MUSCLE PERFORMANCE… AND RESISTANCE EXERCISE— DEFINITIONS AND GUIDING PRINCIPLES

- **Strength**
- *Contractile tissue* produce tension…….
- a *single maximum effort,//*force exerted by a muscle or muscle group to overcome resistance.
- ***Functional strength……. Neuromuscular ability….***
- to produce, reduce, or control forces, imposed, during functional activities, in a smooth, coordinated manner.
- Insufficient muscular strength can contribute to major functional losses of even the most basic activities of daily living.
- ***Strength training.***
- integral component…. 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
- Adaptations::::: Increase in maximum force-producing capacity of muscle,

REASON::: neural adaptations then an increase in muscle fiber size.

Power

- work (force distance) per unit of time (force distance/time).
- *Rate of performing work. Or*
- *Rate* muscle contracts and produces a resultant force
- Relation of force and velocity affect muscle power.
- Because work can be produced over a very brief **OR** an extended period of time,
- power can be expressed by either a single burst of high-intensity activity (an-aerobic power)
- by repeated bursts of less intense muscle activity (such as climbing a flight of stairs).(aerobic power)

Power training.

- ***Many motor skills in our lives are composed*** of movements with both strength and speed.
- Muscle strength foundation muscle power.
- The greater the intensity of the exercise and the shorter the time period taken to generate force, the greater is the muscle power.
- *Power training…plyometric training* or *stretch-shortening drills….*

Endurance…..

- ***Cardiopulmonary endurance*** *(total body endurance) is associated with* repetitive, dynamic motor activities such as walking, cycling, swimming, or upper extremity ergometry, which involve use of the large muscles of the body.
- ***Muscle endurance*** *(sometimes referred to as local endurance) is the ability of a muscle to contract repeatedly…* generate and sustain tension, and resist fatigue over an extended period of time….. Aerobic power
- ***Endurance training……***
- ***In muscle performance improvment of endurance is more advantageous than Strength training***

Potential Benefits of Resistance Exercise

- • Enhanced muscle performance:..restoration, improvement & maintain…of muscle strength, power, and endurance
- • Increased strength of connective tissues……
- • Greater bone mineral density or less bone demineralization…..
- • Decreased stress on joints during physical activity
- • Reduced risk of soft tissue injury during physical activity
- • Possible improvement in capacity to repair and heal damaged soft tissues…
- • Enhanced physical performance during daily living, occupational, and recreational activities
- • Positive changes in body composition: ↑lean mass↓fat
- • Enhanced feeling of physical well-being

Overload Principle

- muscle performance based on *overload principle.*
- **Application of the Overload Principle**
- focuses on the *progressive loading* of muscle by manipulating, for example, the intensity or volume of exercise.
- *Intensity of resistance exercise refers* to how much weight (resistance) is imposed on the muscle depend on purpose…
- strength/endurance….

- Simply stated, if muscle performance is to improve, a load that exceeds the metabolic capacity of the muscle must be applied;
- that is, the muscle must be challenged to perform at a level greater than that to which it is accustomed.
- If the demands remain constant after the muscle has adapted, the level of muscle performance can be maintained but not increased

SAID Principle

- The SAID principle (specific adaptation to imposed demands) framework of specificity……..foundation an exercise programs built.
- extension of Wolff's law (body systems adapt over time to the stresses placed on them).
- It help therapists to prescribe ex & to select the parameters which meet the specific functional goals
- **Specificity of Training**
- *Specificity of training, also referred to as specificity of exercise,*
- improvement of strength, power, and endurance, are highly specific to the training method employed.
- considered mode (type) and velocity of exercise, patient or limb position (joint angle) and the movement pattern during exercise. ……..e.g.?

Transfer of Training

- In contrast to the SAID principle, carryover of training effects from one variation of exercise or task to another has also been reported.
- *Transfer of training, overflow, or cross-training.*
- *very limited basis with* respect to the velocity of training and the type or mode of exercise.
- Strength training at one speed/high speed/low speed.
- Effects can occur from an exercised limb to a nonexercised, contralateral limb in a resistance training program…evidence
- Strength and endurance relation

Reversibility Principle

- Adaptive changes……..transient….
- *Detraining….*begins within a week or two after the cessation of resistance exercises and continues until training effects are lost.
- Prevention…functional activities or participates in a maintenance program of resistance exercises,

SKELETAL MUSCLE FUNCTION AND ADAPTATION TO RESISTANCE EXERCISE

- **Factors that Influence Tension Generation in Normal Skeletal Muscle**
- morphological, biomechanical, neurological, metabolic, and biochemical factors.
- All contribute to the *magnitude, duration, and speed of force production* as well as how resistant or susceptible a muscle is to fatigue.

- As well as properties of muscles…….

SKELETAL MUSCLE FUNCTION AND ADAPTATION TO RESISTANCE EXERCISE

- Cross-section and size of the muscle (includes muscle fiber number and size)……
- Fiber arrangement and fiber length (also relates to cross-sectional diameter of the muscle)……(short fiber with pinnate & multipinnate,.. e.g. Quard, deltoid, gastrocnemeous)
- Fiber-type distribution of muscle: type I (tonic, slowtwitch) and type IIA & IIB (phasic, fast-twitch)……
- Length-tension relationship of muscle at time of contraction…
- Recruitment of motor units……&Frequency of firing of motor units……
- Type of muscle contraction…ecentric-→isometric-→concentric)
- Speed of muscle contraction (force-velocity relationship)…..
  concentric .↑speed↓tension…
- **ecentric:** ↑speed↑tesion

Energy Stores and Blood Supply

- Energy need (fuel) to contract, generate tension, and resist fatigue.
- predominant fiber in muscle and adequacy of blood supply,……
- The three main energy systems (ATP-PC system, anaerobic/glycolytic/ lactic acid system, aerobic system).

Fatigue

- ***Muscle (local) fatigue.***
- Muscle (local) fatigue—……
- Decrease in amplitude of motor unit potentials.
- Fatigue occur static or dynamic work……
- This *acute physiological response to exercise is normal* and *reversible, but characterized by a gradual decline* in the force-producing capacity of the neuromuscular system, that is, a *temporary state of exhaustion (failure), leading* to a decrease in muscle strength.

Factors affect Fatigue

- Disturbances in contractile mechanism of the muscle..decrease in energy stores, insufficient oxygen, and a build-up of H
- Inhibitory (protective) influences from the central nervous system
- Possibly a decrease in the conduction of impulses at myoneural junction, particularly in fast-twitch Fibers
- **The fiber-type distribution of a muscle**
- **(type** I and type II),….
- Type II (phasic, fast-twitch) (types IIA and IIB
- Type IIB early fatigue than IIA.
- Type I (tonic, slow-twitch) muscle fibers generate a low level of muscle tension but can sustain the contraction for a long time. More resistant to fatigue than type II….

BOX 6.2 Signs and Symptoms of Muscle Fatigue

- • An uncomfortable sensation in the muscle, even pain and cramping
- • Tremulousness in the contracting muscle.. jerky, not smooth
- • Inability to complete the movement pattern through the full range of available motion during dynamic exercise.
- • substitute movement…….
- • Inability to continue low-intensity physical activity
- • Decline in peak torque during isokinetic testing

Cardiopulmonary (general) fatigue

- ***This type of fatigue is*** the diminished response of an individual (the entire body) as the result of prolonged physical activity, walking, jogging, cycling, lifting or digging.
- It is related to the body's ability to use oxygen efficiently.

Cardiopulmonary fatigue:

- 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.***
- **Factors effect fatigue:**
- A patient's health status, diet, or lifestyle. In patients with neuromuscular, cardiopulmonary, oncologic, inflammatory, or psychological disorders, the onset of fatigue is often abnormal.

Recovery from Exercise

- 90% to 95% of the pre-exercise capacity, 3 to 4 minutes, greatest in the first minute.

During recovery:

- Oxygen stores are replenished in muscles.
- Energy stores are replenished.
- Lactic acid is removed from skeletal muscle and blood within approximately 1hour after exercise.
- Glycogen is replaced over several days.

Age

- Muscle performance changes throughout the life span.

Infancy, Early Childhood, and Preadolescence

- At birth, muscle accounts for about 25% of body weight.
- Total number of muscle fibers is established prior to or early during infancy.
- Postnatal changes in distribution of type I and type II fibers in muscle are relatively complete by the end of the first year of life.
- Muscle fiber size and muscle mass increase linearly from infancy to puberty.
- Muscle strength and muscle endurance increase linearly with chronological age in boys and girls throughout childhood until puberty.
- Muscle mass (absolute and relative) and muscle strength is just slightly greater (approximately 10%) in boys than girls from early childhood to puberty.
- Training-induced strength gains occur equally in both sexes during childhood without evidence of hypertrophy until puberty.

Puberty

- Rapid acceleration in muscle fiber size and muscle mass, especially in boys. During puberty, muscle mass increases more than 30% per year.
- Rapid increase in muscle strength in both sexes.
- 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, with significantly greater muscle hypertrophy in boys.

Young and Middle Adulthood

- Muscle mass peaks in women between 16 and 20 years of age; muscle mass in men peaks between 18 and 25 years of age.
- Decreases in muscle mass occur as early as 25 years of age.
- Muscle mass constitutes approximately 40% of total body weight during early adulthood, with men having slightly more muscle mass than women.

- Strength continues to develop into the second decade, especially in men.
- Muscle strength and endurance 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 a modest increase in physical activity.

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, skeletal muscle mass has decreased by 50% compared to peak muscle mass during young adulthood.
- Muscle fiber size (cross-sectional area), type I and type II fiber numbers, and the number of alpha motoneurons all decrease. Preferential atrophy of type II muscle fibers occurs.
- Decrease in the speed of muscle contractions and peak power.
- Gradual but 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.

- Minimal decline in performance of functional skills during the sixth decade.
- Significant deterioration in functional abilities by the eighth decade associated with a decline in muscular endurance.
- With a resistance training program, a significant improvement in muscle strength, power, and endurance is possible during late adulthood.
- Evidence of the impact of resistance training on the level of performance of functional motor skills is mixed but promising.

Psychological and Cognitive Factors

- positively or negatively influence.

- Fear of Injury,
- disease,
- mental status etc

- In contrast, psychological factors can also positively influence physical performance.

1) Attention

- Able to focus on a given task (exercise) to learn how to perform it correctly.
- Ability to process relevant data while screening out irrelevant information from the environment and to respond to internal cues from the body.
- Both necessary for learning and carrying out an exercise program independently.
- Attention to the form and technique during resistance training is necessary for patient safety and optimal long-term training effects.

2) Motivation and Feedback

- Improve muscle performance for functional activities.
- Use of activities that are meaningful and are perceived as having potential usefulness or periodically modifying an exercise routine help maintain a patient's interest in resistance training.
- Charting or graphing a patient's strength gains,
- **Feed back::…..**has positive impact on a patient's motivation and adherence to an exercise program.
- Isokinetic dynamometer computrized
- Documentation wt distance speed etc.

Physiological Adaptations to Resistance Exercise

- Resistance exercise impact on all systems of the body.
- Initially number of *acute physiological* responses and then later adapt.
- Adaptations to resistance exercise, known as *chronic physiological responses.*

1) Neural Adaptations

- Rapid gain in the tension-generating capacity due to neural responses,
- Increase in electromyographic (EMG) activity during the first 4 to 8 weeks, no or little hypertrophy.

- used in motor learning and improved coordination and include *increased recruitment in the number of motor units firing as well as* an *increased rate and synchronization of firing.*
- Due to decrease in the inhibitory function of the central nervous system (CNS), decreased sensitivity of the Golgi tendon organ (GTO), or changes at the myoneural junction of the motor unit.

Skeletal Muscle Adaptations

- **1: Hypertrophy**
- Tension-producing directly ..cross-sectional area of the individual muscle fibers.
- Increase myofibrill volume.
- moderate- to high-intensity resistance training, usually by 4 to 8 weeks,.. 2 to 3 weeks with very high-intensity resistance training, hypertrophy important adaptation.
- An increase in protein (actin and myosin) synthesis and a decrease in protein degradation.
- type IIB muscle fibers increase in size most readily with resistance training.

2: Hyperplasia

- *Hyperplasia,* an increase in the *number of muscle fibers.*
- Result of longitudinal splitting of fibers.
- In literature::: not occur; or if occur to a slight degree, its impact is insignificant.
- In a recent review articles…… (less than 5%) of the increase in muscle size that occurs with resistance training.

3: Muscle Fiber Type Adaptation

- Type II (phasic) muscle fibers more……hypertrophy
- plasticity exists in muscle fibers with respect to contractile and metabolic properties.
- Transformation of type IIB to type IIA is common with endurance training…….
- There is some evidence that demonstrates type I to type II fiber type conversion…….
- no evidence of type II to type I conversion…..

Vascular and Metabolic Adaptations

- Adaptations of the cardiovascular and respiratory systems as the result of low-intensity, high-volume resistance training……..(aerobic response…)
- Opposite to endurance training,….. with high-intensity, low-volume training, capillary bed density actually decreases because of an increase in the number of myofilaments per fiber.
- Athletes in heavy resistance training actually have fewer capillaries per muscle fiber than endurance athletes and even untrained individuals.
- metabolic changes:, dec. mitochondrial density. Due to dec. oxidative capacity of muscle

Adaptations of Connective Tissues

S**trength in tendons** probably occurs at musculotendinous junction,

In ligament occur at the ligament–bone interface….

to support adaptive strength and size changes in muscle, the connective tissue in muscle.

- Less injured……. eccentric resistance training than with other types of resistance exercises.

- **Bone**

- High correlation between muscle strength and the level of physical activity with bone mineral density.
- reduce the risk of fractures or Improve bone density when osteopenia or osteoporosis is already present

Determinants of a Resistance Exercise Program

- • *Alignment*
- • *Stabilization*
- • *Intensity:*
- • *Volume:*
- • *Exercise order: the sequence in which muscle groups are* exercised during an exercise session
- • *Frequency*
- • *Rest interval:*
- • *Duration:*
- • *Mode of exercise*
- • *Velocity of exercise*
- • *Periodization:*
- • *Integration of exercises into functional activities:*

Alignment

- ***Alignment and muscle action***

E.g. to strengthen the gluteus medius the hip must remain slightly extended, not flexed; and the pelvis must be rotated slightly forward as the patient abducts the lower extremity against the applied resistance. If the hip is flexed as the leg abducts, the adjacent tensor fasciae latae becomes the prime mover and is strengthened.

- ***Alignment and gravity***

stabilization

- *Holding down a body segment or holding the body steady. Proximal attachment or vice versa…..*
- ***External stabilization:***
- *manually by the* therapist ,by the patient , with equipment, such as belts and straps, or firm support surface……..
- ***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

Intensity

- Amount of resistance (weight)…..
- ***exercise load*** **(training load):,** the extent to which the muscle is loaded or how much weight is lifted, lowered, or held.
- Consistent with overload principle,……
- The intensity of exercise and degree of muscle overloaded dependent on volume, frequency, and order of exercise or the length of rest intervals.
- **Submaximal Versus Maximal Exercise Loads**

➢ Many factors

- goals and expected functional outcomes ,
- the cause of deficits in muscle performance,
- the extent of impairment,
- the stage of healing of injured tissues,
- the patient's age,
- general health,
- fitness level,
- Determine level of exercise…….

Submaximal loading.

- ***Indications…….***:
- Beginning of an exercise program to evaluate the patient's response to resistance exercise after inactivity
- early stages of soft tissue healing…..
- After immobilization when the articular cartilage de-conditioned…….bone demineralization…pathological fractures
- children or older adults
- improve muscle endurance
- warm up and cool down prior to and after a session of exercise
- During slow-velocity isokinetic training to minimize compressive forces on joints

Near maximal or maximal loading.

- ***Indications***:
- **Goal:** increase muscle strength and power and possibly increase muscle size.
- Healthy adults in the *advanced phase of a rehabilitation program after a musculoskeletal injury in* preparation for returning to high-demand occupational or recreational activities
- In a conditioning program for individuals with no known pathology
- For individuals training for competitive weight lifting or body building

Initial Level of Resistance (Load) and Documentation of Training Effects

- manual resistance exercise…..subjective,…… based on the therapist's judgment.
- In an exercise program using mechanical resistance…… quantitatively.
- **Repetition Maximum**
- measurement and calculation, an appropriate exercise load… a repetition maximum(RM).
- First reported by DeLorme in PRE…
- A *repetition maximum (RM) is defined as the greatest amount of weight* (load) a muscle can move through the available range of motion (ROM) a specific number of times.

Use of a repetition maximum

- *Two main reasons* determining a repetition maximum:
- (1) baseline measurement……. exercise-induced improvements in strength can be compared
- (2) to identify an exercise load (amount of weight) for a specified number of repetitions.
- **DeLorme reported use of a 1 RM…….**as the baseline measurement of a subject's maximum effort but used a 10 RM (the amount of weight that could be lifted and lowered exactly 10 times) during training.
- In the clinical setting, a practical, time-saving way …to establish a baseline RM….select a specific amount of resistance (weight)…..document repetitions full range before fatigue.
- **sign of fatigue…..**

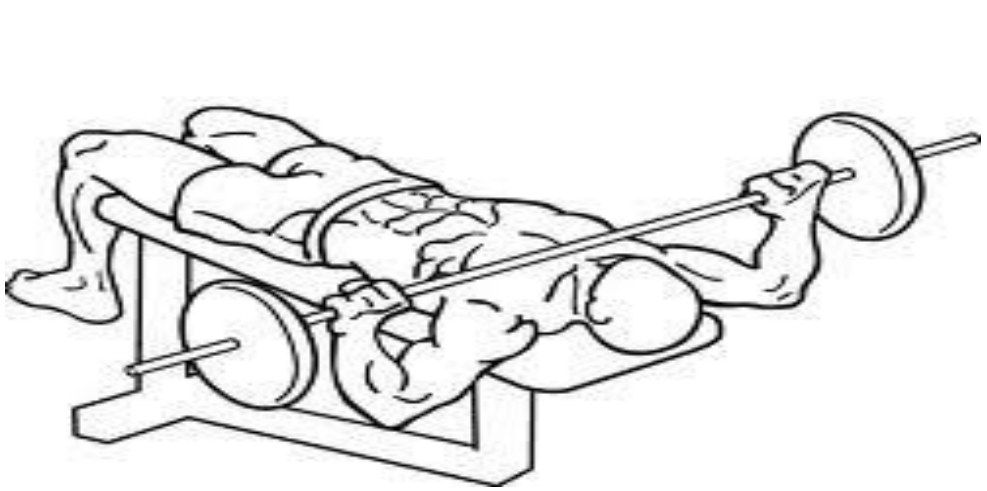
Alternative Methods of Determining Baseline Strength and a Beginning Exercise Load

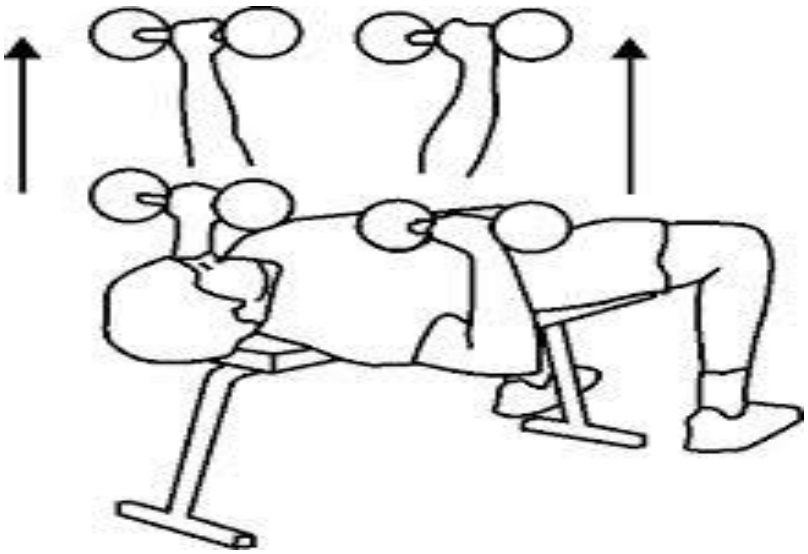
- Cable tensiometry and isokinetic or hand held dynamometry are alternatives to a repetition maximum for establishing a baseline measurement of strength.
- A percentage of body weight also has been proposed to estimate how much resistance (load) should be used in a strengthening program.
- The percentages as guidelines for the advanced stage of rehabilitation and are based on 10 repetitions of each exercise at the beginning of an exercise program.
- Percentages vary for different muscle groups.

Percentage of Body Weight as an Initial Exercise Load

- • Universal bench press: 30% body weight
- • Universal leg extension: 20% body weight
- • Universal leg curl: 10% to 15% body weight
- • Universal leg press: 50% body weight

Bench press & leg press





Leg curls & leg extension

Training Zone

- Measure Baseline RM,…initiation of resistance training is often calculated as a *percentage of a 1RM* for a particular muscle group.
- **At the beginning** percentage low (30% to 40%) for sedentary, untrained individuals
- **or** very high (80% to 95%) for those already highly trained.
- **For healthy but untrained adults,** a typical training zone usually falls between 60% and 70% of an RM.
- **The lower percentage** safer at the beginning of a program to focus on learning exercise form and technique.
- **low to moderate percentage ..children and the elderly..**
- **patients deficits in muscle strength** or to train for muscular endurance, 30% to 50% level.

Volume

- *summation* of total number of repetitions and sets of a particular exercise during a single exercise session multiplied by the resistance used.
- The same combination of repetitions and sets should not be used for all muscle groups.
- inverse relationship number of repetitions performed and the intensity of the resistance. ……So load directly dictates the number of repetitions.

Repetitions and Sets:

- Number of times a particular movement is repeated.
- Number of muscle contractions to move the limb through a series of continuous and complete movt against a specific exercise load.
- If the RM designation is used, the number of repetitions at a specific exercise load define repititions/sets.
- 10 repetitions at a particular exercise load is a 10 RM.
- If a 1 RM has been established as a baseline level of strength, a percentage of the 1 RM **used influences** the number of repetitions a patient is able to perform. (**depend on goal..)…E.G. strenght or endurance?**

- The “average,” untrained adult, when exercising with a load that is equivalent to 75% of the 1 RM, is able to complete approximately
- 10 repetitions before needing to rest.
- At 60% intensity about 15 repetitions are possible,
- 90% intensity only 4 or 5 repetitions are usually possible.

Sets/Bout

- ***A predetermined number of repetitions grouped together****….. Brief interval b/w them*
- As few as one set and as many as six sets have yielded positive training effects.
- Single-set exercises at low intensities are most common in the very early phases of a resistance exercise program or in a maintenance program.
- Multiple-set exercises are used to progress the program and have been shown to be superior to single set regimens in advanced training

Training to Improve Strength or Endurance: Impact of Exercise Load and Repetitions

- **To Improve Muscle Strength**
- In DeLorme's three sets of a 10 RM to gains in strength.

➢ Current recommendations are to use an exercise load that causes fatigue after 6 to 12 repetitions for two to three sets (6 to 12 RM)……

- **To Improve Muscle Endurance**
- Improve endurance…many repetitions of an exercise against a submaximal load. …..
- e.g…….(3-5 sets of 40-50 repetitions)
- Endurance training can also be accomplished by maintaining an isometric muscle contraction for incrementally longer periods of time.
- very low levels of resistance ,…can be initiated very early in a rehabilitation program without risk of injury to healing tissues.

Exercise Order

- The sequence in which exercises are performed during an exercise session..
- When multiple muscle groups are exercised in a single session, as is often the case in rehabilitation or conditioning programs,
- large muscle groups should be exercised before small muscle groups
- multijoint muscles before single-joint muscles.
- after an appropriate warm-up, higher intensity exercises should be performed before lower intensity exercises.

Frequency

Exercise sessions/day /week. frequency depend:….

- intensity and volume,
- patient's goals,
- general health status,
- previous participation in a resistance exercise program,
- response to training.

❖ If greater the intensity and volume of exercise……

- Decline in performance…..overtraining, excessive frequency, inadequate rest, and progressive fatigue.
- Some forms of exercise should be performed less frequently than others because they require greater recovery time……..
- Although an optimal frequency not determined.

Continue……

- **Frequency under different conditions:**
- early postsurgical patients…operated limb is immobilized….low-intensity isometric (setting) exercises.
- As the intensity and volume of exercise increases, every other day or up to five exercise sessions per week is common.
- Frequency reduced for a maintenance program,..

  two times per week.
- With prepubescent children and the very elderly, frequency two to three sessions per week.
- Highly trained athletes involved in body building, power lifting, and `weight lifting at a high intensity…up to 6 days per week.

Duration

- *Total number of weeks or months*
- Depending on the cause….
- strength gains, observed early in a resistance training program (after 2 to 3 weeks) are the result of neural adaptation…
- For significant changes….at least 6 to 12 weeks of resistance training is required

Rest Interval (Recovery Period)

- Allow time for the body to recover from the acute effects of exercise associated with muscle fatigue or to offset adverse responses.. delayed-onset muscle soreness.
- Appropriate balance of progressive loading and adequate rest intervals can improve muscle performance.

Integration of Rest into Exercise

- Dependent on the intensity and volume of exercise……
- Moderate-intensity, a 2- to 3-minute rest period after each set is recommended.
- A shorter rest intervaL after low-intensity exercise;
- longer r(4 to 5 minutes)…
- During rest, perform exercise of another muscle group/limb.

➢ Patients with pathological conditions early fatigued,

➢ as well as children and the elderly, should rest at least 3 minutes between sets by performing an un-resisted exercise….

- Moderate intensities (in intermediate phase of rehabilitation program..)
- **48-hou**rs rest interval between **exercise sessions** allows the patient adequate time for recovery.

- **Mode of Exercise**

a) Type of Muscle Contraction

- *Isometric (static)*.

- Dynamic resistance exercises can be performed using ***concentric*** *(shortening) or* ***eccentric*** *(lengthening) contractions* or both.

- ***isokinetic***

b) Position for Exercise:

- **Weight-Bearing or Non-Weight-Bearing**

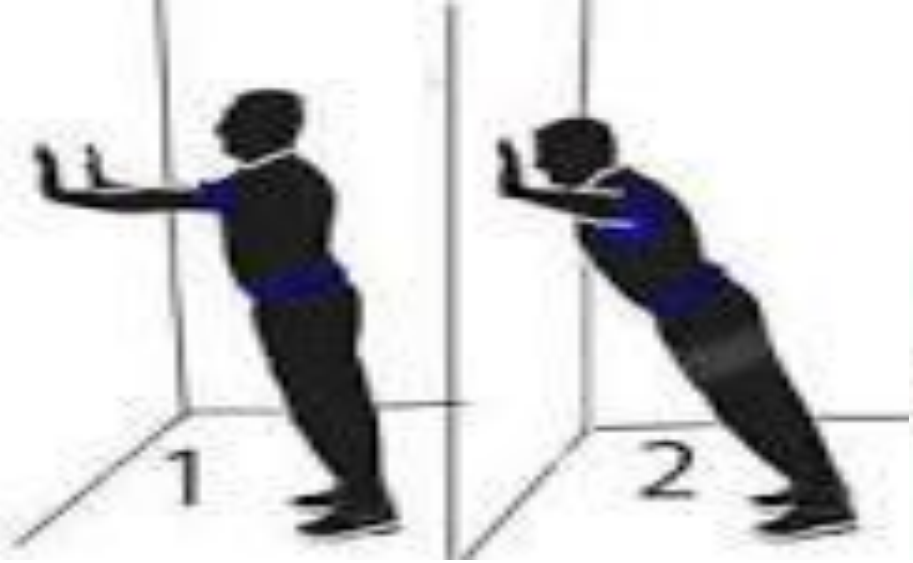
- non-weight-bearing…*open-chain exercise is* often used.

- weight-bearing position….*closed-chain*

c) Forms of Resistance

- ***Manual resistance***
- ***mechanical resistance*** :A *constant or variable load can be imposed using* mechanical resistance
- *Accommodating resistance*
- *Body weight or partial body*

- push-ups standing,
- push-ups while leaning against a countertop,
- push-ups in horizontal position,
- finally push-ups head-down position.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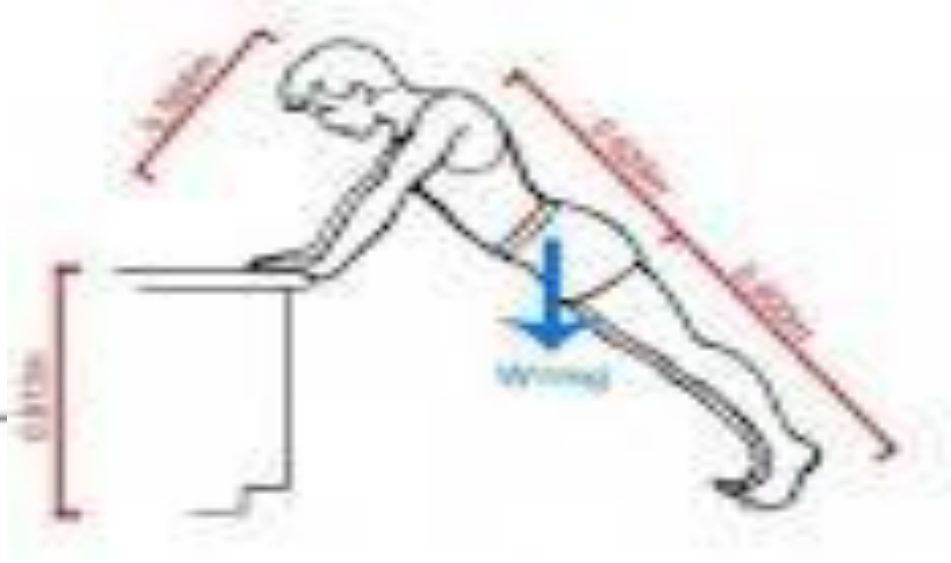


d) Energy Systems

- Modes of exercise can also be classified by the energy systems used during the exercise.
- ***Anaerobic exercise*** *involves* high-intensity (near-maximal) exercise carried out for a very few number of repetitions because muscles rapidly fatigue.
- **Strengthening exercises fall into this category.**

- ***Aerobic* exercise** is associated with low-intensity, repetitive exercise of large muscle groups performed over an extended period of time. Increases muscular and cardiopulmonary endurance.

Range of Movement: Short-Arc or Full-Arc Exercise

- Resistance through the full, available range of movement *(full-arc exercise) …develop strength through* the ROM.
- through only a portion of the available range *short-arc exercise…used* to avoid a painful arc of motion or a range where the joint is unstable or to protect healing tissues after injury or surgery.
- **Mode of Exercise and Application to Function**
- have a positive impact on function.
- When tissue healing allows, the type of muscle contractions performed or the position in which an exercise is carried out the desired functional activity

2: Velocity of Exercise

- significantly affects the tension and subsequently affects muscular **strength and power.**
- The velocity of exercise is frequently manipulated in a resistance training program ***to prepare the patient for a variety of functional activities*** that occur across a range of slow to fast velocities.
- **Force-Velocity Relationship**
- **Concentric exercises**
- **E-centric exercises**

Concentric Muscle Contraction

- As the velocity of muscle *shortening increases, the force* the muscle/tension *decreases.*
- **Shortening complete before full tension generation due to high velocity.**
- **Eccentric Muscle Contraction**
- as the velocity of active muscle *lengthening increases, force production* in the muscle initially *increases but then quickly levels off.*
- *The **initial increase in force*** **production may be a protective response** of the muscle when it is first overloaded.
- It is thought that this increase may be important for ***shock absorption or rapid deceleration of a limb during quick changes of direction.***
- The rise in tension may also be caused by stretch of the noncontractile tissue in muscle.

Application to Resistance Training

- free weights at slow to medium velocities of limb movement so the patient can control of the moving weight.
- Because many functional activities----> fast velocities of limb movement.
- isokinetic dynamometer late 1960s. tool implement resistance training at fast as well as slow velocities.
- **Speed training fundamental TO successful rehab.**
- Accordingly, training velocities for resistance exercises match or approach the demands of the desired functional activities.
- Isokinetic training, using *velocity spectrum rehabilitation* regimens, and *plyometric training, also known as stretch-shortening drills,….*

Periodization

- *periodized training,*
- ***Systematic variation*** in exercise intensity and repetitions, sets, or frequency at regular intervals over a specified period of time.
-
- developed for highly trained athletes preparing for competitive weight-lifting or power lifting events.

- To prevent overtraining and psychological staleness prior to competition and to optimize performance during competition.
- In preparation for competition, the training calendar is broken down into cycles, or phases, that sometimes extend over an entire year.
- The idea is to prepare for a “peak” performance at the time of competition.

TABLE 6.4 Characteristics of Periodized Training

Period of Training	Intensity of Exercise	Volume and Frequency of Exercise
Preparation	Lower loads	High number of reps and sets More exercises per session More frequent exercise sessions per day and per week
Competition	Higher loads (peaking just prior to competition)	Decreased reps and sets Fewer exercises per session Less frequent exercise sessions per day per week
Recuperation	Gradual decrease in exercise loads	Additional decrease in reps, sets, number of exercises, and frequency

Integration of Function
Balance of Stability and Active Mobility

- ability to perform functional movement/tasks **require** a balance of **active movement with a stable neuromuscular control.**
- Sufficient performance of agonist and antagonist muscles about a joint contributes to the dynamic stability of individual joints.
- For example, a person must be able to hold the trunk erect and stabilize the spine while lifting a heavy object.
- Stability is also necessary to control quick changes of direction during functional movements.
- Hence, a resistance exercise program must address the static strength as well as the dynamic strength of the trunk and extremities.

Balance of Strength, Power, and Endurance…

- Functional tasks for daily living, occupational, and recreational activities require combinations of muscle strength, power, and endurance.
- Various motor tasks require slow and controlled movements, rapid movements, repeated movements, and long-term positioning….
- Analysis of the tasks a patient do to provide ***task-specific resistance exercise program***.

Task-Specific Movement Patterns During Resistance Exercise

- strengthening isolated muscle groups as well as strengthening muscles in combined patterns.
- Apply exercise in anatomical planes, diagonal patterns, and combined task-specific movement patterns.
- **Use of simulated functional movements under controlled, supervised conditions is a means to return a patient safely to independent functional activities.**
- Pushing, pulling, lifting, and holding activities,….
- **successful self-management** is to teach a patient how to judge the speed, level, and duration of tension generation in muscle as well as the appropriate timing that is necessary to perform a motor task safely.

TYPES OF RESISTANCE EXERCISE

Progression of a Resistance Training Program: Factors for Consideration

Factors	Progression
Intensity (exercise load)	Submaximal → maximal (or near-maximal) intensity Low load → high load
Body position (nonweight- or weight-bearing)	Variable: depending on pathology and impairments, weight-bearing restrictions (pain, swelling, instability) and goals of the rehabilitation program
Repetitions and sets	Low volume → high volume
Frequency	Variable: depends on intensity and volume of exercise
Type of muscle contraction	Static → dynamic Concentric and eccentric: variable progression
Range of motion	Short arc → full arc Stable portion of range → unstable portion of range
Plane of movement	Uniplanar → multiplanar
Speed of movement	Slow → fast velocities
Neuromuscular control	Proximal → distal control
Functional movement patterns	Simple → complex Single joint → multijoint Proximal control → distal control

Manual and Mechanical Resistance Exercise

- **1:Manual Resistance Exercise**
- **2:Mechanical resistance exercise**
- **3:Isometric Exercise (Static Exercise)**

effective and efficient method of muscle strengthening.

- isometric strength gains of 5% per week occurred when healthy subjects performed a single, near-maximal isometric contraction everyday over a 6-week period.
- *Repetitive isometric* contractions (a set of 20 per day) held for 6 seconds each against near-maximal resistance consistently improved isometric strength.
- A cross-exercise effect (a limited increase in strength of the contralateral, unexercised muscle group), as the result of transfer of training, has also been observed with maximum isometric training.

Rationale for Use of Isometric Exercise

- The need for static strength and endurance functional activities.
- Loss of static muscle strength occurs rapidly with immobilization and disuse, with estimates from 8% per week to as much as 5% per day.
- Functional demands often needs….high level of resistance for a short period of time or a low level of resistance over a prolonged period of time.
- Daily living muscular endurance than muscle strength….
- Dynamic stability of joints by co-contraction of muscle

Isometric Exercise: Rationale and Indications

- To prevent or minimize muscle atrophy when joint movement not done… (casts, splints, skeletal traction)
- • To activate muscles to begin to re-establish neuromuscular control but protect healing tissues 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 could compromise joint integrity or cause joint pain
- • To develop static muscle strength at particular points with task-related needs

Types of Isometric Exercise

- ***A) Muscle-setting exercises.***
- involve low intensity isometric contractions performed against little to no resistance.
- decrease muscle pain and spasm, promote relaxation and circulation after injury to soft tissues during the *acute stage of healing.*
- E.g. quadriceps and gluteal muscles.
- does not improve muscle strength……except in very weak muscles.
- retard muscle atrophy and maintain mobility between muscle fibers when immobilization early phase of rehabilitation.

B: Stabilization exercises.

- used to develop a submaximal but sustained level of co-contraction to improve postural stability or dynamic stability of a joint by means of **mid-range isometric** ***contractions against resistance in antigravity positions and in weight bearing postures.***
- Body weight or manual resistance sources of resistance.
- **Include** *rhythmic stabilization and alternating isometrics, associated with proprioceptive* neuromuscular facilitation (PNF) .
- Stabilization exercises that focus on trunk/postural control include *dynamic, core, and segmental stabilization exercises.*
- ***C) Multiple-angle isometrics.***
- resistance manually or mechanically, at multiple joint positions available ROM.
- improve strength….when dynamic resistance exercise is painful or inadvisable.

Characteristics and Effects of Isometric Training

- Effective use of isometric exercise in a resistance training
- ***Intensity of muscle contraction.***
- sufficient to use an exercise intensity 60% to 80% of a muscle's force-developing capacity to improve strength.
- Resistance must be progressively increased to continue to overload the muscle….
- ***Duration of muscle activation***
- 6 seconds and no more than 10 seconds.
- ***Repetitive contractions:*** for 6 to 10 seconds each, decreases muscle cramping and increases the effectiveness of the isometric regimen.

Characteristics and Effects of Isometric Training

- ***Joint angle and mode specificity.***
- Gains in muscle strength occur only at or closely adjacent to the training angle.
- Physiological overflow is minimal, occurring no more than 10◦ in either direction in the ROM from the training angle.
- multiple-angle isometrics, resistance at **four to six points** in the ROM is usually recommended. Isometric resistance training is also mode-specific.
- Increases static strength but little to no impact on dynamic strength….

3) Dynamic Exercise—Concentric and Eccentric

- **Concentric :, eccentric: , resistance applied by**

1) constant resistance, body weight, a free weight, or a simple weight-pulley system;
2) a weight machine that provides variable resistance;
3) an isokinetic device that controls the velocity of limb movement

- **Rationale for Use of Concentric and Eccentric Exercise**
- In conditioning & rehabilitation program.
- Concentric muscle contractions accelerate body segments,
- eccentric decelerate body segments (e.g., during sudden changes of direction or momentum).
- Eccentric contractions shock absorption during high-impact activities.

3) Dynamic Exercise—Concentric and Eccentric…continue

- A combination of concentric and eccentric muscle action in daily life, walking up and down inclines, ascending and descending stairs, rising from a chair and sitting back down, or picking up or setting down an object.
- Both improve muscle strength power and endurance.
- **Eccentric training more important** … reduce the risk of musculoskeletal injury or re-injury ……high-intensity deceleration and quick changes of direction

Rationale for Use of Concentric and Eccentric Exercise

- Regimens eccentric loading, such as *plyometric training (stretch-shortening drills)* or fast-velocity, eccentric isokinetic for high-demand sports or work-related activities.
- Adaptive gains in eccentric and concentric strength appear to be similar……
- **Delayed-muscle soreness** with high-intensity eccentric exercise may influence the outcome of these two modes of training.

Rationale for Use of Concentric and Eccentric Exercise

- ***velocity of exercise. ……***
- The velocity at which concentric or eccentric exercises are performed directly affects the force-generating capacity of the neuromuscular unit.

- At slow velocities with a maximum load, an eccentric contraction generates greater tension than a concentric contraction.
- At slow velocities, therefore, a greater load (weight) can be lowered (with control) than lifted.
- As the velocity of exercise increases, concentric contraction tension rapidly and consistently decreases, whereas eccentric contraction forces increase slightly but then rapidly reach a plateau under maximum load conditions

Energy expenditure.

- *Eccentric exercise consumes less* oxygen and energy stores than concentric exercise against similar loads.
- **eccentric activities** may improve muscular ***endurance*** more efficiently than similar concentric activities because muscle fatigue occurs less quickly with eccentric exercise

Cross-training effect. Concentric and eccentric training

- involves a combination of concentric and eccentric contractions (lifting and lowering a weight). ……
- ***Exercise-induced muscle soreness.***
- Repeated and rapidly progressed eccentric muscle contractions associated with a higher incidence and severity of delayed-onset muscle soreness (DOMS) than resisted concentric exercise.
- Result of greater damage to muscle and connective tissue when heavy loads are controlled and lowered.

Dynamic Exercise—Constant and Variable Resistance

- common systems used are against constant or variable resistance **is**
- ***progressive resistance exercise (PRE)***.
- **Dynamic Constant External Resistance Exercise (DCER)**
- *constant external load, provided by free* weights such as a handheld or cuff weight, , weight machines, or pulley systems.
- This terminology (DCER exercise) 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.
- **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.

N–K Exercise Unit with torque arm and interchangeable weights provides constant external resistance

Dynamic Constant External Resistance Exercise (DCER)

- **DCER limitation:**
- When lifting or lowering a constant load, the contracting muscle is challenged maximally at only one point in the ROM where the maximum torque of the resistance matches the maximum torque output of the muscle.
- A therapist needs to be aware of the changing torque of the exercise and the changing length–tension relationship of the muscle and modify body position and resistance accordingly to match where in the range the maximum load needs to be applied.
- **Despite this limitation,** constant external resistance has been and continues to be an effective form of muscle loading for training-induced improvements in muscle performance.

Variable-Resistance Exercise

Specially designed resistance equipment offer varying resistance to contracting 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, or by hydraulic or pneumatic mechanisms.
- How effectively these machines vary the resistance to match muscle torque curves is questionable.
- Dynamic exercise with elastic resistance products (bands and tubing) as a variable-resistance exercise because of the inherent properties of the material and its response to stretch.
- , when dynamic exercise is performed against manual resistance, a skilled therapist can vary the load applied to the contracting muscle throughout the ROM depend on response.

Special Considerations for DCER and Variable-Resistance Exercise

- During either DCER or the variable-resistance exercise, the velocity and excursion of limb movement is controlled exclusively by the patient (with the exception of manual resistance exercise and performing exercises on units that have range-limiting devices).
- Exercises must be performed at a relatively *slow velocity to avoid momentum and* uncontrolled movements, which could jeopardize the safety of the patient.
- Hydraulic and pneumatic variable-resistance equipment and elastic resistance products do allow safe, high-velocity resistance training for high velocity daily activities requirements..

Isokinetic Exercise

- *Dynamic exercise :* velocity is predetermined and held constant By isokinetic dynamometer.
- **Concentric Isokinetic Exercises***
- Isometric 0/sec
- Slow 30–60/sec
- Medium 60-180/sec
- Fast 180-360/sec and above

Reciprocal versus isolated muscle training.

Use of reciprocal training of agonist and antagonist muscles emphasizing quick reversals of motion is possible on an isokinetic dynamometer. E.g. concentric contraction of the quadriceps followed by concentric contraction of the hamstrings. OR

- same muscle in a concentric mode, followed by an eccentric mode, thus strengthening only one muscle group at a time.
- ***Specificity of training.***
- Isokinetic training is *speed-specific,*. BUT not mode specific
- So patients typically train at several medium and fast velocities (between 90 and 360/sec) using ***velocity spectrum rehabilitation.***

Isokinetic strengthening of the internal and external rotators of the shoulder with the arm at the side to protect a potentially unstable glenohumeral joint.

Isokinetic Exercise

- ***Compressive forces on joints.***
- During concentric exercise**,** as force output decreases, the compressive forces are less at faster velocities than slow velocities.
- ***Accommodation to fatigue.***
- Because the resistance encountered is directly proportional to the force applied to the resistance arm of the isokinetic unit, as the contracting muscle fatigues, a patient is still able to perform additional repetitions even though the force output of the muscle temporarily diminishes.
- ***Accommodation to a painful arc.***
- this form of training accommodates for the painful arc.
- 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 as soon as the patient stops pushing against the torque arm of the dynamometer.

Isokinetic Exercise

- **Training Effects and Carryover to Function**
- isokinetic training is effective for improving muscle performance.
- use of high-velocity concentric and eccentric isokinetic training was associated with enhanced performance (increased velocity of serving in tennis and throwing a ball).
- isokinetic training affords a spectrum of velocities for training, the velocity of limb movement during many daily living and sport-related activities.

Training Effects and Carryover to Function CONTINUE….

- **Limitations:**
- isokinetic exercise usually isolates a single muscle or opposite muscle groups, involves movement of a single joint, is uniplanar, and does not involve weight bearing.
- Strength of single muscle can be attained
- **BUT**
- Most functional activities require multiple muscle groups and movement of multiple joints in several planes of motion, some in weight-bearing positions.
- can be addressed by adapting the setup of the equipment to allow multiaxis movements in diagonal planes or multi-joint resisted movements with the addition of an attachment for closed-chain training.

Isokinetic exercises

- **Special Considerations for Isokinetic Training**
- **Availability of Equipment**
- **Appropriate Setup**

more comfortable position

Initiation and Progression of Isokinetic Training During Rehabilitation

- Isokinetic training is begun in the later stages of rehabilitation, when active motion through the full (or partial) ROM is pain-free.

Progression of Isokinetic Trainingfor Rehabilitation

- • Initially to keep resistance low, submaximal isokinetic exercise is implemented before maximal intensity isokinetic exercise
- • Short-arc before full-arc motions, to avoid unstable or painful portion of the range. This is accomplished by a mechanical range-limiting device or with a computerized dynamometer.
- • Slow to medium training velocities (60–180/sec)before progressing to faster velocities.
- • Maximal concentric contractions at various velocities before introducing eccentric isokinetic exercises for the following reasons.
- 1::**• Concentric isokinetic exercise is easier to learn and is fully under the control of the patient.**
- **2::• During eccentric isokinetic not in pt.control.**

Open-Chain and Closed-Chain Exercise

- **Background**
- **Controversy and Inconsistency in Use of Open-Chain and Closed-Chain Terminology**
- **Alternatives to Open-Chain and Closed-Chain Terminology**

open chain exercise	close chain exercises
• Distal segment moves in space	• Distal segment remains in contact with or stationary on support surface
• Independent joint movement; no predictable joint motion in adjacent joints	• Interdependent joint movements; relatively predictable movement patterns in adjacent joints
• Movement of body segments only distal to the moving joint	• Movement of body segments may occur distal and/or proximal to the moving joint
• Muscle activation occurs predominantly in the prime mover and is isolated to muscles of the moving joint	• Muscle activation occurs in multiple muscle groups, both distal and proximal to the moving joint

Open chain

- Typically performed in non weight-bearing positions
- Resistance is applied to the moving distal segment
- **Use of external rotary loading**
- External stabilization (manually or with equipment) usually required

close chain

- Typically but not always performed in weight-bearing positions
- Resistance is applied simultaneously to multiple moving segments
- **Use of axial loading**
- Internal stabilization by means of muscle action, joint compression, and postural control

Rationale for Use of Open-Chain and Closed-Chain Exercises

- Based on the goals and potential benefits and limitations inherent in either form of exercise.

- Functional activities involve many combinations and considerable variations of open- and closed-chain motions, task-specific open-chain and closed-chain exercises into a rehabilitation or conditioning program in the upper and lower extremities.

Characteristics.....

- **Isolation of Muscle Groups**
- Open-chain testing and training ……than closed-chain exercises.
- Substitute motions that compensate for strength deficits of individual muscles is greater with closed-chain exercise than open chain exercise.
- **Control of Movements**
- During open-chain more control….*single moving joint than with multiple* moving joints as occurs during closed-chain training.
- Stabilization……open & close chain exercises….
- The greater levels of control afforded by open-chain training are particularly advantageous during the early phases of rehabilitation.

Joint Approximation

- Almost all muscle contractions have a compressive component that approximates the joint surfaces and provides stability to the joint whether in open- or closed-chain situations.
- Joint approximation also occurs during weight bearing and is associated with lower levels of shear forces at a moving joint.
- Most on “knee & (glenohumeral joint”.
- The joint approximation that occurs with the axial loading and weight bearing during closed-chain exercises is thought to cause an increase in joint congruency, which in turn contributes to stability.

Co-activation and Dynamic Stabilization

- closed-chain in weight-bearing positions,… .assumed and commonly reported in the neuro-rehabilitation…>……stimulate joint and muscle mechanoreceptors, facilitate co-activation of agonists and antagonists (co-contraction), and consequently promote dynamic stability.
- e.g…During a standing squat, the quadriceps and hamstrings are thought to contract concurrently to control the knee and hip….other knee exercise…
- In the upper extremity, close chain exercise……coactivation of the scapular and glenohumeral stabilizers…… dynamic stability of the shoulder complex.

Co-activation and Dynamic Stabilization

- co-activation (cocontraction) of agonist and antagonist muscle groups may occur with selected open-chain exercises.
- Exercise interventions,
- Alternating isometrics associated with PNF, some stretch-shortening drills performed in non-weight-bearing positions, and high-velocity isokinetic training, may stimulate co-activation of muscle groups to promote dynamic stability.
- open-chain, high-velocity, concentric isokinetic training of knee musculature, coactivation of agonist and antagonist muscle groups was noted briefly at the end the range of knee extension…….
- Only occur with high velocity not with slow velocity (60/sec).

Proprioception, Kinesthesia, Neuromuscular Control, and Balance

- **Kinesthesia**>>>>foundations of motor learning for neuromuscular control of functional movements…….
- After soft tissue or joint injury…….
- **High priority in rehabilitation……**.for balance….
- closed-chain training provides greater proprioceptive and kinesthetic feedback than open-chain training. ……..
- The weight-bearing element (axial loading)….joint approximation,……stimulate mechanoreceptors in muscles and in and around joints to enhance sensory input for the control of movement.
- closed-chain positioning improve balance and postural control in the upright position…….

Carryover to Function and Injury Prevention

- Both open- and closed-chain exercises improve muscle strength, power, and endurance.
- consistent with motor learning and task-specific training should be incorporated into a rehabilitation program……**desired function.**
- specificity of training by both open & close chain…….
- **Implementation and Progression of Open- and Closed-Chain Exercises**
- intensity, volume, frequency, and rest intervals……

Introduction of Open-Chain Training

- in nonweight- bearing posture,….
- option when weight bearing is contraindicated or must be significantly restricted or **when unloading in a closed-chain position is not possible.**
- Soft tissue pain and swelling or restricted motion of any segment of limb…..use of open-chain exercises at adjacent joints.
- E.g…..Tibia fracture……
- open-chain activity can be replicated with open-chain exercises, first perform isolated then combination movement…

Closed-Chain Exercises and Weight-Bearing Restrictions—Use of Unloading

- weight bearing restricted, use open-chain exercises or **partial weight bearing close chain…….**
- simple upper extremity; but in the lower extremity not possible…….
- **Use of aquatic exercises,**…. in **parallel bars** feasible for unloading strategies for lower extremity..
- **Limitations:** difficult to control the extent of weight bearing for close chain in parallel bars and in aquatics.
- lower limb movements in the parallel bars or in water tend to be slower than what typically occurs during functional tasks.
- An alternative "**harnessing system"** to unload the lower extremities. perform a variety of closed-chain exercises and to begin ambulation on a treadmill at functional speeds early in rehabilitation.

PRECAUTIONS FOR RESISTANCE EXERCISE

General Precautions During Resistance Training

1. •temperature…… clothing
2. • Caution the patient that pain should *not occur during* exercise.
3. • Do not initiate resistance training at a maximal level of resistance, eccentric exercise…to prevent(DOMS).
4. • Avoid use of heavy resistance during exercise for children, older adults, and patients with osteoporosis.
5. • Do not apply resistance on unstable joint or distal to a fracture site not completely healed.
6. • prevent the **Valsalva maneuver/breath holding;** emphasize exhalation during exertion.

General Precautions During Resistance Training

7) • Avoid uncontrolled, ballistic movements as they compromise safety and effectiveness.

8. • **Prevent incorrect or substitute motions** by adequate stabilization and an appropriate level of resistance.

9 • Avoid exercises that place excessive, unintended secondary stress on the back.

10 • Be aware of medications a patient is using that can alter acute and chronic responses to exercise.

11 • Avoid cumulative fatigue… and the effects of **overtraining or overwork** by inadequate rest intervals

12 • Discontinue if pain, dizziness, or unusual or shortness of breath.

Valsalva Maneuver

- **a) At-Risk Patients :**
- History of coronary artery disease, myocardial infarction, cerebrovascular disorders, or hypertension,..who have had neurosurgery or eye surgery or who have intervertebral disc pathology. …monitored closely.
- **B) Prevention During Resistance Exercise**
- Prevent breath-holding…….
- Have the patient exhale with each resisted effort.
- high-risk patients avoid high-intensity resistance exercises.

Overtraining and Overwork

Overtraining

- **Decline physical performance**
- high-intensity, high-volume strength and endurance training programs.
- *chronic fatigue, staleness, and burnout.*
- When overtraining occurs, individual progressively fatigues more quickly and requires more time to recover from strenuous exercise because of physiological and psychological factors.
- Inadequate rest intervals between exercise sessions, too rapid progression of exercises, and inadequate diet and fluid intake.
- **(periodization).**

Overwork

- *overwork weakness,*
- progressive deterioration of strength in muscles already weakened by non-progressive neuromuscular disease.
- **GB syndrome**
- **Postpolio syndrome is also thought to be related to long-term overuse of weak muscles**.
- **Prevention is key to overwork weakness.**
- Patients in resistance training program, impaired neuromuscular function or a systemic, metabolic, or inflammatory disease that increases susceptibility to muscle fatigue must be **monitored closely**,
- progressed slowly and cautiously, and re-evaluated….
- No exhaustion……longer and more frequent rest intervals.

Exercise-Induced Muscle Soreness

- **Acute Muscle Soreness**
- during or directly after strenuous exercise.
- Muscle fatigued:::: lack of adequate blood flow and oxygen (ischemia) and a temporary buildup of metabolites,….
- **Sensation…** burning or aching in the muscle.
- Noxious metabolic wastes……free nerve endings….. Pain…..transient and subsides quickly after exercise.
- An appropriate cool-down period of low-intensity exercise (active recovery) can facilitate this process

Delayed-Onset Muscle Soreness

- After vigorous and unaccustomed resistance training or any form of muscular overexertion, delayed-onset muscle soreness (DOMS),…….muscle belly or at the myotendinous junction,……12 to 24 hours after the cessation of exercise.
- eccentric muscle contractions most severe DOMS symptoms.
- DOMS sensation usually intensifies and peaks 24 to 48--72 hours after exercise.
- variation…..last up to 10 to 14 days, gradually dissipate.

Delayed-Onset Muscle Soreness: Clinical Signs and Symptoms

- • Muscle soreness and aching beginning 12 to 24 hours after exercise and peaking at 48 to 72 hours
- • Tenderness muscle belly or at the myotendinous junction
- • Increased soreness with passive lengthening or active contraction of the involved muscle
- • Local edema and warmth
- • Muscle stiffness reflected by spontaneous muscle shortening before the onset of pain
- • Decreased ROM
- • Decreased muscle strength prior to onset of muscle soreness that persists for up to 1 to 2 weeks after soreness has remitted

Etiology of DOMS.

- Research 1900s,….. DOMS is still unclear.
- Several theories have been proposed.
- ***Metabolic waste accumulation theory:***
- *both* acute and delayed-onset muscle soreness
- D**isapproved**:….requires only about 1 hour of recovery after exercise to exhaustion to remove almost all lactic acid from skeletal muscle and blood

- **The *muscle spasm theory :***
- Spasm as cause of DOMS. …pain protective spasm.
- caused the DOMS sensation and an ongoing reflex pain–spasm cycle that lasted for several days after exercise.

Etiology of DOMS.

- **current research:**
- DOMS may be contraction-induced, mechanical disruption (microtrauma) of muscle fibers and/or connective tissue in and around muscle that results in degeneration of the tissue……. elevated blood serum levels of **creatine kinase**, is present for several days after exercise and is accompanied by inflammation and edema.
- The temporary loss of strength……. and perception of soreness or aching….

Prevention and treatment of DOMS

- ***Prevention and treatment***
- short or long period of inactivity ineffective….
- Initial onset prevented or at least kept to a minimum by progressing the intensity and volume of exercise *gradually,…warm up- cool down periods.*
- Repetitive concentric exercise prior to DOMS-inducing eccentric exercise……
- Best prevention ….(**adaptation theory)….**
- **Evidence:..** continuation of a training program that has induced DOMS does not worsen the muscle damage or slow the recovery process.
- Light, high-speed (isokinetic), concentric exercise has been reported to reduce muscle soreness and hasten the remediation of strength deficits associated with DOMS, but other reports suggest no significant improvement in strength or relief of muscle soreness with light exercise.

Prevention and treatment of DOMS

- Therapeutic modalities and Soft Tissue Mob., Electrical stimulation to reduce soreness effective and ineffective.
- **Cryotherapy….**after vigorous eccentric exercise reduces signs of muscle damage (creatine kinase activity), no effect on muscle tenderness or strength deficit.
- **compression sleeve :…**no increase in circumferential measurements of the upper arm (which could suggest prevention of soft tissue swelling), more rapid reduction in the perception of muscle soreness, and more rapid reduction of peak torque than recovery from DOMS without the use of compression.
- Finally, topical salicylate creams, reduce the severity and hasten the recovery from DOMS-related symptoms.

Pathological Fracture

- A *pathological fracture (fragility fracture) is a* fracture of bone already weakened by disease that occurs
- as the result of minor stress to the skeletal system. Pathological fractures most commonly occur in the vertebrae, hips, wrists, and ribs.
- osteoporosis or osteopenia participates in a resistance exercise program, the risk of pathological fracture.
- **Osteoporosis changes**…….
- Need to know history of osteoporosis….As well factors lead to osteoporosis.

Pathological Fracture

- Type (I) & type II osteoporosis……
- **Prevention of Pathological Fracture.**

Precautions to Reduce the Risk of Pathological Fracture During Exercise

- • Avoid high-intensity (high-load), high-volume weight training. Depending on the severity of osteoporosis, begin weight training at low intensities; initially, perform only one set of several exercises and keep the intensity low for the first 6 to 8 weeks.
- • Progress intensity and volume (repetitions) gradually; eventually work up to three or four sets of each exercise at moderate levels of intensity.
- • Avoid high-impact activities such as jumping or .

  Perform most strengthening exercises in weight-bearing postures that involve low impact to no impact, such as lunges or step-ups/step-downs against additional resistance (hand-held weights, a weighted vest, or elastic resistance).
- • Avoid high-velocity movements of the spine or extremities.

Precautions to Reduce the Risk of Pathological Fracture During Exercise

- • Avoid trunk flexion with rotation and end-range resisted flexion of the spine…….
- • Avoid lower extremity weight-bearing activities that involve torsional movements of hip…..
- • To avoid loss of balance or falling during lower extremity exercises while standing, hold onto a stable surface….
- If the patient is at high risk for falling or has a history of falls, perform exercises in a chair to provide weight bearing through the spine.
- keep proper supervision……

CONTRAINDICATIONS TO RESISTANCE EXERCISE

- **1) Pain**
- severe joint or muscle pain during active-free (unresisted) movements, dynamic resistance exercises should not be initiated.
- During testing, if a patient experiences acute muscle pain during a resisted isometric contraction, resistance exercises (static or dynamic) should not be initiated.
- If a patient experiences pain that cannot be eliminated by reducing the resistance, the exercise should be stopped.

2) Inflammation

- Dynamic and static resistance training is absolutely contraindicated in the presence of inflammatory neuromuscular disease.
- (Guillain-Barré) or inflammatory muscle disease (polymyositis, dermatomyositis)
- resistance exercises may actually cause irreversible deterioration of strength as the result of damage to muscle.
- *Dynamic resistance* exercises are contraindicated in the presence of acute inflammation of a joint.
- The use of dynamic resisted exercise can irritate the joint and cause more inflammation.
- Gentle setting (static) appropriate. exercises against negligible resistance are
- **3) Severe Cardiopulmonary Disease**

MECHANICAL RESISTANCE EXERCISE

Mechanical Resistance Exercise: Advantages and Disadvantages

- **Advantages**
- • Establishes a quantitative baseline measurement of muscle performance against which improvement can be judged.
- • 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.
- • Heavy exercise loads, far beyond that which can be applied manually by a therapist, can be used to induce a training effect for already strong muscle groups.
- • Increases in level of resistance can be incrementally and quantitatively documented.
- • Quantitative improvement is an effective source of motivation for the patient.
- • Useful for improving dynamic or static muscular strength.
- • Adds variety to a resistance training program.
- • Practical for improving muscular endurance.
- • Some equipment provides variable resistance through the ROM.
- • High-velocity resistance training is possible and safe with some forms of mechanical resistance (hydraulic and pneumatic variable resistance machines, isokinetic units, elastic resistance…
- • Appropriate for independent exercise in a home program after careful patient education and a period of supervision.

Disadvantages

- • 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.
- • Equipment that provides constant external resistance maximally loads the muscle at only one point in the ROM.
- • No accommodation for a painful arc (except with hydraulic, pneumatic, or isokinetic equipment).
- • Expense for purchase and maintenance of equipment.
- • With free weights and weight machines, gradation in resistance is dependent on the manufacturer’s increments of resistance.

Summary of Guidelines for Resistance Training in Conditioning Programs for Healthy Adults (50–60 years old)

- • Prior to resistance training, perform warm-up activities followed by flexibility exercises.
- • Perform dynamic exercises that target the major muscle groups of the body (approximately 8–10 muscle groups of the upper and lower extremities and trunk) for total body muscular fitness.
- • Balance flexion-dominant (pulling) exercises with extension-dominant (pushing) exercises.
- • Move through the full, available, and pain-free ROM.
- • Include both concentric (lifting) and eccentric (lowering) muscle actions.
- • Use *moderate-intensity exercises: at least 8 to 12 repetitions* per set.
- • Perform 1 to 3 sets of each exercise.
- • Use slow to moderate speeds of movement.
- • Exercises should not interfere with normal breathing.
- • Include rest intervals of 2 to 3 minutes between sets. While resting one muscle group, exercise a different muscle group.
- • Frequency: two to three times per week.
- • Increase intensity gradually (increments of approximately 5%) to progress the program as strength and muscular endurance improve.
- • Whenever possible, train with a partner for feedback and assistance.
- • Cool down after completion of exercises.

Resistance Training for Children: Special Guidelines & Considerations

- No formal resistance training for children less than 6 to 7 years of age.
- • At age 6 to 7, introduce the concept of an exercise session initially using exercises without weights, then with light (only 1- or 2-pound) weights.
- • Maintain *close and continuous supervision by trained* personnel or a parent who has received instruction.
- • Focus on proper form, exercise technique, and safety (alignment, stabilization, controlled motion).
- • Emphasize *low intensity throughout childhood to avoid* potential injury to a child's growing skeletal system and to joints and supportive soft tissues.
- • Emphasize a variety of short-duration, play-oriented exercises to prevent boredom, overheating, and muscle fatigue.
- • Perform warm-up activities for at least 5 to 10 minutes before initiating resistance exercises.
- • Select low exercise loads that allow a *minimum of 8 to 12* or 12 to 15 repetitions. Emphasize multi-joint, combined movements.
- • Perform only one to two sets of each exercise; rest at least 3 minutes between sets of exercises.
- • Initially progress resistance training by increasing repetitions, not resistance, or by increasing the total number of exercises. Later, increase weight by no more than 5% at a time.
- • Limit the frequency to two sessions per week.
- • Use properly fitting equipment that is designed or can be adapted for a child's size.

Resistance Training for Older Adults (≥ 60–65 Years): Guidelines and Special Considerations

- • Secure approval to initiate exercise from the participant's physician.
- • close supervision during the early phases of training to ensure safety.
- • Monitor vital signs, particularly when the program is progressed.
- • 5 to 10 minutes of warm-up activities before each session of resistance exercises.
- • Begin with low-resistance, low-repetition exercises, especially for eccentric exercises, to minimize loads on joints and to allow time for connective tissue as well as muscle to adapt.
- • Emphasize low to moderate levels of resistance (10–12 repetitions) for 6 to 8 weeks. Progress by increasing repetitions. Later, increase resistance by small increments.
- • Throughout program avoid high-resistance exercises avoid excessive stress on joints.
- • **two to three times weekly**, allowing a 48-hour rest interval between sessions.
- • Modify exercises for age-related postural changes, such as excessive kyphosis, that can alter the biomechanics of an exercise.
- • Avoid flexion-dominant resistance training that could emphasize postural changes.
- • When possible, use machines that allow the participant to perform exercises in a seated position to avoid loss of balance.

SELECTED RESISTANCE TRAINING REGIMENS

- For the past 50 to 60 years…great interest in resistance exercise and functional training.
- muscle strength, power, and endurance.
- Based on the overload principle,……USE mechanical resistance to load the muscle.
- Several frequently used regimens…….driving force optimal for strength muscle performance….
- They are progressive resistive exercise (PRE), circuit weight training, plyometric training (stretch-shortening drills), and isokinetic training regimens.

Progressive Resistance Exercise

- system of dynamic resistance training.
- constant external load to muscles by some mechanical means (usually a free weight or weight machine) and incrementally increased.
- The *repetition maximum (RM) for* determining and progressing the resistance.
- PRE also was beneficial for patients with a variety of pathological conditions including musculoskeletal injuries, osteoarthritis, osteoporosis, hypertension, adult-onset (type II) diabetes, and chronic obstructive pulmonary disease.
- **Delorme and Oxford Regimens**
- The concept of PRE.. 60 years ago by DeLorme,… used the term ***heavy resistance training*** *and later* ***load-resisting exercise t****o* describe a new system of strength training.
- DeLorme proposed and studied the use of three sets of a 10 RM with *progressive loading during each set. Other investigators* developed a regimen, the Oxford technique, with *regressive loading in each set.*

Delorme and Oxford Regimens

- The DeLorme technique: warm-up period ,
- whereas the Oxford technique diminishes the resistance as the muscle fatigues.
- Both incorporate rest interval between sets; step wise resistance variation. Show result in training-induced strength gains over time.
- Comparing both regimens, no significant difference in adaptive strength after a 9-week exercise program.
- DeLorme and Oxford first introduced, numerous variations of PRE protocols…. determine an optimal intensity of resistance training, optimal number of repetitions and sets, optimal frequency, and optimal progression of loading.

TABLE 6.10 Comparison or Two PRE Regimens

TABLE 6.10 Comparison or Two PRE Regimens

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

DAPRE Regimen

- Overloading with how much resistance in PRE program imprecise and arbitrary.
- increase the weight by 5% to 10% when all prescribed repetitions and sets can be completed easily without significant fatigue.
- The Daily Adjustable Progressive Resistive Exercise (DAPRE) based on a 6 RM *working weight* (Table)….
- The *adjusted working weight, which is based* on the maximum number of repetitions possible using the working weight in Set #3 of the regimen, determines the working weight for the next exercise session…….

TABLE 6.11 DAPRE Technique

Sets	Repetitions	Amount of Resistance
1	10	50% 6 RM*
2	6	75% 6 RM
3	Maximum possible	100% 6 RM
4	Maximum possible	100% adjusted working weight**

*6 RM = working weight

Circuit Weight Training

- Another system of training that employs mechanical resistance is *circuit weight training.*
- *A pre-established* sequence (circuit) of continuous exercises is performed in succession at individual exercise stations that target a variety of major muscle groups (usually 8 to 12) as an aspect of total body conditioning.
- circuit training sequence:
- Typically, repetitions are higher and intensity (resistance) is lower than in other forms of weight training.
- For example, two to three sets of 8 to 12 repetitions at 90% to 100% 10 RM or 10 to 20 repetitions at 40% to 50% 1 RM are per formed with a minimum amount of rest (15 to 20 seconds) between sets and stations.

BOX 6.18 Example of a Resistance Training Circuit

Station #1: Bench press → #2: Leg press or squats → #3: Sit-ups → #4: Upright rowing → #5: Hamstring curls → #6: Prone trunk extension → #7: Shoulder press → #8: Heel raises → #9: Push-ups→ #10: Leg lifts or lowering

Continue…….

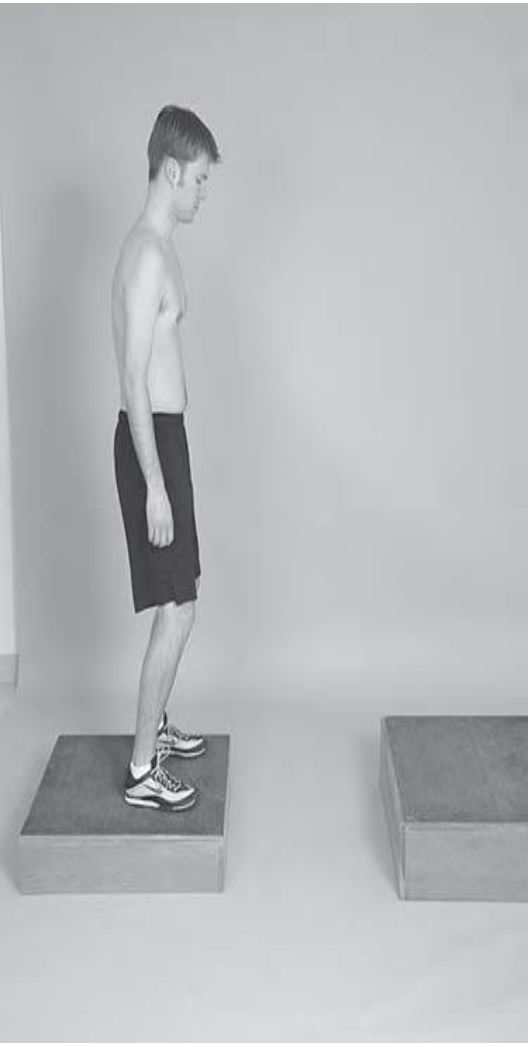
- **progression:**
- increasing the number of sets or repetitions, the resistance, the number of exercise stations, and the number of circuit revolutions.
- *Exercise order is an important consideration when setting* up a weight training circuit.
- Exercises with free weights or weight machines should alternate among upper extremity, lower extremity, and trunk musculature and between muscle groups involved in pushing or pulling actions. enables one muscle group to rest and recover from exercise…….
- Multi-joint, multi muscle groups involve…..

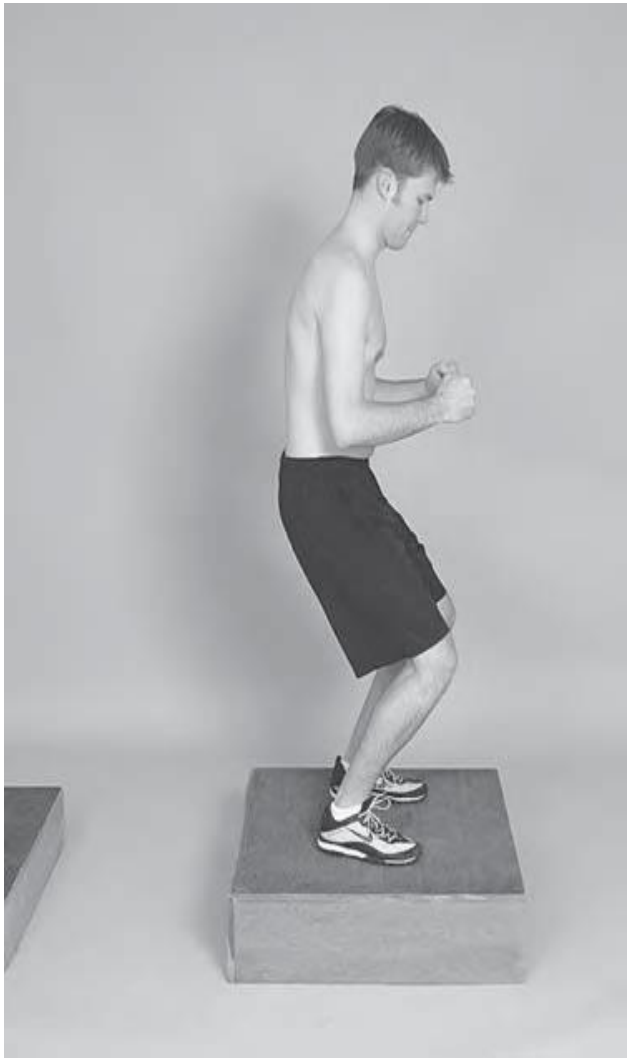
Plyometric Training—Stretch-Shortening Drills

- High-intensity, high-velocity exercises emphasize the development of muscular power and coordination.
- bursts of force to high-demand occupational, recreational, or sport-related activities.
- Advance phase of rehabilitation to prepare for activities that require rapid starting and stopping movements.

Definitions and Characteristics

- *1) stretch shortening drills or stretch-strengthening drills,* employs high-velocity eccentric to concentric muscle loading, reflexive reactions, and functional movement patterns……
- The rapid eccentric loading phase is the *stretch cycle, and the concentric phase is the shortening cycle.*
- *Time period b/w* the stretch and shortening cycles is known as the ***amortization*** *phase. A*mortization phase is kept very brief by a rapid reversal of movements to capitalize on the increased tension in the muscle.
- Body weight or an external form of loading, such as elastic bands or tubing or a weighted ball..





Neurological and Biomechanical Influences

- Utilize the series-elastic properties of soft tissues and the stretch reflex of the neuromuscular unit.
- The spring-like properties of the series elastic components of muscle-tendon units produce **elastic energy** during the initial phase (the stretch cycle.
- This energy is briefly stored and then retrieved for use during the concentric contraction (shortening cycle) that follows.
- The storage and release of this elastic energy augments the force production of the concentric muscle contraction.
- the stretch-shortening cycle is to stimulate the proprioceptors of muscles, tendons, ligaments, and joints, increase the excitability of the neuromuscular receptors, and improve the reactivity of the neuromuscular system.
- The term ***reactive neuromuscular training***.

- the loaded, eccentric contraction (stretch cycle) is thought to prepare the contractile elements of the muscle for a concentric contraction (shortening cycle) by stimulation and activation of the **monosynaptic stretch reflex**
- A decrease in the amortization phase theoretically increases the force output during the shortening cycle

Effects of Plyometric Training

- An increase in a muscle's ability to resist stretch, which may enhance the muscle's dynamic restraint capabilities.
- associated with a decreased incidence of lower extremity injury.
- ***Preparation for plyometrics:***
- Prior to training….adequate baseline muscle strength and endurance as well as flexibility of muscles.
- Criteria to begin plyometric training usually include an 80% to 85% level of strength and 90% to 95% ROM.
- ***Specificity of training.***
- ***D***esigned with specific functional activities in mind and should include movement patterns that replicate the desired activity.

Progression.

- ***Speed of drills.***
- performed rapidly but safely. The rate of stretch of the contracting muscle is more important than the length of the stretch.
- (decreasing the amortization phase)…
- E.g. jumping activity is performed, progression of the plyometric activity….reducing the time on the ground between each jump.
- ***Intensity.***
- Increase resistance not enough to slow down the activity.
- Progression by weight or from simple to complex movements.
- ***Repetitions and frequency.***
- Increase the number of repetitions *as proper form (technique) is maintained; increase the number* in a session; or increase the number of sessions in a week
- . A 48- to 72-hour recovery period is recommended

Upper Extremities

- Catching and throwing a weighted ball with a partner or against a wall: bilaterally then unilaterally
- Stretch-shortening drills with elastic tubing using anatomical and diagonal motions
- Dribbling a ball on the floor or against a wall
- Drop push-ups: from boxes to floor and back to boxes
- Clap push-ups

Lower Extremities

- Repetitive jumping on the floor: in place; forward/backward; side to side; diagonally to four corners; jump with rotation; zigzag jumping; later, jump on foam
- Vertical jumps and reaches
- Multiple jumps across a floor (bounding)
- Box jumping: initially off and freeze; then off and back on box increasing speed and height
- Side to side jumps (box to floor to box)
- Jumping over objects on the floor
- Hopping activities: in place; across a surface; over objects on the floor
- Depth jumps (advanced): jump from a box, squat to absorb shock, and then jump and reach as high as possible

Isokinetic Regimens

Proprio-cepters neuromuscular facilitation (PNF)

- Used in continuem rehabilitation early phase of tissue healing when isometric techniques are appropriate to the final phase of rehabilitation when high-speed, diagonal movements can be performed against maximum resistance.
- Hallmarks of this approach to therapeutic exercise are the use of diagonal patterns and the application of sensory cues—specifically proprioceptive, cutaneous, visual, and auditory stimuli—to elicit or augment motor responses.
- Diagonal pattern facilitate the responsiveness of the weaker muscle groups.

Diagonal Patterns

- composed of *multijoint, multiplanar, diagonal, and rotational* movements of the extremities, trunk, and neck.
- Two pairs of diagonal patterns for the upper and lower extremities:
- diagonal 1 (D1) and diagonal 2 (D2). Each of these patterns can be performed in either flexion or extension.
- Hence, the terminology used is D1Flexion or D1Extension and D2Flexion or D2Extension of the upper or lower extremities.
- focus on the shoulder or the hip joints or pattern is named by *the position of the shoulder or hip when the diagonal pattern has been completed.*
- *Flexion or extension of the shoulder* or hip is coupled with abduction or adduction as well as external or internal rotation.
- Motions of body segments distal to the shoulder or hip also occur simultaneously during each diagonal pattern.

- As mentioned, the diagonal patterns can be carried out unilaterally or bilaterally. Bilateral patterns can be done *symmetrically (e.g., D1Flexion of both extremities);*
- *asymmetrically (D1Flexion of one extremity coupled* with D2Flexion of the other extremity); or *reciprocally* (D1Flexion of one extremity and D1 Extension of the opposite extremity).

Upper limb diagonal patterns

Joints or Segments	Diagonal 1: Flexion (D_1Flx)	Diagonal 1: Extension (D_1Ext)
		UPPER EXTREMITY COMPONE
Shoulder	*Flexion-adduction-external rotation*	*Extension-abduction-internal rotation*
Scapula	Elevation, abduction, upward rotation	Depression, adduction downward rotation
Elbow	Flexion or extension	Flexion or extension
Forearm	Supination	Pronation
Wrist	Flexion, radial deviation	Extension, ulnar deviation
Fingers and thumb	Flexion, adduction	Extension, abduction


A


B


A


B

Upper limb

Diagonal 2: Flexion (D_2Flx)	Diagonal 2: Extension (D_2Ext)
T MOTIONS	
Flexion-abduction-external rotation	*Extension-adduction-internal rotation*
Elevation, abduction, upward rotation	Depression, adduction downward rotation
Flexion or extension	Flexion or extension
Supination	Pronation
Extension, radial deviation	Flexion, ulnar deviation
Extension, abduction	Flexion, adduction


A


B


A


B

Lower limb pattern

	D_1 flex	D_1 EXT
Hip	Flexion-adduction-external rotation	Extension-abduction-internal rotation
Knee	Flexion or extension	Flexion or extension
Ankle	Dorsiflexion, inversion	Plantarflexion, eversion
Toes	Extension	Flexion


A


B


A


B

Lower limb patteren

D2 flex	D2 ext
Flexion-abduction-internal rotation	*Extension-adduction-external rotation*
Flexion or extension	Flexion or extension
Dorsiflexion, eversion	Plantarflexion, inversion
Extension	Flexion


A


B


A


B

Specific Techniques with PNF:

- **Rhythmic Initiation**
- Rhythmic initiation is used to promote the ability to initiate a movement pattern.
- After the patient voluntarily relaxes, the therapist moves the patient's limb *passively through the available range of the desired movement pattern several* times so the patient becomes familiar with the sequence of movements within the pattern.
- It also helps the patient understand the *rate at which movement is to occur. Practicing* assisted or active movements (without resistance) also helps the patient learn a movement pattern.
- **Repeated Contractions**
- Repeated, dynamic contractions, initiated with repeated quick stretches followed by resistance, are applied at any point in the ROM to strengthen a weak agonist component of a diagonal pattern

Reversal of Antagonists

- Many functional activities involve quick reversals of the direction of movement.
- This is evident in diverse activities such as sawing or chopping wood, dancing, playing tennis, or grasping and releasing objects.
- The reversal of antagonists technique involves stimulation of a weak agonist pattern by first resisting static or dynamic contractions of the antagonist pattern.
- The reversals of a movement pattern are instituted *just before the previous pattern has* been fully completed.
- The reversal of antagonists technique is based on Sherrington's law of *successive induction.*
- There are two categories of reversal techniques available to strengthen weak muscle groups.

1::::Slow reversal.

- *Dynamic concentric* contraction of a stronger agonist pattern immediately followed by dynamic concentric contraction of the weaker antagonist pattern.
- There is no voluntary relaxation between patterns. This promotes rapid, reciprocal action of agonists and antagonists.

- ***2:::Slow reversal hold:***
- Slow reversal hold adds an isometric contraction at the end of the range of a pattern to enhance end-range holding of a weakened muscle. With no period of relaxation, the direction of movement is then rapidly reversed by means of *dynamic contraction of the agonist* muscle groups quickly followed by isometric contraction of those same muscles.
- This is one of several techniques used to enhance dynamic stability, particularly in proximal muscle groups.

Alternating Isometrics

- postural muscles of the trunk or proximal stabilizing muscles of the shoulder girdle and hip is alternating isometrics.
- Manual resistance is applied in a single plane on one side of a body segment and then on the other.
- The patient is instructed to “hold” his or her position as resistance is alternated from one direction to the opposite direction.
- No joint movement should occur.
- Alternating isometrics can be applied with the extremities in open-chain or closed-chain positions. Strengthen the trunk and proximal extremities muscles simultaneiously
- **Examples:** trunk in sitting and sidelying…….
- unilaterally or bilaterally in the extremities


A


B

Rhythmic Stabilization

- Rhythmic stabilization is used as a progression of alternating isometrics and is designed to promote stability through co-contraction of the proximal stabilizing musculature of the trunk as well as the shoulder and pelvic girdle regions of the body.
- Rhythmic stabilization is typically performed in weight-bearing positions to incorporate joint approximation into the procedure, hence further facilitating cocontraction.
- The therapist applies multidirectional, rather than unidirectional, resistance by placing manual contacts on opposite sides of the body and applying resistance *simultaneously in opposite directions as the patient holds* the selected position.
- Multiple muscle groups around joints must contract, most importantly the rotators, to hold the position.

Equipments for resistance training

- **Free Weights and Simple Weight-Pulley Systems**
- **Variable-Resistance Machines**
- **Elastic Resistance Bands and Tubing**

A) Thera-Band B) Elastic Resistance Bands
C) Tubing

- **Equipment for Closed-Chain Training**

a) Body Weight Resistance— Multipurpose Exercise Systems

b) Balance Boards

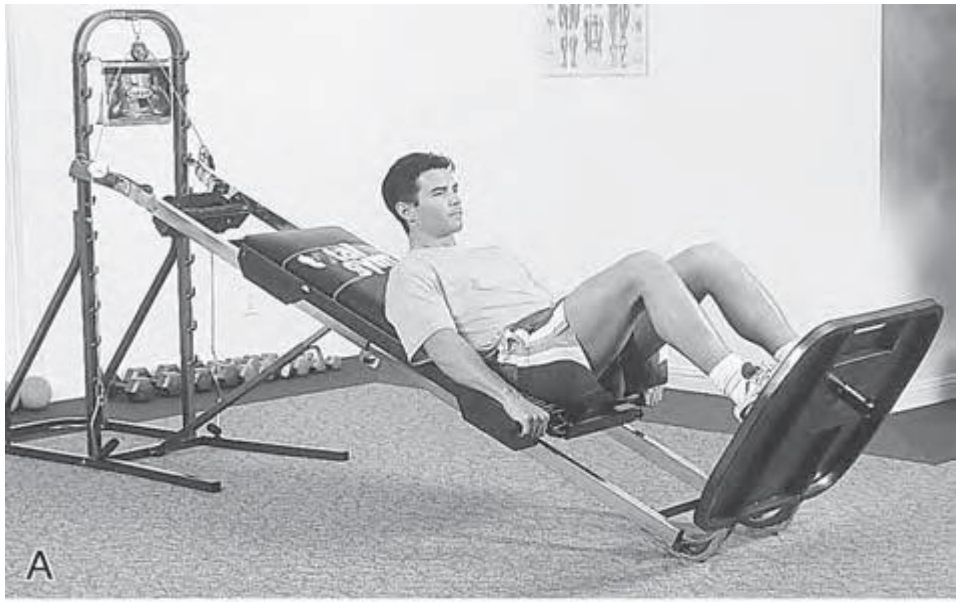
c) slide boards

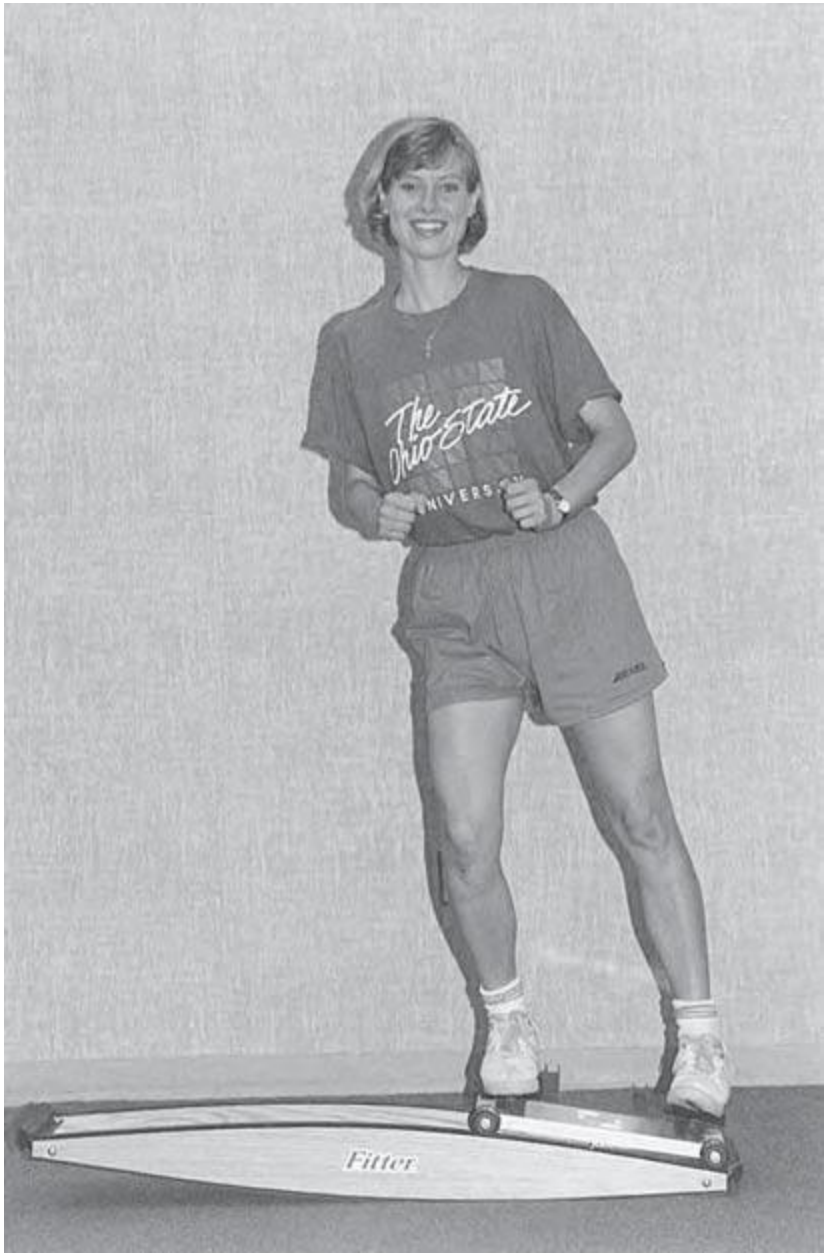
d) Mini-Trampolines (Rebounders)

Pulley weight machines,

variable resistance unit

Close chain training equipment (profitter for close chain…)





Equipments for resistance training

- **Reciprocal Exercise Equipment**

A) Stationary Exercise Cycles

B) Portable Resistive Reciprocal Exercise Units

C) stair stepping machines

D) Elliptical Trainers and Cross-Country Ski Machines

E) Upper extremity ergometer

- **Equipment for Dynamic Stabilization Training**
- **A) swiss balls/stability balls**
- **B) body blade**
- **Isokinetic Testing and Training Equipment**
- **A) Isokinetic Dynamometers**

Reciprocal exercise units

Dynamic stabilization(body blade), iso-kinetic dynamometer