INTRODUCTION TO THERAPEUTIC EXERCISE

- **Therapeutic exercise:** is the systematic, planned performance of bodily movements, postures, or physical activities.
- **Aims of Therapeutic Exercise**:
  1. Remediate or prevent impairments.
  2. Improve, restore, or enhance physical function.
  3. Prevent or reduce health-related risk factors.
  4. Optimize overall health status, fitness, or sense of well-being.
- **Therapeutic exercise programs:** designed by physical therapists are individualized to the unique needs of each patient or client.
  - **A patient:** is an individual with impairments and functional limitations who is receiving physical therapy to improve function and prevent disability.
  - **A client:** is an individual without dysfunction who engages in physical therapy to promote health and wellness and to prevent dysfunction.
- **Aspects of Physical Function**: The ability to function independently at home, in the workplace, within the community, or during leisure and recreational activities is contingent upon physical as well as psychological and social function. The multidimensional aspects of physical function encompass the diverse yet interrelated areas of performance that are depicted in Figure 1. These aspects of function are characterized by the following definitions.

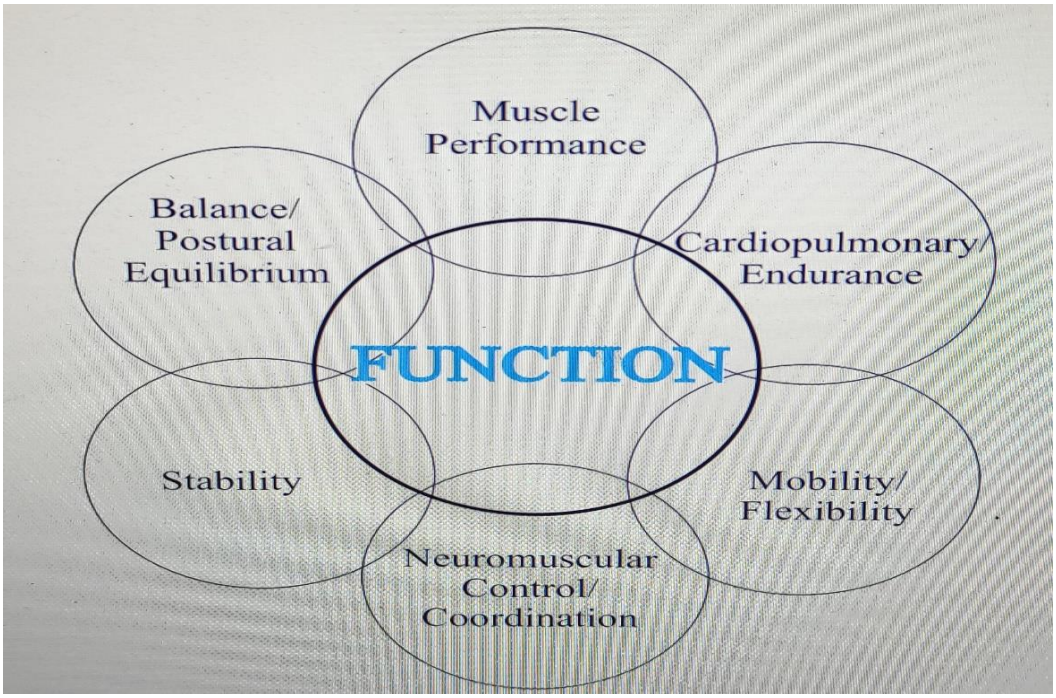


Fig.1: Aspects of Physical Function.

1. Balance: The ability to align body segments against gravity to maintain or move the body (center of mass) within the available base of support without falling; the ability to move the body in equilibrium with gravity via interaction of the sensory and motor systems.

2. Cardiopulmonary Endurance/fitness: The ability to perform low intensity, repetitive, total body movements (walking, jogging, cycling, swimming) over an extended period of time.

3. Stability: The ability of the neuromuscular system through synergistic muscle actions to hold a proximal or distal body segment in a stationary position or to control a stable base during superimposed movement.

- Joint stability: is the maintenance of proper alignment of bony partners of a joint by means of passive and dynamic components.
- Postural control, postural stability, and equilibrium: Used interchangeably with static or dynamic balance.

4. Mobility and Flexibility:

- **Flexibility:** The ability to move freely, without restriction; used interchangeably with mobility.
- **Mobility:** The ability of structures or segments of the body to move or be moved in order to allow the occurrence of range of motion (ROM) for functional activities (functional ROM).
- Passive mobility: Is dependent on soft tissue (contractile and noncontractile) extensibility.
- Active mobility: Requires neuromuscular activation.

5. Muscle performance. The capacity of muscle to produce tension and do physical work. Muscle performance including: strength, power, and endurance.

- **Muscle strength:** Is the greatest measurable force that can be exerted by a muscle or muscle group to overcome resistance during a single maximum effort.
- **Muscle power:** Is the work (force × distance) produced by a muscle per unit of time (force × distance / time). In other words, it is the rate of performing work.
- **Muscle endurance:** Is the ability to perform low-intensity, repetitive, or sustained activities over a prolonged period of time.

6. Neuromuscular control / Coordination:

- **Neuromuscular control:** Interaction of the sensory and motor systems that enables synergists, agonists and antagonists, as well as stabilizers and neutralizers to respond to proprioceptive and kinesthetic information to work in correct sequence and creating coordinated movement.
- **Coordination:** The correct timing and sequencing of muscle firing combined with the appropriate intensity of muscular contraction leading to the effective initiation, guiding, and grading of movement. It is the basis of smooth, accurate, efficient movement and occurs at a conscious or automatic level.

❖ **Common Body Function Impairments Managed With Therapeutic Exercise:**

1. Musculoskeletal:

■ Pain.
■ Muscle weakness/reduced torque production.
■ Decreased muscular endurance.
■ Limited range of motion due to:
  - Restriction of the joint capsule.
  - Restriction of periarticular connective tissue.
  - Decreased muscle length.
  - Joint hypermobility.

■ Faulty posture.
■ Muscle length/strength imbalances.

2. Neuromuscular:

■ Pain.
■ Impaired balance, postural stability, or control.
■ Incoordination, faulty timing.
■ Delayed motor development.
■ Abnormal tone (hypotonia, hypertonia, and dystonia).
■ Ineffective/inefficient functional movement strategies.

3. Cardiovascular/Pulmonary:

■ Decreased aerobic capacity (cardiopulmonary endurance).
■ Impaired circulation (lymphatic, venous, and arterial).
■ Pain with sustained physical activity (intermittent claudication).

4. Integumentary:

■ Skin hypomobility (e.g., immobile or adherent scarring).

❖ **Categories of prevention.**

1. Primary prevention: Activities such as health promotion designed to prevent disease in an at-risk population.
2. Secondary prevention: Early diagnosis and reduction of the severity or duration of existing disease and sequelae.
3. Tertiary prevention: Use of rehabilitation to reduce the degree or limit the progression of existing disability and improve multiple aspects of function in persons with chronic, irreversible health conditions.

➢ **Types of Therapeutic Exercise Intervention**:

1. Aerobic conditioning and reconditioning.
2. Muscle performance exercises.
3. Stretching techniques including muscle-lengthening procedures and joint mobilization techniques.
4. Neuromuscular control, inhibition, and facilitation techniques.
5. Postural control, body mechanics, and stabilization exercises.
6. Balance exercises and agility training.

7. Relaxation exercises.
8. Breathing exercises and ventilatory muscle training.
9. Task-specific functional training

- **Exercise Safety**:
  - **Safety:** is a fundamental consideration in every aspect of the program whether the exercises are performed independently or under a therapist's supervision.
  - **Safety including:**

    A. Patient safety.

    B. Therapist safety.

A. Patient safety:

- **Factors affect patient's safety during exercise:**

1) Patient's health history and current health status.
2) Medications can adversely affect a patient's balance and coordination during exercise or cardiopulmonary response to exercise.
3) Risk factors must be identified.
4) Medical clearance from a patient's physician may be indicated before beginning an exercise program.
5) The environment in which exercises are performed which including:
   (a) Adequate space and a proper support surface for exercise.
   (b) Exercise equipment be used in the clinical setting or at home.

   * to ensure patient safety the equipment must be:
     - well maintained and in good working condition.
     - fit the patient.
     - applied and used properly.
6) Specific to each exercise in a program, the accuracy with which a patient performs an exercise that including:
   (a) proper posture or alignment of the body.
   (b) Execution of the correct movement patterns.
   (c) Performing each exercise with the appropriate intensity, speed, and duration.
7) A patient must be informed of the signs of fatigue, the relationship of fatigue to the risk of injury, and the importance of rest for recovery during and after an exercise routine.

B. Therapist safety:

The therapist must incorporate principles of proper body mechanics and joint protection into the manual techniques to minimize his or her own risk of injury.

Practical Part

Fundamental and Derived Positions

There are five fundamental positions which are usually described along with their derivatives. The starting positions from which exercises start or in which they may be given.

I. Fundamental Positions:

1. Lying position.
2. Sitting position.
3. Standing position.
4. Kneeling position.
5. Hanging position.

1-Lying (Ly) or Supine (Sup.):

- The body is supine with the arms by the sides and legs straight figure 1.
- This is the position in which the body is most supported with a large base and low centre of gravity.

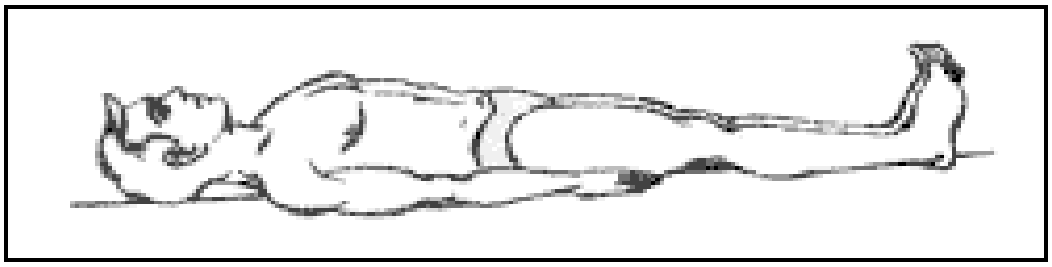


Fig. 1: Supine Lying position.

2-Sitting (Sitt.):

- Body is erect, arms by the sides, thighs are fully supported and together. Right angles are maintained at the hips, knees and ankles figure 2.
- The centre of gravity is low but near to the rear edge of the base.

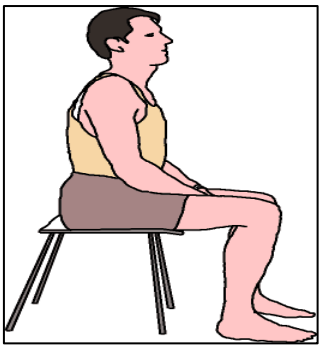


Fig. 2: Sitting position.

3-Kneeling (Kn.):

- Body is upright from the knees which are held at a right angle. Arms are by the sides figure 3.
- The base consists only of the legs and the centre of gravity is high and the line of gravity falls close to the edge of the base.
- It is unstable and difficult to maintain.

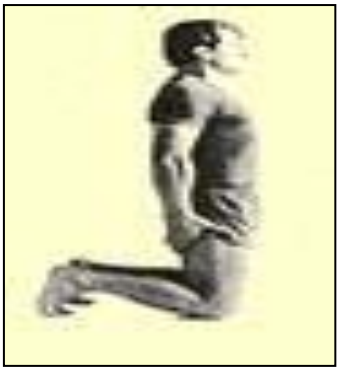


Fig.3: Kneeling position.

4-Standing (St.):

- Body is erect with arms by the sides. The feet are slightly apart at the toes figure 4.
- The base is small and the centre of gravity is high.
- It is easier to maintain than kneeling.

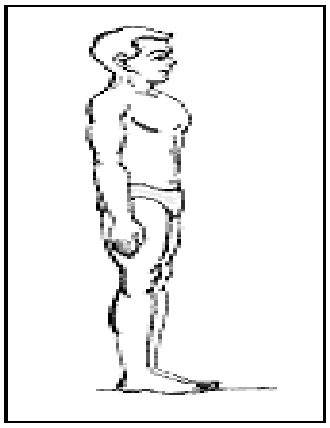


Fig.4: Standing position.

5-Hanging (Hg.):

- Body hangs from a beam or overhead support. Arms are wide apart figure 5.
- It is used only for very strong people.

Fig.5: Hanging position.

II. Derived positions:

- obtained from the fundamental positions by changing the position of the arms, legs, and trunk in each of the fundamental position.
- The purposes of derived positions:
  - Increase or decrease the size and stability of BOS.

- Raise or lower the COG.
- Ensure general or local relaxation.
- Alter the position of the body in relation to gravity.
- Provide control or fixation for a particular part of the body, so that movement may be localized to a specific area.
- Increase or decrease the muscle work required to maintain the position.
- Increase or decrease the leverage.
- Provide a convenient position from which a particular exercise is to be performed.

1. <u>Positions derived from Lying:</u>

A. Side Lying (S. Ly.):

- Turning onto the side with the under arm by the side and legs straight figure 6.
- It is rrarely used.
- The base is small and rounded.

Fig. 6: Side lying position.

B. Prone Lying (Pr. Ly.) or Prone (Pr.):

- Body is face down with arms by the side and legs straight figure 7.

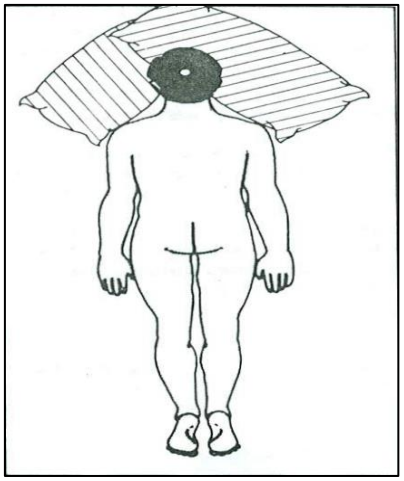


Fig.7: Prone lying position.

C. Across Prone Lying (Acr. Pr. Ly.):

- Lying across a support with the anterior superior iliac spines just off the front edge of the support.
- The head and hands may rest on the floor.
- The feet should be held by a partner or support from a wall bar figure 8.

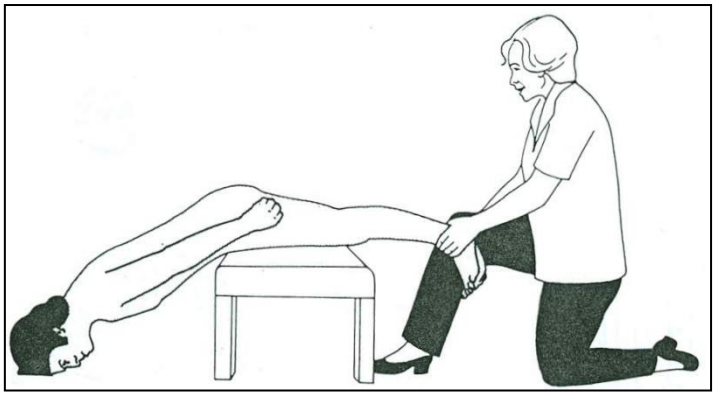


Fig.8: Across Prone Lying position.

D. Quarter Turn (1/4 Tn.)

- Body is turned through 45° from either Lying, Side Lying or Prone Lying and supported by pillows down the raised side of the trunk.
- The direction of the 1/4 turn is indicated by stating the starting position and direction, e.g. 1/4 Tn.L. from Ly.

E. Half Lying (1/2 Ly.):

- Body is bent at hips and the trunk is raised from lying to any angle up to 90° figure 9.
- More comfortably the legs may be slightly raised or lowered from the horizontal and the knees bent.

Fig.9: Half Lying position.

F. Side Half Lying (S. 1/2 Ly.):

- The trunk and head are turned to one side so that the patient rests on one buttock and leg and that side of the trunk figure 10.

Fig.10: Side Half Lying position.

G. Crook Lying position:

- From lying, the hip and knees are bent so that the feet rest on the floor or plinth. Very little muscle work is required Tension is removed from the structure anterior to the hip joint so that the pelvis rolls backward and the lumbar spine is relaxed on to the supporting surface figure 11.
- **Uses:** 1- To train relaxation and posture.
  2- In pelvic and back exercises.

Fig.11: Crook Lying position.

2. Positions derived from Sitting:

A. Forward Lean Sitting (Fwd. Ln. Sitt.):

- The trunk is inclined forwards and the head is supported on pillows on a table at the front.

B. Half Sitting (1/2 Sitt.):

- Sitting on the side of a seat so that only one buttock is supported.
- The leg on the side of the unsupported buttock is usually bent at the knee figure 12.

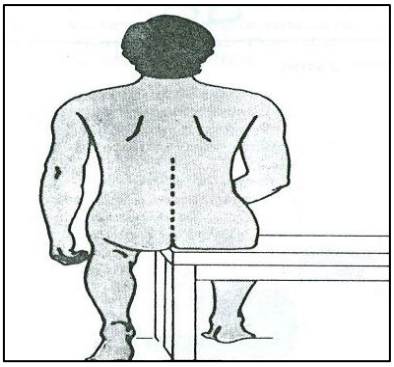


Fig.12: Half Sitting position.

C. Cross Sitting:

- This is also similar to crook sitting, but the ankles are crossed and the hips strongly abducted and laterally rotated, so that the lateral aspect of the knees is pressed to the floor figure 13.
- Tension on the hamstring muscle is reduced but the adductors of the hip are stretched.

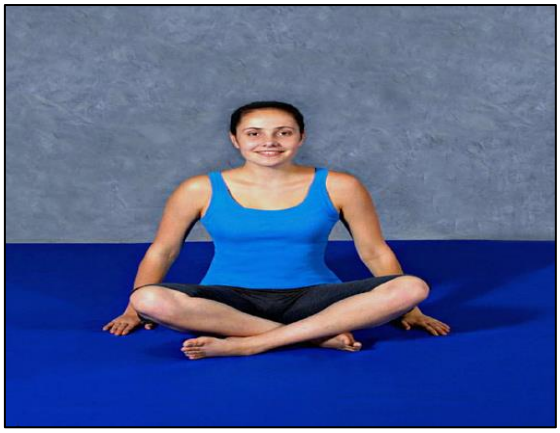


Fig.13: Cross Sitting position.

D. Long Sitting (Long Sitt.):

- The legs are stretched out in front, knees straight.
- The trunk is upright and position is an uncomfortable one to maintain figure 14.

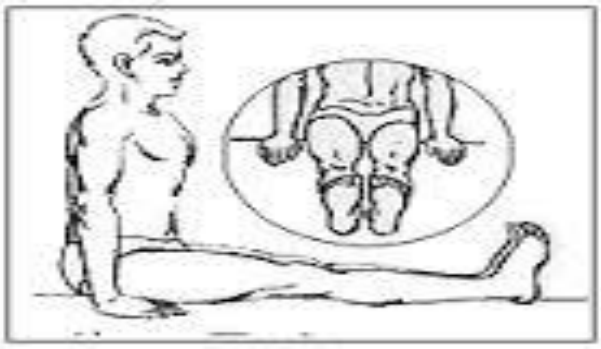


Fig.14: Long Sitting position.

3. <u>Positions derived from Kneeling:</u>

A. Kneel Sitting (Kn. Sitt.):

- From kneeling to sitting back on the heels.
- A stable position and much used for retraining balance and by children at play figure 15.

Fig.15: Kneel Sitting position.

B. Half Kneeling (1/2 Kn.):

- From kneeling, one leg is taken forward to be bent at right angles at the hip, knee and ankle.
- A stage in rising from kneeling to standing or transferring from floor to stool.

- One knee supports most of the weight and other leg is bent to a right angle at hip, knee and ankle so that the foot is supported on the ground in a forward direction figure 16.

Fig.16: Half Kneeling position.

C. Side Sitting (Side Sitt.):

- From kneel sitting the buttocks are moved sideways so that one or both buttocks rest on the floor beside the feet figure 17.

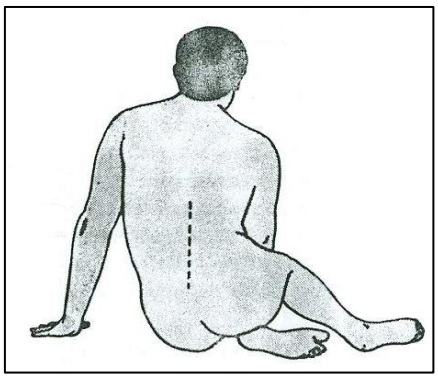


Fig.17: Side Sitting position.

D. Prone Kneeling (Pr. Kn.):

- Kneeling supported by all four limbs.
- The arms should be straight and the hands in line below the shoulders.
- Right angles should be maintained at the hip and knee and the ankles may be plantar flexed or dorsi flexed figure 18.
- The position is stable, comfortable and suitable for many trunk and head exercises. The pelvis is free for antro-posterior and lateral movement, but fixed rotation. The body may be inclined forwards and downwards.

Fig.18: prone kneeling position**.**

E. Inclined prone kneeling:

- The same as prone kneeling, but there is more than 90 degrees flexion of both elbows, shoulders are flexed and abducted, head rested on the hands or on the plinth figure 19.

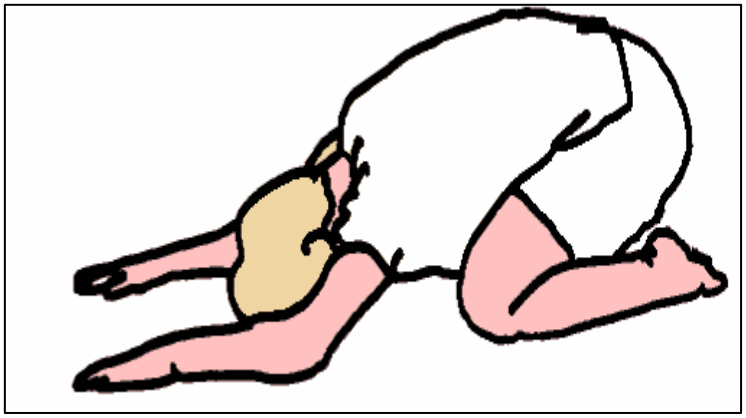


Fig.19: Inclined prone kneeling position.

4. Positions derived from Standing:

A. High Standing (High St.):

- Standing on a platform or stool of any height.
- Normally used when one leg is to be moved and allows the patient to be more accessible to the therapist.
- The position is usually stabilized by allowing the patient to grasp a support.

B. Toe Standing (T. St.):

- The body is raised onto the toes.
- The smallest possible base is now in use.
- The heels are pressed together and raised from the floor figure 20.
- The base is reduced and the center of gravity is raised.

Fig.20: Toe Standing position.

C. Stride standing:

- The legs are abducted and the heels are apart and remain in 45° figure 21.
- Large base lead to easy and stable position.
- **Uses:** used as starting easy position for many exercises.

Fig.21: Stride standing position.

D. Walk standing:

- One leg is placed forward to the same line of the other leg figure 22.
- The base is much enlarged in the antro-posterior direction stabilizing the body for exercises in a sagittal plane. Rotation of the pelvis towards the side of the forward leg is prevented by the position of the back leg.
- **Uses:** Tension on of the forward leg prevents forward tilting of the pelvis in trunk flexion exercises.

Fig.22: Walk standing position.

E. Step Standing (Step. St.):

- Standing with one foot on a higher level than the other figure 23.
- Used for teaching weight transference before walking upstairs.

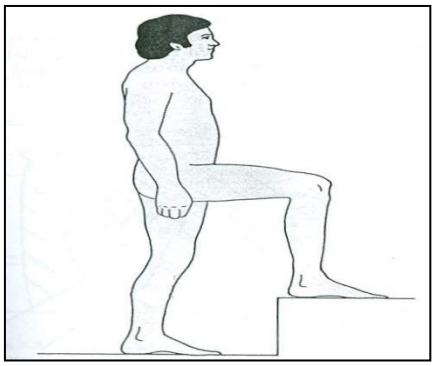


Fig.23: Step Standing position.

F. Half Standing (1/2 St.):

- Standing on one leg, one hip is hitched up or one leg is bent at the hip and knee.

G. Close Standing (Cl. St.):

- The feet are together and parallel.

- Harder to maintain than standing.

H. Oblique Stride (Obl. Std.):

- The feet are a pace apart part way between walk and stride. This position allows oblique transfer of weight.

I. Lunge (Lge.):

- The feet are well apart and at right angles to each other figure 24.
- If the rear leg is bent then the weight is in a back lunge position.
- If the front leg is bent the weight is in a forward lunge position.
- This position allows transfer of body weight from one leg to the other, with maximum stability for working in this position.

Fig.24: Lunge position.

5. <u>Positions derived from Hanging:</u>

A. Arch Hanging (Arch Hang.):

- The starting position for forward and backward swinging of the trunk or for bar somersaults.

B. Half Hanging (1/2 Hang.):

- Hanging by one arm. The position achieved during lateral travel on the beam.

6. <u>Positions derived by moving the Arms (A):</u>

A. Stretch (Str.):

- The arms are held straight above the head in the position of elevation at the shoulder, i.e. palms facing inwards.

B. Yard (Yd.):

- The arms are held straight out from the side of the body, palms facing downwards figure 25.

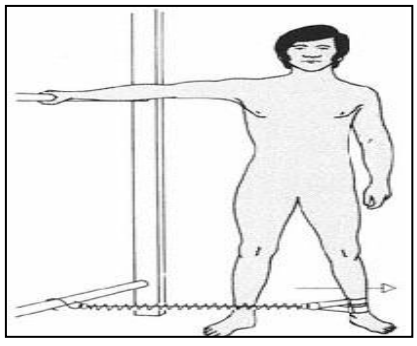


Fig.25: Yard arm position.

C. Reach (Rch.):

- The arms are held straight in front of the body palms facing inwards figure 26.

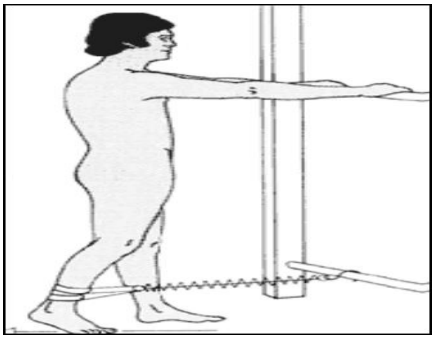


Fig.26: Reach arm position.

D. Head Rest (H. Rst.):

- The hands rest on the head, more usually on the occiput, and the position is usually used to gain upper trunk extension

E. Bend (Bd.):

- The elbow is bent and the hands lie adjacent to the shoulders.
- A starting position usually used for thrusts upwards, forwards, downwards and backwards.

F. Wing (Wg.):

- The hands rest on the hips.
- used in rotatory movements of the trunk.

G. Heave (Hve.):

- Usually used with a grasp. The arms lie abducted at the shoulder, the elbows bent upwards at a right angle so that a grasp may be taken of the edges of the bed or plinth figure 27.
- Used to fix the upper half of the body.

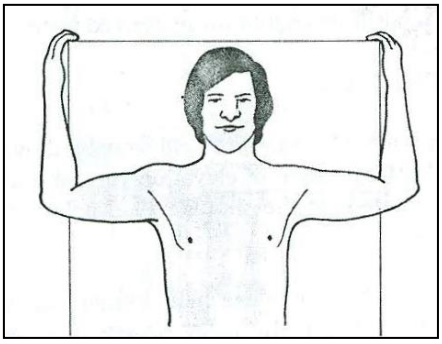


Fig.27: Heave arm position.

H. Grasp (Gr.):

- The hands grasp a convenient support. May be used with Stretch, Yard, Reach or Heave

I. Low Grasp (Low Gr.):

- The hands grasp when they are by the sides.

J. Forehead Support (F. head Supp.):

- The forehead rests on the hands placed either palm down or with loosely grasping thumb and forefinger.

K. Arm Lean (A. Ln.):

- The forearms and the hands palms down are placed on a support in front of the body, the head may rest on them or they may rest on and be covered by a pillow on which the head rests.
- Used in Forward Lean positions figure 28.

Fig.28: Arm Lean position.

L. Forward Propping (Fwd. Prop.):

- The hands rest flat on the seat and in front of the trunk.

M. Backward Propping (Bwd. Prop.):

- Hands rest flat On the seat fingers pointing backwards and behind the trunk figure 29.

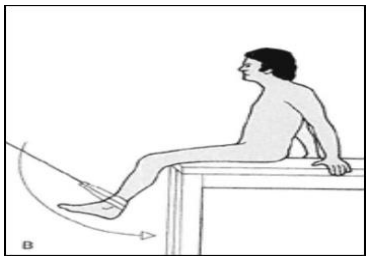


Fig.29: Backward Propping.

N. Reverse Propping (Rev. Prop.):

- The hands rest as above but the fingers point forwards.

All three propping positions are used for thrusting actions in which the arm is braced in extension and the trunk may be balanced and/or moved on the arm/s.

7. <u>Positions derived by moving the Legs (Lg):</u>

A. Crook (Ck.):

- The knees and hips may be bent slightly by using one pillow under the knees or, in the extremely flexed position, the soles of the feet will be flat on the support figure 30.

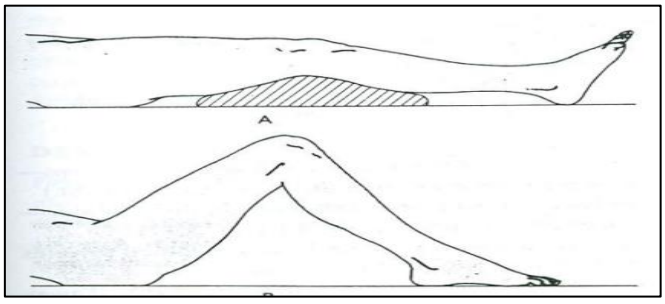


Fig.30: Crook leg position.

B. Cross Leg (X Leg):

- The legs are crossed at the ankles. The knees are flexed and the hips flexed, abducted and laterally rotated.
- This position is taken up on the floor or on a high mat.

C. Cross Ankle (X Ankle):

- The legs may be crossed at the ankles when the body is in the Lying, Sitting, Kneeling or Standing positions.

8. Positions derived by moving the Trunk(Tr):

A. Stoop (Stp.):

- The body is bent forwards at the hips with erect back and head.

B. Relaxed or Slack Stoop (Lax Stp.):

- The head and trunk are flexed.

C. Arch Trunk:

- The head and trunk are extended.

D. Turn Trunk(Tn.):

- The trunk is rotated through any degree less than 90° either by moving the shoulder girdle or the pelvis or both depending on the fundamental position.

N.B - To describe a position:

- First consider which parts of the body are not in the normal relationships as in the fundamental position.
- Then name their position in the following order—Head, Arm, Trunk, Leg and fundamental position.

Resistance Exercise For Impaired Muscle Performance

Muscle performance

- It is the capacity of a muscle to do work (force × distance).
- It is a complex component of functional movement and is influenced by all of the body systems.
- The key elements of muscle performance are strength, power, and endurance.

- If any one or more of muscle performance is impaired, may lead to: functional limitations and disability or increased risk of dysfunction.
- Many factors, such as injury, disease, immobilization, disuse, and inactivity, may result in impaired muscle performance, leading to weakness and muscle atrophy.

➢ **Elements of muscle performance**:

1- muscle strength: Is the greatest measurable force that can be exerted by a muscle or muscle group to overcome resistance during a single maximum effort.

- **Functional strength:** the ability of the neuromuscular system to produce, reduce, or control forces imposed during functional activities, in a smooth, coordinated manner.
- Insufficient muscular strength results in functional losses of activities of daily living.

2- Muscle power: Is the work (force × distance) produced by a muscle per unit of time (force × distance / time). In other words, it is the rate of performing work.

- **Factors that affect muscle power:**
- The rate at which a muscle contracts and produces a resultant force.
- The relationship of force and velocity.
- **power can be expressed by two aspects:**
- **Anaerobic power:** single burst of high-intensity activity (such as lifting a heavy weight overhead or performing a high jump).
- **Aerobic power:** repeated bursts of less intense muscle activity (such as climbing a flight of stairs).

3- Endurance: Is the ability to perform low-intensity, repetitive, or sustained activities over a prolonged period of time.

- **Cardiopulmonary endurance (total body endurance):** repetitive, dynamic motor activities such as walking or swimming (use of the large muscles of the body).
- **Muscle endurance (local endurance):** is the ability of a muscle to contract repeatedly against a load (resistance), generate and sustain tension, and resist fatigue over an extended period of time.
- Maintenance of balance and proper alignment of the body segments requires sustained control (endurance) by the postural muscles.
- All daily living tasks require some degree of muscle and cardiopulmonary endurance.
- Strength and muscle endurance do not always correlate well with each other. For example, an individual who is strong has no difficulty lifting a 10 pound object several times, but does the worker have sufficient muscle endurance (ULs, LLs and stabilizing muscles of the trunk) to lift 10-pound objects several hundred times during the day's work without excessive fatigue or potential injury.

MUSCLE PERFORMANCE AND RESISTANCE EXERCISE:

The three elements of muscle performance (strength, power, endurance) can be enhanced by some form of resistance exercise.

Resistance exercise (training): is any form of active exercise in which dynamic or static muscle contraction is resisted by an outside force applied manually or mechanically**.**

❖ **Factors influence of appropriate, effective, or safe resistance training and how the exercises are designed, implemented, and progressed:**

1. The underlying pathology.
2. Extent and severity of muscle performance impairments.
3. Presence of other deficits.
4. Stage of tissue healing after injury or surgery.
5. Patient's age, overall level of fitness, and the ability to cooperate and learn all must be considered.

❖ **Benefits of Resistance Exercise:**

1. Enhanced muscle performance: restoration, improvement or maintenance of muscle strength, power, and endurance.
2. Increased strength of connective tissues: tendons, ligaments, intramuscular connective tissue.
3. Greater bone mineral density or less bone demineralization.
4. Decreased stress on joints during physical activity.
5. Reduced risk of soft tissue injury during physical activity.
6. Improvement in capacity to repair and heal damaged soft tissues due to positive impact on tissue remodeling.
7. Possible improvement in balance.
8. Enhanced physical performance during daily living, occupational, and recreational activities.
9. Positive changes in body composition: ↑ lean muscle mass or ↓ body fat.
10. Enhanced feeling of physical well-being.
11. Improvement in quality of life.

Most resistance training programs seek to achieve a balance of strength, power, and muscular endurance to suit an individual's needs and goals.

➢ **Resistance training programs:**

1- Strength training (strengthening exercise): is defined as a systematic procedure of a muscle or muscle group lifting, lowering, or controlling heavy loads (resistance) for a relatively low number of repetitions or over a short period of time.

2- Power training: is movements involve both strength and speed. Muscle strength is a necessary foundation for developing muscle power.

- **Power can be enhanced by:**
  - Increasing the work.
  - Reducing the time.
- **Power =** force × distance / time.
- The greater the intensity of the exercise and the shorter the time taken to generate force, the greater the muscle power (such as plyometric training).

3- Endurance training: is characterized by having a muscle contract and lift or lower a light load for many repetitions or sustain a muscle contraction for an extended period of time.

- **key elements of endurance training are:**
  - Low-intensity muscle contractions.
  - Large number of repetitions.
  - Prolonged time period.
- **Endurance training has a more positive impact on improving function than strength training as:**
  - It is using low levels of resistance minimizes adverse forces on joints.
  - Produces less irritation to soft tissues.
  - More comfortable than heavy resistance training.

➢ **Guiding principles of exercise training:**

A- Overload Principle:

- To improve the muscle performance apply a load that exceeds the capacity of the muscle, the muscle must be challenged to perform at a level greater than that to which it is accustomed.
- If the demands (load) remain constant after the muscle has adapted, the level of muscle performance can be maintained but not increased.
- **Application of the Overload principle focuses on the progressive loading of muscle by**:
  - Increase the intensity (weight or resistance).
  - Or Increase volume (repetitions, sets, frequency).
- **In strength training:** increase the amount of resistance.
- **In endurance training:** increase the time of muscle contraction or the number of repetitions.

B- The SAID principle (specific adaptation to imposed demands):

- Is an extension of Wolff's law (body systems adapt over time to the stresses placed on them).
- It helps therapists to determine specific training to meet specific functional needs. For example, if the desired function is the ability to ascend and descend stairs, exercise should be performed eccentrically and concentrically in a weight-bearing pattern.

C- Reversibility Principle:

- Adaptive changes in the body's systems (increased strength or endurance) are transient unless training is regularly used for functional activities or unless an individual participates in a maintenance program of resistance exercises.
- Reduction in muscle performance, begins within a week or two after the cessation of resistance exercises and continues until training effects are lost (Detraining).

D- Transfer of Training, overflow, or cross-training:

- Contrast to the SAID principle.

- Carryover of training effects from:
  - One variation of exercise or task to another.
  - An exercised limb to a non-exercised, contralateral limb.
- The overflow effects are less than the training effects resulting from specificity of training (SAID**)**.
- Transfer of training has been reported to occur on a very limited basis with respect to:
  1- The velocity of training.
  2- The type or mode of exercise.
- program of exercises designed to develop muscle strength has been shown to improve muscular endurance at least moderately.
- In contrast, endurance training has little to no cross-training effect on strength.

❖ **Factors that Influence Tension Generation in Normal Skeletal Muscle**:

I. Energy Stores and Blood Supply.
II. Fatigue.
III. Recovery from Exercise.
IV. Age.
V. Psychological and Cognitive Factors.
V1. Attention.
VII. Motivation and Feedback.

I- Energy Stores and Blood Supply:

- Muscle needs adequate sources of energy (fuel) to: Contract, generate tension, and resist fatigue.
- The blood supply, which transports oxygen and nutrients and removes waste products, affect the tension capacity of a muscle and its resistance to fatigue.

II- Fatigue:

- It has a variety of definitions that are based on the **type of fatigue.**

A- Muscle (local) fatigue: Diminished response of muscle to a repeated stimulus is reflected in a progressive decrement in the amplitude of motor unit potentials.

- It is normal and reversible (acute physiological response to exercise).
- It is characterized by a gradual decline in the force capacity of the neuromuscular system.
- It is a temporary state of exhaustion (failure).

- **The diminished response of the muscle is caused by:**
  - Disturbances in the contractile mechanism of the muscle itself because of a decrease in energy store and insufficient oxygen.
  - Inhibitory (protective) influences from the central nervous System (decrease in the conduction of impulses at the myoneural junction).
- **Muscle Fiber Types and Resistance to Fatigue**:

Characteristics	Type I	Type II A	Type II B

Fiber	Tonic	Phasic	Phasic
Twitch rate	Slow	Fast	Fast
Diameter	Small	Intermediate	Large
Energy system	Aerobic	Aerobic	Anaerobic
Capillary density	High	High	Low
Time of contraction	Long	Short	Short
Resistance to fatigue	High	Intermediate	Low
Maximum muscle shortening Velocity	Slow	Fast	Fast

- **Signs and Symptoms of Muscle Fatigue:**
  - An uncomfortable sensation in the muscle (pain and cramping).
  - Tremulousness in the contracting muscle.
  - Active movements jerky, not smooth.
  - Slowing and inability to complete the movement pattern through the full range of available motion during dynamic exercise against the same level of resistance.
  - Use of substitute motions that is, incorrect movement patterns to complete the movement pattern.
  - Inability to continue low-intensity physical activity.
  - Decline in peak torque during isokinetic testing.

B- Cardiopulmonary (general) fatigue:

- Diminished response of an individual (the entire body) as the result of prolonged physical activity (walking, jogging, cycling, or repetitive lifting or digging).
- Cardiopulmonary fatigue associated with endurance training is **caused by:**
  - Decrease in blood sugar (glucose) levels.
  - Decrease in glycogen stores in muscle and liver.
  - Depletion of potassium, especially in the elderly patient.

❖ **Threshold for fatigue:**

- It is the level of exercise that cannot be sustained indefinitely.
- patient's threshold for fatigue could be noted as:
  - The length of time a contraction is maintained.
  - The number of repetitions of an exercise that initially can be performed.
- This sets a baseline from which adaptive changes in physical performance can be measured.

❖ **Factors that influence fatigue:**

1- A patient's health status:

- In patients with neuromuscular, cardiopulmonary (cardiac, peripheral vascular, pulmonary diseases), oncologic (cancer undergoing chemotherapy or radiation therapy), inflammatory, or psychological disorders, the onset of fatigue is often abnormal (abruptly or more rapidly) due to deficits of oxygen transport system.
- In patients with multiple sclerosis, patient awakens rested and functions well during the early morning. By mid-afternoon reaches a peak of fatigue. Then by early evening the fatigue diminishes, and strength returns.

2- Diet and lifestyle (sedentary or active).

3- Environmental factors such as:

- outside or room temperature.
- air quality.
- altitude.

III- Recovery from Exercise:

- Adequate time for recovery from fatiguing exercise must be built into every resistance training program.
- This applies to both intra-session and inter-session recovery.
- Recovery from acute exercise, where the force-producing capacity of muscle returns to 90% to 95% of the pre-exercise capacity, usually takes 3 to 4 minutes, with the greatest proportion of recovery occurring in the first minute.
- **Changes that occur in muscle during recovery are:**
  - Oxygen stores are replenished in muscles.
  - Energy stores are replenished.
  - Lactic acid is removed from skeletal muscle and blood within approximately 1 hour after exercise.
  - Glycogen is replaced over several days.

IV- Age:

❖ **Muscle performance changes throughout the life span.**

A) Infancy, Early Childhood, and Preadolescence:

- **At birth to early infancy:**
  - muscle accounts for about 25% of body weight.
  - Total number of muscle fibers is established.
- **By the end of the first year:**
  - distribution of type I and type II fibers in muscle are complete.
- **from infancy to puberty:**
  - Muscle fiber size and muscle mass increase.
  - Muscle strength and muscle endurance increase.
  - Muscle mass and muscle strength is just slightly greater (approximately 10%) in boys than girls.

- Training-induced strength gains occur equally in both sexes during childhood without evidence of hypertrophy.

B) Puberty:

- Rapid acceleration in muscle fiber size and muscle mass, especially in boys (more than 30% per year).
- Rapid increase in muscle strength (marked difference in strength levels develops in boys and girls) In boys, muscle mass and body height and weight peak before muscle strength; in girls, strength peaks before body weight.
- Relative strength gains as the result of resistance training are comparable between the sexes (increased muscle hypertrophy in boys).

C- Young and Middle Adulthood:

- Muscle mass peaks in women (between 16 and 20 years) and in men (between 18 and 25 years).
- Decreases in muscle mass occur as early as 25 years of age.
- Muscle mass constitutes approximately 40% of total body weight (men slightly more muscle mass than women).
- Strength and endurance develop into the second decade, especially in men and reach a peak during the second decade (earlier for women than men).
- By sometime in the third decade, strength declines between 8% and 10% per decade through the fifth or sixth decade.
- Strength and muscle endurance deteriorate less rapidly in physically active versus sedentary adults.
- Improvements in strength and endurance are possible with only increase in physical activity.

D) Late Adulthood:

- Rate of decline of muscle strength accelerates to 15% to 20% per decade during the sixth and seventh decades and increases to 30% per decade thereafter.
- Loss of muscle mass continues; by the eighth decade (by 50% compared to young adulthood).
- Muscle fiber size (cross-sectional area), type I and type II fiber numbers, and the number of alpha motoneurons all decrease.
- Decrease in the speed of muscle contractions and peak power.
- Progressive decrease in endurance and maximum oxygen uptake.
- Loss of flexibility reduces the force-producing capacity of muscle.
- Minimal decline in performance of functional skills during the sixth decade.
- Significant deterioration in functional abilities by the eighth decade.
- With a resistance training a significant improvement in muscle strength, power, and endurance is possible during late adulthood.

V- Psychological and Cognitive Factors:

It can positively influence muscle performance. It can negatively influence muscle performance.

1- Mental status (fear of pain, injury, or reinjury).

2- Depression related to physical illness.

3- Impaired attention or memory as the result of age, head injury, or the side effects of medication.

VI- Attention:

- A patient focus on a given task (exercise) to learn how to perform it correctly for safety and optimal long-term training effects.
- Attention involves:
  - The ability to process relevant data while screening out irrelevant information from the environment.
  - Respond to internal cues from the body.
- Both are necessary at first learning an exercise and later at carrying out an exercise program independently.

VII- Motivation and Feedback:

- Patient must be willing to put forth and maintain sufficient effort and adhere to an exercise program over time.
- Use of activities that are meaningful.
- Periodically modifying an exercise routine help maintain a patient's interest in resistance training.
- Charting or graphing a patient's strength gains in muscle performance and functional activities.

❖ **Determinants and Correlates that Affect Tension Generation of Skeletal Muscle**:

Factor	Influence
1- Cross-section and size of the muscle (includes muscle fiber number and size)	**The larger the muscle diameter, the greater its tension-producing capacity**
2- Fiber arrangement and fiber length (also relates to cross-sectional diameter of the muscle)	**Short fibers with pinnate and multipinnate design in high force producing muscles (quadriceps, gastrocnemius, deltoid, biceps brachii) Long parallel design in muscles with high rate of shortening but less force production (sartorius, lumbricals)**
3- Fiber-type distribution of muscle: type I (tonic, slow- twitch) and type IIA & IIB (phasic, fast-twitch).	**High percentage of type I fibers: low force production, slow rate of maximum force development, resistant to fatigue High percentage of type IIA and IIB fibers: rapid high force production; rapid fatigue**

4- Length-tension relationship of muscle at time of contraction.	**Muscle produces greatest tension when it is near or at the physiological resting position at the time of contraction**
5- Recruitment of motor units	**The greater the number and synchronization of motor units firing, the greater the force production**
6- Frequency of firing of motor units.	**The higher the frequency of firing, the greater the tension.**
7- Type of muscle contraction	**Force output from greatest to least: eccentric, isometric, concentric muscle contraction**
8- Speed of muscle contraction (force-velocity relationship).	**Concentric contraction: ↑ speed → ↓ tension. Eccentric contraction: ↑ speed → ↑ tension.**

❖ Physiological Adaptations to Resistance Exercise:

- The use of resistance exercise in rehabilitation programs has a substantial impact on all systems of the body.
- Body systems accommodate over time to the newly imposed physical demands.
- Training-induced adaptations to resistance exercise, known as chronic physiological response.

Variable	Strength Training Adaptation	Endurance Training Adaptations
1- Skeletal muscle structure	• **Hypertrophy of muscle fibers; greater in type II fibers (Hyperplasia possibly).** • **Fiber type composition: - remodeling of type IIB to type IIA.** • **no change in type I to type II distribution (no conversion).** • **Capillary bed density: ↓ or no change.** • **Mitochondrial density and volume: ↓**	• **Hypertrophy: minimal or no change.** • **Capillary bed density: ↑** • **Mitochondrial density and volume: ↑**
2- Neural system	• **Motor unit recruitment: ↑motor units firing** • **Rate of firing: ↑ (↓ twitch contraction time)** • **Synchronization of firing: ↑**	
3- Metabolic system	• **ATP and CP storage: ↑** • **Myoglobin storage: ↑** • **Stored triglycerides: not known**	• **ATP and CP storage: ↑** • **Myoglobin storage: ↑**

		• **Stored triglycerides: ↑**
4- Enzymes	• **Creatine phosphokinase: ↑** • **Myokinase: ↑**	• **Similar ↑** • **Similar ↑**
5- Body composition	• **Lean body (fat-free) mass: ↑** • **% body fat: ↓**	• **Lean body (fat-free) mass: no change** • **% body fat: ↓**
6- Connective tissue	• **Tensile strength of tendons, ligaments, and connective tissue in muscle: ↑** • **Bone: ↑ bone mineral density; no change or possible ↑ in bone mass**	• **Tensile strength of tendons, ligaments, and connective tissue in muscle: ↑** • **Bone: ↑ mineralization with weight-bearing activities**

❖ DETERMINANTS OF RESISTANCE EXERCISE:

1- Alignment :

a) Alignment and muscle action.

- It is determined by:
  - The direction of muscle fibers
  - The line of pull of the muscle to be strengthened.
- Direction of movement of a segment replicates the action of the muscle.
- Example, to strengthen the gluteus medius, the hip must remain slightly extended, not flexed; as the patient abducts the LL against resistance. If the hip is flexed, the adjacent tensor fasciae latae becomes the prime mover and is strengthened.

b) Alignment and gravity.

- The alignment or position of the patient or the limb with respect to gravity during resistance exercises.
- The patient or limb should be positioned so the muscle being strengthened acts against the resistance of gravity and the weight.

2- Stabilization:

- Stabilization refers to: holding down a body segment or holding the body steady.
- Importance of stabilization:
  - To maintain appropriate alignment, ensure the correct muscle action and movement pattern.

- To avoid unwanted substitute motions during resistance exercise.

➢ Stabilization can be achieved externally or internally.

a) External stabilization:

- Manually: by the therapist or the patient.
- Equipment: such as belts and straps.
- Firm support surface: such as the back of a chair or the surface of the treatment table.

b) Internal stabilization:

- Isometric contraction of an adjacent muscle group that does not enter into the movement pattern but holds the body segment of the proximal attachment of the muscle being strengthened firmly in place.

3- Intensity: The exercise load (level of resistance).

4- Volume: The total number of repetitions and sets in an exercise session multiplied by the resistance used.

5- Exercise order: The sequence in which muscle groups are exercised during an exercise session.

6- Frequency: The number of exercise sessions per day or per week.

7- Rest interval: Time allotted for recuperation between sets and sessions of exercise.

8- Duration: Total time frame of a resistance training program.

9- Mode of exercise: Type of muscle contraction, position of the patient, form (source) of resistance, arc of movement, or the primary energy system utilized.

10- Velocity of exercise: The velocity at which a muscle contracts.

11- Periodization: Variation of intensity and volume during specific periods of resistance training.

12- Integration of exercises into functional activities: Use of resistance exercises that approximate or replicate functional demands.

❖ **TYPES OF RESISTANCE EXERCISE**:

1- Manual Resistance Exercise:

➢ Is a type of active-resistive exercise in which resistance is provided by therapist, health professional , or patient(self-R).

➢ The amount of resistance cannot be measured quantitatively.

➢ Is useful in**:**

- Early stages of an exercise (muscle is weak and can overcome only minimal to moderate resistance).
- Range of joint movements needs to controlled.

2- Mechanical Resistance Exercise:

➢ It is a form of active-resistive exercise in which resistance is applied through the use of equipment or mechanical apparatus.

➢ The amount of resistance can be measured quantitatively and incrementally progressed over time.

- It is also useful when the amount of resistance necessary is greater than what the therapist can apply manually.

❖ **TYPES OF RESISTANCE EXERCISE IN RELATION TO MUSCLE CONTRACTION:**

A- Isometric Exercise (Static Exercise):

- It is a static form of exercise in which a muscle contracts and produces force without an appreciable change in the length of the muscle and without visible joint motion.
- Although there is no mechanical work done (force × distance), a measurable amount of tension and force output are produced by the muscle.
- Sources of resistance for isometric exercise include:
  - Holding against a force applied manually.
  - Holding a weight in a particular position.
  - Maintaining a position against the resistance of body weight.
  - Pushing or pulling an immovable object.

- **Types of Isometric Exercise:**

a) Muscle-setting exercises: low intensity isometric contractions against little to no resistance.

- They are used to:
  - Decrease muscle pain and spasm.
  - Promote relaxation and circulation after injury to soft tissues during the acute stage of healing.
  - Retard muscle atrophy and maintain mobility between muscle fibers (during immobilization).
- Two common examples of muscle setting are:
  - The quadriceps.
  - The gluteal muscles.
- Muscle setting does not improve muscle strength except in very weak muscles because it is performed against no appreciable resistance.

b) Stabilization exercises:

- It is used to: develop a submaximal but sustained level of cocontraction to improve postural stability or dynamic stability of a joint in antigravity positions and in weight bearing postures.
- Sources of resistance: Body weight or manual resistance.
- The Variations terms are used to describe stabilization exercises:
  - Rhythmic stabilization.
  - Alternating isometrics.

c) Multiple-angle isometrics:

- Resistance is applied, manually or mechanically, at multiple joint positions within the available ROM.

- ❑ It is used to improve strength throughout the ROM when joint motion is permissible but dynamic resistance exercise is painful or inadvisable.

- **Indications of Isometric Exercise:**
  - To prevent or minimize muscle atrophy during joint immobilization (casts, splints, skeletal traction).
  - To activate muscles (facilitate muscle firing) (neuromuscular control) when joint movement is not advisable after soft tissue injury or surgery.
  - To develop postural or joint stability.
  - To improve muscle strength when use of dynamic resistance exercise could compromise joint integrity or cause joint pain.
  - To develop static muscle strength at particular points in the ROM consistent with specific task-related needs.

B- Dynamic Exercise (Concentric and Eccentric):

- A dynamic muscle contraction causes joint movement and excursion of a body segment as the muscle contracts and shortens (concentric contraction) or lengthens under tension (eccentric contraction) figure 2.

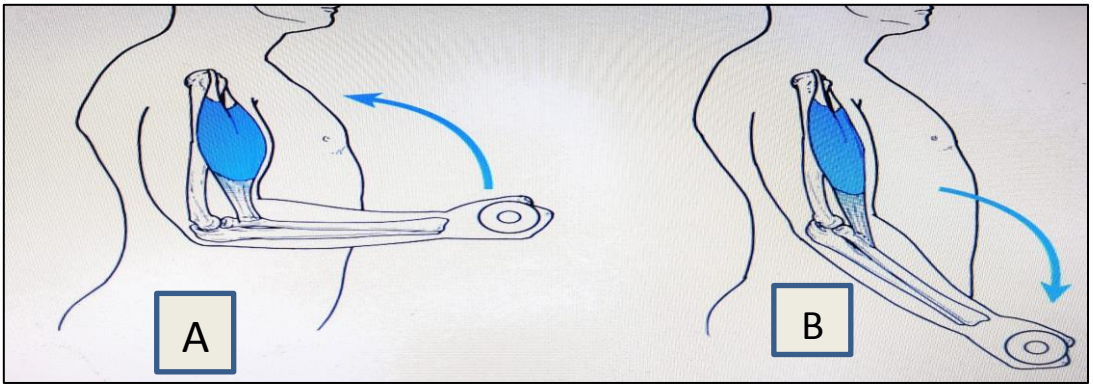


Fig.2: (A) Concentric and (B) eccentric strengthening of the elbow flexors occurs as a weight is lifted and lowered.

- **Characteristics and Effects of Concentric and Eccentric Exercise:**
  - Greater loads can be controlled by eccentric than cocentric muscle contractions may be associated with the contributions of the contractile and noncontractile components of muscle.
  - Training-induced gain in muscle strength and mass are greater with maximum effort eccentric training than maximum effort concentric training.
  - Eccentric contractions are more efficient metabolically and generate less fatigue than concentric contractions.
  - Greater delayed-onset muscle soreness in eccentric than concentric exercises result of greater damage to muscle and connective tissue.
- **Type of Dynamic Exercise (Constant and Variable) Resistance:**

1- Dynamic Constant External Resistance (DCER):

- It is a form of resistance training where a limb moves through a ROM against a constant external load, provided by free weights such as a handheld or cuff weight, torque arm units figure 3, weight machines, or pulley systems).
- Terminology (DCER exercise) is used in lieu of the term "isotonic exercise" because although the imposed load (weight) does not change the torque imposed by the weight and the tension generated by the muscle do change throughout the range of movement**.**

Fig.3: N–K Exercise Unit with torque arm and interchangeable weights provides constant external resistance.

- If the load is less than the torque generated by the muscle, the muscle contracts concentrically and accelerates the load.
- if the load exceeds the muscle's torque production, the muscle contracts eccentrically to decelerate the load.

2- Variable-Resistance Exercise:

- Specially designed resistance equipment imposes varying levels of resistance to the contracting muscles to load the muscles more effectively at multiple points in the ROM.
- The resistance is altered throughout the range by means of a weight cable system that moves over an asymmetrically shaped cam, by a lever arm system figure 4, or by hydraulic or pneumatic mechanisms figure 5.

Fig4: Weight cable system.

Fig.5: Pneumatic mechanisms.

C- Isokinetic exercise:

- It is a form of dynamic exercise in which the velocity of muscle shortening or lengthening and the angular limb velocity is predetermined and held constant figure 7.
- The term isokinetic refers to movement that occurs at an equal (constant) velocity.
- Unlike DCER exercise where a specific weight (amount of resistance) is selected and superimposed on the contracting muscle, in isokinetic resistance training the velocity of limb movement, not the load, is manipulated.

- Isokinetic exercise is also called accommodating resistance exercise.
- At each repetition of exercise, the contracting muscle produces variable but maximum force output, consistent with the muscle's variable tension generating capabilities at all portions in the range of movement, not at only one small portion of the range as occurs with DCER training.

Fig.7: Isokinetic device.

❖ **<u>Characteristics of Isokinetic Training:</u>**

1. Constant velocity. the velocity of muscle shortening or lengthening is preset and controlled by the unit and remains constant throughout the ROM.
2. Range and selection of training velocities. a wide range of exercise velocities (very slow to fast velocities).
3. Reciprocal versus isolated muscle training. Use of reciprocal training of agonist and antagonist muscles (quick reversals of motion). For example: the training parameter can be set so the patient performs concentric contraction of the quadriceps followed by concentric contraction of the hamstrings.
4. Specificity of training. Isokinetic training for the most part is speed-specific. Patient can train at several medium and fast velocities (between 90˚ and 360˚/sec) using a system of training known as velocity spectrum rehabilitation.
5. Compressive forces on joints. the compressive forces across the moving joint are less at faster angular velocities than at slow velocities.
6. Accommodation to fatigue. resistance of the isokinetic unit is directly proportional to the force, as the contracting muscle fatigues, a patient is still able to perform additional repetitions even though the force output of the muscle temporarily diminishes.
7. Accommodation to a painful arc.
   - If a patient experiences transient pain at some portion of motion during exercise The patient simply pushes less vigorously against the resistance arm to move without pain through that portion of the range.
   - If a patient needs to stop a resisted motion because of sudden onset of pain, the resistance is eliminated.

❖ **<u>Initiation and Progression of Isokinetic Training During Rehabilitation:</u>**

1. Initially to keep resistance low, submaximal isokinetic exercise before maximal effort.

2. Short-arc movements are used before full-arc motions to avoid movement in an unstable or painful portion of the rang.
3. Slow to medium training velocities before progressing to faster velocities.
4. Maximal concentric contractions before eccentric isokinetic exercises for the following reasons:
    - Concentric isokinetic exercise is easier to learn and is fully under the control of the patient.
    - Eccentric isokinetic exercise the velocity of movement of the resistance arm is robotically controlled by the dynamometer, not the patient.

❖ **Manual Resistance Exercise: Advantages and Disadvantages**

➢ **Advantages:**

1. Most effective during the early stages of rehabilitation when muscles are weak (4/5 or less).
2. Effective form of exercise for transition from assisted to mechanically resisted movements.
3. More finely graded resistance than mechanical resistance.
4. Resistance is adjusted throughout the ROM as the therapist responds to the patient's efforts or a painful arc.
5. Muscle works maximally at all portions of the ROM.
6. The range of joint movement can be carefully controlled by the therapist to protect healing tissues or to prevent movement into an unstable portion of the range.
7. Useful for dynamic or static strengthening.
8. Direct manual stabilization prevents substitute motions.
9. Can be performed in a variety of patient positions.
10. Placement of resistance is easily adjusted.
11. Gives the therapist an opportunity for direct interaction with the patient to monitor the patient's performance continually.

➢ **Disadvantages:**

1. Exercise load (amount of resistance) is subjective; it cannot be measured or quantitatively documented.
2. Amount of resistance is limited to the strength of the therapist; therefore, resistance imposed is not adequate to strengthen already strong muscle groups.
3. Little value for strong muscle groups.
4. Speed of movement is slow to moderate, which may not carry over to most functional activities.
5. Cannot be performed independently by the patient to strengthen most muscle groups.
6. Not useful in home program (need assistance).
7. time-intensive for the therapist.
8. Impractical for improving muscular endurance; too time consuming.

❖ **Mechanical Resistance Exercise: Advantages and Disadvantages**

- **Advantages:**
  1. Establishes quantitative baseline measurement of muscle performance against.
  2. Most appropriate during intermediate and advanced phases of rehabilitation when muscle strength is 4/5 or greater or when the strength of the patient exceeds the therapist's strength.
  3. Heavy exercise loads, beyond that which can be applied manually by a therapist.
  4. Increases in level of resistance can be incrementally and quantitatively documented.
  5. Quantitative improvement is an effective source of motivation for the patient.
  6. Useful for improving dynamic or static strength. 7- Adds variety to a resistance training program.
  7. Practical for improving muscular endurance.
  8. Some equipment provides variable resistance through the ROM.
  9. High-velocity resistance training is possible and safe.
  10. Appropriate for independent exercise in a home program after careful patient education and a period of supervision.
- **Disadvantages:**
  1. Not appropriate when muscles are very weak or soft tissues are in the very early stages of healing, with the exception of some equipment that provides assistance, support, or control against gravity.
  2. Equipment that provides constant external resistance maximally loads the muscle at only one point in the ROM.
  3. No accommodation for a painful arc (except with hydraulic, pneumatic, or isokinetic equipment).
  4. Expense for purchase and maintenance of equipment.
  5. With free weights and weight machines, gradation in resistance is dependent on the manufacturer's increments of resistance.

❖ **SELECTED RESISTANCE TRAINING REGIMENS**:

- Progressive resistance exercise (PRE): is a system of dynamic resistance training in which a constant external load is applied to the muscle by some mechanical means (usually a free weight or weight machine) and incrementally increased.
- The repetition maximum (RM): is used as the basis for determining and progressing the resistance.

DeLorme Regimen	Oxford Regimen
Determination of a 10 RM ▪ **10 reps @ 50% of the 10 RM** ▪ **10 reps @ 75% of the 10 RM** ▪ **10 reps @ 100% of the 10 RM**	**Determination of a 10 RM** ▪ **10 reps @ 100% of the 10 RM** ▪ **10 reps @ 75% of the 10 RM** ▪ **10 reps @ 50% of the 10 RM**

❖ **Precautions for Resistance Exercise:**

The exercises must not only be effective but safe.

1. pain should not occur during exercise.
2. Do not initiate resistance training at a maximal level of resistance particularly with eccentric exercise to minimize delayed-onset muscle soreness (DOMS).
3. Use light to moderate exercise during the recovery period.
4. Select suitable clothing for exercise.
5. Avoid use of heavy resistance during exercise for children, older adults, and patients with osteoporosis.
6. Do not apply resistance across an unstable joint or distal to an unhealed fracture.
7. Have the patient avoid breath-holding during resisted exercises to prevent the Valsalva maneuver; emphasize exhalation during exertion.
8. Prevent incorrect or substitute motions by adequate stabilization.
9. Be aware of medications a patient is using that can alter acute and chronic responses to exercise.
10. Avoid cumulative fatigue by incorporating adequate rest intervals.
11. Discontinue exercises if the patient experiences pain, dizziness, or unusual or precipitous shortness of breath.

❖ **Prevention During Resistance Exercise:**

1. Avoid breath-holding.
2. Ask the patient to breathe rhythmically, count, or talk during exercise.
3. Have the patient exhale when lifting and inhale when lowering an exercise load.

❖ **Contraindications to Resistance Exercise:**

1. Pain:

➢ If a patient experiences severe joint or muscle pain during active- free (unresisted) movements, dynamic resistance exercises should not be initiated.

2. Inflammation:

➢ Dynamic and static resistance training is absolutely contraindicated in the presence of inflammatory neuromuscular disease. For example, in patients with acute anterior horn cell disease (Guillain-Barré) or inflammatory muscle disease (polymyositis, dermatomyositis).

➢ Dynamic resistance exercises are contraindicated in the presence of acute inflammation of a joint. Gentle setting (static) exercises against negligible resistance are appropriate.

3. Severe Cardiopulmonary:

➢ Disease Severe cardiac or respiratory diseases or disorders associated with acute symptoms contraindicate resistance training. For example, patients with severe coronary artery disease, carditis, or cardiac myopathy، congestive heart failure, uncontrolled hypertension or dysrhythmias.

Practical Application of Resisted exercises:

Preparation for Resistance Exercises:

- Select and prescribe the forms of resistance exercise that are appropriate and expected to be effective, such as whether to implement manual or mechanical resistance exercises, or both. If implementing mechanical resistance exercise, determine what equipment is needed and available.
- Review the anticipated goals and expected functional outcomes with the patient.
- Explain the exercise plan and procedures. Be sure that the patient and/or family understands and gives consent.
- Have the patient wear nonrestrictive clothing and supportive shoes appropriate for exercise.
- If possible, select a firm but comfortable support surface for exercise.
- Demonstrate each exercise and the desired movement pattern.

Warm-Up:

- Prior to initiating resistance exercises, warm-up with light, repetitive، dynamic, site-specific movements without applying resistance.
- For example, prior to lower extremity resistance exercises, have the patient walk on a treadmill, if possible, for 5 to 10 minutes followed by flexibility exercises for the trunk and lower extremities.

Placement of Resistance:

- Resistance typically is applied to the distal end of the body part in which the muscle to be strengthened attaches.

N.B: on biomechanical basis, Distal placement of resistance generates the greatest amount of external torque with the least amount of manual or mechanical resistance (load). For example, to strengthen the anterior deltoid, resistance is applied to the distal humerus as the patient flexes the shoulder.

- Resistance may be applied across an intermediate joint if that joint is stable and pain-free and if there is adequate muscle strength supporting the joint. For example, to strengthen the anterior deltoid using mechanical resistance, a handheld weight is a common source of resistance.
- Revise the placement of resistance if pressure from the load is uncomfortable for the patient.

Stabilization:

Stabilization is necessary to avoid unwanted, substitute motions.

- For nonweight-bearing resisted exercises, external stabilization of a segment usually is applied at the proximal attachment of the muscle to be strengthened, for example, stabilization should occur at the anterior shoulder as elbow flexion is resisted.
- Equipment such as belts or straps are effective sources of external stabilization.
- During multijoint resisted exercises in weight-bearing postures, the patient must use muscle control (internal stabilization) to hold nonmoving segments in proper alignment. Stabilization is applied at the proximal attachment of the muscle being strengthened.

Direction of Resistance:

During concentric exercise resistance is applied in the direction directly opposite to the desired motion, whereas during eccentric exercise resistance is applied in the same direction as the desired motion.

Intensity of Exercise/Amount of Resistance:

NOTE: The intensity of the exercise (submaximal to nearmaximal) must be consistent with the intended goals of resistance training and the type of muscle contraction as well as other aspects of dosage.

- Initially, have the patient practice the movement pattern against a minimal load to learn the correct exercise technique.
- Have the patient exert a forceful but controlled and painfree effort. The level of resistance allows movements that are smooth and nonballistic or tremulous.
- Adjust the alignment, stabilization, or the amount of resistance if the patient is unable to complete the ROM or tremors or substitute motions occur.

Number of Repetitions, Sets, and Rest Intervals:

- for most adults, use 8 to 12 repetitions of a specific motion against a moderate exercise load. This typically induces expected acute and chronic responses that is, muscular fatigue and adaptive gains in muscular strength, respectively.
- Decrease the amount of resistance if the patient cannot complete 8 to 12 repetitions.
- After a brief rest, perform additional repetitions a second set of 8 to 12 repetitions, if possible.
- For progressive overloading, initially increase the number of repetitions or sets; at a later point in the exercise program, gradually increase the resistance.

Instructions:

use simple instructions that are easily understood. Do not use medical terminology or jargon. For example, tell the patient to "Bend and straighten your elbow" rather than "Flex and extend your elbow".

Monitoring the Patient:

Assess the patient's responses before, during, and after exercise. monitor the patient's vital signs. Adhere to relevant precautions.

Cool-Down:

Cool-down after a series of resistance exercises with rhythmic, unresisted movements, such as arm swinging, walking, or stationary cycling.

Body Mechanics of the Therapist:

- Select a treatment table with a suitable height or adjust the height of the patient's bed, to enhance use of proper body mechanics.
- Assume a position close to the patient to avoid stresses on your low back and to maximize control of the patient's upper or lower extremity.

- Use a wide base of support to maintain a stable posture. Shift your weight to move as the patient moves his or her limb

Application of Manual Resistance and Stabilization:

- Stabilize the proximal attachment of the contracting muscle with one hand, when necessary, while applying resistance distally to the moving segment.
- Grade and vary the amount of resistance to equal the abilities of the muscle through all portions of the available ROM.
- Allow smooth, controlled movements.
- Hold the patient's extremity close to your body so some of the force applied is from the weight of your body not just the strength of your upper extremities.
- With alternating isometric contractions of agonist and antagonist muscles, maintain manual contacts at all times as the isometric contractions are repeated.

❖ Upper Extremity:

▸ Shoulder Flexion.

- Patient position: supine.
- Therapist position: walk standing beside the affected side.
- Hand Placement and Procedure: Apply resistance to the anterior aspect of the distal arm or to the distal portion of the forearm if the elbow is stable and pain-free. Stabilization of the scapula and trunk is provided by the treatment table figure 1.

Fig.1:Resisted shoulder flexion.

▸ Shoulder Extension.

- Hand Placement and Procedure: Apply resistance to the posterior aspect of the distal arm or the distal portion of the forearm. Stabilization of the scapula is provided by the table.

▸ Shoulder Hyperextension.

- The patient assumes the supine position, close to the edge of the table, side-lying, or prone.
- Hand Placement and Procedure: Apply resistance in the same manner as for extension of the shoulder. Stabilize the anterior aspect of the shoulder if the patient is supine. If the patient is side-lying, adequate stabilization must be given to the trunk and scapula. This usually can be done if the therapist places the patient close to the edge of the table and stabilizes the patient with the lower trunk. If the patient is lying prone, manually stabilize the scapula.

- **Shoulder Abduction and Adduction.**
  - Patient position: supine with the patient's elbow flexed to 90°.
  - Therapist position: walk standing beside the affected side.
  - Hand Placement and Procedure: Apply resistance to the distal portion of the arm with the patient's elbow flexed to 90°. To resist abduction, apply resistance to the lateral aspect of the arm. To resist adduction, apply resistance to the medial aspect of the arm. Stabilization is applied to the superior aspect of the shoulder, if necessary, to prevent the patient from initiating abduction by shrugging the shoulder (elevation of the scapula). Allow the glenohumeral joint to externally rotate when resisting abduction above 90° to prevent impingement figure 2.

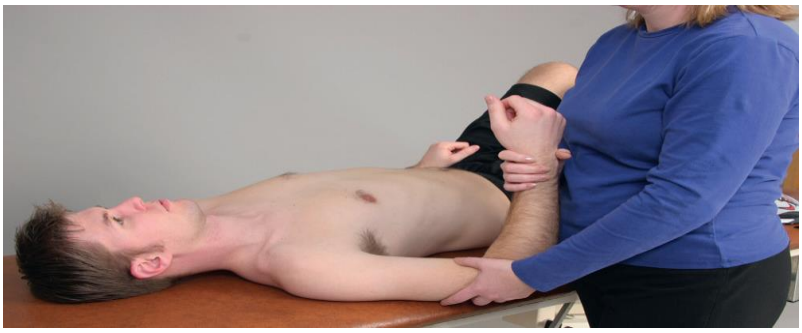


Fig.2: Resisted shoulder abduction.

- **Elevation of the Arm in the Plane of the Scapula ("Scaption").**
  - Hand Placement and Procedure: Same as previously described for shoulder flexion. Apply resistance as the patient elevates the arm in the plane of the scapula (30° to 40° anterior to the frontal plane of the body)
- **Shoulder Internal and External Rotation.**
  - Hand Placement and Procedure: Flex the elbow to 90° and position the shoulder in the plane of the scapula. Apply resistance to the distal portion of the forearm during internal rotation and external rotation. Stabilize at the level of the clavicle during internal rotation; the back and scapula are stabilized by the table during external rotation figure 3.

Fig.3: Resisted external rotation of the shoulder with the shoulder positioned in flexion and abduction (approaching the plane of the scapula).

Fig.4: Resisted internal rotation of the shoulder with the shoulder in 90° of abduction.

- **Shoulder Horizontal Abduction and Adduction.**
  - Hand Placement and Procedure: Flex the shoulder and elbow to 90° and place the shoulder in neutral rotation. Apply resistance to the distal portion of the arm just above the elbow during horizontal adduction and abduction. Stabilize the anterior aspect of the shoulder during horizontal adduction. The table stabilizes the scapula and trunk during horizontal abduction. To resist horizontal abduction from 0° to 45°, the patient must be close to the edge of the table while supine or be placed side-lying or prone.
- **Elevation and Depression of the Scapula.**
  - Hand Placement and Procedure: Have the patient assume a supine, side-lying, or sitting position. Apply resistance along the superior aspect of the shoulder girdle just above the clavicle during scapular elevation Figure 5.

Fig.5: Scapular elevation

- **Alternate position: Scapular Depression.**
  - To resist unilateral scapular depression in the supine position, have the patient attempt to reach down toward the foot and push the hand into the therapist's hand.
  - When the patient has considerable strength, the exercise can be performed to include weight bearing through the upper extremity by having the patient sit on the edge of a low table and lift the body weight with both hands.
- **Protraction and Retraction of the Scapula.**
  - Hand Placement and Procedure: Apply resistance to the anterior portion of the shoulder at the head of the humerus to resist protraction and to the posterior aspect of the shoulder to resist retraction. Resistance may also be applied directly to the scapula

if the patient sits or lies on the side, facing the therapist. Stabilize the trunk to prevent trunk rotation.

- **Elbow Flexion and Extension.**
  - Hand Placement and Procedure: To strengthen the elbow flexors, apply resistance to the anterior aspect of the distal forearm. The forearm may be positioned in supination, pronation, and neutral to resist individual flexor muscles of the elbow figure 6. To strengthen the elbow extensors, place the patient prone or supine and apply resistance to the distal aspect of the forearm. Stabilize the upper portion of the humerus during both motions figure 7.

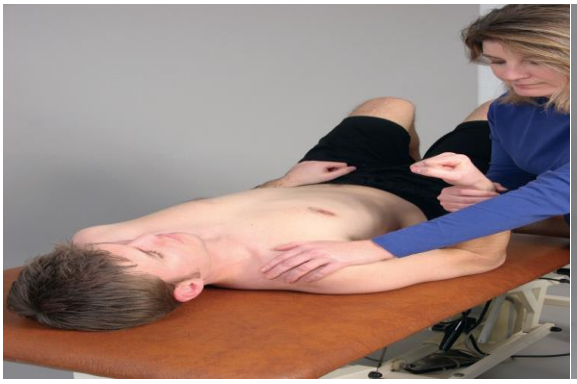


Fig.6: Resisted elbow flexion.

Fig.7: Resisted elbow extension.

- **Forearm Pronation and Supination.**
  - Hand Placement and Procedure: Apply resistance to the radius of the distal forearm with the patient's elbow flexed to 90° to prevent rotation of the humerus. Therapist should not apply resistance to the hand to avoid twisting forces at the wrist figure 8.

Fig.8: Resisted pronation of the forearm.

- **Wrist Flexion and Extension.**
  - Hand Placement and Procedure: Apply resistance to the volar and dorsal aspects of the hand at the level of the metacarpals to resist flexion and extension, respectively. Stabilize the volar or dorsal aspect of the distal forearm figure 9.

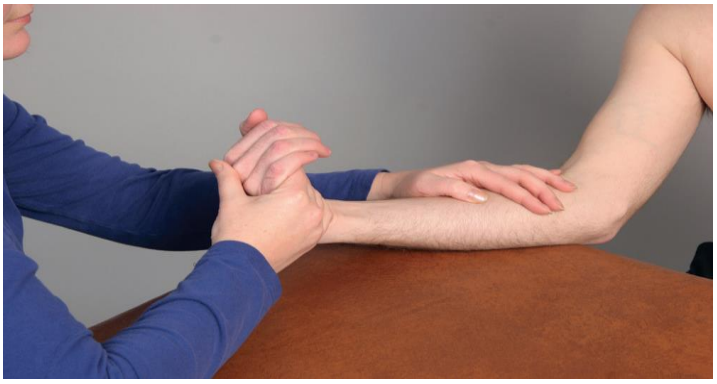


Fig.9: Resisted wrist flexion and stabilization of the forearm.

- **Wrist Radial and Ulnar Deviation.**
  - Hand Placement and Procedure: Apply resistance to the second and fifth metacarpals alternately to resist radial and ulnar deviation. Stabilize the distal forearm.
- **Motions of the Fingers and Thumb.**
  - Hand Placement and Procedure: Apply resistance just distal to the joint that is moving. Resistance is applied to one joint motion at a time. Stabilize the joints proximal and distal to the moving joint figure 10,11.

Fig.10: Resisted flexion of (PIP) joint of the index finger with stabilization of (MCP) and (DIP) joints.

Fig.11: Resisted opposition of the thumb.

❖ Lower Extremity:

- **Hip Flexion with Knee Flexion.**
  - Hand Placement and Procedur: Apply resistance to the anterior portion of the distal thigh. Simultaneous resistance to knee flexion may be applied at the distal and posterior aspect of the lower leg, just above the ankle figure 12. Stabilization of the pelvis and lumbar spine is provided by adequate strength of the abdominal muscles.

- **PRECAUTION:** If, when the opposite hip is extended, the pelvis rotates anteriorly, and lordosis in the lumbar spine increases during resisted hip flexion, have the patient flex the opposite hip and knee and plant the foot on the table to stabilize the pelvis and protect the low back region

Fig.12: Resisted flexion of the hip with the knee flexed.

- **Hip Extension.**
  - Hand Placement and Procedure: Apply resistance to the posterior aspect of the distal thigh with one hand and to the inferior and distal aspect of the heel with the other hand. Stabilization of the pelvis and lumbar spine is provided by the table figure 13.

Fig.13: Resisted hip and knee extension

- **Hip Hyperextension.**
  - Patient position: prone.
  - Hand Placement and Procedure: With the patient in a prone position, apply resistance to the posterior aspect of the distal thigh. Stabilize the posterior aspect of the pelvis to avoid motion of the lumbar spine figure 14.

Fig.14: Hip hyper-extension with stabilization of the pelvis.

- **Hip Abduction and Adduction.**
  - Hand Placement and Procedure: Apply resistance to the lateral and the medial aspects of the distal thigh to resist abduction and adduction, respectively, or to the lateral and medial aspects of the distal leg just above the malleoli if the knee is stable and pain-free figure 15. Stabilization is applied to the pelvis to avoid hip-hiking from substitute

action of the quadratus lumborum and to keep the thigh in neutral position to prevent external rotation of the femur and subsequent substitution by the iliopsoas.

Fig.15: Resisted hip abduction.

- **Hip Internal and External Rotation.**

A. Hand Placement and Procedure: Patient position is supine with the hip and knee extended. Apply resistance to the lateral aspect of the distal thigh to resist external rotation and to the medial aspect of the thigh to resist internal rotation. Stabilize the pelvis.

B. Hand Placement and Procedure: Patient position is supine with the hip and knee flexed. Apply resistance to the medial aspect of the lower leg just above the malleolus during external rotation and to the lateral aspect of the lower leg during internal rotation. Stabilize the anterior aspect of the pelvis as the thigh is supported to keep the hip in 90° of flexion figure 16.

C. Hand Placement and Procedure Patient position: prone, with the hip extended and the knee flexed. Apply resistance to the medial and lateral aspects of the lower leg. Stabilize the pelvis by applying pressure across the buttocks figure 17.

Fig.16: Resisted external rotation of the hip

Fig.17: Resisted internal rotation of the hip

- **Knee Flexion**.

Resistance to knee flexion may be combined with resistance to hip flexion, as described earlier with the patient supine.

- Alternate patient position: prone with the hips extended figure 18.
- Hand Placement and Procedure: Apply resistance to the posterior aspect of the lower leg just above the heel. Stabilize the posterior pelvis across the buttocks.
- Additional patient position: sitting at the edge of a table with the hips and knees flexed and the back supported and stabilized.

Fig.18: Resisted knee flexion.

- **Knee Extension.**
  - Alternate Patient Positions

A. If the patient is lying supine on a table, the hip must be abducted and the knee flexed so the lower leg is over the side of the table. This position should not be used if the rectus femoris or iliopsoas is tight because it causes an anterior tilt of the pelvis and places stress on the low back.

B. If the patient is prone, place a rolled towel under the anterior aspect of the distal thigh; this allows the patella to glide normally during knee extension.

C. If the patient is sitting, place a rolled towel under the posterior aspect of the distal thigh figure 19.

- Hand Placement and Procedure: Apply resistance to the anterior aspect of the lower leg. Stabilize the femur, pelvis, or trunk as necessary.

Fig.19: Resisted knee extension

- **Ankle Dorsiflexion and Plantarflexion.**
  - Hand Placement and Procedure: Apply resistance to the dorsum of the foot just above the toes to resist dorsiflexion and to the plantar surface of the foot at the metatarsals to resist plantarflexion. Stabilize the lower leg figure 20.

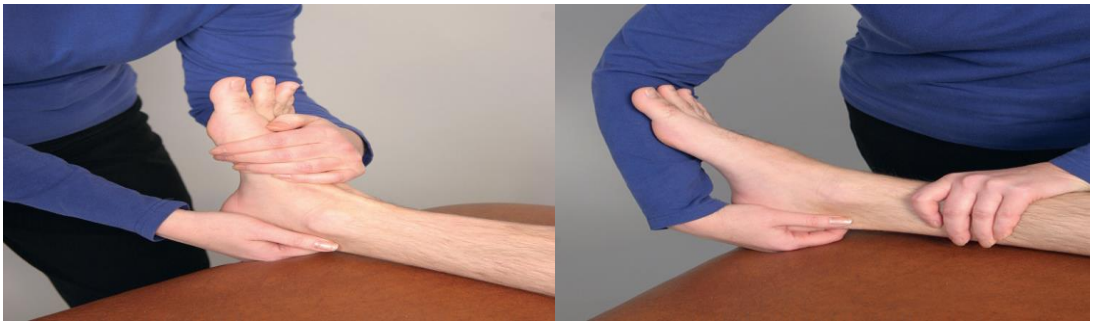


Fig.20: Resisted dorsiflexion & Resisted plantarflexion of the ankle.

- **Ankle Inversion and Eversion.**
  - Hand Placement and Procedure: Apply resistance to the medial aspect of the first metatarsal to resist inversion and to the lateral aspect of the fifth metatarsal to resist eversion. Stabilize the lower leg.
- **Flexion and Extension of the Toes.**
  - Hand Placement and Procedure: Apply resistance to the plantar and dorsal surfaces of the toes as the patient flexes and extends the toes. Stabilize the joints above and below the joint that is moving.

CORE STABILITY EXERCISES

I. In lumbar region:

The core can be described as figure 1:

- Front: Abdominal muscles.
- Back: Multifidus.
- Roof: Diaphragm .
- Floor: Pelvic floor muscles.

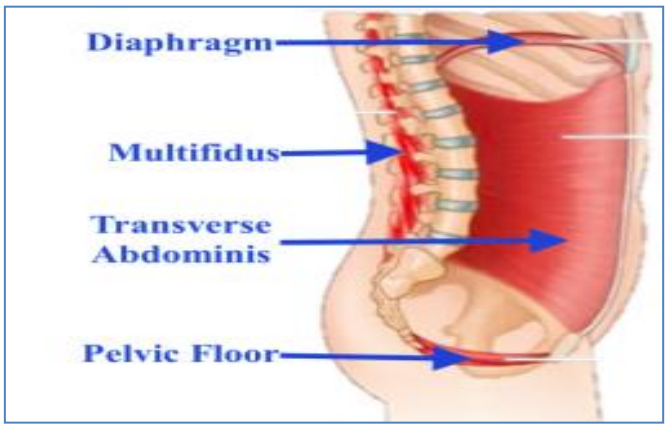


Fig.1: Core muscles in lumbar region.

These muscles work together to:

1- produce maximum stability in the abdominal and lumbar (lower) back region.

2- coordinate the movement of the arms, legs, and spine.

II. in the cervical spine:

- The core muscles are: longus colli and other deep musculature.
- The goal is: To activate and control the muscles that control axial extension (cervical retraction).
- This requires: Capital flexion, slight flattening of the cervical lordosis, and flattening of the upper thoracic kyphosis

Core stability: It is the ability of the core muscles to stabilize the lumbar spine and pelvic girdle also, the longus colli and other deep musculature in the cervical spine during static postures and dynamic movements.

Core stability training: It is a form of training that challenges the stability of the spine while training muscle activity patterns and postures that ensure sufficient stability without unnecessarily overloading the tissue.

❖ **Factors affecting the core stability:**

- **Active subsystem:** including (muscles- tendons surrounding the spinal column).
- **Passive subsystem**: including (vertebrae- discs- joint capsules- ligaments).
- **Neuromuscular control (neural and feedback subsystem):** constituted the various force and motion transducers, located in ligaments, tendons, and muscles, and in the neural control).

❖ **The core stability depends on:**

A. Global musculature, in combination with local musculature.
B. Muscular strength.
C. Proper sensory input that alerts the central nervous system about interaction between the body and the environment, providing constant feedback and allowing refinement of movement.

Core strength and Core stability:

- **Core strength**: is developed by performing exercises specific to the muscles of the abdomen, buttock, back and hips. Most of these exercises isolate a particular muscle group to develop specific strength (e.g. back extensions, curl ups).
- **Core stability**: is the interaction of coordination and strength of the abdominal, back and buttock muscles during activity to ensure the spine is stabilized and provides a firm base to support both powerful and very basic everyday movements of the arms and legs.

Importance of core stability training:

- Efficiency of the core muscles: enables each of the structural components to operate optimally through:
  - Distribution of weight.
  - Absorption of force.
  - Transfer of ground reaction forces.
- Inefficiency of the core muscles can results in:
  - Unstable body (because abnormal forces are distributed above and below misaligned segment).
  - Repetitive microtrauma.
  - Faulty biomechanics & injury.
  - Compensatory actions which can lead to deformity.

- **Core Stability Exercises Training Goals:**
  - Improves spinal and postural control.
  - Prevent deformities.
  - Improves athletic performance.
  - Maintains healthy and balanced muscles.
  - Improve balance and stability.
  - Enhances physical functioning in everyday activities (i.e. Functional Fitness).
  - Facilitates powerful movements such as those executed during sport.
  - Helps to protect joints and muscles and reduce risk of injury.
- **Assessment of core muscles:**

1- Lateral musculature test (side bridge test):

- Test performed on both sides of the body.
- Subject lying in full side bridge, legs extended, top foot is placed in front of the lower for support.
- Subject supported himself on one elbow and on feet.

- Uninvolved arm placed across the chest figure 2.
- Asked him to maintain the isometric contraction as much as possible.
- Failure occurs when person loses the straight-back posture and hip returns to ground.

Fig.2: Side bridge test.

2- Flexor endurance test:

- Begins with person in a sit-up posture with the back resting against aback support which angled at 60 degrees.
- Both knees and hips flexed at 90 degrees.
- Arms folded across chest and hands placed on opposite shoulders figure 3.
- Toes are secured by examiner or toe straps.
- Test begins by pulling back support ten centimeters away from the person, and we asked him to maintain the isometric contraction as much as possible.
- Failure occurs when subject falls back and touches the back support.

Fig.3: Flexor endurance test.

3- Extensor endurance test (back extensors test):

- The subjects are horizontally positioned with the lower extremities fixed to an examination table (at the levels of pelvis, knees) while the upper body is extended over the edge of the table .
- The upper limbs are held across the chest with the hands resting on the opposite shoulders, and we asked him to maintain the isometric contraction as much as possible figure 4.
- Failure occurs when the upper body drops from the horizontal position.

Fig.4: Extensor endurance test.

4- Using the pressure biofeedback unit:

- used to train the subject how to contract and isolate the local core muscles at the beginning of the treatment programme.
- used as an objective tools to assess the strength of the core muscles figure 5.

Fig.5: Pressure biofeedback unit.

A) In the cervical region:

- Patient position: Supine.
- For cranio-cervical flexion teach the patient to perform slow, controlled nodding motion of the head on the upper cervical spine ("yes" motion) figure 6.
- Once able to activate the motion, the Stabilizer may be used to monitor the amount of cervical flattening and measure the muscular endurance for holding the contraction.

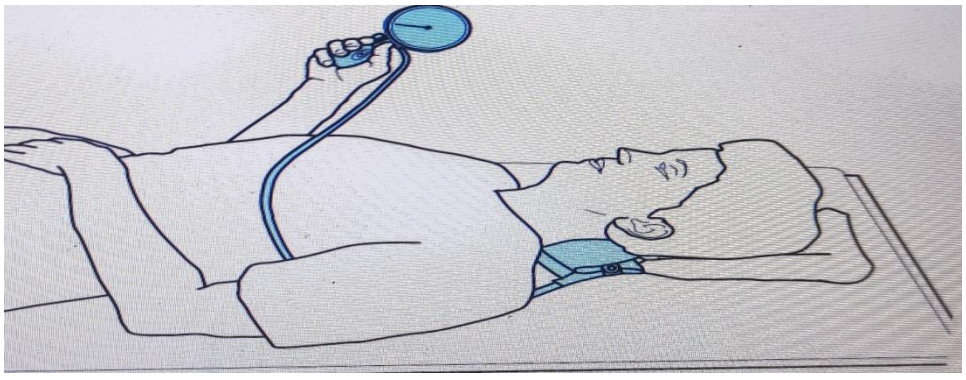


Fig.6: Pressure biofeedback unit for cervical region.

B) In lumbar region:

Prone test with pressure biofeedback unit (abdominal drawing test):

- The patient lies prone and the pressure biofeedback unit is placed under the abdomen (the distal edge of the pad in line with the right and left anterior superior iliac spines) figure 7.

- The pressure pad is inflated to 70 mmHg (sufficiently to detect changes in position of the abdominal wall and does not press into the abdominal contents.
- At rest, small deviations of the indicator with abdominal movement during normal respiration, and it is essential to identify the point about which the level fluctuates.
- Instruct the patient to relax the abdomen by taking a relaxed breath in and out and then, without breathing in, draw the abdomen in towards the spine without taking a breath.
- An optimal performance of the test reduces the pressure by approximately 4-10 mmHg in the absence of spinal or pelvic movement which indicates contraction of the transversus abdominus.
- If the pressure falls 0-4 mmHg, the patient may have contracted the transversus abdominus but with insufficient shorting

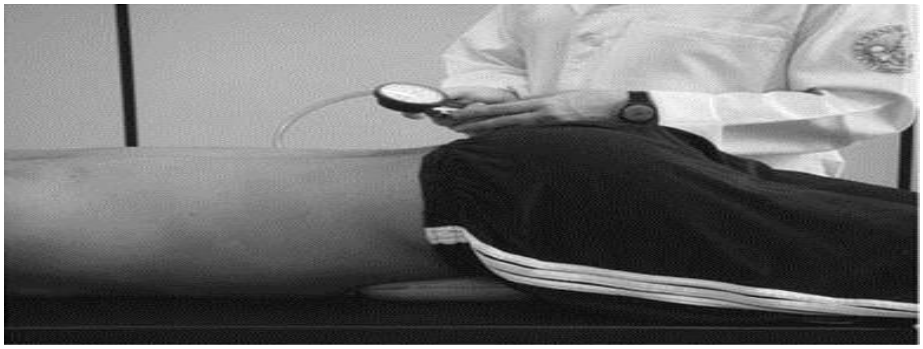


Fig.7: Prone test with pressure biofeedback unit.

❖ **<u>Implications for practice for the local muscle system</u>:**

- Develop the skill of an independent contraction of the local muscles.
- Decrease the contribution of the overactive global muscles.
- Use a motor relearning approach to re-teach the skill of developing a 'corset' action of transverses abdominis and multifidus in response to the cue to draw in the abdominal wall.
- Use specific feedback techniques (as pressure biofeedback unit) to develop kinaesthetic awareness of local muscles.
- Use repeated movements of the lumbopelvic region, in more comfortable and easy positions initially (prone, supine) to improve position sense, then can be graduated to quadruped and kneeling positions.

❖ **A core stability exercise should be done in stages with gradual progression in respect to the following:**

- Body position (easy to difficult positions).
- Range of motion (small to large range).
- Loading (physioball, weight vest, weights on hands or around lower limb).
- Amount of speed (slow to fast).
- Feedback (eyes open to eyes closed).
- Static to dynamic.
- Duration and frequency (sets, reps).

Practical Part:

Stages for core stability training:

All core exercises must start with a "drawing in" maneuver, or abdominal brace. So, at first we must train the patient how to contract and isolate the deeper local core muscles (by using the pressure biofeedback unit). Once the patient can do a perfect abdominal bracing and able to be maintained it through exercise, we can start the progression of core exercises.

Note: All exercises should be repeated 12-15 times, and the isometric contraction for each repetition should be hold for 5 sec, except the plank exercises should be repeated for 3 times and isometric contraction for about 20-30 sec.

❖ Guidelines for Stabilization Training, Principles and Progression:

- Begin training awareness of safe spinal motions and the neutral spine position (functional ROM and position).
- Have patient learn to activate the deep (core) stabilizing musculature while in the neutral position.
- Add extremity motions to load the global musculature while maintaining a stable neutral spine position (dynamic stabilization).
- Increase repetitions to improve holding capacity (endurance) in the stabilizing musculature; increase load (change lever arm or add resistance) to improve strength while maintaining a stable neutral spine position.
- Use alternating isometric contractions and rhythmic stabilization techniques to enhance stabilization and balance with fluctuating loads.
- Progress to movement from one position to another in conjunction with extremity motions while maintaining a stable neutral spine (transitional stabilization).
- Use unstable surfaces to improve the stabilizing response and improve balance.

Lower Cervical and Upper Thoracic

❖ Extensor Activation and Training:

- Patient position and procedure*:* Prone with forehead on the treatment table and arms at the sides. Have the patient lift the forehead off the treatment table, keeping the chin tucked and eyes focused on the table to maintain the neutral spinal position hold 10 sec figure 1.

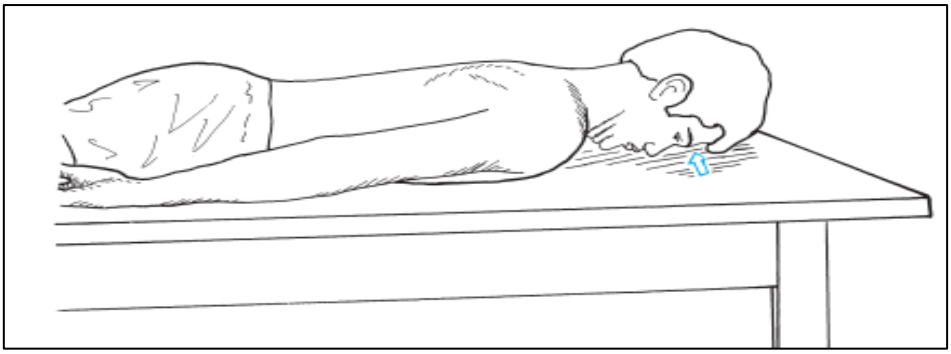


Fig.1: Extensor Activation.

Progression:

(A) Global Muscle Stabilization Exercises:

a) **Stabilization Exercises for the Cervical Region** (**craniocervical flexion and gentle axial extension):** hold 10 seconds x 10 repetitions.

b) **Stabilization with Progressive Limb Loading:** Initially, the only resistance load comes from simple upper extremity movements. When the patient can perform multiple repetitions of the upper extremity motions, resistance is added with handheld weights or elastic resistance.

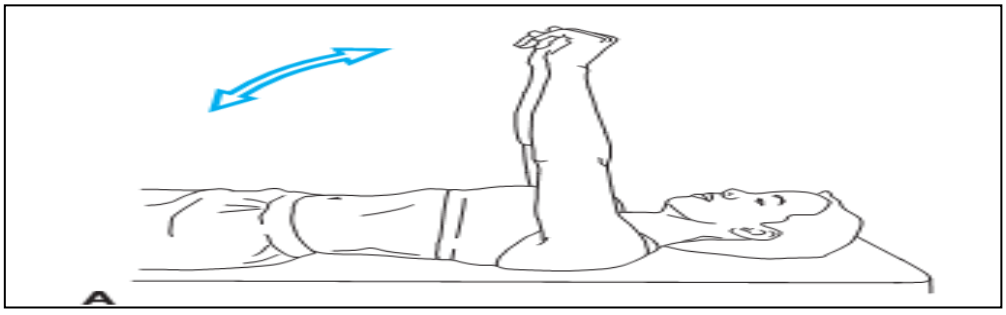
- **Extremity loading :** (arms motions).
- **External resistance :** (free weights or elastic resistance).
- **Unstable surfaces :** ball while sitting, quadruped position, or standing supporting the ball between the head and the wall.

- **Cervical Stabilization with Progressive Limb Loading Emphasis on Cervical Flexors**:

Arm motioms:

* Shoulder flexion to 90 degree figure 2A.
* Shoulder abduction 90 degree figure 2B.
* Shoulder external rotation with arms at sides figure 2C.
* Shoulder flexion to end of range figure 2D.
* Shoulder abduction combined with external rotation to end of range figure 2E.
* Diagonal patterns.
* Reaching forward, outward, upward.

Patient position: Supine , Sitting (sitting on ball for less stability) , Standing with wall support (ball front head), and Standing with no support.



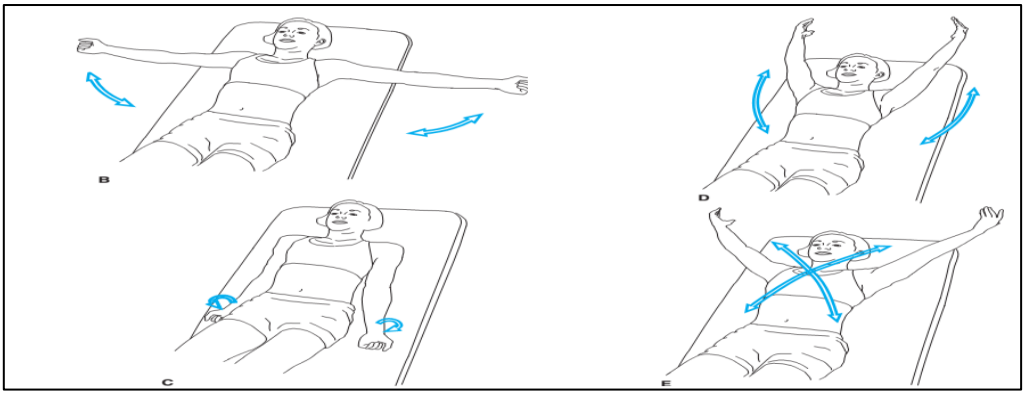


Fig.2: Progressive Limb Loading Emphasis on Cervical Flexors.

- **Cervical Stabilization with Progressive Limb Loading—Emphasis on Cervical and Thoracic Extensors:**

Arm motion:

* Arms at side: laterally rotate shoulders and adduct scapulae figure 3A.
* Arms in 90/90 position (abducted and laterally rotated), horizontally abduct shoulders and adduct scapulae figure 3B.
* Elevate shoulder in full flexion figure 3C.
* Arms abducted to 90 and laterally rotated, elbows extended: horizontally abduct shoulders and adduct scapulae figure 3D.
* Upper extremity diagonal patterns.
* Standing: reaching forward, outward, upward in functional patterns.
* Standing, no support: pushing/pulling and lifting activities.

Patient position: Prone forehead on treatment table, Quadruped over gym ball, Standing back supported by wall (ball behind head).and Standing no support.

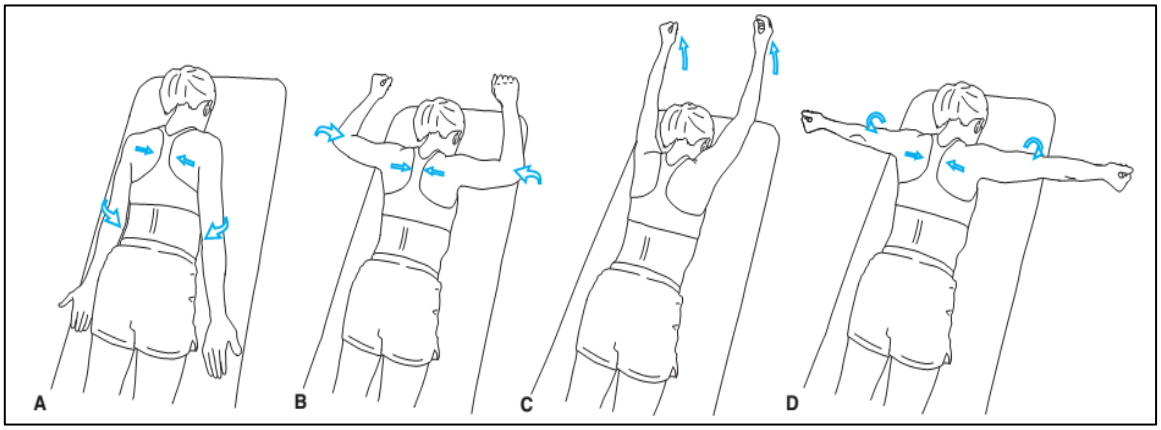


Fig.3: Progressive Limb Loading—Emphasis on Cervical and Thoracic Extensors.

(B) ISOMETRIC AND DYNAMIC EXERCISES:

1- Isometric Resistance Activities by therapist or patient himself.

* Flexion figure 4A.
* Side bending.
* Axial extension figure 4B.
* Rotation.

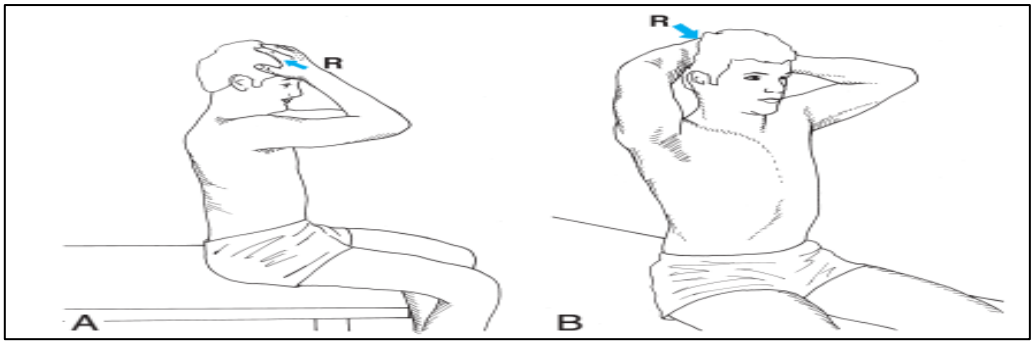


Fig.4: Self-resistance for isometric (A) cervical flexion and (B) axial extension.

2- Dynamic Cervical Flexion:

Patient position and procedure:

Supine. If the patient cannot tuck the chin and curl the neck to lift the head off the mat, begin with the patient on a slant board or large wedge-shaped bolster under the thorax and head to reduce the effects of gravity and Progress by decreasing the angle of the board or wedge and then adding manual resistance figure 5.

Fig.5: Dynamic Cervical Flexion

3- Intermediate and Advanced Training:

For strengthening the cervical and upper thoracic flexors and extensors as stabilizers begin by:

- Sitting on a large gym ball figure 6A.
- Walking forward while rolling the ball up the back. With the ball behind the mid-thoracic area, the cervical flexors must stabilize figure 6B.
- Continue walking forward until the ball is under the head; the cervical extensors now must stabilize. Walk back and forth between the two positions (B and C) to alternate control between the flexors and extensors.
- Progress by adding arm motions or arm motions with weights to increase resistance.

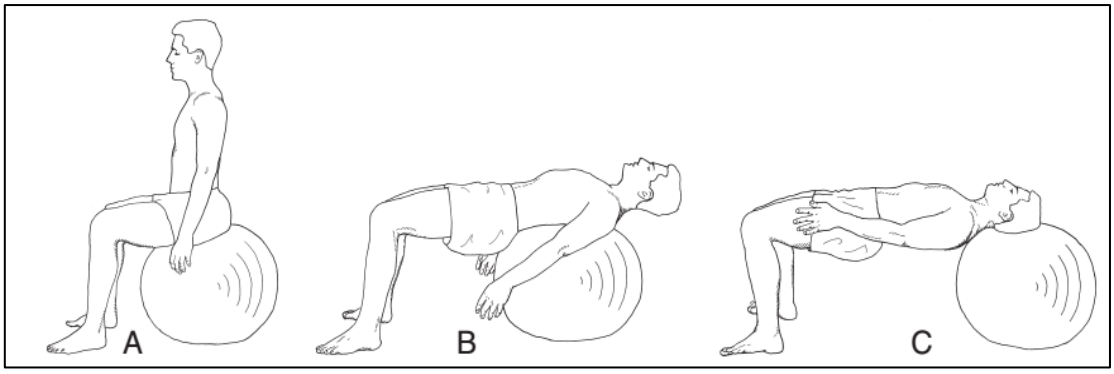


Fig.6: Intermediate and Advanced Training of cervical.

4- Transitional Stabilization for the Cervical and Upper Thoracic Regions:

Standing with a basketball-size inflatable ball between the head and the wall. Have the patient roll the ball along the wall, using the head. This requires the patient to turn the body as he or she walks along figure 7C.

Sitting on a large gym ball. Have the patient walk the feet forward and backward , alternating stabilization between the flexors and extensors. Progress to advanced training by adding arm motions and then arm motions with weights in each of the positions figure 7A,B.

(C) FUNCTIONAL TRAINING:

**** Rolling.***

**** Supine to sit/sit to lying down.***

**** Sit to stand/stand to sit.***

**** In and out of a car.***

**** Walking.***

Thoraco-lumbar Musculature

Three techniques for abdominal muscle activation:

1-Drawing-In Maneuver (Abdominal Hollowing Exercise) for Transverse Abdominis Activation

Patient positions: Training may be easiest in the quadruped position in order to use the effects of gravity on the abdominal wall. Hook-lying (with knees 70 to 90 and feet resting on an exercise mat), prone-lying, or semireclined positions may be used if more comfortable for the patient. It is important to progress training to sitting and standing as soon as possible for functional activities.

Procedure: Teach the patient using demonstration, verbal cues, and tactile facilitation. Explain that the muscle encircles the trunk; and when activated, the waistline draws inward . Palpation of the muscle is possible just distal to the anterior superior iliac spine (ASIS) and lateral to the rectus abdominis. When the internal oblique (IO) contracts, a bulge of the muscle is felt; when the TrA contracts, flat tension is felt. The goal is to activate the TrA with minimal or no contraction of the IO. This is a gentle contraction.

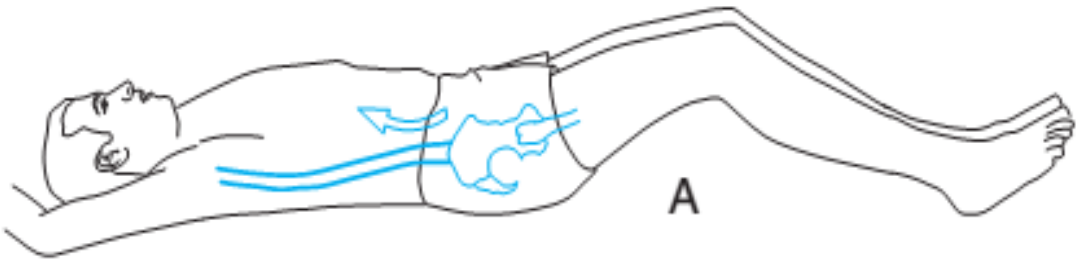
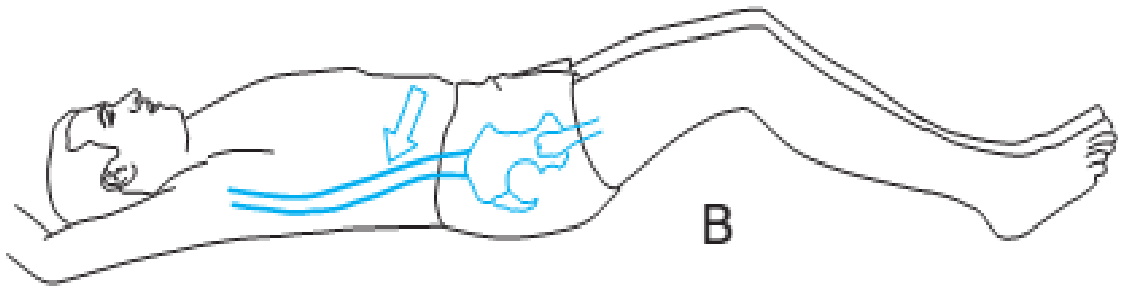


Fig.the drawingin maneuver

Fig. Palpation of the transversus abdominis muscle.

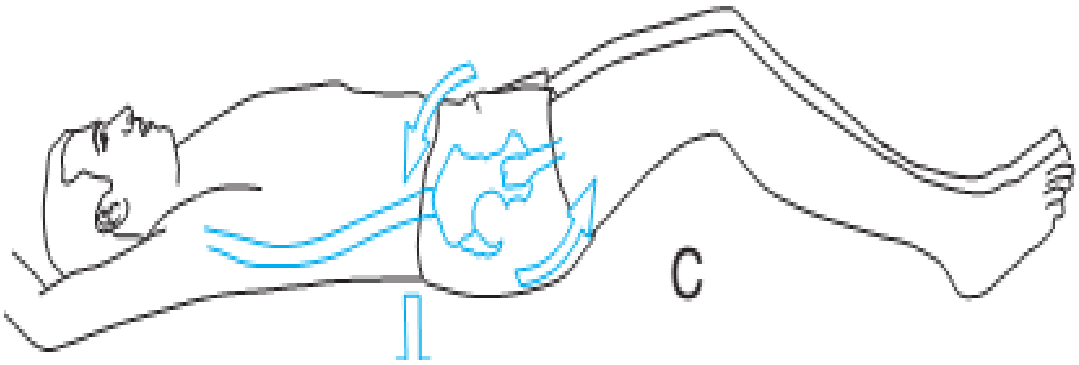
2- Abdominal Bracing

In contrast to the drawing-in maneuver, abdominal bracing occurs by setting the abdominals and actively flaring out laterally around the waist. There is no head or trunk flexion, no elevation of the lower ribs, no protrusion of the abdomen, and no pressure through the feet. The patient should be able to hold the braced position while breathing in a relaxed manner. This technique has been taught for a number of years as the method to stabilize the spine; and it has been shown to activate the oblique abdominal muscles consistent with their global stabilization function.



3- Posterior Pelvic Tilt

Pelvic tilt exercises principally activate the rectus abdominis muscle, which is used primarily for dynamic trunk flexion activity. It is not considered a core spinal stabilization muscle; therefore, it is not emphasized in the training for stabilization.42 It is used mostly to teach awareness of movement of the pelvis and lumbar spine. It is activated when the patient explores his or her lumbar ROM with pelvic tilts to find the neutral position or functional spinal range.



Multifidus Activation and Training

Patient position and procedure: Prone or side-lying. Place your palpating digits (thumbs or index fingers) immediately lateral to the spinous processes of the lumbar spinePalpate each spinal level so comparisons in the activation of the multifidus (Mf) muscle can be made between each segment as well as from side to side. Instruct the patient to “swell the muscle” out against your digits. Palpate for consistency of muscle contraction at each level. Facilitation techniques include using the drawingin maneuver and gently contracting the pelvic floor muscles. In the side-lying position, facilitate by gently applying manual resistance to the thorax or pelvis to activate the rotation function of the Mf.

Stabilization Exercises for the thoraco- lumbar Region

(A) **Global Muscle Stabilization Exercises**

1- Stabilization with Progressive Limb Loading - Emphasis on Abdominals

Level 1: *core activation* Draw in and hold 10 seconds

Level 2: Opposite LE on mat; bent leg fall out in the supine position. This requires control to prevent pelvic rotation; stability is assisted by the opposite lower extremity while hook-lying.

Level 3:

A, B, or C : Opposite LE is on table

Level 4: A, B, or C:

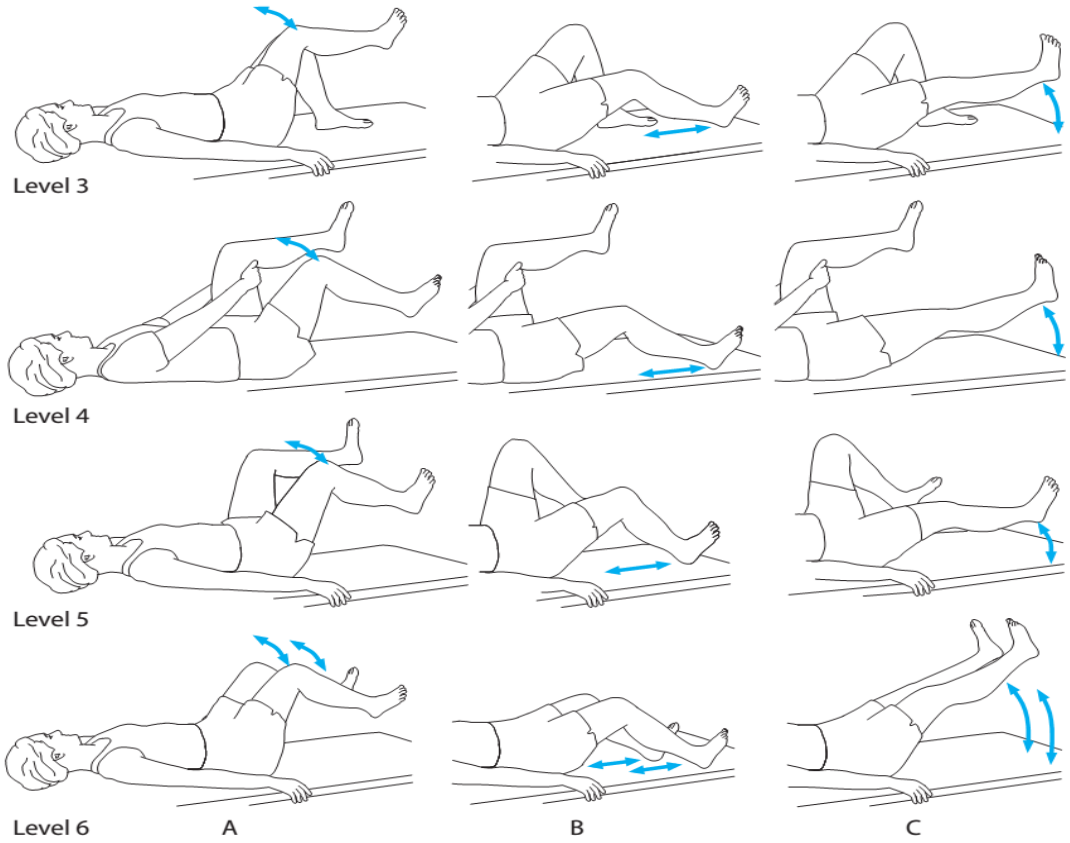
Hold opposite LE @ 90 of hip flexion with UE assistance

***Level 5: A, B, or C*:**

Hold opposite LE @ 90 of hip flexion (no UE assistance)

***Level 6: A, B, or C*:**

Bilateral LE movement



2- Stabilization with Progressive Limb Loading - Emphasis on Trunk Extensors

A- Flex one upper extremity (UE)

B- Extend one lower extremity (LE) by sliding it along the exercise mat

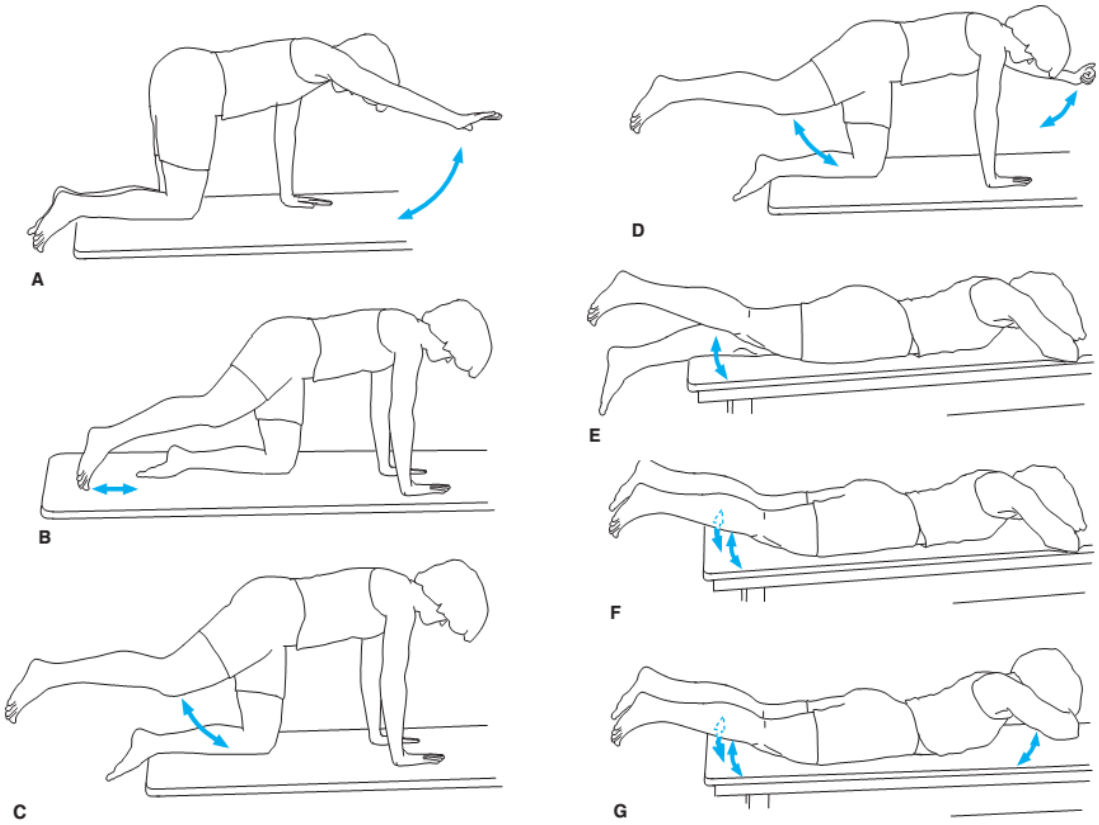
C- Extend one (LE) and lift 6–8 inches off exercise mat

D- Flex one UE and extend contralateral LE

E- Extend one LE

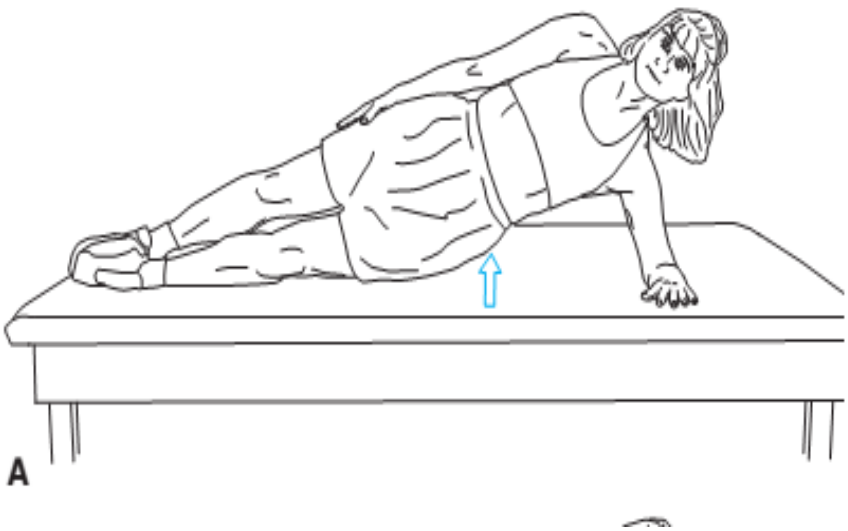
F- Extend both LE

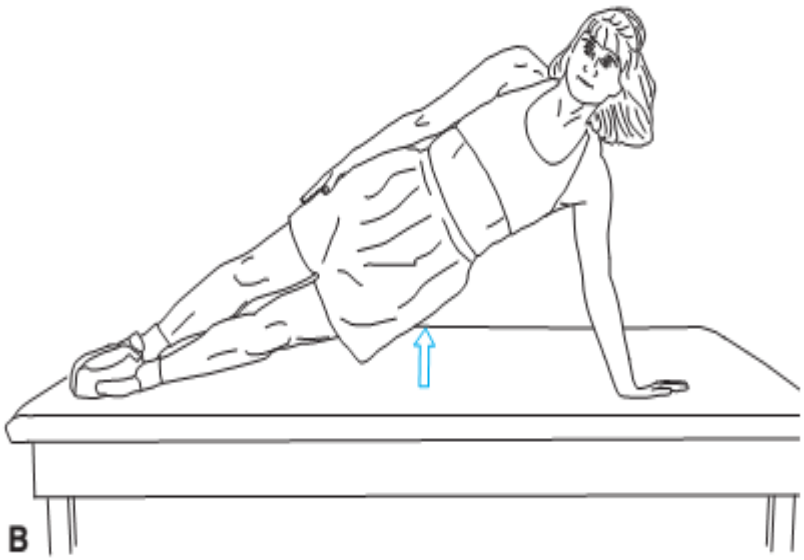
G- Lift head, arms and LE.



3-Quadratus Lumborum—Stabilization Exercises

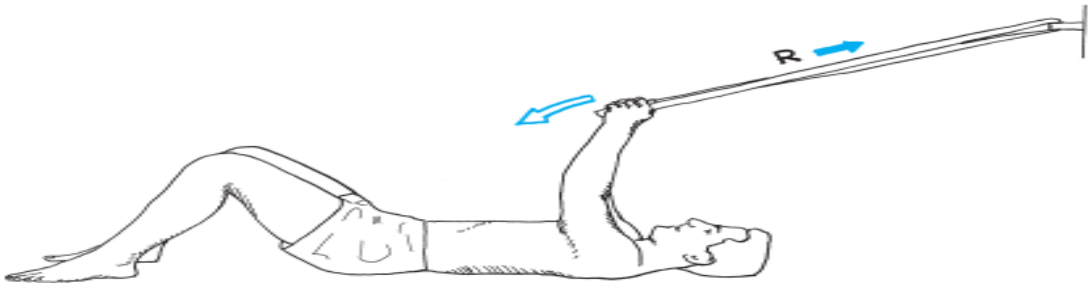
Patient position and procedure: Begin side-lying. Have the patient prop up on the elbow and then lift the pelvis off the mat, supporting the lower body with the lateral side of the knee on the downward side. The position can be maintained for an isometric hold or performed intermittently . Progress by having the patient support the upper body with the hand (with the elbow extended) and lateral aspect of the foot on the downward side.

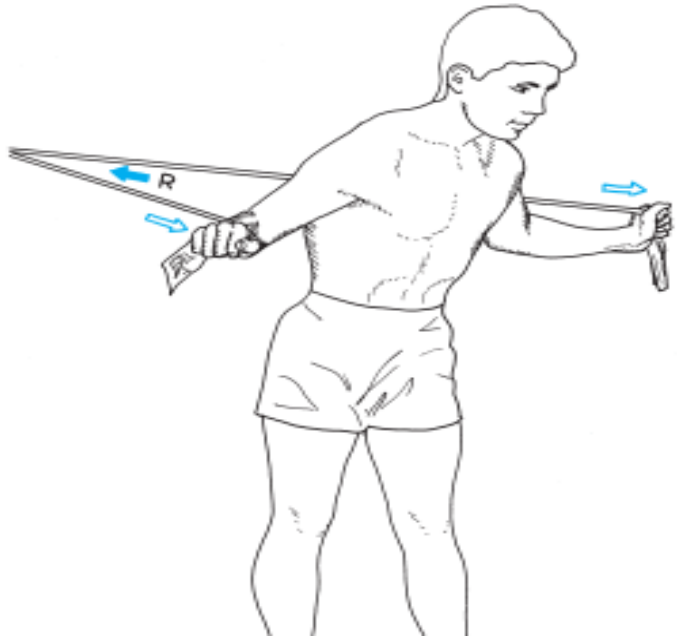


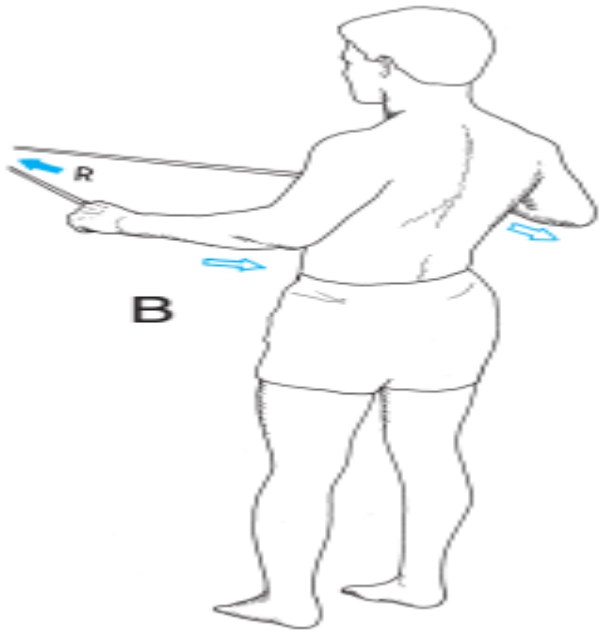


4- External resistance

Use weights, elastic resistance, or pulleys for strengthening.

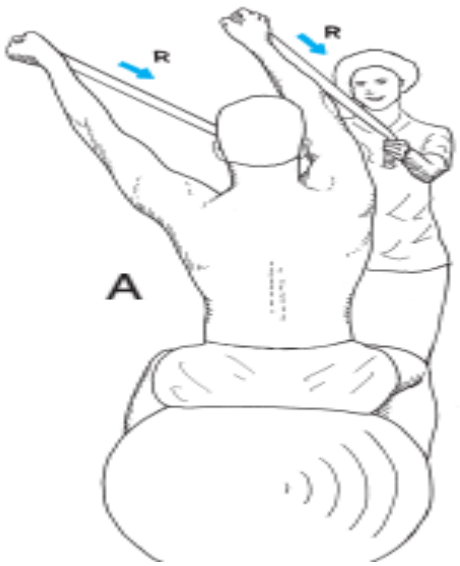


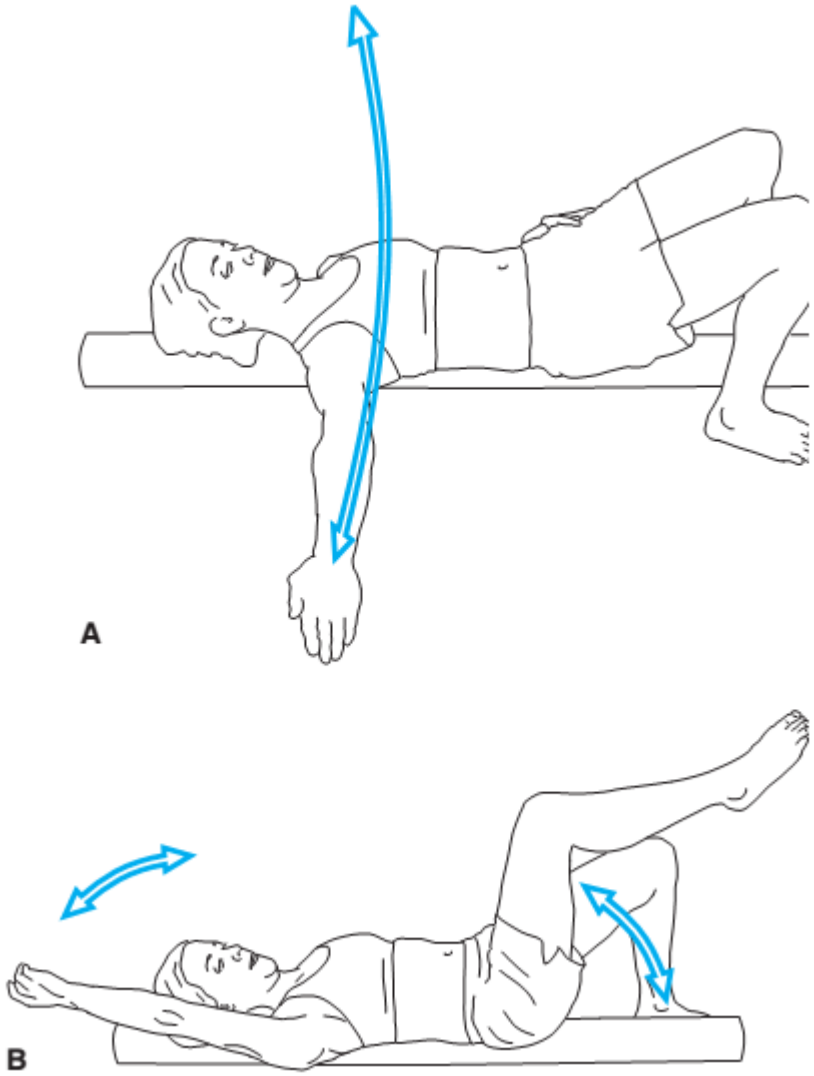




5- Unstable surfaces

Use a large gym ball, foam roller



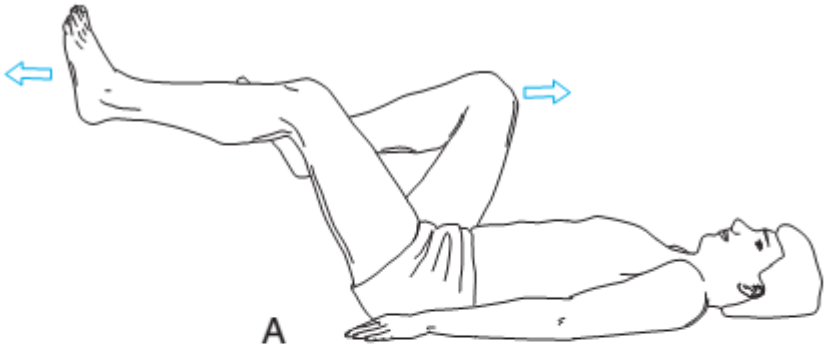


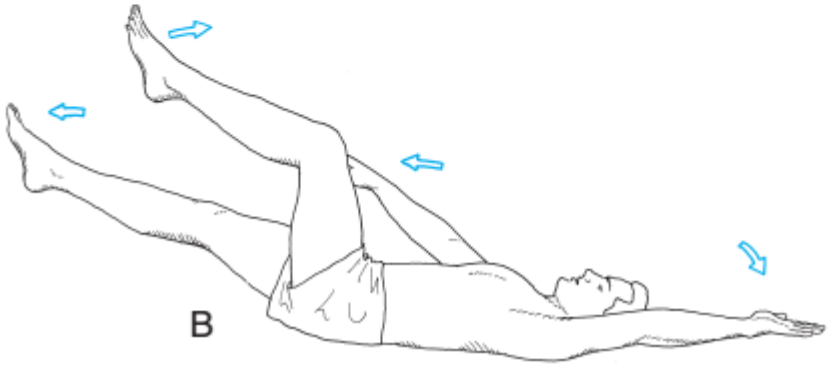
6- Alternating motions

(A) Alternating lower extremity motions with the “modified bicycle”

(*B*) reciprocal and alternating patterns using the upper and lower extremities simultaneously require a strong controlling action in the abdominals.

(C) Strength, balance, and coordination are required to maintain spinal stabilization while sitting on a gym ball and moving the extremities. This activity is progressed by adding weights to the extremities.





B) ISOMETRIC EXERCISES:

Alternating Isometric Contractions and Rhythmic Stabilization

Patient positions and procedures: Begin with the patient supine in the most stable position. Progress to sitting on a stable surface, sitting on an unstable surface such as a large gym ball, kneeling, and then standing. Sitting, kneeling, and standing require stabilizing action in the hip, knee, and ankle musculature, respectively, as well as the spinal muscles. Apply resistance directly against the patient's shoulders or pelvis,

1- Have the patient find the neutral spine position and then activate the stabilizing muscles with the drawingin maneuver prior to applying the resistive force. Then instruct the patient to

“meet my resistance” while applying a force to stimulate isometric contractions. Apply the resistance in alternating directions at a controlled speed while the patient learns to maintain a steady position.

2- Initially, provide verbal cues, such as “hold against my resistance, but do not overpower me. Feel your abdominal muscles contracting. Now I’m pulling in the opposite direction. Match the resistance and feel your back muscles contracting.”

3- Progress by shifting the directions of resistance without the verbal cues and then by increasing the speed.

4- Begin with alternating resistance in the sagittal plane; progress to side-to-side and then transverse plane resistance. Isometric resistance to trunk rotation (transverse plane resistance) has been shown to be the most effective in stimulating the oblique abdominals, transversus abdominis, and deep spinal extensor muscles.

5- Alternating resistance to pelvic rotation can also be done by having the patient assume a modified bridge position. Apply resistance directly to the pelvis to stimulate rotation while the patient isometrically holds the pelvis and spine in a stable position.

(C) DYNAMIC EXERCISES

1- Dynamic Strengthening Abdominal Muscles:

***Curl-ups*.**

First, instruct the patient to perform the drawingin maneuver to cause a stabilizing contraction of the abdominal muscles and then lift the head. Progress by lifting the shoulders until the scapulae and thorax clear the mat, keeping the arms horizontal (Fig. 16.40). A full sit-up is not necessary because once the thorax clears the mat the rest of the motion is performed by the hip flexor muscles.

Further progress the difficulty of the curl-up by having the patient change the arm position from horizontal to folded across the chest and then to behind the head.

During all these activities, the low back should not arch; if it does, reduce the progression until the abdominals are strong enough to maintain lumbar flexion.

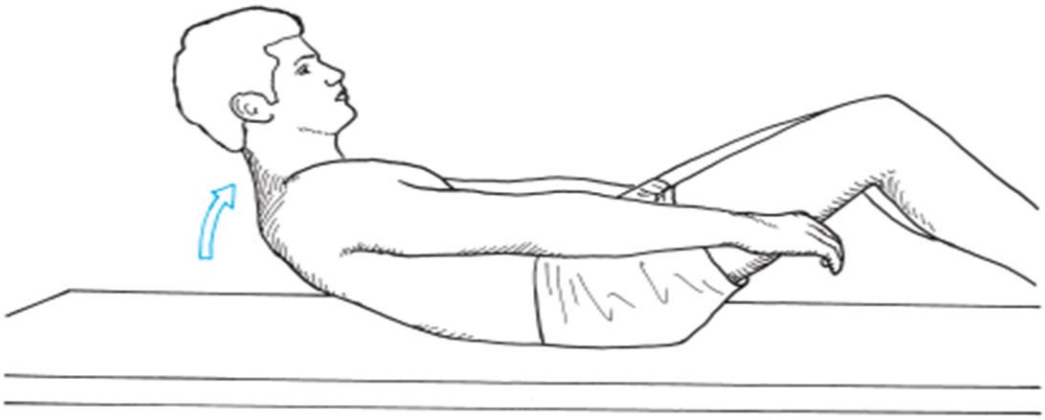


Fig.Curl-ups

Curl-downs.

If the patient is unable to perform the curl-up, begin with curl-downs by having the patient start in the hook-sitting or long-sitting position and lower the trunk only to the point where he or she can maintain a flat low back and then return to the sitting position.

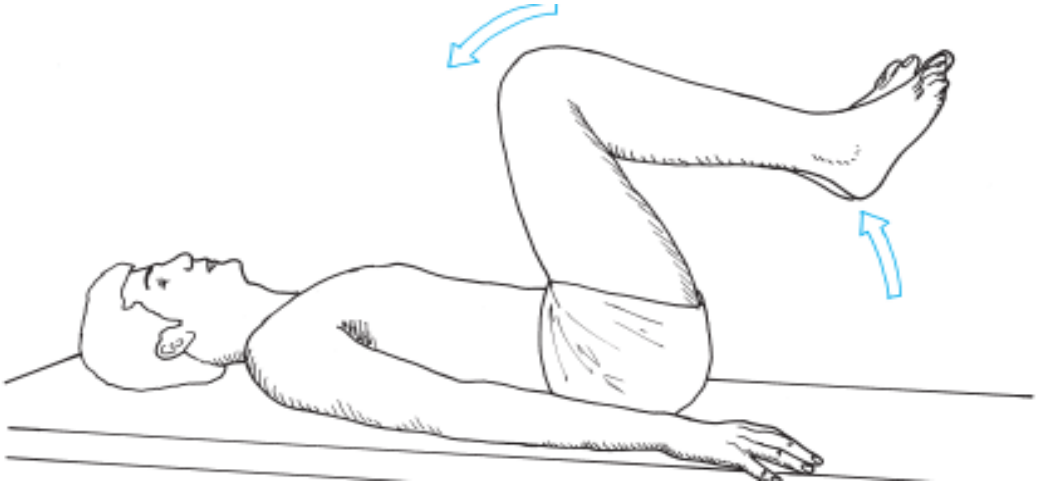
Once the patient can curl-down full range, reverse and perform a curl-up.

Diagonal curl-ups.

Have the patient reach one hand toward the outside of the opposite knee while curling up; then alternate. Reverse the muscle action by bringing one knee up toward the opposite shoulder; then repeat with the other knee. Diagonal exercises emphasize the oblique muscles.

Double knee-to-chest.

To emphasize the lower rectus abdominis and oblique muscles, have the patient set a posterior pelvic tilt; then bring both knees to the chest and return. Progress the difficulty by decreasing the angle of hip and knee flexion



Pelvic lifts.

Have the patient begin with the hips at 90 and knees extended; then lift the buttocks upward off the mat (small motion).The feet move upward toward the ceiling. The patient should not push against the mat with the hands.

Bilateral straight-leg raising

Have the patient begin with legs extended; then perform a posterior pelvic tilt followed by flexing both hips, keeping the knees extended. If the pelvis and spine cannot be kept stable, the knees should be flexed to a degree that allows control. If the hips are abducted before initiating this exercise, greater stress is placed on the oblique abdominal muscles.

P R E C A U T I O N : The strong pull of the psoas major causes shear forces on the lumbar vertebrae. Also this bilateral straight-leg raise (SLR) causes increased spinal

compression loads. If there is any low-back pain or discomfort, especially with spinal hypermobility or instability, this exercise should not be performed even if the abdominals are strong enough to maintain a posterior pelvic tilt.

Bilateral straight-leg lowering.

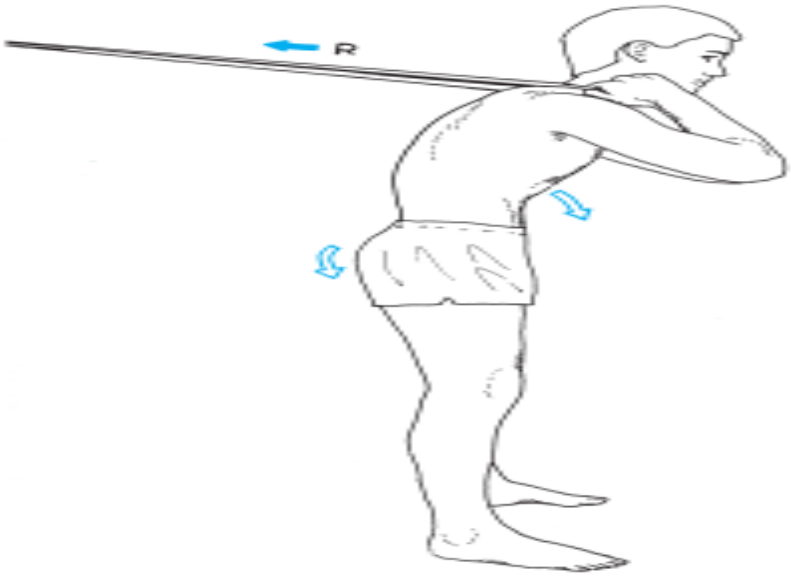
Bilateral straight-leg lowering can be performed if the bilateral SLR is difficult. Have the patient begin with the hips at 90 and knees extended; then lower the extremities as far as possible while maintaining stability in the lumbar spine (should not increase the lordosis), followed by raising the legs back to 90. See precaution under the bilateral SLR exercise.

Trunk Flexion (Abdominals)—Sitting or Standing

Patient position and procedures: Sitting or standing. Pulleys or elastic material are secured at shoulder level behind the patient. Progress the resistance as the patient's abdominal strength increases.

Have the patient hold the handles or ends of the elastic material with each hand and then flex the trunk, with emphasis on bringing the rib cage down toward the pubic bone and performing a posterior pelvic tilt, rather than flexing at the hips .

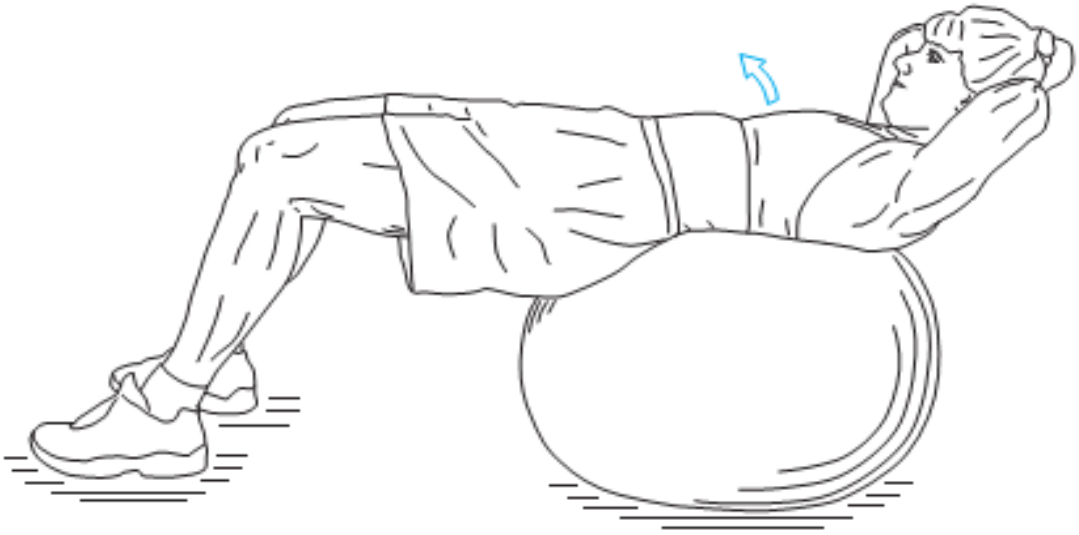
Have the patient perform diagonal motions by bringing one arm down toward the opposite knee with emphasis on moving the rib cage down toward the opposite side of the pelvis. Repeat the diagonal motion in the opposite direction.



Trunk Flexion (Abdominals)—Unstable Surfaces

Use of unstable surfaces, such as a gym ball or a balance board, while doing abdominal

curl-up exercises has been shown to increase activity in the internal and external obliques and the rectus abdominis.

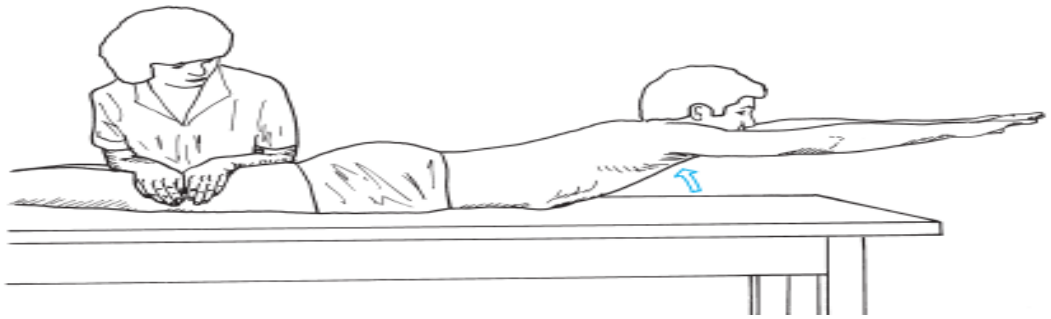


2- Dynamic Strengthening—Erector Spinae and Multifidus Muscles:

Thoracic elevation.

Begin with the arms at the side, progress to behind the head or reaching overhead as strength improves. Have the patient tuck in the chin and lift the head and thorax. The lower extremities must be stabilized

P R E C A U T I O N S : Extension exercises in the prone position are performed at the end of the ROM in spinal extension and therefore may not be appropriate for individuals with symptoms from conditions such as arthritis or nerve root compression.

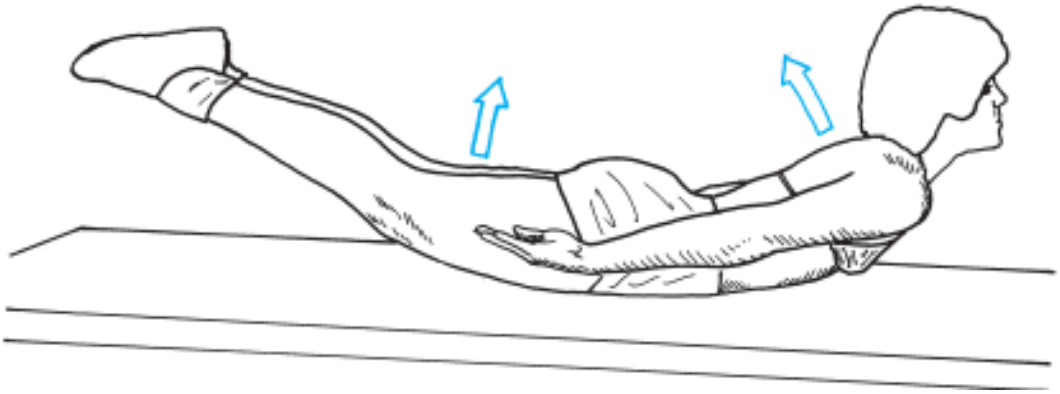


Leg lifts.

Initially have the patient lift only one leg, alternate with the other leg, and finally lift both legs and extend the spine. Stabilize the thorax by having the patient hold onto the side of the treatment table.

"Superman."

Progress the extension exercises by having the patient lift both upper and lower extremities simultaneously



Elastic resistance or weighted pulleys.

Secure pulleys or elastic resistance in front of the patient at shoulder level.
Have him or her hold onto the ends of the material or handles and extend the spine

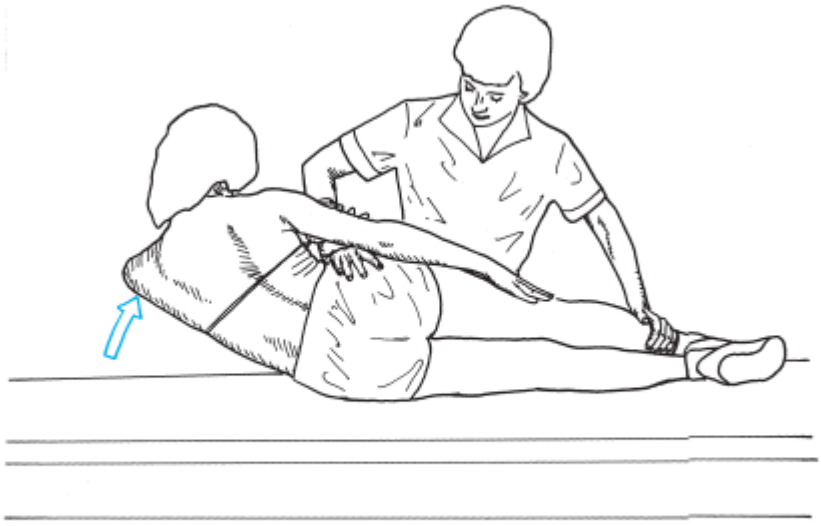
For trunk rotation, use a pulley or elastic resistance secured under the foot or to a stable object opposite to the side being exercised. Have the patient pull against the resistance, extending and rotating the back.

3-Trunk Side Bending (Lateral Abdominals, Erector Spinae, Quadratus Lumborum)
-Trunk side-bending exercises are used for general strengthening of the muscles that side-bend the trunk.

-Side-bending exercises are also used if there is scoliosis

Patient position and procedure: Side-lying on the concave side of the curve with the apex at the edge of the table or mat so the thorax is lowered. If you have access
to a split table with one end that can be lowered, begin with the apex of the curve at the bend

of the table. Have the patient place the lower arm folded across the chest
and upper arm along the side of the body and side-bend the trunk up against gravity. Progress by having the patient clasp both hands behind the head. Stabilization of the pelvis and lower extremities must be provided.



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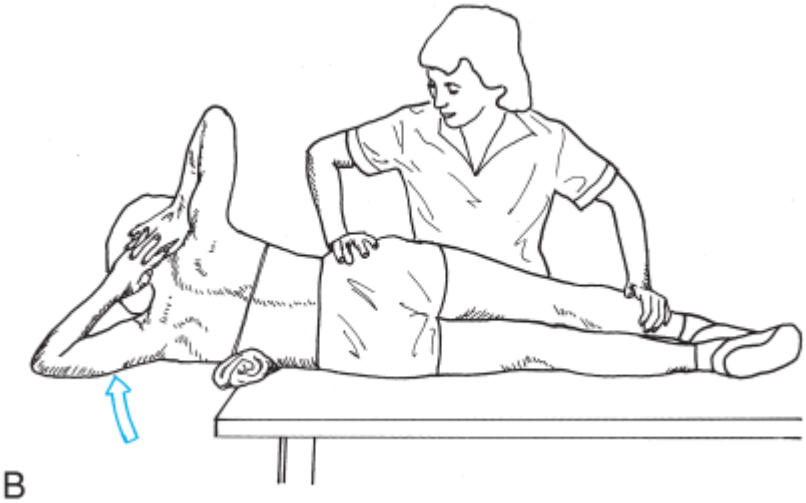


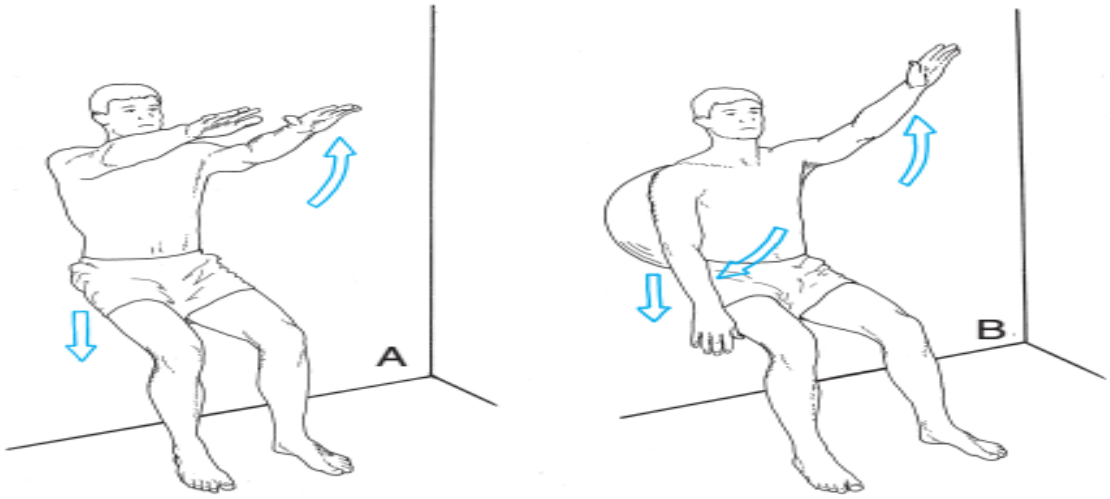
B

(D)Transitional Stabilization

Patient position and procedure:

Standing with the back to a wall and the spine held in its neutral position. Place a towel behind the back so it slides easier along the wall. The exercise is more challenging if a large gym ball is placed between the back and the wall. Have the patient slide his or her back down the wall into a partial
squat and hold the position for isometric strengthening of the hip and knee extensors or move up and down for concentric/eccentric strengthening.

Superimpose arm motions such as alternating or bilateral shoulder flexion/extension. Use handheld weights to add resistance for upper and lower extremity strengthening



(E) FUNCTIONAL TRAINING

Rolling. Rolling with a neutral spine requires that the patient first find the neutral spine, perform the drawing-in maneuver, and then roll the trunk as a unit.

Supine to sit/sit to lying down. Have the patient use the log roll maneuver (as described above) to roll from supine to side-lying while simultaneously flexing the hips and knees and pushing up with the arms.

Sit to stand/stand to sit. The patient's level of function dictates how much assistance from the upper extremities is needed to accomplish "sit to stand" or "stand to sit." If the hip and knee extensors are not strong enough to elevate the body, the patient requires a chair with armrests so there is some leverage for pushing up; alternatively, an elevated seat may be necessary. The patient focus on the hip motion while keeping the spine "solid like a board." The reverse is also practiced.

In and out of a car. Approach the open car door and seat with the back toward the seat; stabilize the spine in its neutral position with the drawing-in maneuver, then bend at the hips and sit down. Once seated, flex both hips and knees and pivot the whole body around as a unit, maintaining a stable spine. When exiting a car, keep both knees together and pivot the legs and trunk outward as a unit. Once the feet are on the ground, bend at the hips and elevate the trunk as a unit.

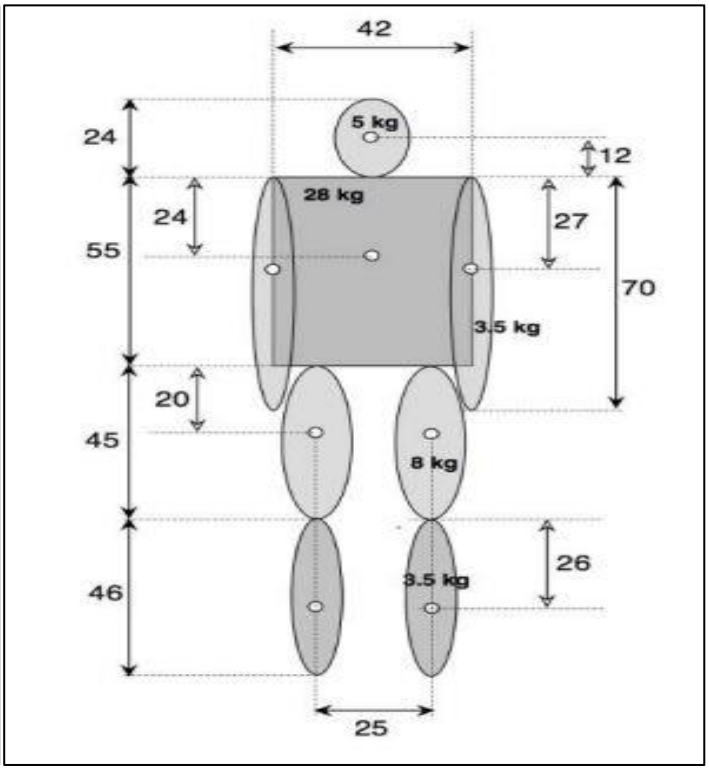
Walking. For some patients walking may provoke symptoms. Remind the patient to use the neutral spine and drawingin maneuvers to stabilize the spine while walking.
It is not possible to maintain conscious control for long, so remind the patient to check the spinal posture and reactivate the drawing-in maneuver whenever the symptoms recur.

Pick up. Maitain the trunk straight and squate with knees

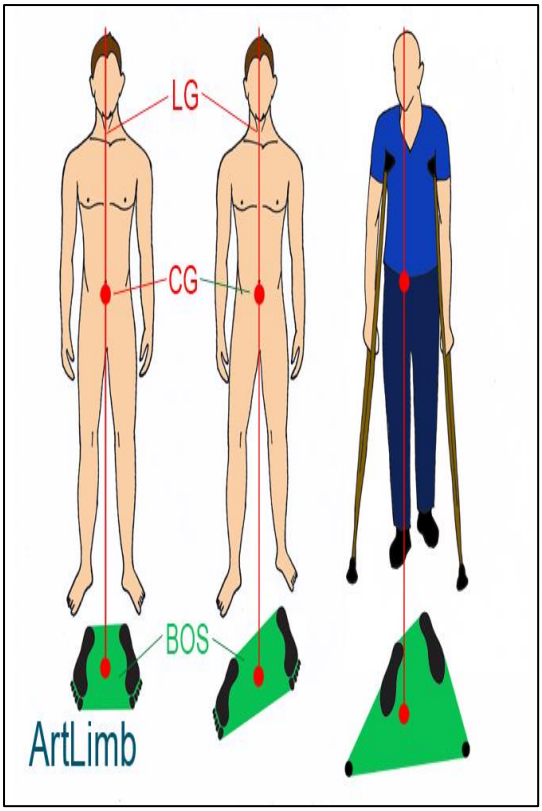
BALANCE AND COORDINATION

Key Terms and Definitions

- ***Center of mass*** **(COM): Is a point that corresponds to the center of the total body mass and is the point where the body is in perfect equilibrium. It is determined by finding the weighted average of the COM of each body segment.**



- ***Base of support*** **(BOS): Is the perimeter of the contact area between the body and its support surface. A wide stance, such as is seen with many elderly individuals, increases stability, whereas a narrow BOS, such as tandem stance or walking, reduces it.**



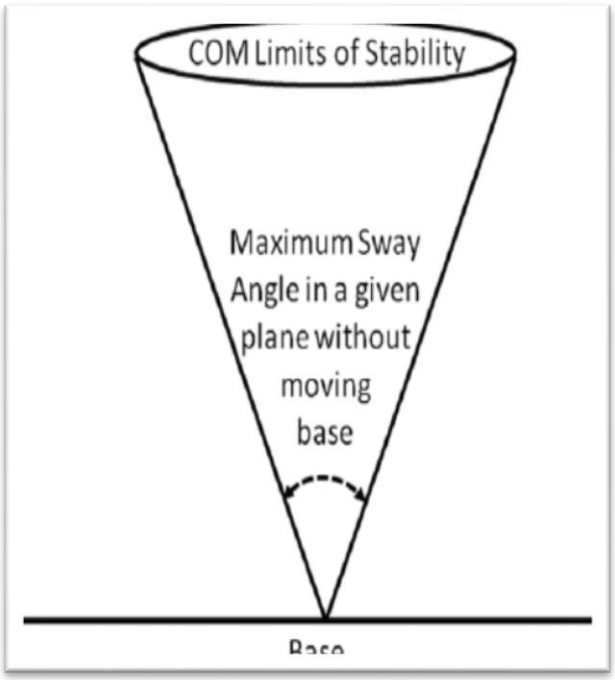
❖ ***Center of gravity*** **(COG):**

- **The vertical projection of the center of mass to the ground.**
- **The central point within the limits of stability area.**
- **When normal person stands upright the COG is centered over the base of support provided by the feet.**
- **In the anatomical position, the COG of most adult humans is located slightly anterior to the second sacral vertebra or approximately 55% of a person's height.**

❖ ***Limits of stability*****:**

- **Is the sway boundaries in which an individual can maintain equilibrium without changing his or her BOS.**
- **For normal adults, the anteroposterior sway limit is approximately 12˚ from the most posterior to most anterior position.**
- **Lateral stability varies with foot spacing and height; adults standing with 4 inches between the feet can sway approximately 16˚ from side to side.**

- **A person sitting without trunk support has much greater limits of stability than when standing because the height of the COM above the BOS is less and the BOS is much larger.**



Balance

- **Balance: Is the ability to maintain the body COM over its BOS and within the limits of stability, whether stationary or moving.**
- **Importance of functional balance system:**

1- Allow humans to see clearly while moving.

2- Identify orientation with respect to gravity.

3- Determine direction and speed of movement.

4- Make automatic postural adjustments to maintain postural and stability in various conditions and activities.

Types of balance:

(1) **Static balance**

(Equilibrium)

The individual's ability to maintain a stable antigravity position at rest by maintaining the COG within the available BOS when standing and sitting

(2) Dynamic balance (Equilibrium)

The individual's ability to to stabilize the body when moving on a stable surface such as sit-to-stand transfers or Walking.

(3) The automatic postural responses to the disruption of the COG position such as standing on a bus that suddenly accelerates forward.

- **Biomechanical components of balance:**

1- Base of support (BOS).

2- Center of gravity (COG).

3- Limits of stability.

- **Requirements of balance control:**

1- Perception: The integration of sensory information to assess the position and motion of the body in space.

2- Action: The ability to generate forces for controlling body position.

- **The postural (balance) control requires interaction of the nervous and musculoskeletal.**

(A) The musculoskeletal components: ROM, spinal flexibility and muscle properties.

(B) The neural components: Are processes including

1- Neuromuscular response synergies.

2- Sensory processes (visual, vestibular, somatosensory).

3- Higher level integrative processes for mappingsensation to action.

<u>The postural (balance) control systems</u>

Are systems operate as a control circuit.

<u>I- The sensory sources:</u> Afferent information from

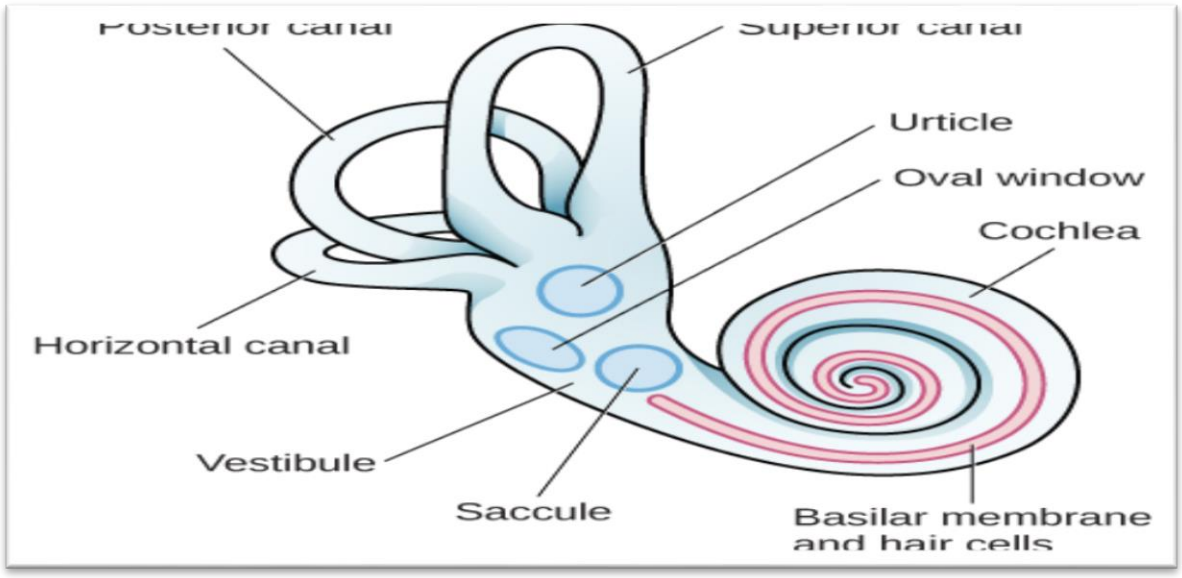
A- The visual system.

- **provides information regarding to the position and motion of the head relative to the surrounding objects.**
- **They are important, but are not absolutely necessary as we can keep our balance when we close our eyes.**

Visual inputs sometimes provide inaccurate information.

B- The vestibular system.

- **Provides information about the motion, equilibrium, and spatial orientation by the vestibular apparatus (utricle, saccule, and 3 semicircular canals are located at right angles to each other and filled with endolymph fluid) in ear.**
- **Utricle and saccule: detect gravity (information in vertical orientation) and linear movement.**
- **semicircular canals: detect rotational movement (head rotate, stimulate receptors in specific canal, send impulse to brain about movement).**



C- The somatosensory system.

- **provides information about the position and motion of the body and body parts relative to each other and the support surface.**
- **Information from:**

1- Muscle proprioceptors including muscle spindles and Golgi tendon organs (sensitive to muscle length and tension).

2- Joint receptors (sensitive to joint position, movement, and stress). 3- Skin mechanoreceptors (sensitive to vibration, light touch, deep pressure, skin stretch).

<u>II- The CNS involvement:</u>

It can be divided into 2 components

A- Sensory organization: The processes that determine the timing, direction, and amplitude of corrective postural actions based on the afferent information.

B- Muscle coordination: Describes the generation and execution of corrective motor responses with respect to temporal sequencing and distribution of contractile activity among the muscles of the body.

III- Musculoskeletal system:

- **including**

1- Postural alignment.

2- Musculoskeletal flexibility such as:

a. **Joint range of motion (ROM).**

b. **Joint integrity.**

c. **Muscle performance (i.e., muscle strength, power, and endurance).**

d. **Sensation (touch, pressure, vibration, proprioception).**

Motor Strategies for Balance Control

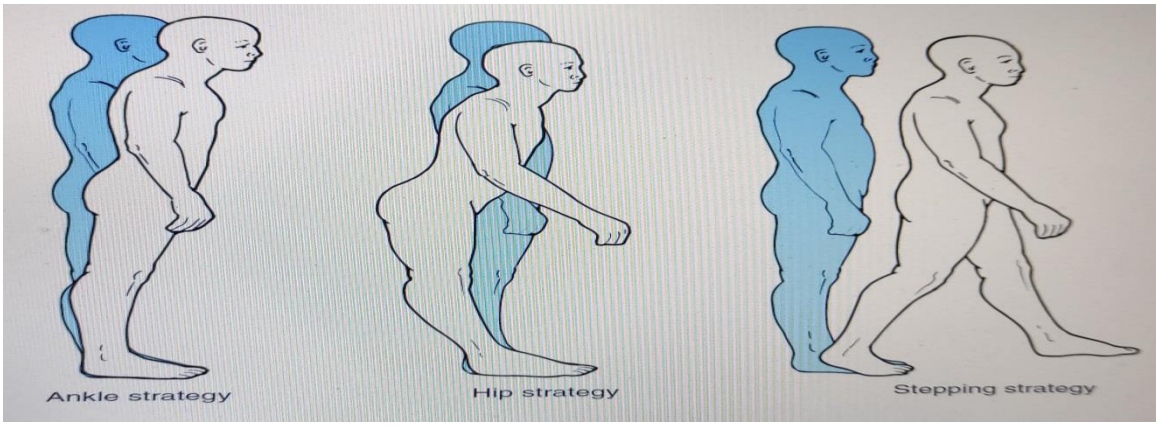
To maintain balance, the body must continually adjust its position in space to keep the COG within the BOS and to prevent falling.

- **The 3 Motor Strategies for Balance Control:**

1- Ankle Strategy: Reposition the COM after small displacements to slow speed disturbance by oscillation around the ankle joint.

2- Hip Strategy: uses rapid compensatory hip flexion or extension to reposition the COM (near the edge of the sway envelope) within the BOS in response to moderate to large postural disturbance.

3- Stepping Strategy: A step is used to enlarge the BOS when sudden or large amplitude forces displace the COM beyond the limits of control.



Assessment of Balance

I- Subjective assessment.

(A) **History:**

1- History of falls (whether onset of falls is sudden versus gradual; the frequency and direction of falls).

2- The environmental conditions.

3- The subject activities.

4- Presence of dizziness, vertigo, or lightheadedness at time of

the fall.

5- Current and past medications.

(B) Assessments to identify:

1- Sensory input (proprioceptive, visual, vestibular).

2- Sensory processing (sensorimotor integration, anticipatory and reactive balance control).

3- Biomechanical and motor (postural alignment, muscle strength and endurance, joint ROM and flexibility, motor coordination, pain).

4- Tests and observations to determine the impact of balance control system deficits on functional performance.

5- Environmental assessments to determine fall risk hazards in a person's home.

Clinical tests used to evaluate balance

1- Observe balance during different activities with or without assistive devices.

2- Observations of patient catching ball, opening doors, lifting objects of different weights.

3- Functional reach test or multidirectional reach test.

4- Observation of patient's responses to pushes (small or large, slow or rapid) from different positions.

5- Safety during gait with or without assistive devices.

Balance during single leg stance

Balance holding a weight

Balance while catching a ball

Balance while standing with resistance provided to the arms via elastic resistance.

<u>Assessment of Balance</u>

II- Objective assessment.

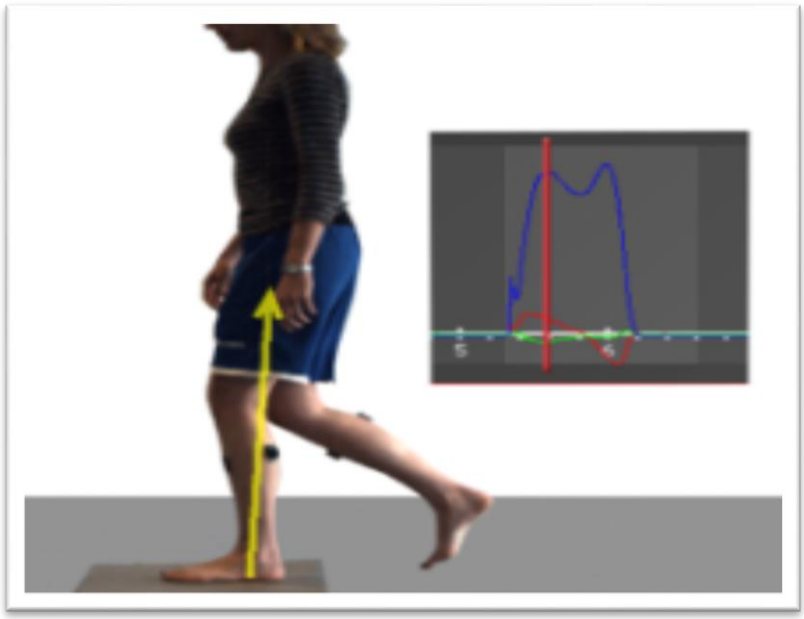
(A) **Force platforms:**

- **Are floor-mounted, electronic, pressure-sensitive plates that measure the JRF and moments applied to its top surface by a body standing, stepping. or jumping on them.**
- **They evaluate 3 aspects of postural control:**

1- Steadiness.

2- Symmetry.

3- dynamic stability.



(B) Biodex medical balance system:

- **Utilizes a dynamic multiaxial platform that allow up to 20˚ of deflection in any direction.**
- **This degree of deflection can stress the joint mechanoreceptors.**
- **Provides proprioceptive feedback for balance control (at end ROM).**
- **Assesses deficits in dynamic muscular control of posture relative to the joint pathology.**
- **Calculates the ability of patient to control the angle of the platform when tilted.**

Balance Training

- **Factors to be considered when developing program for balance impairments:**

1- Most balance intervention programs require a multi-systems approach. For example, an individual who has experienced prolonged bed rest or inactivity following an illness may require a program that includes:

(a) Stretching the lower extremities and trunk to improve postural alignment and mobility

(b) Strengthening exercises to improve motor performance.

(c) Dynamic, functional balance activities to improve the ability to perform daily activities safely.

2- Identified deficits in static or dynamic.

Goals of balance training:

1- Improve postural control and alignment.

2- Improve use of balance strategies.

3-Maintain appropriate and controlled body motion during task performance (energy required and fatigue).

4- Prevent injury.

5- Returning to normal functional activities or sports.

Indications of balance training:

1- Patients with neurological conditions.

2- Fractures of the bones in lower limbs and trunk.

3- Soft tissue lesions in lower limbs and trunk.

4- Surgical procedures involving lower limbs and trunk.

5- Facilitate contraction of selective muscle groups (as part of strengthening program).

Static Balance Control

- **Activities to promote static balance control include having the patient maintain sitting, half-kneeling, tall kneeling, and standing postures on a firm surface.**
- **More challenging activities include practice in the tandem and single-leg stance, lunge, and squat positions.**

- **Progress these activities by:**
  - **Working on soft surfaces (e.g., foam, sand, grass).**
  - **Narrowing the base of support.**
  - **Moving the arms, or closing the eyes.**
  - **Provide resistance via handheld weights or elastic resistance.**
  - **Add a secondary task (i.e., catching a ball or mental calculations)**

to further increase the level of difficulty.

Coordination Exercises

- **It is the ability to execute smooth, controlled motor responses (optimal interaction of muscle function).**
- **It is the ability to select the right muscle at the right time with proper intensity to achieve proper action.**
- **It is the process that in activation of motor units of multiple muscles with simultaneous inhibition of all other muscles to carry out the desired activity.**
- **The primary center for coordination of motion Cerebellum.**

Characteristics of coordinated movement:

Appropriate Muscular tension.

Distance

Timing

Speed

Direction

Smooth accurate motor response Depends on:

Flexibility and ROM

Vision

Deep sensations

Motor system

Vestibular system and cerebellum

Components of coordinated motion

1- Volition:

- **It is the ability to initiate, maintain or stop an activity or motion.**

2- Perception:

- **It is the ability to integrate motor impulses and sensory feedback due to intact proprioception and subcortical centers.**
- **When proprioception is affected it is compensated with visual feedback.**

3- Engram formation:

- **It is the neurological muscular activity developed in the extrapyramidal system.**
- **Research proved that high repititions of precise performance must be performed in order to develop an engram.**

Types of coordination

1- Fine motor skills:

- **Require coordinated movement of small muscles (hand, face).**
- **Examples: Writing**
  Drawing
  Buttoning a shirt
  Blowing bubbles

2- Gross motor skills:

- **Require coordinated movement of large muscles or group of muscles (trunk, extremities).**
- **Examples: Walking**
  Running
  Lifting activities

3- Hand-eye skills:

- **The ability of the visual system to coordinate visual information received and then control or direct the hand in the accomplishment of a task.**
- **Examples: Catching a ball**
  Sewing
  Computer mouse use

❖ **Causes of coordination impairments:**

1- Injury or disease of cerebellum and basal ganglia (ataxia, parkinsonism).

2- Alcohol or drug intoxication.

3- poisoning.

4- Infectious diseases.

<u>Examples of coordination tests</u> Upper limb

1. Finger to nose test

2. finger to finger test.

3. Finger to doctor finger test.

4. rebound phenomena.

5. Buttoning and unbuttoning.

<u>Examples of coordination tests</u> lower limb

Heel to knee test

Walking along a straight line

Rom berg test

- **In any of the coordination tests for upper limb, we may find:**
- **Intention tremors.**
- **Decomposition of motions.**
- **Dysmetria Hypermetria.**

  Or

  Hypometria.

<u>Balance and Coordination Exercises</u>

Static balance training:

Positions for the retraining of balance are selected on the basis of progression from the easy to the more difficult Positions. The patient maintains the balance in the following positions:

- **Forearm support prone lying**
- **Forearm support prone kneeling**
- **Prone kneeling**
- **Reach grasp kneeling**

- **Half kneeling**
- **Sitting**
- **Standing**
- **Walk standing**
- **In standing and walk standing the patient may be progressed from using parallel bars, through the range of walking aids to standing unaided.**
- **Resistance is applied to all the components needed to maintain a particular position. Resistance can be applied to Shoulders, Pelvis, Knees, Hands that gripping a support or a walking aid.**
- **A slow increase of alternating resistance is used to build up a co-contraction, i.e. rhythmic stabilization on shoulders and pelvis.**
- **A combination of stabilizing points may be used to advantage, e.g. the shoulder and the pelvis.**
- **Balance during single leg stance.**
- **Standing with arm holding a weight.**
- **Balance while standing and catching a ball**

Dynamic Balance Control

There are three basic types of movable support:

(1) Balance boards, which can vary in size from the usual balance wobble board to a large rocker board.

(2) A roll, of different size.

(3) Large inflated balls of varying size and type.

To promote dynamic balance control, interventions may involve the following:

- **Have the patient maintain equal weight distribution and upright trunk postural alignment while on moving surfaces, such as sitting on a therapeutic ball, standing on wobble boards, or bouncing on a mini trampoline.**
- **Progress the activities by superimposing movements such as shifting the body weight, rotating the trunk, moving the head or arms.**

Balance while standing on wobble boards with arm movements.

- **Vary the position of the arms from out to the side to above the head.**

Balance while standing on wobble boards with arms above the head.

- **Practice stepping exercises starting with small steps, then mini-lunges, to full lunges.**
- **Progress the exercise program to include hopping, skipping, rope jumping, and hopping down from small stool while maintaining balance.**
- **Have the patient perform arm and leg exercises while standing with normal stance, tandem stance, and single leg stance**

Guidelines for progression of balance exercises:

1) Types of stances

a. Bilateral – two legs planted (includes narrow, wide)

b. Tandem – specifically one foot planted directly in front of the other foot, heel near or against toe

c. Single Limb – one leg planted on surface only

2) Types of surfaces

a. Compliant surface – generally a softer surface, that complies to the feet

b. Noncompliant surface – a firm, hard surface that does not comply to the feet

c. Unstable surface – could be either a soft or hard surface but is unstable (ex: balance board)

3) Types of perturbations – disturbances to patient's balance

a. Degree of force

i. small

ii. moderate

iii. large

b. Speed applied

i. slow

ii. moderate

iii. rapid

c. Patient's awareness of its application

i. **Predictable**

ii. **Unpredictable**

Examples for progression of balance training:

1) **Sitting**

a. **Gradually remove upper extremity support: both hands on ⇒ one hand free ⇒ two hands free.**

b. **Make the seating surface less stable using therapy ball.**

c. **Modify lower extremity support: sitting cross legged, one leg up.**

d. **Modify trunk support: not using chair back rest.**

e. **Add upper extremity activities: reaching, throwing.**

f. **Add manual resistance.**

g. **Add visual challenges, head movements.**

2) **Standing**

a. **Decrease the level of external device use: parallel bars ⇒ walker ⇒ quad cane ⇒ cane ⇒ no device.**

b. **Move from bilateral stance to single limb stance**

c. **March in place.**

d. **Add upper extremity or functional activities.**

e. **Make the standing surface less stable.**

f. **Add vertical changes to the standing surface – steps, etc.**

g. **Increase the distance moved away from midline.**

h. **Change the speed of movement.**

i. **Add manual resistance.**

j. **Change the base of support: wide ⇒ narrow.**

k. **Add movements of the head and/or eyes.**

l. **Challenge the visual system: close eyes, etc.**

3) **Walking**

a. **Decrease the level of external device use: parallel bars ⇒ walker ⇒ quad cane ⇒ cane ⇒ no device.**

b. **Make the walking surface less stable, change the angles of surfaces.**

c. **Add obstacles, distractions, objects to carry or manipulate.**

d. **Increase the speed of walking.**

e. **Add manual resistance.**

f. **Add sudden directional changes.**

g. **Add movements of the head and/or eyes.**

h. **Challenge the visual system.**

General principles of coordination exercises involve:

1. **Constant repetition of a few motor activities**
2. **Use of sensory cues (tactile, visual, proprioceptive) to enhance motor performance**
3. **Increase of speed of the activity over time**
4. **Activities are broken down into components that are simple enough to be performed correctly.**
5. **Assistance is provided whenever necessary.**
6. **The patient there fore should have a short rest after two or three repetitions, to avoid fatigue.**
7. **High repetition of precise performance must be performed for the engram to form.**
8. **Whenever a new movement is trained, various inputs are given, like instruction(auditory), sensory stimulation(touch) ,or positions in which the patient can view the movement (visual stimulation) to enhance motor performance.**

Therapeutic exercises used to improve coordination:

1. **Frenkel's exercises**
2. **Proprioceptive Neuromuscular Facilitation**
3. **Neurophysiological Basis of Developmental techniques**
4. **Sensory Integrative Therapy**

FRENKEL'S EXERCISES: Frenkel 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: Concentration of the attention, Precision and Repetition

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

Frenkel's Exercises principles:

- **Start unilateral then bilateral.**
- **Start fast then slow movement.**
- **Start by proximal then by distal joints.**
- **Start by symmetrical then asymmetrical movement.**
- **The patient must see the movements and verbal feedback is very important.**

Technique:

- **The patient is positioned and suitably clothed so that he can see the limbs throughout the exercise. A concise explanation and demonstration of the exercise is given before movement to give the patient a clear mental picture of it the patient must give his full attention to the performance of the exercise to make the movement smooth and accurate.**
- **The speed of movement should be rhythmic through counting.**
- **The exercise must be repeated many times until it is perfect and easy.**
- **Frequent rest periods must be allowed between exercise to prevent fatigue The patient retains little or no ability to recognize fatigue**

- **Progression is made by altering:**

1. **Speed of exercise: quick movements require less control than slow ones.**
2. **Range of exercise: Wide range of movements, in which large joints are used.**
3. **Complexity of the exercise: exercise should be starting with very simple movements and gradually advance to more complicated ones.**

Frenkel's exercises from supine

- **Flex and extend one leg by the heel sliding down a straight line on the table. Abduct and adduct hip smoothly with knee bent and heel on the table. Abduct and adduct leg with knee and hip extended by sliding the whole leg on the table. Flex and extend hip and knee with heel off the table .**
- **Flex and extend both legs together with the heel sliding on the table.**
- **Flex one leg while extending the other. Flex and extend one leg while taking the other leg into abduction and adduction.**

Frenkle's Exercises for the legs in sitting:

One leg is stretched to slide the heel to a position indicated by a mark on the floor. The alternate leg is lifted to place the heel on the marked point. From stride sitting posture patient is asked to stand and them site. Rise and site with knees together.

Frenkle's Exercises for the legs in standing:

In stride standing weight is transferred from one foot to other. Place foot forward and backward on straight line.

Equilibrium coordination tests:

- **Standing in a normal comfortable posture.**
- **Standing with feet together (narrow base of support)**
- **Standing with one foot exactly in front of the other in tendon (toe of one foot touching heed of opposite foot).**
- **Standing on one foot.**
- **Arm position may be altered in each of the above postures (that is arm at sides, overhead, hands on waist).**

- **Displace balance unexpectedly (with carefully guarding patient).**
- **Standing and then alternate between forward trunk flexion and return to neutral.**
- **Standing with trunk laterally flexed to each side.**
- **Standing to test the ability to maintain an upright posture without visual feedback.**
- **Standing in tandem position from eyes open to eyes closed.**