation. Her manner must be courteous, pleasant and understanding and her voice low-pitched and clear. A simple explanation of the routine and any instructions required are given to the patient in language and terms which he can understand, so that any anxiety or fear of the unknown is removed.

It must be remembered that situations and routines with which one becomes very familiar often appear strange and terrifying when encountered for the first time. Conversation, apart from these instructions, should direct the patient's thoughts to contemplation of restful and pleasant topics.

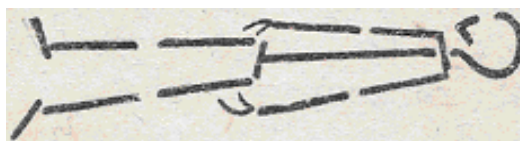
Confidence in the physiotherapist and the treatment is gradually built up over a period of time; immediate results are not to be expected and are rarely achieved, often because of psychological factors beyond the control of the physiotherapist or patient. In successful cases a habit of relaxation is built up in place of a habit of tension, but the formation of new habits takes time. Regular and frequent practice on the part of the patient is essential, until finally he becomes, an expert in the art of 'letting go' or relaxing, and the normal rhythm of life, in which activity alternates with relaxation, can be re-established.

d. Additional Methods of promoting Relaxation

Tension may persist in spite of the provision of conditions conducive to relaxation, in which case additional methods to help the patient may be employed. Very little should be attempted at first, the period of time being extended as the ability to relax improves.

Consciousness of Breathing. Under conditions of quiet and comfort the patient's mind may remain active and turn to mundane problems and anxieties, with associated physical tension; in this case it may help him to concentrate on his own rhythm of breathing, which must be deep with a slight pause at the end of expiration. Expiration is a phase of relaxation and should be accompanied by a feeling of 'letting go' in the whole body.

Progressive Relaxation, A method by which relaxation may be achieved progressively was devised and practiced by Jacobson of Chicago, and something similar appears in modern literature on the Yoga System as the 'Savasana' or 'Still Pose'.



Savasana - The Still Pose

Contrast Method. Difficulty in appreciating the sensation of relaxation is not uncommon; the patient does not know that the muscles are tense or what to do in order to relax them. This can often be taught by demonstrating the contrast between maximal contraction and the degree of relaxation which follows it, the patient being told to contract any group or series of muscles as strongly as possible and then to 'let go' and 'continue to let go'.

Success may be achieved by another method by which the patient is urged to step up this preliminary contraction until he is so tired that he has to let go; there is a large element of suggestion about this as it is unlikely and undesirable that a state of fatigue should actually be produced. This method follows the biological principle that activity of living cells tends to be followed by inhibition of that activity.

Routine contraction followed by relaxation is carried out in each area of the body, the attention traveling in logical sequence from limb to limb and to the trunk and head including the neck and face muscles until all areas can remain relaxed at one and the same time. Much practice may be necessary before this is accomplished, and it is not unusual for the muscles of the leg, for instance, to again become tense while attention has been focused on relaxation of the face muscles. Before the routine has been completed, the patient frequently drops off to sleep and general relaxation is obtained. When possible he should be allowed to wake naturally; alternatively, he must be wakened gently in sufficient time for getting up and dressing to be unhurried. Later, the patient learns to relax the muscles at will from the state of tension in which they are normally maintained, and without previous voluntary contraction.

Physiological Relaxation. This method of relieving tension was devised by Laura Mitchell, MC.S.P., Dip.T.P., in 1957. It is based on the physiological principle of reciprocal relaxation.

The position of tension of the whole body is defined in detail, viz. raised shoulders, bent-up elbows and hands, head and trunk flexed, etc. The patient changes the position of every joint in turn, by exact voluntary orders which he is taught to give to his own body, e.g., 'Stretch the fingers out long', 'Stop', 'Feel the straightened-out fingers and the fingertips touching the support'.

In this way, the patient induces, firstly, reciprocal relaxation in the muscles that had been working to maintain the tense positions, and then in the opposite group which he used to change that position. He registers the new position of the joints and skin pressures associated with them because these two senses reach the cortex. In this way, he changes the pattern of tension of the whole body to one of ease by means of a method which he can use by himself at any time, and so can stop mounting tension.

Passive Movement. Rhythmical passive movements of the limbs and head may assist the degree of general relaxation in some cases. These movements are generally given as a sequel to massage. Group movements of joints, e.g. flexion and extension of hip, knee and ankle, are preferable, but a very high standard of performance on the part of the physiotherapist is required to obtain results. The rhythm of small pendular movements pleases some patients.

The ability to promote a state of relaxation depends very largely on the individual physiotherapist and the particular patient with whom she is dealing, and details of successful methods employed vary widely. Ideal conditions are rarely obtainable and, indeed, are hardly desirable, for many patients must eventually learn to relax where and when they opportunity presents itself, e.g. in the train or on a mountain top after a strenuous climb. General relaxation can sometimes be carried out effectively in groups, as in the case of pregnant women, who tend to relax easily, and with some asthmatic and bronchitic sufferers who have had previous individual instruction.

LOCAL RELAXATION

General relaxation takes time and is not always essential or desirable. Methods of obtaining local relaxation depend to some extent on the cause and distribution of the tension.

Preparatory to Massage and Passive Movement

Massage and passive movement both presuppose relaxation of the area under treatment. Relaxation is obtained of a specific area by the application to that area of the general principles already described for the whole body. A general attitude of rest, however, will assist the process, e.g. the abducted and flexed arm supported by a table or slings is more inclined to relax when the patient lies or reclines in a chair, than when he sits bolt upright

For the Relief of Spasm

Spasm due to pain is protective and is most effectively reduced by the relief of the pain which caused it. However, if it persists because of fear of pain, techniques

which ensure pain-free movement are often successful. Hold-relax is applicable in these circumstances, or pendular movements which start in the free range and gradually increase in amplitude may restore confidence and achieve relaxation.

The relief of pathological spasm resulting from lesions affecting the central nervous system is only temporary unless some voluntary control remains and can be re-established. Temporary relief is useful to permit the re-development of voluntary control which is masked by the spasm and to maintain joint range and circulation in the affected area. The initiation of reflex movements by the use of the stretch reflex applied at the same time as a command for the patient voluntary effort of contraction can be used for this purpose but care must be taken to ensure that spasm which is useful is not reduced by hyperactivity of the antagonistic reflex unless sufficient voluntary power is present, e.g. extensor spasm of leg which makes it possible for the patient to stand.

In preventing and combating Adaptive Shortening

Persistent tension or hypertonicity of muscles acting upon one aspect of a joint produces a state of muscular imbalance which leads to adaptive shortening of the tense muscles and progressive lengthening and weakening of the antagonists on the opposing aspect of the joint. Both agonistic and antagonistic muscles are inefficient when this situation develops. Relaxation techniques for the shortened muscles and strengthening techniques for their antagonists are followed by integration of their reciprocal action to establish the increase in the range of movement.

CHAPTER 9

JOINT MOBILITY

Skeletal movements occurring at joints, type of movement, range of movement depends on anatomical structure of joint and position of muscles controlling it.

Joints are classified into synovial and nonsynovial joints.

1. Non synovial joints: are subclassified into

a) Fibrous joints: Bony components in this joint are united by thin fibrous tissue.

Ex: coronal suture

b) Cartilaginous joints: Bony components in this joint are connected by either hyaline cartilage or fibro cartilage.

Ex: symphysis pubis, 1st sternocoastal joint.

2) Synovial joints: are subclassified into

i) Uniaxial: Movement takes place about one axis. In a hinge joint it is flexion and extension eg: inter-phalangeal joints. In a pivot joint it is rotatory eg: atlanto-axial joint.

ii) Bi-axial: movement takes place about two axes. Ellipsoid joint-allow flexion, extension, abduction, adduction and circumduction. Saddle joint – such as carpometacarpal joint of thumb.

iii) Polyaxial: Movements about many axes occurs in ball and socket joints. They allow flexion, extension, abduction, adduction, circumduction and rotation.

LIMITATION OF JOINT RANGE OF MOTION

The following factors are responsible for limitation.

- i) Tightness of skin, superficial fascia.
- ii) Muscular weakness or insufficiency.
- iii) Adhesion formation.
- iv) Presence of foreign bodies in the joint.
- v) Tearing of intracapsular fibrocartilage.
- vi) Cartilaginous or bony destruction.
- vii) Sometimes the cause is unknown.

MOBILISING METHODS

1. Relaxation: when spasm causes limitation of movement, relaxation leads to an increase in range.

2. Relaxed passive movements including accessory movements: accessory movement is necessary to maintain or regain full joint function.

3. Passive manual mobilization techniques

i) Mobilization of joints

ii) Manipulations

iii) Controlled sustained stretching.

These techniques increase the mobility in joints and are followed by active exercise to maintain acquired range.

4. Active exercise

i) Assisted exercises: rhythmical movement, in which muscular contraction and assistance combine at the limit of the free range against the resistance of the limiting structures, is successful in increasing range.

ii) Free exercises: pendular movement is used with an attempt to increase the amplitude, series of contractions or pressing movements are performed at the limit of the range.

iii) Resisted exercises: techniques of PNF and strengthening exercises are effective for mobilization of stiff joints.

iv) Objective, occupational and diversional activities such as ball exercises, scrubbing, hiking etc. These techniques increase the circulation, improve patient interest and are useful for maintaining range and to increase joint mobility.

Techniques of joint mobilization.

I. ANKLE JOINT:

Relaxed passive movements

Half lying with the patient's knee bent over a firm pillow or across a physiotherapist's knee, leaving the heel unsupported. The physiotherapist places one hand above the joint and other hand round the foot.

Assisted exercises for the foot

Manual assistance can be given using the same grasp as passive movements. Self assistance given by means of a rope and pulley.

Free exercises**Non-weight bearing exercises for ankle joint**

1. Legs crossed sitting; foot dorsiflexion and plantarflexion.
 1. Inclined long sitting; alternate foot dorsiflexion and plantarflexion.
 2. Sitting; alternate heel and toe raising.

Weight bearing exercises

1. Reach grasp high toe standing; heel raising and lowering.
2. Reach grasp standing; foot inversion and eversion.
3. High standing; walk up inclined form.



Leg cross sitting



Inclined long sitting



Sitting

II. KNEE JOINT**Relaxed passive movements**

1. Hip and knee flexion and extension: patient in lying position, the physiotherapist gives support under the thigh with one hand and other hand grasps round the ankle. The hip and knee are then moved into flexion and extension.

Assisted and assisted-resisted exercises for knee joint

1. Knee flexion and extension: Manual assistance may be given for the flexors or extensors of the knee from side lying with the limb supported in the hands or on the surface of the plinth.

Free exercises for the knee joint

Non-weight bearing exercises

1. Lying; one hip and flexion and extension.
2. Side lying; one hip and knee flexion and extension.
3. Prone lying; alternate knee flexion and extension.

Partial weight bearing exercises

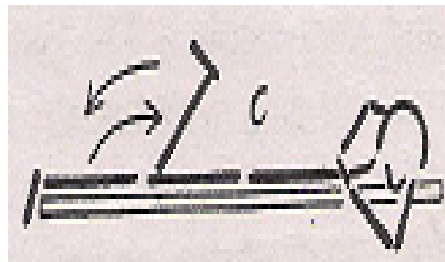
1. Bicycling on free or stationary bicycle.
2. Rowing on rowing machine.
3. Long sitting; receive and pass ball.

Weight bearing exercises

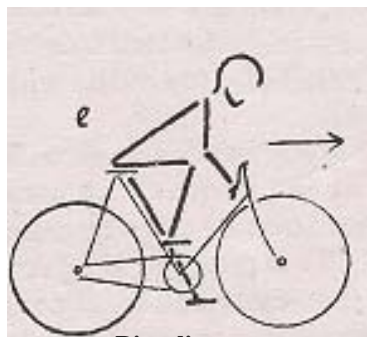
1. Crouch position; alternate leg stretching, with or without spring.
2. Prone kneeling; sit back on heels.



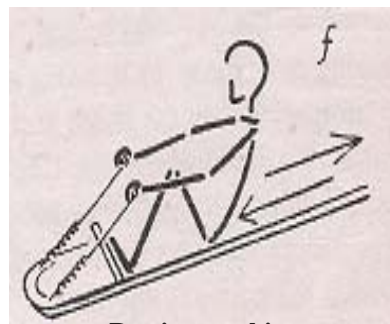
High sitting



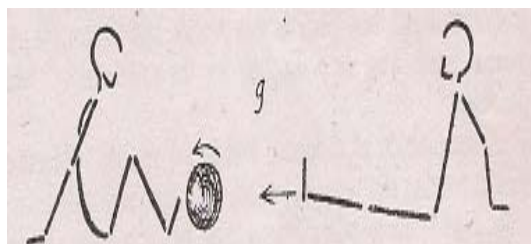
Prone lying



Bicycling



Rowing machine



Long sitting; receive and pass ball

III. HIP JOINT

Relaxed passive movements

1. Hip abduction and adduction, medial and lateral rotation, flexion and extension: the leg which is not to be moved is fully abducted and fixed, either by a sandbag or by bending the knee over the side of the plinth, and the patient relaxes. With the forearm supinated, one of the physiotherapist hands supports under the thigh, and with the other pronated she supports the lower leg at the ankle joint. Traction is given and the leg is moved into abduction and adduction. Medial and lateral rotation can be performed by giving traction on the heel and rolling the knee inwards and outwards with a stroking movement.

Assisted exercises for hip joint

As the limb to be moved is heavy, suspension and the use of roller skates are valuable means of assistance.

Free exercises

Non weight bearing exercises:

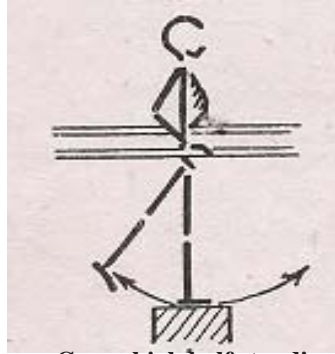
1. Grasp high half standing; leg swinging forwards and backwards.
2. Prone lying; leg medial and lateral rotation.

Partial weight bearing exercises

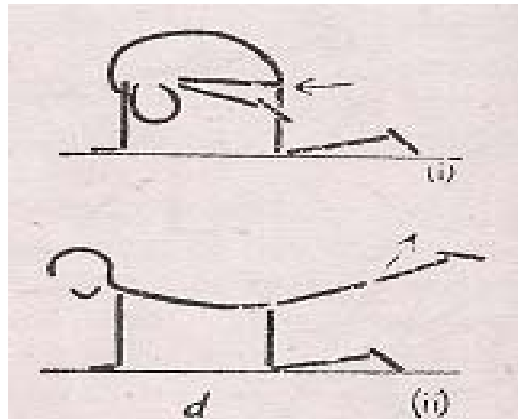
1. Heave grasp high half standing; arm stretching and one knee bending.
2. Crouch position; step or spring to stride prone falling.

Weight bearing exercises

1. Half kneeling; or step standing; forward pressing.
2. Stride standing; pelvis and trunk rotation.



Grasp high half standing



Prone kneeling

The prevention of muscle wasting

In flaccid paralysis

1. The affected muscles must be protected over stretching by adequate support and splintage.
2. The circulation of area must be maintained to ensure adequate nutrition to the paralyzed muscles by active exercise for other normal muscles in the area, contrast baths etc.
3. The range of movement in joints immobilized by the paralysis and extensibility of the affected muscles must be maintained by passive movements.
4. Remembrance of pattern of movement must be stimulated and kept alive by passive movement while active movement is impossible.
5. The strength and use of normal muscles in the area must be maintained by resisted exercise.

In spastic paralysis: It can be treated by proprioceptive neuromuscular facilitation techniques, controlled sustained passive stretching, active or passive mobilization may be preceded by massage or packing with ice.

The initiation of muscle contraction:

1. Warmth: moderate warmth improves the quality of contraction.
2. Stabilization: stabilization of the bones of origin of the affected muscles and of joints distal to those over which this muscles work, improves there efficiency.
3. Grip or manual contact: The therapist's hands give pressure only in the direction of the movement and give sensory stimulation.
4. Stretch: stimulation of the muscle spindles elicit reflex contraction of that muscle provided the reflex arc is intact.

Types of exercises used to strengthen muscles

Assisted-resisted exercises: these are rarely used to strengthen muscles except in cases of marked weakness.

Free exercises: free exercises are valuable as they can be practiced at regular and frequent intervals and at home.

Resisted exercises: these exercises create the tension in muscles essential for increase in power and hypertrophy.

CHAPTER 11

STRETCHING

Stretching is a general term used to describe any therapeutic maneuver designed to increase mobility of soft tissues and subsequently improve ROM.

Flexibility is the ability to move a single joint or series of joints smoothly and easily through an unrestricted, pain free ROM.

Hypomobility refers to decreased mobility or restricted motion.

Contracture is defined as the adaptive shortening of the muscle-tendon unit and other soft tissues that cross or surround a joint.

Indications for stretching

1. When ROM is limited due to adhesions, contractures etc.
2. Structural deformities.
3. When there is muscle weakness and shortening of opposing tissue.
4. Muscle soreness.

Contraindications

1. Recent fracture.
2. Acute inflammation.
3. Bony blocks joint motion.
4. When a haematoma exist.
5. Hypermobility exists.

Types of stretching

Self stretching: any stretching exercise that is carried out independently by a patient after instruction and supervision by a therapist is referred to as self stretching.

Static stretching: it is most common term used to describe a method by which soft tissues are lengthened just past the point of tissue resistance and then held in a lengthened position for an extended period of time with a sustained stretch force.

Static progressive stretching: the shortened soft tissues are held in a comfortably lengthened position until a degree of relaxation is felt by the patient or therapist. Then the shortened structures are lengthened even further and again held in the new end range position.

Cyclic (intermittent) stretching

A relatively short-duration stretch force that is repeatedly but gradually applied, released, and then reapplied is described as a cyclic stretching.

Ballistic stretching

A rapid, forceful intermittent stretch, that is, a high speed and high intensity stretch is commonly called ballistic stretching.

Mechanical stretching

There are many ways to use equipment to stretch a contracture and increase joint ROM. The equipment can be simple as a cuff weight or weight pulley system or as sophisticated as some orthosis or automated stretching machines.

Manual stretching

A therapist applies an external force to move the involved body segment slightly beyond the point of tissue resistance and available ROM.

Neuromuscular inhibition techniques: these procedures reflexively relax tension in shortened muscles prior to or during stretching.

Hold –Relax (HR)**Procedure**

1. Start with the range limiting muscle in a comfortably lengthened position.
2. Ask the patient to isometrically contract the tight muscle against resistance.
3. Then have the patient voluntarily relax.
4. The therapist moves the extremity through the gained range.
5. Repeat the entire procedure.

Precautions

1. The isometric contraction of the range should not be painful.
2. Multiple repetitions of prestretch isometric contractions can lead to an acute increase in arterial blood pressure.

Hold relax with agonist contraction (HR-AC)**Procedure**

1. Follow the same procedure as done for hold relax.
2. After the patient contracts the range-limiting muscle, have the patient perform a concentric contraction.

Precautions

Same as for hold relax.

Agonist contraction (AC)**Procedure**

1. Passively lengthen the range-limiting muscle to a comfortable position.
2. Have the patient perform a concentric contraction of the agonist muscle.
3. Apply mild resistance to the contracting muscle.
4. The range-limiting muscle will relax and lengthen as a result of reciprocal inhibition.

Precautions

1. Do not apply excessive resistance to the contracting muscle.
2. The AC technique is least effective if the patient has already achieved nearly full ROM.

Joint mobilization/manipulation: these are stretching techniques specifically applied to joint structures and are used to stretch capsular restrictions.

Soft tissue mobilization and manipulation: various techniques, including friction massage, myofascial release etc are designed to improve tissue mobility.

Selective stretching: it is a process whereby the overall function of a patient may be improved by applying stretching techniques.

Determinants of stretching exercises

Intensity: The lower the intensity, the longer the time the patient will tolerate stretching and soft tissues can be held in a lengthened position. The higher the intensity, the less frequently the stretching intervention can be applied.

Duration: stretch duration of 15, 30, 45, or 60 seconds or 2 minutes to lower extremity musculature have produced significant gains in ROM.

Frequency: frequency of stretching needs to occur a minimum of two times per week.

CHAPTER 12

FRENKEL'S EXERCISES

Dr. H. S. Frenkel was Medical Superintendent of the Sanatorium 'Freihof' in Switzerland towards the end of the last century. He made a special study of tabes dorsalis and devised a method of treating the ataxia, which is a prominent symptom of the disease, by means of systematic and graduated exercises. Since then his methods have been used to treat the incoordination which results from many other diseases, e.g. disseminated sclerosis.

He aimed at establishing voluntary control of movement by the use of any part of the sensory mechanism which remained intact, notably sight, sound and touch, to compensate, for the loss of kinaesthetic sensation. The process of learning this alternative method of control is similar to that required to learn any new exercise, the essentials being—

- a. Concentration of the attention.
- b. Precision.
- c. Repetition.

The ultimate aim is to establish control of movement so that the patient is able and confident in his ability to carry out those activities which are essential for independence in everyday life.

Technique

1. The patient is positioned and suitably clothed so that he can see the limbs throughout the exercise.
2. A concise explanation and demonstration of the exercise is given before movement is attempted, to give the patient a clear mental picture of it.
3. The patient must give his full attention to the performance of the exercise to make the movement smooth and accurate.
4. The speed of movement is dictated by the physiotherapist by means of rhythmic counting, movement of her hand, or the use of suitable music.
5. The range of movement is indicated by marking the spot on which the foot or hand is to be placed.
6. The exercise must be repeated many times until it is perfect and easy. It is then discarded and a more difficult one is substituted.
7. As these exercises are very tiring at first, frequent rest periods must be allowed. The patient retains little or no ability to recognize fatigue, but it is usually indicated by deterioration in the quality of the movement, or by a rise in

in the pulse rate.

Progression

Progression is made by altering the speed, range and complexity of the exercise. Fairly quick movements require less control than slow ones. Later, alteration in the speed of consecutive movements and interruptions which involve stopping and starting to command, are introduced. Wide range and primitive movements, in which large joints are used, gradually give way to those involving the use of small joints, limited range and a more frequent alteration of direction. Finally simple movements are built up into sequences to form specific actions which require the use and control of a number of joints and more than one limb, e.g. walking.

According to the degree of disability, re-education exercises start in lying with the head propped up and with the limbs fully supported and progress is made to exercises in sitting, and then in standing.

Examples of Frenkel's exercises

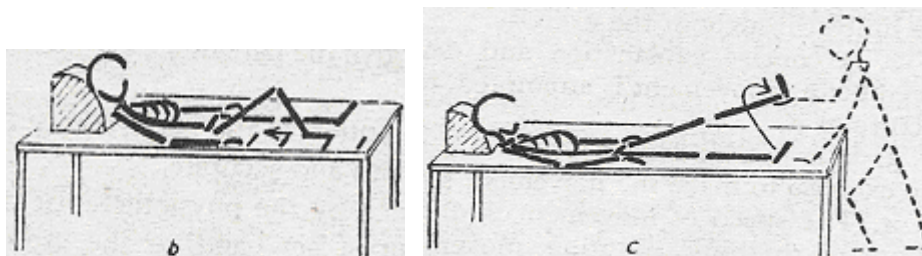
Exercise for the legs in lying.

a. lying (Head raised); Hip abduction and adduction.

The leg is fully supported throughout on the smooth surface of a plinth or on a re-education board.

b. lying (Head raised); one Hip and Knee flexion and extension. The heel is supported throughout and slides on the plinth to a position indicated by the physiotherapist.

c. lying (Head raised); one Leg raising top/ace Heel on specified mark. The mark may be made on the plinth, on the patient's other foot or shin, or the heel may be placed in the palm of the physiotherapist's hand.



Exercise for the legs in lying

d. lying (Head raised); Hip and Knee flexion and extension, abduction and adduction.

The legs may work alternately or in opposition to each other. Stopping and starting during the course of the movement may be introduced to increase the control required to perform any of these exercises.

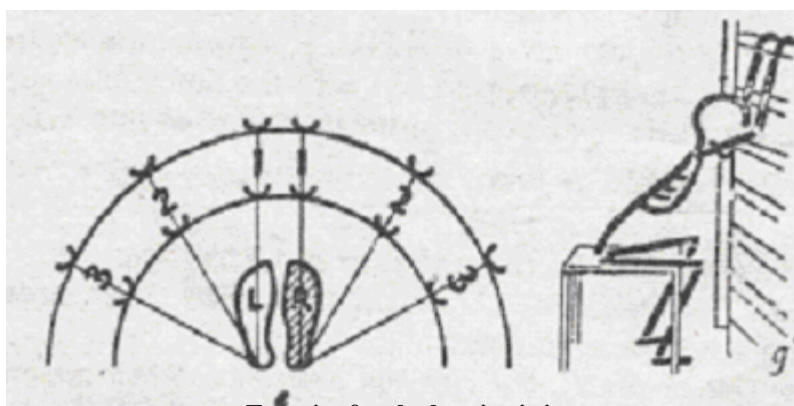
Exercise for the legs in sitting.

e. sitting; one Leg stretching, to slide Heel to a position indicated by a mark on the floor.

f. sitting; alternate Leg stretching and lifting to place Heel or Toe on specified mark.

g. stride sitting; change to standing and then sit down again.

The feet are drawn back and the trunk inclined forwards from the hips to get the centre of gravity over the base. The patient then extends the legs and draws himself up with the help of his hands grasping the wall-bars or other suitable apparatus.



Exercise for the legs in sitting

Exercise for the legs in standing.

h. stride standing; transference -of weight from Foot to Foot.

i. stride standing; walking sideways placing Feet on marks on the floor.

Some support may be necessary, but the patient must be able to see his feet.

j. standing; walking placing Feet on marks.

The length of the stride can be varied by the physiotherapist according to the patient's capacity.

k. standing; turn round.

Patients find this difficult and are helped by marks on the floor.

1. Standing; walking and changing direction to avoid obstacles.

Group work is of great value as control improves, as it teaches the patient to concentrate on his own efforts without being distracted by those of other people. In walking, he gains confidence and becomes accustomed to moving about with others, to altering direction and stopping if he wishes, to avoid bumping into them. The ability to climb stairs and to step on and off a kerb helps him to independence.

Diversional activities such as plaiting, building with toy bricks, or drawing on a blackboard, lead to more useful movements such as using a knife and fork, doing up buttons and doing the hair.

Exercises for the arms.

m. Sitting (one Arm supported on a table or in slings); Shoulder flexion or extension to place Hand on a specified mark.

n. Sitting; one Arm stretching, to thread it through a small hoop or ring.

o. Sitting; picking up objects and putting them down on specified marks.

EXERCISES TO PROMOTE MOVEMENT AND RHYTHM

All exercises are repeated continuously to a rhythmic count, or to suitable music.

a. sitting; one Hip flexion and adduction (to cross one Thigh over the other), the movement is then reversed and repeated.

b. half lying; one Leg abduction to bring Knee to side of plinth, followed by one Knee bending to put Foot on floor, the movement is then reversed and repeated.

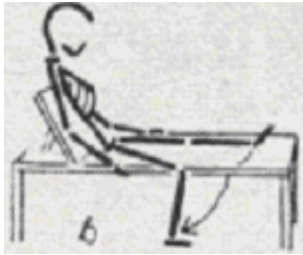
c. sitting, lean forward and take weight on Feet (as if to stand), then sit down again. Later this can be done progressing along the seat as if moving up to make room for someone else to sit.

d. standing; Arm swing forwards and backwards (with partner, holding two sticks).

e. standing or walking; bounce and catch, or throw and catch a ball.

Marching to music, ballroom dancing or swimming, if possible, should be encouraged.

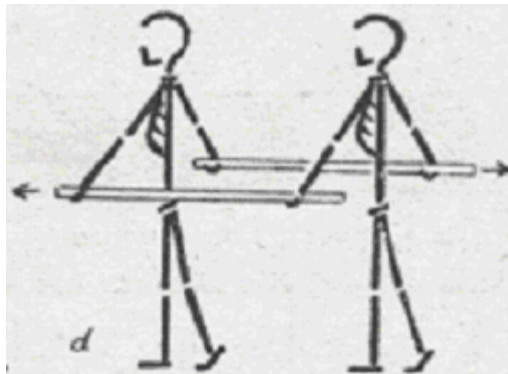
FRENKLE'S EXERCISE



Sitting hip flexion and adduction



**sitting, lean forward and
take weight on feet**



standing arm swinging forward and backward

CHAPTER 13

PROPRIOCEPTIVE NEUROMUSCULAR FACILITATION

Definition:

Proprioceptive: sensory receptors that give information about movement and position of the body.

Neuromuscular: involving the nerves and muscles.

Facilitation: making easy.

PNF is an approach in which treatment is directed at a total human being, not just at a specific problem or body segment. This method was developed by doctor Herman kabat and miss Margaret knott in 1946 and 1951.

Basic techniques.

1. Patterns of facilitation:

Mass movement patterns are used as the basis for all the techniques of PNF as these movements are similar to the normal functional movements. The pattern of movement is spiral or diagonal and they are observed in everyday use eg: in taking the hand to the mouth. Each pattern of movement has 3 components. Two components of the movement are angular and the third is rotatory eg: flexion adduction with lateral rotation of the leg or extension with rotation to the right of the lower trunk.

Effects and uses:

This pattern of movement represents the normal movements they can be repeated to improve movements which needs.

2. Manual contacts:

Pressure of the physiotherapist's manual contact on the patient provides a means of applying maximal resistance to movement in patterns. Touch contributes to facilitation by stimulating the exteroceptors. Manual contacts must be

- (i) Purposeful: Pressure must be firm, so that the patient must be aware of it.
- (ii) Directional: Pressure is applied only in the direction of the movement.
- (iii) Comfortable: Manual contacts which produce painful stimuli must be avoided.

3. Stretch stimulus and the Stretch reflex:

Proprioceptors situated in the muscles are stimulated by stretching, which increases the intramuscular tension which produces reflex contraction of the muscle. A sharp but controlled stretch reflex of the muscles at the limit of their extended range if given along with the dynamic command increases patient's effort to perform the movement.

Effects and uses:

Stretch reflex when applied to weak muscles increases their response and improves the strength.

4. Traction and approximation: Traction and approximation may be effective in stimulating proprioceptive impulses arising from joint structures. Traction is effective for facilitating flexion movements whereas approximation is effective for facilitating extension movements.

5. Commands to the patient:

The physiotherapist's voice is used as a verbal stimulus to improve patient's effort to perform movement. Commands should be simple, brief, accurate and well timed.

6. Normal timing:

Timing is defined as the sequence of muscle contraction occurring motor activity.

7. Maximal resistance:

It is defined as the greatest amount of resistance which can be given to muscular contraction. Maximal resistance is given both in isometric and isotonic contractions and for all the three components of the movement.

Effects and uses:

Resistance increases the motor units of the muscles and increases the strength and endurance of the muscles.

8. Re-inforcement:

Innumerable combinations of movements are utilized in every day life. So the proprioceptive stimulation which results from tension in strongly contracting muscles leads to spread or overflow of excitation to the weak muscles. Therefore, re-inforcement is used as a means of obtaining the contraction of weak muscles and to correct the imbalance.

TECHNIQUES OF EMPHASIS**1. Repeated contractions**

Repetition of activity against resistance is essential for the development of muscle strength and endurance. The contraction of specific weak muscles of a pattern is repeated while they are being re-inforced by maximal isotonic or isometric contraction of stronger muscles.

CHAPTER 14

HYDROTHERAPY

Hydrotherapy refers to the use of multi-depth immersion pools or tanks that facilitate the application of various established therapeutic interventions including stretching, joint mobilization, strengthening etc.

Application: To cure musculo-skeletal problems.

Indications for hydrotherapy:

1. Muscular problems: Muscular weakness, Muscle spasm, Tightness or contracture of muscles.

2. Bony or skeletal problems: Inflammatory conditions of spine, Arthritis of various joints, Post fracture stiffness.

3. Neurological Problems: Paralytic condition like polio, spinal cord injury, brain injury.

Goals:

1. Facilitate ROM exercises.
2. Initiate resistance exercises.
3. Facilitate weight exercises.
4. Facilitate cardiovascular exercises.
5. Enhance patient relaxation.

Properties of water:

Buoyancy: it is the upward force that works opposite to gravity. Buoyancy provides the patient with relative weightlessness and joint unloading allowing performance of active motion easily.

Hydrostatic pressure: it is the pressure exerted on the immersed objects. This increased pressure reduces or limits effusion, assists venous return, induces Brady cardia, and centralizes peripheral blood flow.

Viscosity: it is friction occurring between molecules of liquid resulting in resistance to flow. It creates resistance to all active movements.

Surface tension: the surface of the fluid acts a membrane under tension. Surface tension is measured as force per unit length. An extremity that moves through

the surface will perform more work than if kept under water.

Hydromechanics: Hydromechanics is the physical properties and characteristics of fluid in motion.

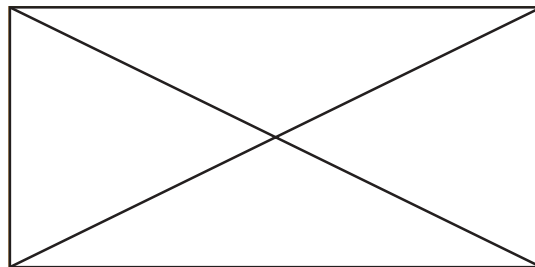
Components:

Laminar flow: Movements where all molecules move parallel to each other, typically slow movement.

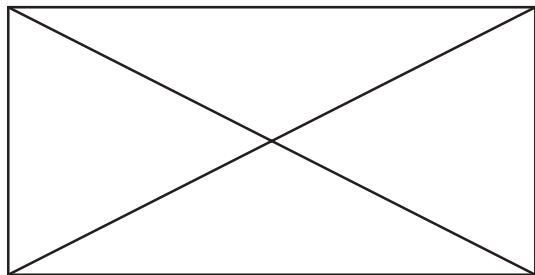
Turbulent flow: movement where molecules do not move parallel to each other, typically faster movements.

Drag: the cumulative effects of turbulence and fluid viscosity acting on a object in motion.

Center of buoyancy: the center of buoyancy is the reference point of an immersed object upon which buoyant forces of fluid act. In vertical position, the human center is located at the sternum.



Laminar flow



Turbulent flow

Application of hydrotherapy in treatment:

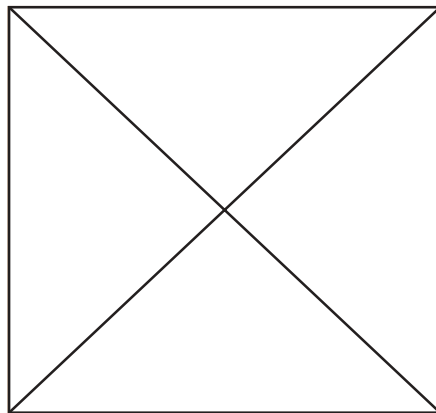
1. Strengthening of muscle: the water provides a remarkable environment to produce very fine exercise progression and it provides more resistance than air. Muscles are strengthened by resistance may be offered by upward force, turbulence force etc. Even manual resistance can be applied along with it.

2. Endurance training: muscular endurance refers to how many times the patient can repeat a particular activity inside water. The endurance activity can be performed against buoyancy, turbulence.

3. Joint mobility: relief of pain and muscle spasm by the warmth of the water and by the support of buoyancy can restore free movement of joint.

4. Co-ordination and balance: the buoyancy of water relieves the patient from weight and makes the activities like walking and step climbing easy.

5. Pain relief: hydrotherapy pool improves circulation and enable tissue fluid to flow through the tissues thus facilitates removal of metabolites and improves nutrition.



Moment of buoyancy causing rotation of the body

CONTRAINDICATION:

1. Infective wounds
2. Hyperpyrexia
3. cardiac failure
4. Deep vein thrombosis.
5. Gastro intestinal disorder
6. Hypo or Hypertension
7. Epilepsy
8. Low vital lung capacity

PRECAUTIONS:

1. **AIDS** – The person suffering from AIDS should not be allowed in pool if any have a recent cut.
2. If the person is mentally retarded.
3. If the person is wearing contact lens.
4. If the person is wearing any hearing aids.
5. Patients have fear of water.
6. Cardiac dysfunction: patients with angina and abnormal blood pressure require close monitoring.
7. Patients with epilepsy.

CHAPTER 15

BREATHING EXERCISES

Breathing exercises are designed to retrain the muscles of respiration, improve ventilation, lessen the work of breathing, and improve gaseous exchange and patient's overall function in daily living activities.

Indications

1. Acute or chronic lung disease: pneumonia, atelectasis, COPD etc.
2. After surgeries.
3. Airway obstruction due to retained secretions.
4. Deficits in CNS: spinal cord injury, myopathies etc.
5. As relaxation procedure.

Aims of breathing exercises:

1. Improve ventilation.
2. Increase the effectiveness of the cough mechanism.
3. Improve the strength, endurance and coordination of respiratory muscles.
4. Promote relaxation.
5. Improve chest and thoracic spine mobility.

Types of breathing

All the breathing patterns should be deep, voluntarily controlled and relaxed.

1. Diaphragmatic breathing:

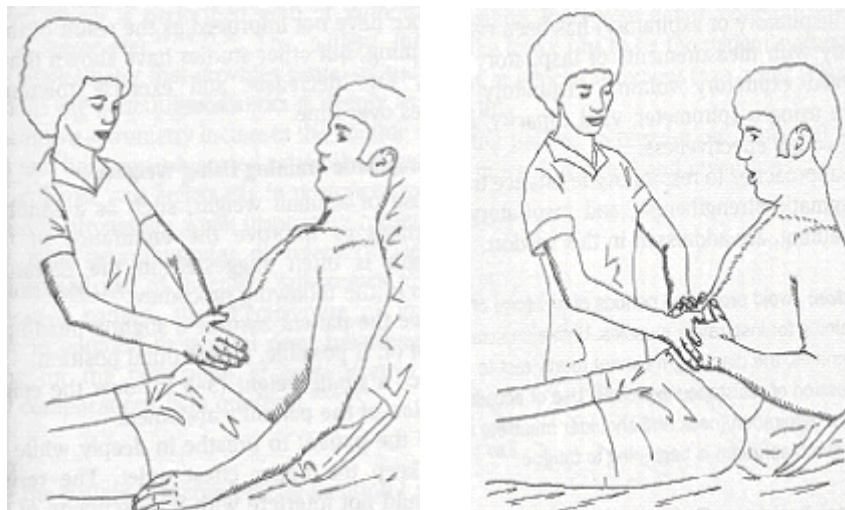
Place the patient in a relaxed position such as reclined sitting. Place your hands on the rectus abdomen just below the anterior costal margin. Ask the patient to breathe in slowly and deeply through the nose. Then tell the patient to slowly let the air out through the mouth. Practice this for 3 or 4 times. Then ask the patient to keep his or her hand on the abdomen and practice.

2. Ventilatory muscle training

The process of improving strength and endurance of muscles of breathing is known as ventilatory muscle training (VMT). This technique usually focuses on muscles of inspiration.

a. Diaphragmatic training using weights

Have the patient assume a supine lying. Place a small weight over the epigastric region of the abdomen. Tell the patient to breathe in deeply while trying to keep the upper chest quiet.



Diaphragmatic breathing

b. Inspiratory resistance training

The patient inhales through a hand held resistive device that he or she place in the mouth. These devices are narrow tubes of varying diameters that provide resistance to airflow during inspiration and improve strength of inspiratory muscles. Gradually the time is increased to 20 to 30 minutes.

c. Incentive respiratory spirometry

It is form of low-level resistance training. The patient inhales through a spirometer that provides visual or auditory feedback as the patient breathes in as deeply as possible. Place the patient in a comfortable position. Have the patient take 3 to 4 breaths and exhale with the fourth breath. Then have the patient place the spirometer in the mouth and maximally inhale through the spirometer and hold the inspiration for several seconds.

3. Segmental breathing

a. Lateral costal expansion

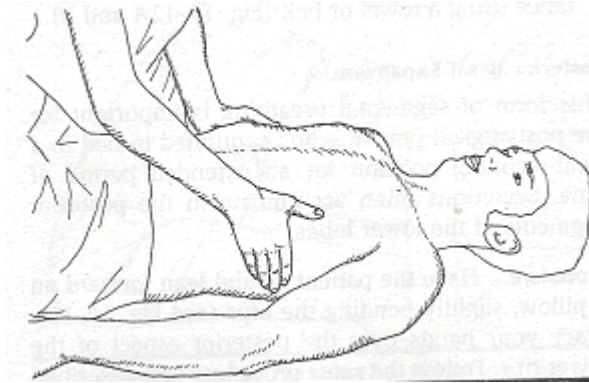
The patient will be in a hook-lying position. Place your hands along the lateral aspect of the lower ribs and ask the patient to breathe out, and feel the rib cage move downward and inward.

b. posterior basal expansion

Have the patient sit and lean forward on a pillow. Place your hands over the posterior aspect of the lower ribs. Follow the same procedure as above.

c. right middle-lobe or lingula expansion

Patient is sitting. Place your hands at either the right or left side of the patient's chest just below the axilla. Follow the same procedure as above.



Lateral costal breathing

d. apical expansion

Patient is sitting. Apply the pressure below the clavicle with the finger tips.

4. Glossopharyngeal breathing

The patient takes several gulps of air. Then the mouth is closed and the tongue pushes the air back and traps it in the pharynx. The air is then forced into the lungs and the glottis is opened. This increases the depth of the inspiration.

5. Pursed-lip breathing

Have the patient assume a comfortable position. Explain to the patient that expiration must be relaxed and contraction abdominals must be avoided. Instruct the patient to breathe slowly and deeply then have the patient purse the lips and exhale.

Coughing

An effective cough is necessary to eliminate respiration obstructions and keep the lungs clear.

The cough mechanism

The following series of action occur when a person coughs.

1. Deep inspiration.
2. Glottis closes and vocal cords tighten.
3. Abdominal muscles contract and the diaphragm elevates.
4. Glottis opens.
5. Explosive expiration of air occurs.

Additional means of facilitating a cough**Manual assisted cough**

If a patient has abdominal weakness, manual pressure on the abdominal area will assist in developing greater intra-abdominal pressure for a more forceful cough.

Therapist assisted techniques

With the patient in a supine or semi-recycling position, the therapist places the heel of one hand on the patient's abdomen at the epigastric area just distal to the xiphoid process. The other hand is kept on the first. After the patient inhales as deeply as possible, the therapist manually assists the patient as he or she attempts to cough.

POSTURAL DRAINAGE

POSTURAL DRAINAGE is a means of mobilizing secretions in one or more lung segments to the central airways by placing the patient in various positions so that the gravity assists in the drainage process. Postural drainage therapy includes the manual techniques such as percussion, vibration and voluntary coughing.

Aims

1. Prevent accumulation of secretions: Chronic bronchitis, cystic fibrosis, prolonged bed rest, post surgical patients etc.,
2. Remove secretions already accumulated: COPD, pneumonia, atelectasis etc.,

Contraindications

1. **Hemorrhage**
2. **Untreated acute conditions:** congestive heart failure, pleural effusion, pulmonary embolism etc.,
3. **Cardiovascular instability:** Hypertension, myocardial infarction
4. **Recent neurosurgery**

Manual techniques used during postural drainage therapy**Percussion**

Percussion is performed with cupped hands over the lung segment being drained. It is continued for several minutes or until the patient needs to alter position to cough.

Vibration

Vibration is applied by placing both the hands directly on the skin and over the chest wall and gently compressing and rapidly vibrating the chest wall as the patient breathes out.

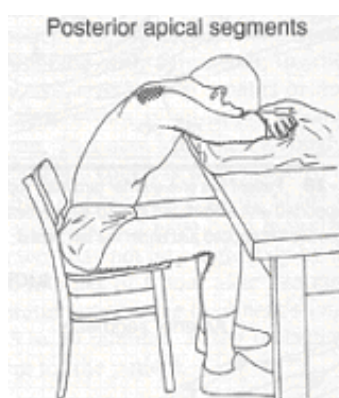
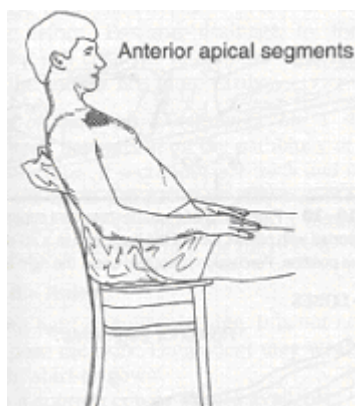
Shaking

Shaking is a more vigorous form of vibration applied during exhalation using an intermittent bouncing maneuver coupled with the wide movement of therapist's hands.

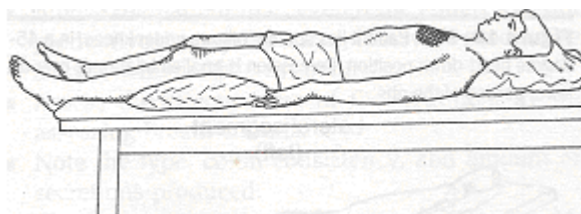
TREATMENT PROCEDURES

Right and left upper lobes.

1. **Anterior apical segments:** Percussion is applied directly under the clavicle
2. **Posterior apical segments:** Percussion is applied directly above the scapulae.

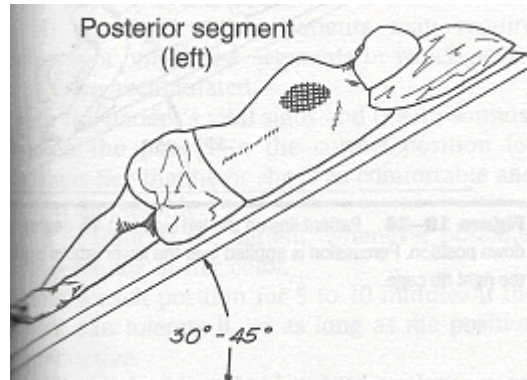


3. **Anterior segments:** Patient lies supine and percussion is applied directly above the nipple.

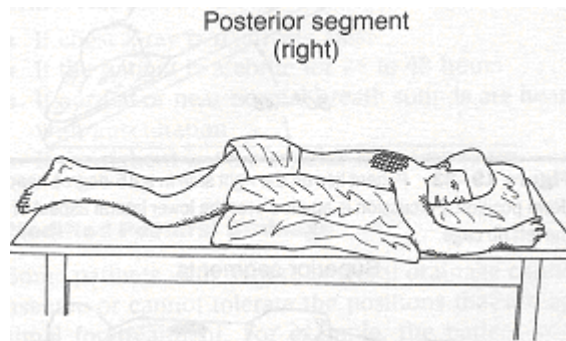


Anterior segments

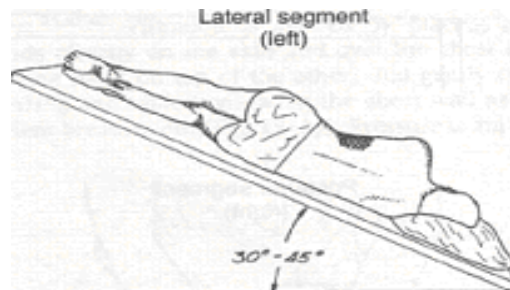
4. **Posterior segment (left):** patient lies one-quarter turn from prone and rests on right side. Head end is elevated to 18 inches. Percussion is applied over the left scapula.



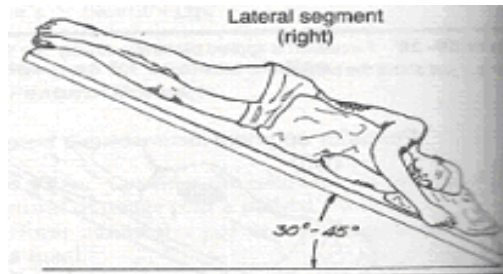
5. Posterior segment (right): patient lies flat one-quarter turn from prone on side. Percussion is applied over the right scapula.



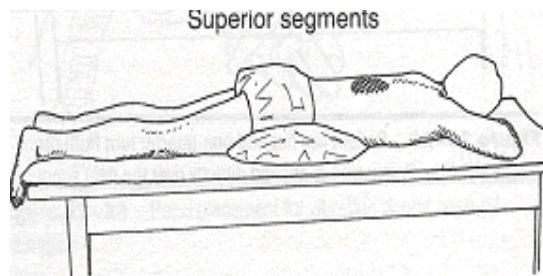
1. Lateral segment (left): patient lies on the right side in a 45 head down position. Percussion is applied over the lower lateral aspect of the left rib cage.



2. Lateral segment (right): patient lies on the left side in a 45 head down position. Percussion is applied over the lower lateral aspect of the right rib cage.



3. Superior segments: patient lies prone, pillows under the abdomen to flatten the back. Percussion is applied bilaterally, directly below the scapula.



CHAPTER 16

POSTURE

Posture is the attitude assumed by the body either with support during muscular inactivity, or by means of co-ordinated action of many muscles working to maintain stability.

Inactive postures: these are attitudes adopted for resting or sleeping, and they are most suitable for this purpose when all the essential muscular activity required to maintain life is reduced to minimum.

Active postures: the integrated action of many muscles is required to maintain active postures, which may be static or dynamic.

Static postures: a constant pattern of posture is maintained by the interaction of groups of muscles which work more or less statically.

Dynamic postures: the pattern of the posture is constantly modified and adjusted to meet the changing circumstances which arise as a result of movement.

The postural mechanism

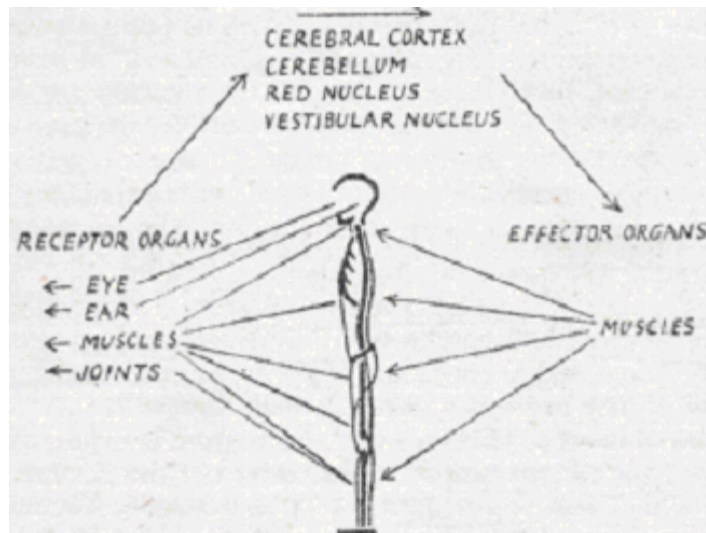
The muscles: the intensity and distribution of muscle work which is required for both static and dynamic postures varies considerably with the pattern of posture, and physical characteristic of the individual. The group of muscle most frequently employed are anti-gravity muscles.

Nervous control: postures are maintained or adopted as a result of neuromuscular coordination, the appropriate muscles being innervated by means of a very complex reflex mechanism.

The postural reflexes: a reflex is by definition, an efferent response to an afferent stimulus. The efferent response in this instance is motor one. The afferent stimulus is from variety of sources of the body such as muscles, eyes, ears and joint structures.

1. Muscles: neuromuscular and neurotendinous spindles within the muscles record changing tension.
2. The eyes: visual sensation records any alteration in the position of the body with regard to the surroundings.
3. The ears: stimulation of the receptors of the vestibular nerve results from the movement of fluid contained in the semicircular canals of the internal ear.
4. Joint structures: in the weight bearing position approximation of bones stimulates receptors in joint structures and elicits reflex reactions.

Impulses from all these receptors are conveyed and coordinated in the central nervous system.



Good posture: posture is said to be good when it fulfils the purpose for which it is used with maximum efficiency and minimum effort.

Development of good posture: the chief factors which predispose to the health and development of the muscles and the postural reflex are-

1. A stable psychological background.
2. Good hygienic conditions.
3. Opportunity for plenty of natural free movement.

Poor posture: posture is poor when it is inefficient, that is, when it fails to serve the purpose for which it was designed, or if unnecessary amount of muscular effort is used to maintain it.

Factors which predispose to poor posture:

General causes: mental attitude, poor hygienic conditions, prolonged fatigue etc.

Local factors: localized pain, muscular weakness, occupational stresses etc.

Principles of re-education

Mental attitude and poor hygienic conditions: it can be only remedied permanently by an alteration in the habitual mental attitude and by improvement of the hygienic conditions.

Postural defects: it may lead to structural changes such as marked lengthening of muscles and ligaments and may lead to limitation joint ROM. Relaxation, joint mobility exercises and repeated presentation of a satisfactory postural pattern will help in improvement.

Pain and muscle weakness: specific exercise to restore the balance of muscle power, local relaxation methods etc are given.

Occupational strains can sometimes be relieved by analysis of the movement required and substitution of a new pattern which is more satisfactory mechanically.

Technique of re-education

Relaxation

The ability to relax is an important factor in re-education.

Examples:

1. Crook lying, lying or prone lying; general relaxation.
2. Crook lying; relax shoulders to supporting surface, with expiration.
3. Sitting; shoulder shrugging and retraction followed by relaxation.

Mobility: the maintenance of normal mobility is essential to enable a wide variety of postures to be assumed. Normal mobility is maintained by general free exercises which are rhythmical in character and include full-range movement of all joints. Exercises and agilities which increase the respiratory excursions are of great importance and those which involve hanging positions give good alignment of the body.

Muscle power: if there is any muscular weakness it can be controlled by muscular development and helps to maintain their muscle tone and efficiency.

Presentation of a good posture

Head: an upward thrust of the vertex in the erect positions may be sufficient to achieve satisfactory alignment of the whole body.

1. Crook lying or lying with feet support; body lengthening.
2. Half lying, sitting or standing; head stretching upwards.

The pelvic tilt:

1. Crook lying; gluteal and abdominal contraction, followed by relaxation, then hollowing of back.
2. Low wing sitting; pelvis tilting and adjustment.

The feet:

1. Sitting; bracing of the longitudinal arch and pressing the toes to the floor.
2. Standing; hip rotation outwards.

CHAPTER 17

EXERCISE THERAPY EQUIPMENT

MAT EXERCISES

ACTIVITIES ON THE MAT/BED

Rolling — the roll over from lying supine to side lying

This requires a total flexion-with-rotation of the body which is initiated from and led by the head and neck. Strong limb activity is recruited to assist whenever it is available, e.g. to roll forward and to the left.

a. trunk rotation is facilitated by a strong pull on the left hand which grasps a fixture at the side of the bed. (Retraction of the left shoulder facilitates the protraction of the right.)

b. the right arm may be used to pull, thrust or swing across towards the opposite hip

c. the left leg can be hooked over the side of the bed and by flexing and adducting can assist rotation of the lower trunk and pelvis.

d. with the knee bent so that pressure on the right foot can lift and push the right side of the pelvis upwards and over, the rolling movement of the lower trunk can be completed.

A reversal of the movement returns the body to the supine position.

Purposes and use of the roll

1. He has the freedom to make the decision as to when he shall roll over to get a different view of his surroundings, ease the pressure on his back or stiffness of his legs; may be he can also reach and use a more comfortable sleeping posture.

2. This roll is the first part of an integrated series of movements which leads directly to a sitting position and to getting out of bed.



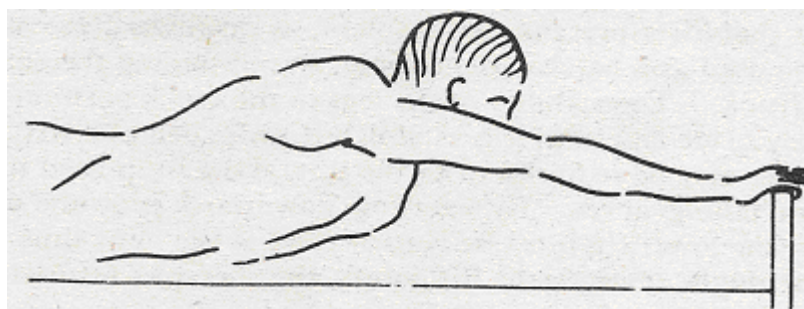
Rolling from supine to side lying

Rolling — the roll over from lying supine through side lying to prone or to roll forwards and to the left (alternative method)

The arm initiates and gives direction to the movement which enables the patient to roll forwards to lie on the left side and when the movement is continued the prone position is reached. The patient extends and rotates the head to watch the right hand as the arm is lifted to a position obliquely across the face and reaching out towards the head of the bed. Extension-rotation of the upper trunk follows the arm movement and brings the body to the side lying position.

Purpose and use of the roll

The most important aspect of this activity and of the prone position is that it helps to combat and counteract the effects of long-term recumbency in bed, sitting up in bed or reclining in a lounge chair.



Rolling from supine to prone

Bridging

From the crook lying position the pelvis is lifted to form the keystone to an arch the supports of which are the shoulders and the feet.

Purposes and use of bridging

- a. For the bed-bound patient bridging makes bedpan routines easier for everyone concerned.
- b. By lifting the lower back from the bed, sensitive pressure areas are relieved of the body weight. When elements of rotation and side flexion added to the lifting movement the weight can be transferred to one buttock or the other as it is lowered to the bed (preliminary training for transfers and ambulation).



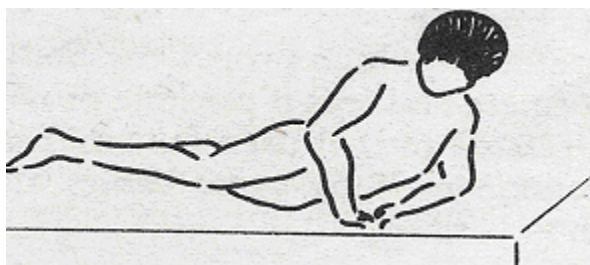
Bridging

Forearm support side lying

This position is usually reached by rolling to one side and then pushing with the elbow to support the upper trunk with the whole forearm. Both the shoulders should lie on the same plane; stability of the pelvis is ensured by bending one leg

Purpose and uses

- a. The position is used en route from lying to sitting.
- b. Some find it convenient for reaching across to a bedside table without sitting up.



Forearm support side lying

Prone lying with forearm support

This position may be reached from side lying with forearm support, the free elbow being moved to a position shoulder width from its fellow so that both shoulders are supported. The upper arms must be vertical to ensure balance in the position with minimum effort.

Purpose and uses

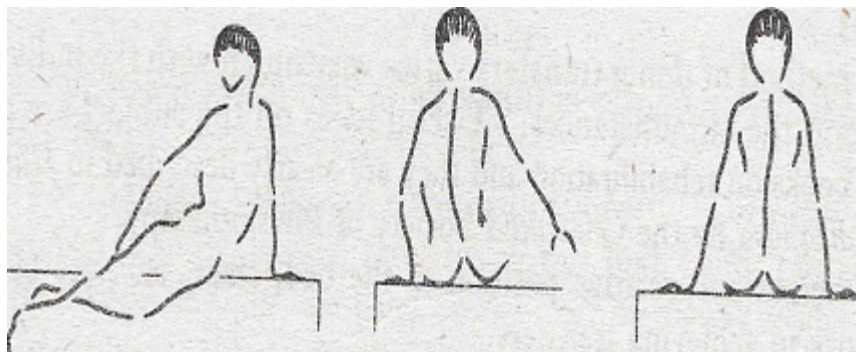
Extensibility of the hip joints and lumbar spine is maintained. Creeping movements which propel the body along the floor using the arms can be initiated from this position.



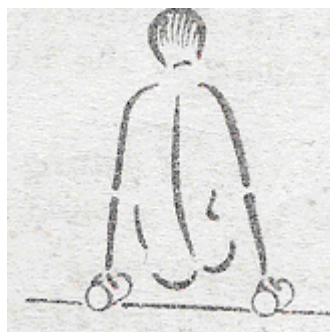
Prone lying with forearm support

Sitting — on the side of the mat/bed

From lying on one side propped up by the elbow the body is pushed upright by extension of the elbow as the legs are lifted and swung over the side of the bed. During the movement the body is pivoted on one buttock until the sitting position is reached when the weight is equally distributed through both buttocks.

**Sitting***Hitching and Hiking*

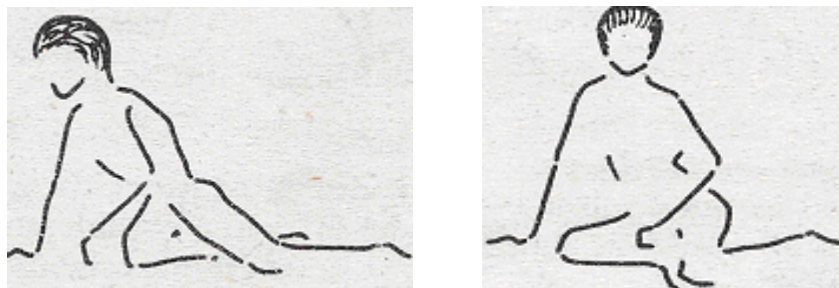
The ability to take the weight on the arms, lift and move the pelvis is essential for transfers for wheelchair patients, e.g. from bed to chair. Blocks, sandbags or short crutches help to make these easier for the patient to practice.

**Hitching****Hiking***Side Sitting*

Unlike the push up to sitting on the side of the bed, the push up to side sitting on the floor includes little or no rotation as the trunk is pivoted to sit upright. The legs are bent and remain resting on the floor.

Purpose and uses

This is an elegant way to sit either on the floor or out of doors for those who find it possible and comfortable. It can be practiced safely and it is easy to return to a resting position.



Side Sitting

Prone Kneeling

Prone kneeling or the 'four foot position' may be reached from prone lying when flexion is initiated by bending the head forward to put the chin on the chest, then by walking the hands backwards as the hips and knees bend.

Purpose and uses

This is the starting position for 'crawling' which gives the patient mobility at door level in any direction he wishes. It may prove very use for patients with vertigo and others who cannot bear weight on the feet for the time being.



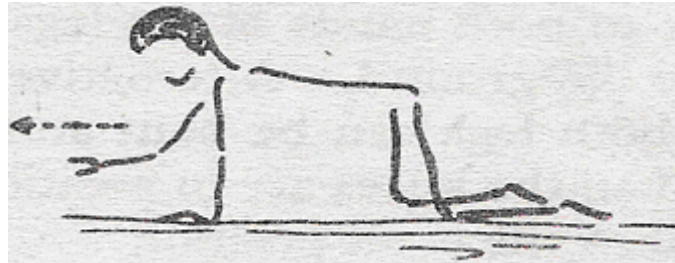
Prone Kneeling

Crawling

When balance and stability have been established in prone kneeling patients can begin to practice lifting a hand or a knee from the floor to balance 'on three legs'.

Purposes and uses of crawling

Crawling activities build up co-ordination of the whole body including reciprocal movement of the arms and legs as required in walking. The direction of the crawl, i.e. forwards, backwards; sideways determines the distribution and emphasis of the neuromuscular activity employed.



Crawling

Kneeling

One can kneel down or get up to kneeling.

Before the patient attempts to kneel it is advisable to make sure that,

- a. the surface on which to kneel is sufficiently comfortable for the patient to tolerate pressure on the knees;
- b. there is sufficient range of knee flexion, i.e. a minimum of about 100° .
- c. any furniture to be used for support is in the right position, firm and immobile. A chair or bed is better pushed back against a wall;
- d. any other disability which affects the patient has been taken into account, e.g. restriction of ankle joint movement, painful toes. Toes inadvertently beat under or pressed against a hard surface can be extremely painful.

Half Kneeling

To reach this position from kneeling the body weight is supported on one knee while the other leg is lifted and brought forwards to put the foot on the floor. From standing the half kneeling position can be assumed either by stepping forwards to kneel or by stepping backwards to kneel on one knee. Good balance or some support is essential for stability.

RE EDUCATION BOARD

It is a semi-circular board. Usually it is made up of wood. It will help in performing movement in gravity eliminated position and also against gravity.

Indications:

1. Hemiplegia.
2. Cerebral palsy.
3. Weakness of muscles.

Uses:

1. Assist in performing movement.
2. Maintain ROM.
3. Strengthening exercises.

SWISS BALL

It is a large inflated ball made up of plastic and filled with air used in physiotherapy department to give balance exercises. It has transverse ridges for friction.

Indications

1. Balance and co-ordination problems
2. Vestibular disease.
3. Cerebral palsy.
4. Lumbar pain.
5. Weakness of trunk muscles.

Uses

1. For postural training.
2. Gives balance training.
3. Head control training.
4. Strengthening of trunk and limb muscle.

SHOULDER WHEEL

It is mainly used for the purpose of shoulder rehabilitation. It is either made up of metal or wood.

Uses

1. To improve the range of motion of shoulder.
2. For strengthening the upper limb muscles.
3. To improve neuro muscular co-ordination.

Indications

1. Frozen shoulder.
2. Periarthritis shoulder.
3. Post traumatic stiffness of shoulder.
4. Weakness of shoulder muscles.

CONTINUOUS PASSIVE MOVEMENT (CPM)

It provides continuous passive motion to the applied joint. The apparatus can be used immediately after the operation to improve the range of motion, reduce pain, discomfort and healing etc. this machine is adjustable, easily controlled, versatile and usually electrically operated.

Benefits:

1. Improves range of motion.
2. Improves fluid dynamics.
3. Prevents adhesion formation.
4. Enhances nutritional status of the joint.
5. Reduces joint diffusion.
6. Facilitates healing.

FINGER LADDER

It is a wooden device which gives the objective reinforcement and motivation to patient for improving shoulder range of motion. It also feed back to the patient about improvement.

Uses

1. For improving range of motion.
2. For improving neuromuscular co-ordination of upper limb.

Indication

1. Frozen shoulder.
2. Periarthritis shoulder.
3. Post traumatic stiffness of shoulder.
4. Weakness of shoulder muscles.

PARALLEL BAR

It is equipment used in physiotherapy gym. It has got two horizontal frames which are mounted on a four vertical frames and a walking platform with one central divider to prevent crossing of leg. A postural correction mirror will be placed at the end of the board. The main purpose is to improve

- (i) Standing tolerance.
- (ii) Gait training.
- (iii) Postural correction.

Uses

1. Gait training
2. Postural training.
3. Trunk control training.
4. Balance training with and without support.
5. Strengthening and mobility management of lower limb.

Indications

1. Hemiplegia.
2. Cerebral palsy.
3. Post fracture and post traumatic gait training.
4. Paraplegia.

MEDICINE BALLS

It is a leather ball which has got many layers of different materials. It has got outer layer made up of thick leather and second layer made of foam and coir. Innermost layer is filled with stone chips and sands. The coir and foam is for preventing injury to patient on direct hit.

Uses

- (i) Strengthening of upper limb muscles.
- (ii) Eye hand co-ordination.
- (iii) Neuro-muscular co-ordination.

Indications

1. Paraplegia.
2. Patient with stiff hip.
3. Hand eye co-ordination.
4. Maintenance of upper limb motion.

EQUILIBRIUM BOARD

It is a board made up of wood or metal used in the physiotherapy department.

Indications

- (i) Imbalance and co-ordination.
- (ii) Stiffness of ankle.
- (iii) Cerebral functioning.

- (iv) Sensory ataxia.
- (v) Hemiplegia.
- (vi) Weakness of ankle muscle.

Uses

1. Strengthening of ankle muscle.
2. Balance and co-ordination.
3. Relaxation.
4. Neuro-muscular co-ordination.

SUSPENSION THERAPY

Suspension: it is the means whereby the parts of the body are supported in slings and elevated by the use of variable length ropes fixed to a point above the body. It is also called as Guthre Smith's apparatus. Suspension frees the body from the friction of the material upon which the body components may be resting.

Principles of suspension apparatus:

1. Free movement, frictionless movement.
2. Gravity eliminated supported movement.
3. Works on pendulum principle.

The supporting ropes:

Ropes should be of 3-ply hemp so that they will not slip and may be of 3 arrangements.

1. **Single rope system:** this has a ring fixed at one end by which it's hung. The other end of rope then passes through one end of a wooden cleat then through the ring of a dog clip and through the other end of the cleat and is then knotted with a half hitch.

The cleat is for altering the length of the rope and should be held horizontally for movement and pulled oblique when supporting is required. The length of the rope is 1.5 m. This type of arrangement is used for suspending the limb parts only.

2. Pulley Rope System

This has a dog clip attached at one end of the rope which is passed over the wheel of a pulley. The rope then passes through the cleat and the second dogclip.

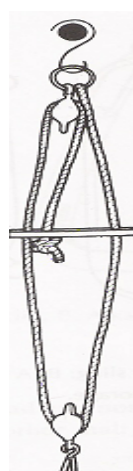
his rope is also of 1.5 m length. Finally, rope will pass from the end of a wooden cleat and a half hitch regular knot can be used. This type of arrangement is used for suspending the limb parts and for its movement also.

3. Double Rope System

This consists of a ring and a cleat at its upper end by which the rope is hung, which creates a corresponding device to persist a certain amount of swivel on the rope. The rope then passes through one side of a cleat, round a pulley wheel at the lower end of the rope which is attached to a dog clip. This system is usually used to support the heavy parts of the body.



Single pulley rope



Double pulley rope

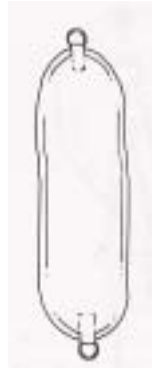
4. SLINGS

SINGLE SLING: Made up of canvas bound with a D-ring at each end. This is used to support the limbs or foot. Measurement is 68 cm long \times 17 cm breadth.

DOUBLE SLING: These are broad slings. Dimension is 68cm long and 59cm wide with D rings at each end and the slings are used to support the pelvis, trunk and thigh.

THREE-RING SLINGS: They are webbing slings 71cm long and 4cm wide three D rings, one of which is freely movable and is placed in the middle. These slings are usually used for wrist, hand, ankle and feet.

HEAD AND SLING: This is a short; split sling with its two halves stitched together to an angle is create a central slit. This slit allows the head is rest under the lower and upper part of skull.



Single sling



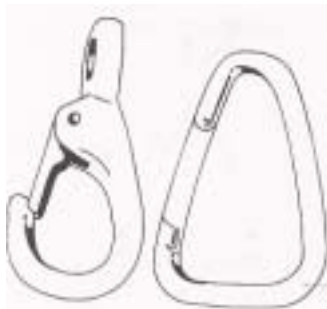
Double sling



Head sling



Three ring sling



A. Dog clip B. Karabiner clip



S hook

TYPES OF SUSPENSION

1. VERTICAL: In this suspension, the rope is fixed so that it hangs vertically above the C.O.G. Vertical suspension is used for the movement of a part through a small range like pendular movement on each side.

2. AXIAL: Axial occurs when all ropes are supporting a part as attached to 'S' hook of the joint which is to be moved. If some resistance is a muscle is required, then the whole fixed pt. is moved away from the muscle which required resistance.

INDICATIONS OF SUSPENSION:

- i) For re-education of weak muscle
- ii) For strengthening muscle in gravity eliminated friction position.

- iii) For improving and maintaining range of movement
- iv) For early neuro-muscular co-ordination training

CONTRA-INDICATIONS

- i) Hyper mobile joint
- ii) Acute trauma or fracture
- iii) Bum
- iv) Generalized Oedema
- v) Skin disease
- vi) Open wounds and sinuses

SUSPENSION FOR UPPER LIMB

THE SHOULDER JOINT

Abduction and Adduction:

Position of the patient: supine.

Fixation point: Over the shoulder joint, single sling is attached to the elbow and one is a Three-ring sling applied to the wrist and hand.

Flexion and Extension:

Position of the patient: side lying

Fixation point: Over the shoulder joint, single sling is attached to the elbow and one is a Three-ring sling applied to the wrist and hand.

ELBOW JOINT

Position of the patient: sitting on a low backed chair.

Fixation point: A single sling and rope supports the arm in vertical fixation, and a three-ring sling and single rope fixed to point above the elbow joint.

WRIST

Flexion and extension

This is more usually performed on a polished board.

HIP JOINT

Abduction and Adduction

Position of the patient: supine lying.

Fixation point: Over the hip joint, single sling is attached to the thigh and one is a Three-ring sling applied to the ankle and foot and they are attached to the rope hung from the fixation point.

Flexion and Extension

Position of the patient: Side lying.

Fixation point: Over the hip joint, single sling is attached to the thigh and one is a Three-ring sling applied to the ankle and foot.

During flexion both the hip and knee should be flexed together to overcome passive insufficiency of hamstring muscle. When extension is performed the knee should be extended to overcome the active insufficiency of hamstring muscle.

Internal and External rotation

Position of the patient: supine lying with Hip and knee flexed at 90 degrees.

Fixation point: Over the hip joint, single sling is attached to the thigh and one is a Three-ring sling applied to the ankle and foot.

KNEE JOINT

Flexion and Extension

Position of the patient: Side lying with thigh slightly flexed.

Fixation point: Over the knee joint, single sling is attached to the thigh and one is a Three-ring sling applied to the ankle and foot.

ANKLE JOINT

It is rarely necessary to use suspension as in this case it is easier to perform supported movements by using a polished board.

CHAPTER 18

WALKING AIDS AND GAIT TRAINING

Walking aids are useful to assist people who have difficulty in walking or people who cannot walk independently. This include crutches, sticks and frames.

1. Crutches: these are used to reduce weight bearing on one or both legs and also give support where balance is impaired and strength is inadequate.

Types:

a. Axillary crutches: They are made of wood with an axillary pad, a hand piece and a rubber ferrule.

The position of the hand piece and the total length are usually adjustable. The axillary pad should rest beneath the apex of axilla and hand grip in slight flexion when weight is not being taken. When weight is being taken through axillary pad, the elbow will go into extension and weight is transmitted down the arm to hand piece.



Crutch



Elbow crutch

b. Elbow crutches: They are made of metal and have a metal or plastic forearm band. They are usually adjustable in length by means of a press clip or metal button and have a rubber ferrule. These crutches are suitable for patients with good balance and strong arms. Weight is transmitted exactly the same way as for axillary crutches.

c. Forearm crutches (gutter crutches): They are made of metal with a padded forearm support and strap, an adjustable hand piece and a rubber ferrule.

These are used for patients with rheumatoid disease for providing support. They cannot take weight through hands, wrists and elbows because of deformity or pain.



Forearm crutch

Preparation for crutch walking:

a. Arms: shoulder extensors, adductors and elbow 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 hand piece.

b. Legs: the strength and mobility of both legs should be assessed and strengthened if necessary. Main attention to the hip abductors and extensor, the knee extensors and the plantar flexors of the ankle should be given.

c. Balance: sitting and standing balance must be tested.

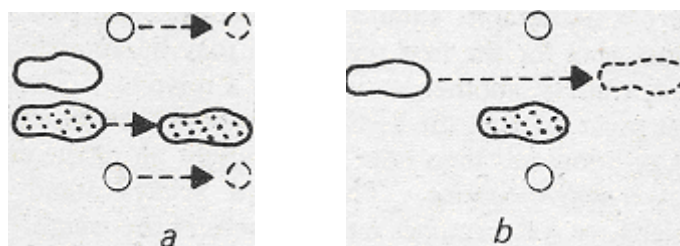
Demonstration: the physiotherapist should demonstrate appropriate crutch walking to the patient.

Crutch walking: during first time, when the patient is to stand and walk, the physiotherapist should have an assistant for supporting the patient.

i. Non-weight bearing: patient should always stand with a triangular base i.e. crutches either in front or behind the weight bearing leg



ii. Partial weight bearing: 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.



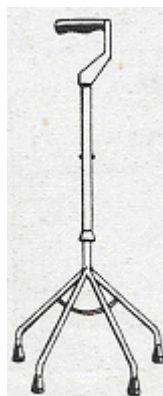
Sticks: sticks may be made up of either wood or metal with curved or straight hand piece. Metal ones are adjustable while the wooden ones are non-adjustable.

Uses: sticks allow more weight to be taken through the leg than crutches. 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.

Tripod or quadripod: metal sticks with three or four prolonged bases and gives more stable support than stick.

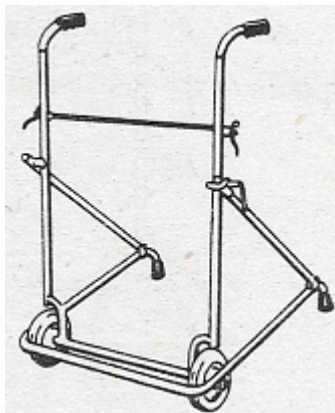


Tripod

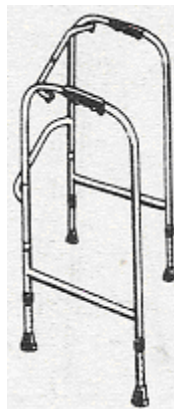


Quadripod

Frames: they are light weight with four feet which can be adjustable in height. Patient lifts the frame forward then leans on it and takes steps. The patient should take even steps, keeping the frame forward. Rotator frames which can be pushed or reciprocal frame where each side moves independently are useful for ataxic patients.



Rollator



Frames

Safety: the physiotherapist must check the safety of all walking aids not only when giving to them to a patient, but regularly throughout the treatment programme.

CHAPTER 19

MASSAGE

Massage signifies a group of procedures, which are usually done with hand on the external tissue of the body in a variety of ways either with a curative, palliative or hygienic point of view.

Classification of technique:

I. On the basis of character of technique:

1. Stroking manipulation

- i. superficial stroking.
- ii. Deep stroking.

2. Pressure manipulation

- i. kneading.
 - a. palmar kneading.
 - b. digital kneading.
 - c. ironing.
- ii. Petrissage.
 - a. Picking up.
 - b. Wringing.
 - c. Skin rolling.
- iii. Friction.
 - a. Circular friction.
 - b. Transverse friction.

3. Percussion manipulations

- i. Clapping.
- ii. Hacking.
- iii. Tapping.
- iv. Beating.
- v. Pounding.
- vi. Tenting.
- vii. Contact heel percussion.

4. Vibratory manipulations

- i. Vibrations.
- ii. Shaking.

II. On the basis of depth of tissue

1. Light massage.
2. Deep massage.

III. On the basis of part of body massaged

- i. General massage.
- ii. Local massage.

Therapeutic uses

Massage is one of the oldest forms of treatment for human ills. It has been used as a therapeutic modality in various conditions since ancient times.

1. To improve mobility of the soft tissues.
2. To reduce muscle spasm and pain under abnormal conditions.
3. To reduce oedema.
4. To increase circulation.
5. To mobilize secretions in the lung.
6. To induce local and general relaxations.

Contraindications**I. General contraindications:**

1. High fever.
2. Renal diseases.
3. Cardiac diseases.
4. Deep x-ray therapy.
5. Osteoporosis.
6. Severe spasticity.

II. Local contraindications:

1. Acute inflammation.
2. Skin diseases.
3. Recent fractures.
4. Varicose veins.

1. Atherosclerosis.
2. Thrombosis.
3. Open wound.

Physiological effects:

1. Effect of massage on the circulatory system: massage aids in the mechanical emptying of the veins and the lymphatics. It facilitates the forward movement of the venous blood and the lymph and there by reduces the chances of stagnation of the blood and the lymph in the tissue space.

On the arterial flow: massage improves the blood supply of the area being massaged. A definite vasodilation along with an increase in the peripheral blood flow is usually observed after massage. This moderate, consistent and definite increase in the arterial flow may be attributed to the following events happening during massage.

Release of vasodilators, activation of axon reflex, decrease of venous congestion.

2. Effects on blood: massage is found to increase RBC and haemoglobin count and may increase the oxygen carrying capacity of blood.

3. Effects on the exchange of metabolites: massage speeds up the lymphatic and venous flow, which promotes rapid disposal of the waste products of metabolism. These changes make the exchange of waste products between the blood and the tissue at cellular level more efficiently.

4. Effects on the nervous system: the nervous system consists of sensory, motor and autonomic component. Different technique of massage produces effects on all these components.

Sensory system: massage has a sedative effect on the central nervous system if applied monotonously with slow rhythm. The use of massage for the relief of pain of various origins is an age-old practice.

Facilitatory effects of massage on motor system: it is said that massage can reflexly increase the muscle tone by stimulation of the skin receptor or stretch of the muscle spindle. Superficial stroking, taping, hacking etc. are commonly used for this purpose.

Inhibitory effects of massage on motor system: massage techniques can also reduce the tone of muscle. It has been claimed that petrissage or massage in which muscles are kneaded can exert an inhibitory effect on motorneuron. It is said that effleurage is capable of producing both stimulating and relaxing effects.

On autonomic nervous system: massage has definite reflex effect and it can influence the functioning of visceral organ by modulating the autonomic nervous system through peripheral sensory stimulation.

5. Effects on the soft tissue: Massage has significant effect on certain properties of the soft tissues like elasticity, plasticity and mobility. The adhesions present between fibres are broken and maximum mobility between fibres and adjacent structures is ensured.

6. Effects on the respiratory system: percussion and vibration techniques of massage assist the removal of secretions from the larger airways. After the removal of secretion gas exchange becomes more efficient.

7. Effects on the skin: massage in general improves the nutritive status of skin, the skin temperature of skin rises. Massage facilitates the movement of skin over the subcutaneous structures. As a result skin becomes soften, more supple and finer.

Techniques of massage

I. Stroking: the uninterrupted linear movement of hand along the whole length of segment is called stroke.

Superficial stroking: it is the rhythmic movement of hand or parts thereof over the skin with the lightest amount of pressure in order to obtain sensory stimulation. The strokes can be applied from proximal to the distal or vice versa.

Effleurage or deep stroking: it is the movement of the palmar aspect of hand over the external surface of the body with constant moderate pressure, in the direction of the venous and lymphatic drainage.

II. Pressure manipulations: in this group of techniques, the hand of the therapist and skin of the patient move together as one and fairly deep localized pressure is applied to the body. It is divided into

- i. Kneading.
- ii. Petrissage.
- iii. Friction.

i. kneading: in this group of techniques, the tissues are pressed down on to the underlying firm structure and intermittent pressure is applied in circular direction, parallel to the long axis of bone.

a. digital kneading: pressure is applied with the fingers (finger kneading) or thumb (thumb kneading).

b. palmar kneading: pressure is applied with the palm.

c. reinforced kneading: both the hands, placed over one another, are used to apply pressure.

III. Petrissage: in this the tissues are grasped and lifted away from the underlying structures and intermittent pressure is applied to the tissues in the direction that is perpendicular to the long axis of the bone. It is divided into

i. Picking up: tissues are lifted away from underlying structures, squeezed and then released using one or both the hands.

ii. Wringing: using both the hands, tissues are lifted away from the underlying structures, squeezed, twisted and then released.

iii. Skin rolling: the skin and fascia are lifted up with both the hands and moved over the subcutaneous tissues by keeping a roll of lifted tissue continuously ahead of the moving thumb.

IV. Friction: in this technique the tissue are subjected to small range of to and fro movement performed with constant deep pressure of the finger or thumb. It is divided in to

i. Circular friction: direction of movement is circular.

ii. Transverse friction: to and fro movement is performed across the length of structure.

V. Vibratory Manipulations: In this group of techniques, the mechanical energy is transmitted to the body by the vibrations of the distal part of upper limb, i.e. hand and/or fingers, which are in constant contact with the subjects skin, using the body weight and generalized co-contraction of the upper limb muscles. This technique is mainly directed towards the lung and other hollow cavities.

Depending upon the direction and frequency of vibration it is divided into two techniques:

Vibration In this technique, the fine vibrations are produced, which tend to produce fine movement of hand in upwards and downward direction.

Shaking In this technique, coarse vibrations are produced, which tend to produce fine movement of hand in sideways direction.

VI. Percussion/tapotment manipulations

In this group of techniques, a succession of soft, gentle blows are applied over the body, which produce a characteristic sound. The striking hands are not in constant contact with the skin and strike the body part at regular interval. This results in the application of an intermittent touch and pressure to the body during these manipulations.

The different parts of hand are used to strike the subject’s skin and accordingly the techniques are named:

Technique	Administered with
Clapping	Cupped palm
Hacking	Ulnar border of the 5th, 4th and 3rd digits
Beating	Anterior aspect of the clenched fist
Tapping	Pulp of the fingers
Pounding	Medial aspect of the clenched fist

On the Basis of Depth of Tissue Approached

Depending upon the depth of tissue approached during manipulations massage techniques can be classified as:

Light Massage Techniques

The force applied during the manoeuvre are light, so that the effect of massage is confined to the superficial tissue only, e.g. stroking, tapping, etc.

Deep Massage Techniques

The forces applied during the massage are moderate to deep so that the effect of massage reaches to the deeper tissues like muscle, e.g. friction, kneading, etc.

On the Basis of Region Massaged

Massage can also be classified as below, according to the region to which it is given.

General massage

Massage applied to the entire body is usually termed as general massage. However, massage administered to a large body segment like the back, lower limb, etc. can also be included in this category.

It is usually administered in debilitated persons following prolonged recumbency and on athletes after exhaustive physical work to bring a sense of well-being and comfort.

Local Massage

When massage is administered in a particular area of the body segment it is termed as local massage. This is used in the treatment of the local pathological conditions. For example, massage of wrist in tenosynovitis, friction to lateral ligament of ankle following sprain, etc. can be considered as local massage.

On the Basis of Means of Administration of Technique

On this basis, the massage can be classified into the following two categories.

Manual Massage

Word manual refers to the 'lying on' of hand over the subject's body. The massage administered with the hand or other body part of the therapist is called manual massage, e.g. technique of classical massage, connective tissue massage, trigger point massage, accupressure massage, etc.

Mechanical Massage

When the mechanical devices based on the principles of massage, administer the mechanical energy to the patient's body, in order to manipulate soft tissue, it may be termed as mechanical massage, e.g. vibrator, compression devices, pneumatic massage, etc.