Course instructions: This is your course material page. You can read it on your monitor or print it. The material will be approximately 54 pages.

To complete the course you must take the quiz. You may print the blank quiz to complete it on paper and log in at a later time to submit it. To print the quiz, close this course material window and go back to the downloads area. Then click on Take Test.

Exercise Strength and Conditioning

The Role Of Exercise In Physical Fitness

Physical fitness is an individual's ability to perform specific types of physical activity. **Physical activity** involves any bodily movement caused by muscular contraction that results in the expenditure of energy. Cardiovascular, resistance weight training and stretching exercises promote physical fitness.

The most important physical fitness components related to personal health include muscular strength, power and endurance, flexibility, cardiovascular--respiratory fitness and body composition.

Exercise Terminology

Strength--is a maximum force that can be generated by a muscle or group of muscles for a single repetition.

Power--is the amount of force that can be generated in a short period of time. Generally, in sports activities, power is the quintessential attribute.

Endurance--is the ability of a muscle or group of muscles to perform many repetitions.

Flexibility--is the possible range of motion around a joint.

Cardiovascular Respiratory Efficiency / Aerobic Fitness – is the ability of the cardiovascular and respiratory systems to accommodate the oxygen needs of the muscular system over a sustained period of time, as seen in endurance events such as distance running, swimming and bicycling.

Body Composition / Somatotypes – there are three primary body types: endomorph (heavy to obese physique); ectomorph (slender body); and mesomorph (muscular physique).

The Physicians Role In Exercise Program Planning And Design

The physicians role in their patients exercise program involves the initial assessment of physical fitness capabilities, short--term and long--term goal planning, design and implementation of an appropriate exercise program relative to **exercise mode, intensity, duration and frequency**, and periodic evaluation of exercise progression**.**

Exercise mode - is the type of exercise performed. For example, the performance of resistance training for strength development and aerobic exercise for cardiovascular--respiratory fitness.

Exercise intensity - is the speed or tempo of the exercise or the weight of the load lifted. Monitoring ones heart rate during aerobic exercise can measure exercise intensity.

Exercise duration - is the amount of time required on a daily basis to achieve ones fitness goals.

Exercise frequency - is the number of times per week that the individual exercises.

Prior to designing an appropriate exercise program for a patient, the physician must first assess the patient's physical fitness capabilities and discuss their exercise goals. The physician must determine whether the patients exercise goals are achievable given their age, sex, current physical status and diagnosis.

General Principles Of Exercise Training

Principle of Use--the human body has the ability to adapt to use and imposed demands thereby increasing the capacity and efficiency of the bodies various systems.

Principle of Disuse--dictates that your level of fitness will decline if you stop exercising.

Overload Principle-- in order for your cells to increase in size (hypertrophy) the workload must be increased beyond what the cells normally experience. This is referred to as overloading. Your body systems must be stressed beyond normal levels of activity if they are to improve. The overload is a positive stressor and is the basis of stress adaptation.

The components of overloading include exercise intensity or load, exercise duration, exercise frequency, exercise repetitions and rest. Each of these components can be increased to impose an overload. **Exercise intensity** or load is probably the most important component of the overload principle. For strength gains to occur, your load should represent an intensity, which is at least 60% to 80% of your muscle's maximum strength. This will usually allow the performance of seven to ten repetitions of a particular exercise before resting. Practically speaking, the amount of resistance you use in an exercise is determined by trial and error. In designing an exercise program, always underestimate an individual's lifting capabilities.

Increasing the length of the exercise period (**exercise duration**) can impose an overload. It is not uncommon for body builders to perform various exercises, in excess of eight hours per day, prior to a competition.

Exercise frequency refers to the number of days per week that an individual exercises. To improve or maintain muscular strength or endurance, the average individual would need to exercise on alternate days or approximately three to four days per week. Generally, each major muscle group should be overloaded every 36 to 48 hours. Conversely, elite athletes preparing for competition may require daily training sessions.

Exercise repetition is one complete movement of an exercise. A series of repetitions, performed consecutively, is referred to as an exercise set. Exercise repetitions will determine the type of adaptation. For example, an increased weight load with low exercise repetitions will result in muscle hypertrophy. A decreased weight load with high exercise repetitions is best for achieving muscle endurance.

Rest is the amount of time between the performance of an exercise set. The amount of rest required will depend upon the load demand. The greater the load, the greater the fatigue, and therefore, a greater rest period is necessary for recovery. The amount of rest is also dependent upon the type of adaptation that is desired. For endurance (oxidative) adaptations to occur, you will normally rest less and exercise at a lower intensity than when you are attempting to develop strength. To develop muscle endurance, rest 30 seconds between sets. High intensity strength training, such as squat activities, may necessitate rest periods of up to 5 minutes between sets. The rest period for most exercise programs is approximately one to two minutes between sets.

Principle of Progression--often referred to as progressive overload or progressive resistance exercise. As exercise adaptations occur over time, your body experiences a sensation of reduced effort for a given performance. This is due to the physiological adaptations enhancing the body's ability to create energy and remove metabolic waste products. To achieve steady improvement, training intensity should be continually increased. However, it is important to progress slowly, as too rapid a progression may lead to overuse injuries.

Principle of Specificity--indicates that you must train a specific energy system (often referred to as metabolic specificity) or specific muscle groups (known as neuromuscular specificity) in order for them to improve.

The Principle of Warm--Up and Warm--Down-- a properly designed exercise program will include a warm--up (low level activities, such as stretching and slow walking, performed prior to more strenuous exercise), a stimulus period (the performance of strenuous exercise) and a warm--down period, also known as the cool--down (performed immediately after the stimulus period). The warm--up and warm--down help to prevent muscle soreness and injury and prevent excessive strain on the heart. For example, if you stop running abruptly, blood may pool in the legs, thereby decreasing the bloods return to the heart.

The Principle of Recuperation--due to the stress placed on the body by exercise, rest and recuperation are essential. Inadequate recuperation can result in over training syndrome and overuse

injuries such as epicondylitis. However, extended periods of rest may lead to deterioration in one's fitness level.

The Principle of Reversibility-- the benefits of training are transient and dependent upon continued exercise. You must continue to exercise to avoid deconditioning (use it or lose it). It is said that for every day of inactivity, it takes two days of exercise to return to one's normal fitness level.

Types of Resistance

Isometric Resistance

An isometric contraction is one in which the muscle neither shortens or lengthens. With an isometric contraction the contracting forces of the muscles are equal to that of the resistance. Isometric resistance can come from myriad sources. For example, an immovable object such as a wall or stationary equipment can be used to create an isometric contraction of the muscles. Additionally, isometric resistance can be created by pressing the hands together with equal force, or provided by another person.

Dynamic Progressive Resistance

This type of exercise resistance increases as the movement of the body continues through the exercise. Surgical tubing, and flex bands are examples of this type of resistance. This type of low tech equipment is effective, economical and portable.

Dynamic Constant Resistance

With this exercise training, the resistance used is constant. The most common examples of this would be free weights and machines that use round pulleys to redirect the resistance.

Dynamic Variable Resistance

Dynamic variable resistance training uses a resistance that is altered during the various ranges of motion of an exercise. Dynamic variable resistance training is done on a weight machine that uses a cam device. Dynamic variable resistance machines attempt to match the mechanics of the human body by increasing or decreasing the resistance to match the strengths and weaknesses of the body as the individual executes certain exercise ranges of motion.

Isokinetic Resistance

With isokinetic resistance the speed at which the muscle lengthens and shortens is constant and the resistance is varied. Any force applied in an attempt to increase velocity results in an equal reaction force limiting the speed of contraction. Isokinetic resistance machines use hydraulic shock absorbers to provide the resistance. This type of equipment is typically not cost effective for the average physician.

Basic Muscle Anatomy

Movement of the human body is dependent upon the interaction between the muscle, bone and joint systems.

Muscle

The human body contains more than 600 muscles. Skeletal muscle has contractile units that convert chemical energy into mechanical energy enabling the muscle to lenthen or shorten. Muscles cannot independently lengthen. They can lengthen only by contracting the opposing muscles. When one muscle (the agonist) contracts, the opposite muscle (the antagonist) lengthens.

Tendons, which are strong, fibrous tissue, connect muscle to bone and facilitate muscle contraction. The attachment of the muscle at the proximal end of the bone (the end closer to the body) is considered the muscle's origin. The attachment at the distal end of the bone (the end farther from the body) is referred to as the muscle's insertion. The origin of the trunk muscles are always at the superior attachment, while the insertion is found at the inferior attachment.

Muscles do not move objects or weights. Instead, they function by moving the bones that rotate about the connective joints. These internal movements transfer a force through the body to the external object or resistance thereby causing the object or resistance to move. Muscles pull the bones, which act as a series of connected levers that move the body or outside objects in any direction desired. The joints hold the structure together and transmit forces through the bony levers of the body to the external environment while the bones provide structural support.

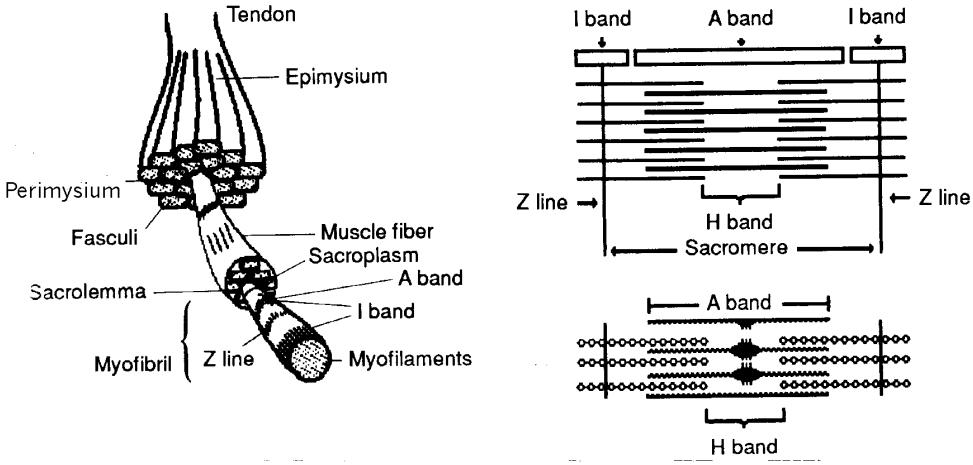
Muscle Physiology

All movement depends upon the contractile, or shortening qualities of muscles acting upon the skeletal system. Joint movement occurs when there is sufficient force generated by the contraction of the muscle fibers crossing the joint.

Muscles are composed of many different structures. The structural unit of a muscle is the muscle fiber (the actual muscle cell). Each muscle fiber is composed of many nuclei. Muscle fiber size may range from .01 millimeter to .10 millimeters in diameter and from 1.0 millimeter to many millimeters in length. The muscle fiber is surrounded and bound together into bundles by connective tissue called endomysium. The bundles of muscle fibers are called fasciculi and are surrounded by white, fibrous connective tissue called perimysium. The external connective tissue that surrounds the entire muscle, made up of many fasciculi, is called epimysium.

Sarcolemma is a protective covering or membrane which surrounds the individual muscle fiber. Each muscle fiber has numerous myofibrils, which act as the contractile unit within the muscle fiber. Each myofibril is surrounded by a gel like substance called sarcoplasm (the protoplasm of the muscle fiber). In the sarcoplasm are mitochondria, small, rod--shaped bodies, often called the powerhouses of the cell because they are major sites of ATP production essential for muscular contraction.

Myofibrils are aligned in columns and have distinct markings, referred to as striations, in a definite repetitive pattern of light and dark bands. The repetitive pattern defines the sarcomere, which is the contractile unit of the muscle. The end of each sarcomere is bound by a Z--line.



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Variations in light and dark patterns are the result of the alignment of two small protein filaments, actin and myosin. Actin filaments are thinner than myosin filaments. Between each pair of Z--lines are a light band, known as the I--band (containing only thin actin filaments), a dark band, referred to as the A--band (the area where actin and myosin filaments overlap each other), an H--zone of slightly lighter contrast (which divides the middle of the A--band and contains only myosin filaments), and a second I--band. During muscular contraction the H--zone disappears as the actin filaments from the A--band extend into it. Actin and myosin filaments slide past one another when contraction of the fiber occurs.

The whole muscle--the bundles and the muscle fibers--is covered by layers of connective tissue that forms the tendon, which connect muscle to bone. When the muscle contracts and shortens, the force is transmitted through the tendon to the bone, thereby causing joint movement.

Types of Muscle Fiber

Skeletal muscle fibers are classified according to the speed of their contraction period, as either being slow twitch or fast twitch. All skeletal muscles have slow and fast twitch fibers.

The **slow twitch, oxidative fiber** type, also known as Type I, is characterized by a slower rate of muscle contraction. This fiber primarily uses the oxygen energy system which replenishes ATP slowly. Slow twitch fibers are used mainly in aerobic endurance activities. Slow twitch fibers are often referred to as "**Red muscle**" because of the fibers reddish tint which is due to large amounts of myoglobin in the fibers and large amounts of red blood cells in the capillaries surrounding the fibers. Myoglobin acts as a reservoir for oxygen when the blood does not supply an adequate amount. Slow twitch fibers are fatigue resistant due to the ample blood and oxygen supply.

The **fast twitch, oxidative, glycolytic fiber** type, also known as Type II A,is characterized by a faster speed of contraction. This fiber type uses both the oxygen and lactic acid energy systems to replenish ATP and is used in both aerobic and anaerobic type activities.

The **fast twitch, glycolytic fiber** type, also known as Type II B, is characterized by a very fast speed of contraction. This fiber type primarily uses the lactic acid energy system and has the ability to use ATP rapidly. This fiber type is the largest of the three fiber types and is used primarily in fast, anaerobic type activities.

Fast twitch fibers are referred to as "**White muscle**" because of the fibers whitish tint due to the small myoglobin content in the fibers and the low number of red blood cells in the capillaries surrounding the fibers. Fast twitch fibers have extensive sarcoplasmic reticulum, which allows for rapid turnover of calcium ions in order for the contraction to be rapid. They also respond to neural stimulation rapidly and contain myosin molecules that break down ATP more rapidly than slow twitch fibers.

The Muscle Contraction Process

There are two regulatory proteins, troponin and tropomyosin, which are part of the actin filament that function in keeping actin and myosin filaments from interacting with one another when the myofibril is in a state of relaxation. For contraction to occur, a nerve impulse travels along the sarcolemma sending a weak electrical charge over the length of the fiber. A series of tubules, known as T--tubules, enter the muscle fiber through pores in the sarcolemma. T--tubules conduct the impulse from the sarcolemma toward the center of the fiber to the sarcoplasmic reticulum,which is a system of channels spread throughout the fiber. Calcium ions, stored in the sarcoplasmic reticulum,are then released and begin the contractile process. Calcium ions bind with troponin which blocks the function of tropomyosin,thereby allowing the actin and myosin filaments to interact and slide against one another.ATPase, an enzyme located on the cross--bridges of the myosin filament, is then freed to act upon ATP causing it to break down into ADP (adenosine diphosphate) and energy. Actin and myosin filaments slide past one another due to the pulling action of the cross--bridges that reach out from myosin filaments and attach themselves to the actin filament. This action takes place simultaneously in thousands of muscle fibers causing forceful pull on your tendons which initiates skeletal movement. The contraction is complete when the myosin filaments reach the Z-- lines.

Types of Muscular Contractions

- An **isometric contraction** involves no shortening or lengthening of the muscle. It occurs when the muscular force generated is inadequate to overcome the resistance. For example, if your 1 repetition maximum for the bicep curl is 50 pounds and you attempt to lift 80 pounds, no movement would occur. While the muscle attempts to either shorten or lengthen, it can not because the resistance is too great. A muscle may utilize varying degrees of these isometric contractions in order to stabilize the body and certain joints during an exercise. The muscle would be working as a stabilizer in this situation.

- An **isotonic, concentric contraction** occurs when a muscle shortens or pulls during muscular contraction because the amount of force generated by the muscle is greater than the load. This type of contraction is seen during the performance of the bicep curl exercise. A muscle can contract concentrically in cooperation with other muscles. This synergistic effort results in a movement that the muscle would not have been able to perform completely on its own. In this situation, the muscle would be considered a synergist or an assistor.

- An **isotonic, eccentric contraction** occurs when the muscle length increases during contraction because the load is greater than the force generated by the muscle.

- An **isokinetic muscle contraction** is one in which the muscle can shorten only at a set speed with the help of a machine or device which provides resistance that changes depending upon how much force one exerts. The Kin--Com and Hydra--Gym machines allow for isokinetic muscle contraction.

- Muscles can contract to prevent an undesired effect of another contracting muscle thereby acting as a neutralizer. For example, the abdominal muscles neutralize part of the effects of the hip extensors and erector spinae during ambulation. Neutralization prevents excessive spinal hyperextension.

Muscle Strength

Muscular Strength--is the ability of a muscle or muscle group to develop force in one maximal effort. Muscular strength is dependent upon the size, type and number of muscle fibers in the muscle and the ability of the nervous system to fully activate the fibers. The greater the number and size of fast--twitch muscle fibers, the greater the muscle strength. Muscle strength is determined by genetics and overload strength training.

Muscle Strength

- Increased muscle strength is achieved by regularly adding weight to your lifting regimen and progressively overloading your muscles. This will shock individual muscle fibers into secreting proteins (actin and myosin) that hypertrophy (thicken) the fibers.
- Increased strength enhances sport performance and activities of daily living. Increased strength improves performance not just because your muscles get stronger, but also your nervous system learns how to more efficiently control them.
- The majority of strength gained in the first month of lifting, isn't from muscle hypertrophy, but from your nervous system learning to recruit more motor units. With lifting, you get stronger and more coordinated.
- Between the ages of 24 and 50, muscle mass decreases by 5% - 10%. After age 50, the loss accelerates to about 10% per decade.
- Bone density decreases with age, at a rate of 6% per decade after the age of forty.

Take the Test -

The most reliable measure of absolute strength is not surprisingly, the maximum amount of weight you can lift once - but try to bench-press 200 pounds and you might just get crushed. Push-ups are a safer alternative. Assume the standard position, with your arms locked and your body straight. Bending your arms, touch your nose to the ground, then press yourself back up (but don't lock your elbows). Do as many as you can without bouncing, resting, or losing your form.

How Do You Measure Up?

Age	**20-29**	**30-39**	**40-49**	**50-59**	**60-69**
Excellent	>40	>31	>24	>23	>23
Good	30-40	24-31	19-24	14-23	11-23
Average	24-29	19-23	13-18	10-13	9-10
Fair	18-23	14-18	10-12	7-9	6-8
Poor	<18	<14	<10	<7	<6

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Mechanoreceptors

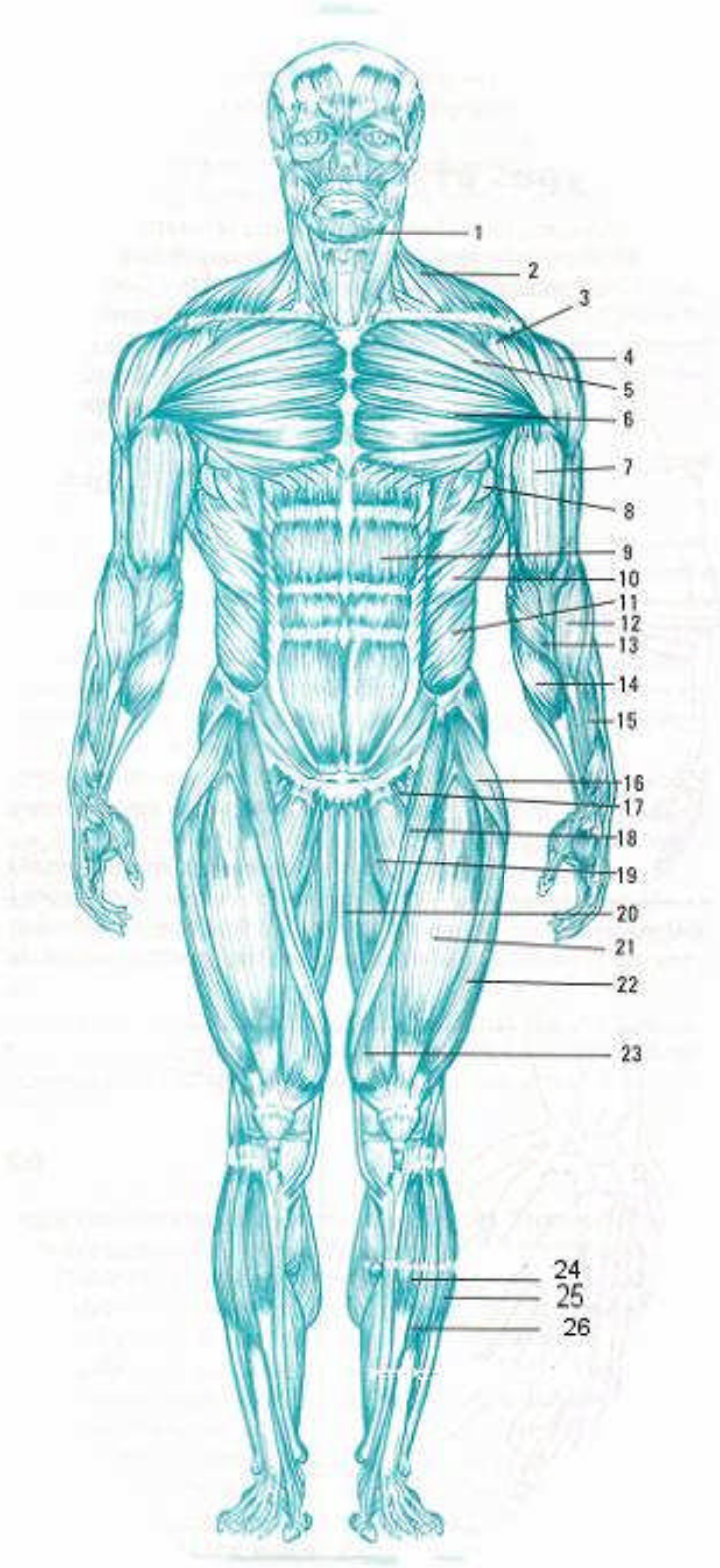
Mechanoreceptors - bring environmental information into the central nervous system.

Type I Mechanoreceptor - keeps the C.N.S. informed of static joint position; influences the activity of muscles crossing a joint; modulates protective muscular reflexes important to joint function and stability; associated with conscious proprioception.
Type II Mechanoreceptor - rapidly adapting acceleration mechanoreceptor located in highest population in the cervical spine and axial skeleton; emit brief bursts of impulses at the beginning of joint movement.
Type III Mechanoreceptor - respond when high tensions are generated in joint ligaments at the extremes of active or passive joint movements; higher in population in the appendicular skeleton; absent from the ligaments in the vertebral column.

Mechanoreceptors are involved in all phases of movement, as well as, being protective of excessive movement/injury. Most voluntary muscle actions are largely involuntary and under the direction of the proprioceptors. Prioprioception is considered the most difficult aspect to rehabilitate following joint injury. Proprioception includes basic coordination and agility exercises. Two terms in proprioception are closed kinetic chain and open kinetic chain. In the closed kinetic chain, proprioception is occurring constantly in all of the joints and ligaments and in the muscle and tendons as they are affected by force or motion. In the closed kinetic chain the proprioceptors are constantly reacting to body weight, body position, gravitational forces and ground forces. An example would be the performance of a squat exercise.

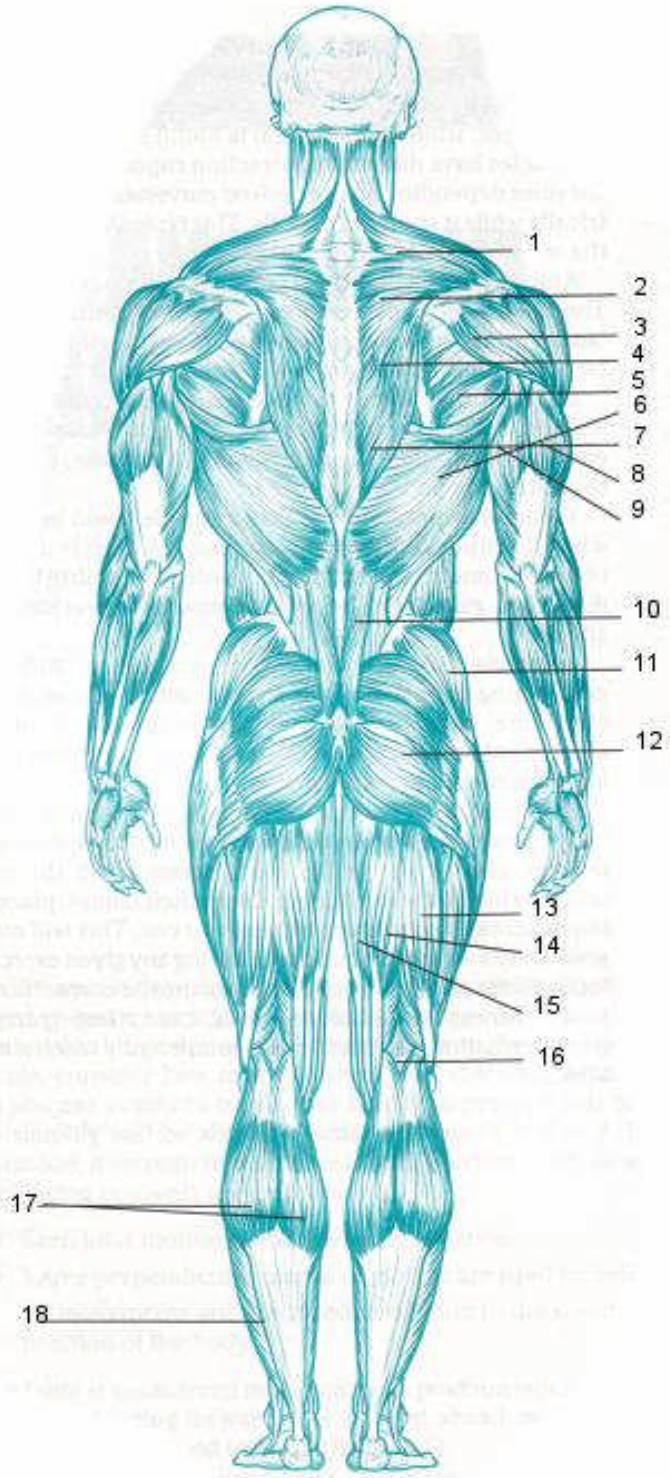
In the open kinetic chain the end joint is distracted or distended. The swing phase of a runner is an open kinetic chain. The rate of proprioceptive stimulus and feedback is less in the open kinetic chain. It is open kinetic chain response that enables the runner to absorb the shock, adapt to the surface and keep the foot stabilized until weight is accepted. Example of open kinetic chain exercise is the seated leg flexion / leg extension exercise.

Anterior Muscles



1. Sternocleidomastoid
2. Trapezius (upper)
3. Anterior deltoid
4. Medial deltoid
5. Clavicular pectoralis major
6. Sternal pectoralis major
7. Biceps brachii
8. Serratus anterior
9. Rectus abdominis
10. Internal oblique (underlying)
11. External oblique
12. Brachioradialis
13. Palmaris longus
14. Flexors
15. Extensors
16. Tensor fascia lata
17. Pectineus
18. Sartorius
19. Adductor longus
20. Gracilis
21. Rectus femoris
22. Vastus lateralis
23. Vastus medialis
24. Tibialis anterior
25. Peroneus longus
26. Extensors

Posterior Muscles



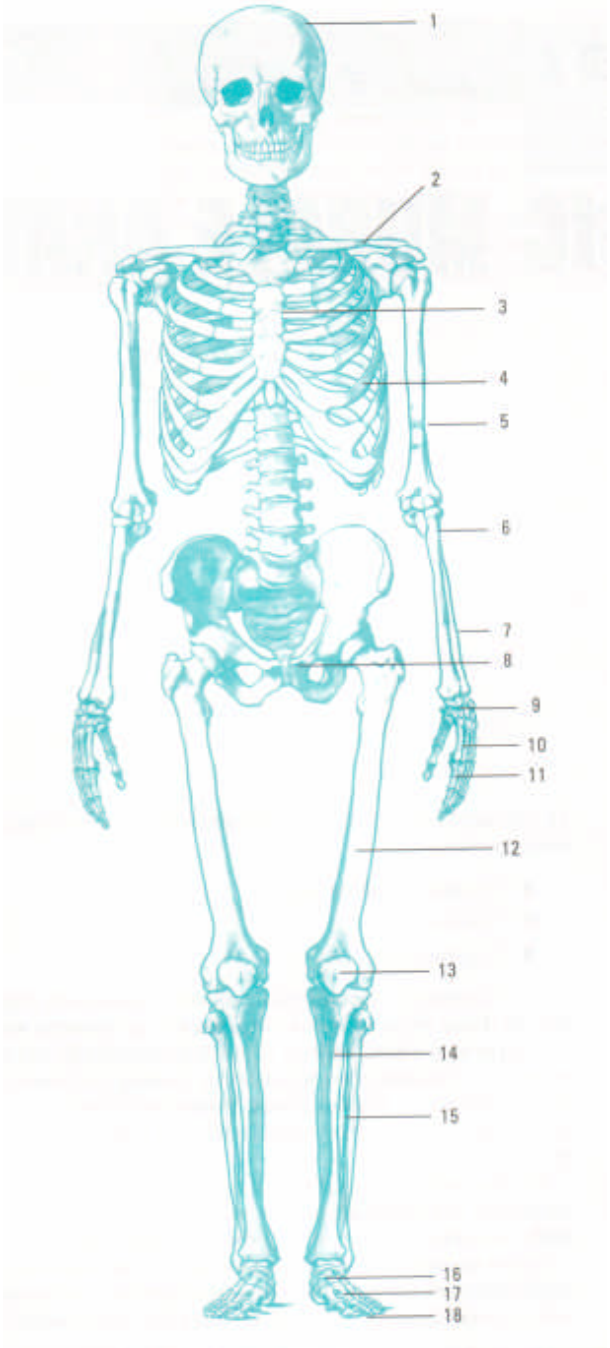
1. Levator scapulae (underlying)
2. Rhomboids (underlying)
3. Posterior deltoid
4. Trapezius (middle)
5. Teres major
6. Latissimus dorsi
7. Trapezius (lower)
8. Triceps brachii (lateral head)
9. Triceps brachii (long head)
10. Erector spinae
11. Gluteus medius
12. Gluteus maximus
13. Biceps femoris
14. Semitendinosus
15. Semimembranosus
16. Popliteus
17. Gastrocnemius
18. Soleus

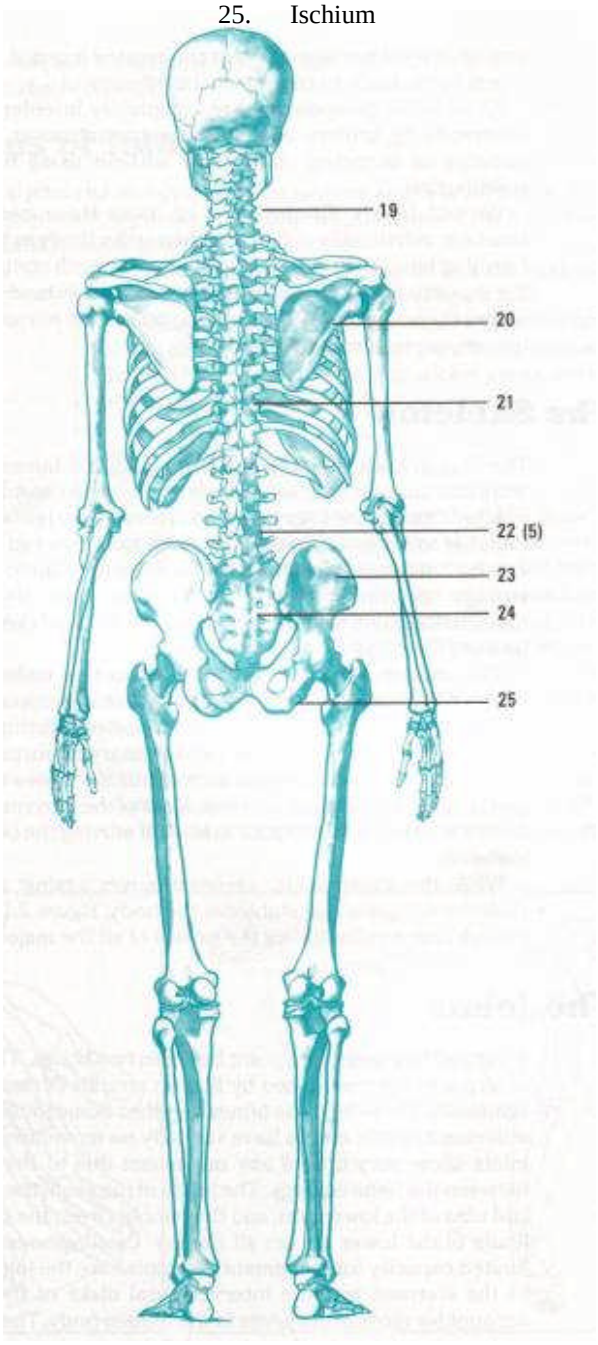
Skeletal Anatomy

The human body contains approximately 206 bones. Bones help to maintain erect posture, protect certain vital organs, act as a system of levers so the muscles can move the body or external objects, produce blood cells and contain several essential minerals.

The axial skeleton consists of 80 bones that make up the head, neck, and trunk. The appendicular skeleton consists of 126 bones that form the shoulders, pelvis, arms, legs, hands, and feet. Most of the movements we perform during resistance training are a result of moving the bones of the appendicular skeleton.

1. Cranium
2. Clavicle
3. Sternum
4. Rib
5. Humerus
6. Radius
7. Ulna
8. Pubis
9. Carpals
10. Metacarpals
11. Phalanges
12. Femur
13. Patella
14. Tibia
15. Fibula
16. Tarsus
17. Metatarsals
18. Phalanges
19. Cervical vertebrae (7)
20. Scapula
21. Thoracic vertebrae (12)
22. Lumbar vertebrae (5)
23. Ilium
24. Sacrum
25. Ischium



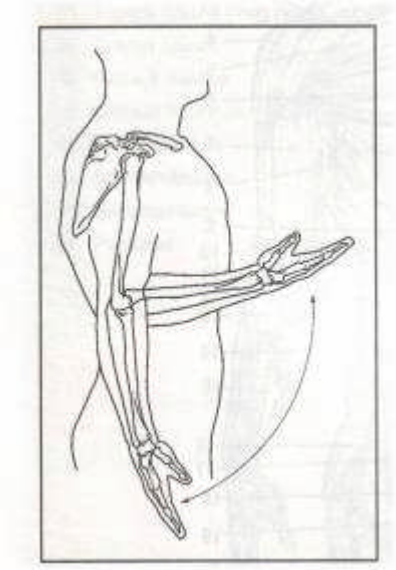


Joints

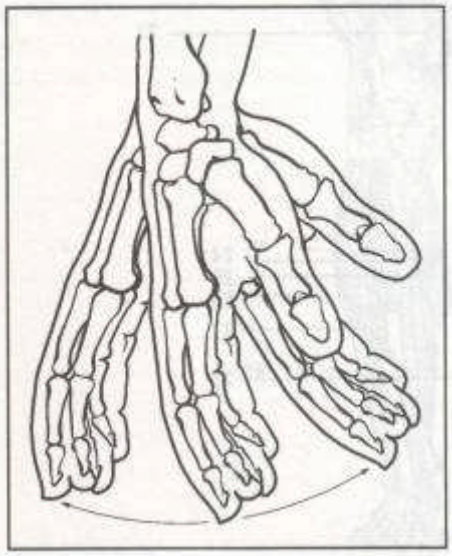
- A joint is defined as the connection point between two bones. Joints are composed of fibrous strands of connective tissue known as ligaments.
- Joints are either fibrous, cartilaginous, or synovial.
- Fibrous joints allow little or no movement due to the small amount of space between the bone articulations. The joints of the skull, the joint between the radius and ulna of the lower arm, and the joint between the distal end of the tibia and fibula of the lower leg are all fibrous.
- Cartilaginous joints have a very limited capacity for movement. Examples are the joints that connect the ribs to the sternum and the intervertebral disks of the spine.
- Synovial joints account for most of the joints in the human body. They allow for considerable and varying amounts of movement.

Types of Joints

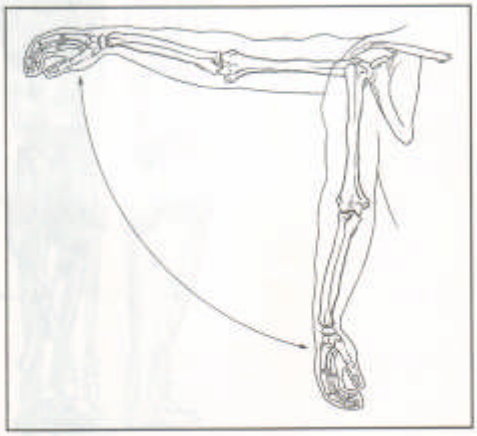
- Uniaxial joints have only one axis of rotation and operate like hinges. The elbow joint and the joints connecting the phalanges of the fingers are examples of uniaxial joints.
- Biaxial joints, such as the wrist and the ankle, allow movement in two perpendicular axes.
- Multiaxial joints have at least three axes of motion and can create movement in all three perpendicular planes. The shoulder and hip, which are ball-and-socket joints, are examples of multiaxial joints.



Uniaxial Joint



Biaxial Joint

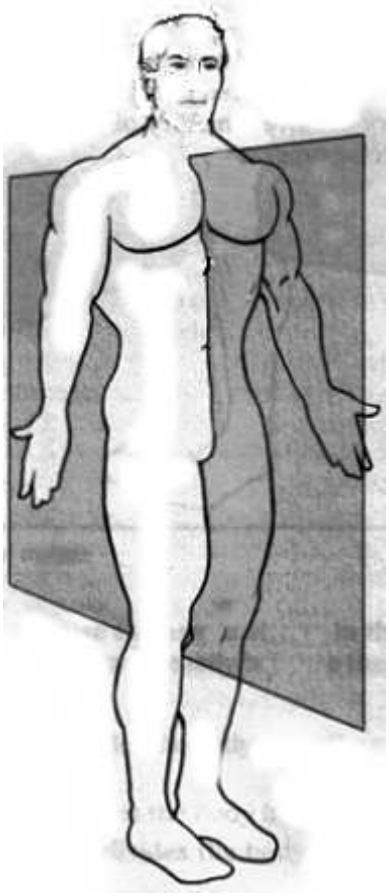


Multiaxial Joint

Three Planes Of Motion

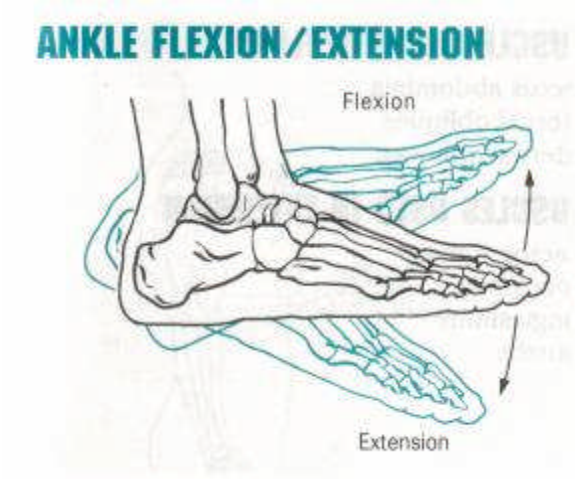
I. Joint Motions of the Median Plane

The median plane (also known as the sagittal plane) divides the body down the middle into symmetrical right and left halves. Joint motions distinctive to the median plane are referred to as flexion and extension. Flexion is any motion that takes a body part forward from the anatomic position. Exceptions to this are flexion of the knee, which brings the lower leg back, and dorsiflexion of the ankle, which brings the foot up. Extension is any motion that brings a body part backward from its anatomic position. The exception to this is extension of the ankle, which pulls the foot down. Ankle extension is also commonly referred to as plantar flexion.



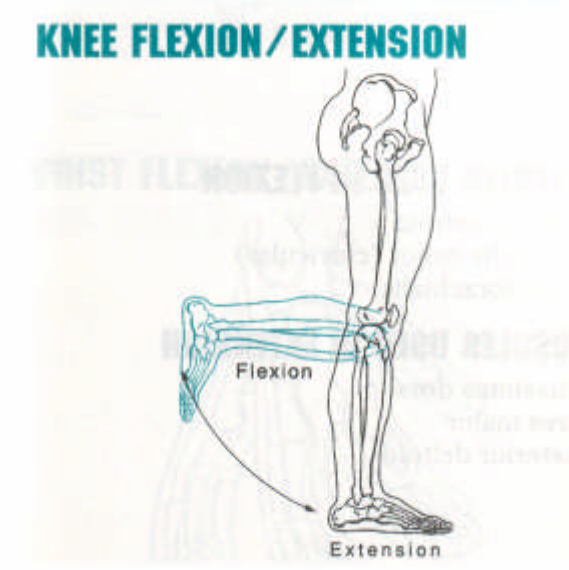
The Median Plane

Joint Motions of the Median Plane



MUSCLES OF ANKLE FLEXION
Tibialis anterior
Extensor hallucis longus
Extensor digitorum longus
Peroneus tertius

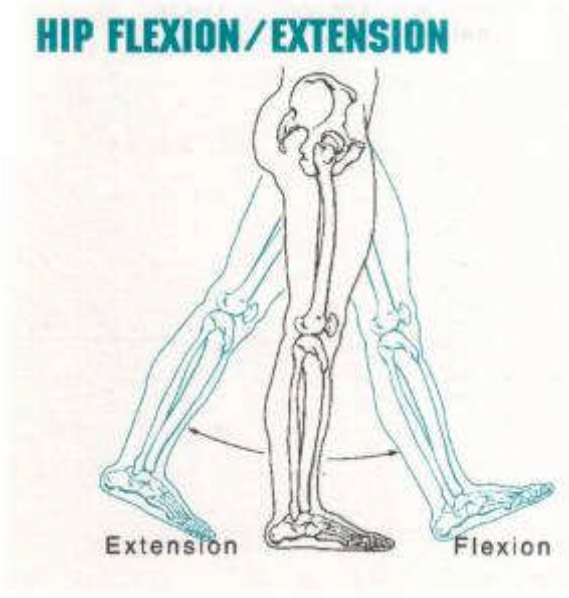
MUSCLES OF ANKLE EXTENSION
Triceps surae (gastrocnemius and soleus)
Peroneus longus
Peroneus brevis
Flexor hallucis longus
Tibialis posterior
Flexor digitorum longus



MUSCLES OF KNEE FLEXION
Semitendinosus
Semimembranosus
Biceps femoris
Popliteus
Gastrocnemius
Sartorius
Gracilis

MUSCLES OF KNEE EXTENSION
Quadriceps (rectus femoris)
Quadriceps (vastus medialis)
Quadriceps (vastus lateralis)
Quadriceps (vastus intermeclius)
Tensor fasciae latae

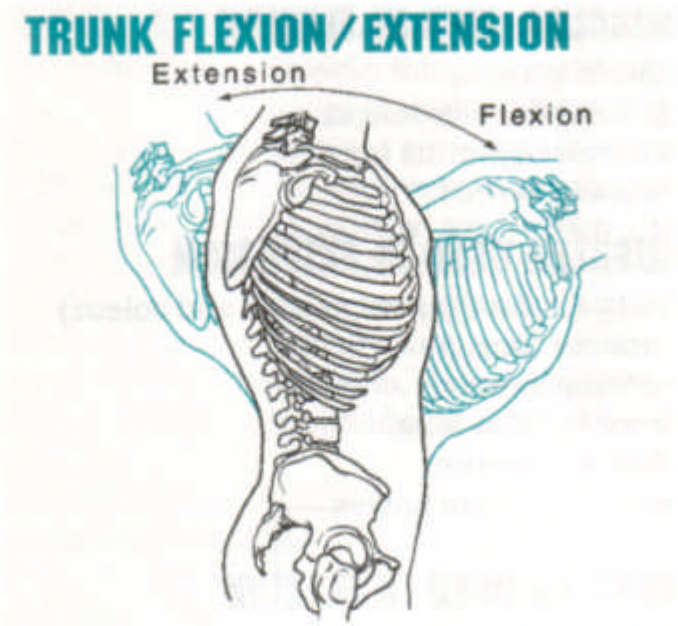
Gluteus maximus (superficial part only)



MUSCLES OF HIP FLEXION
Psoas
Iliacus
Rectus femoris
Tensor fasciae latae
Gluteus minimus (anterior)
Gluteus medius (anterior)
Sartorius
Pectineus

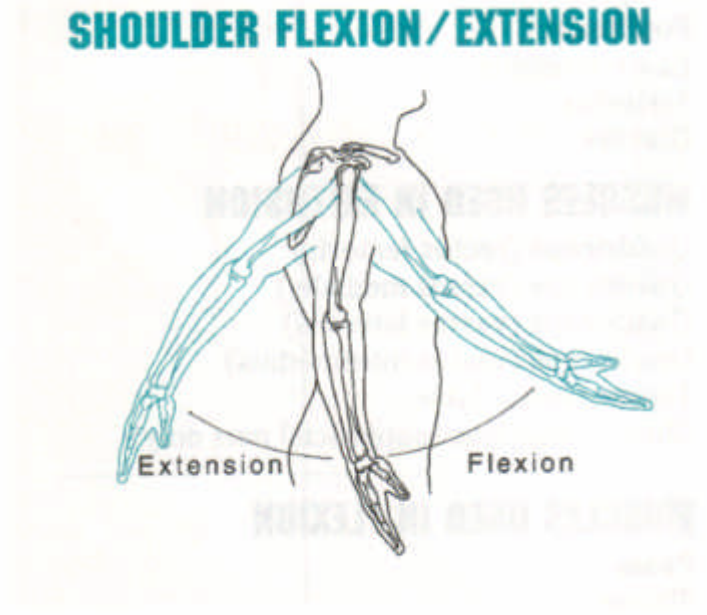
MUSCLES OF HIP EXTENSION
Gluteus maximus
Biceps femoris (long head)
Semimembranosus
Semitendinosus
Gluteus medius (posterior part)

Joint Motions of the Median Plane



MUSCLES OF TRUNK FLEXION
Rectus abdominis
Internal obliques
External obliques

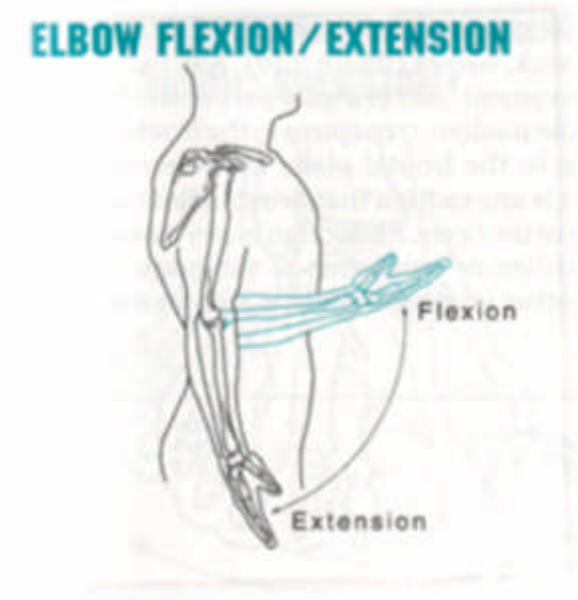
MUSCLES OF TRUNK EXTENSION
Erector spinae
Iliocostalis
Longissimus
Spinalis



MUSCLES OF SHOULDER FLEXION
Anterior deltoid
Pectoralis major (clavicular)
Coracobrachialis

MUSCLES OF SHOULDER EXTENSION
Latissimus dorsi
Teres major
Posterior deltoid

Joint Motions of the Median Plane



MUSCLES OF ELBOW FLEXION
Biceps brachii
Brachialis
Brachioradialis

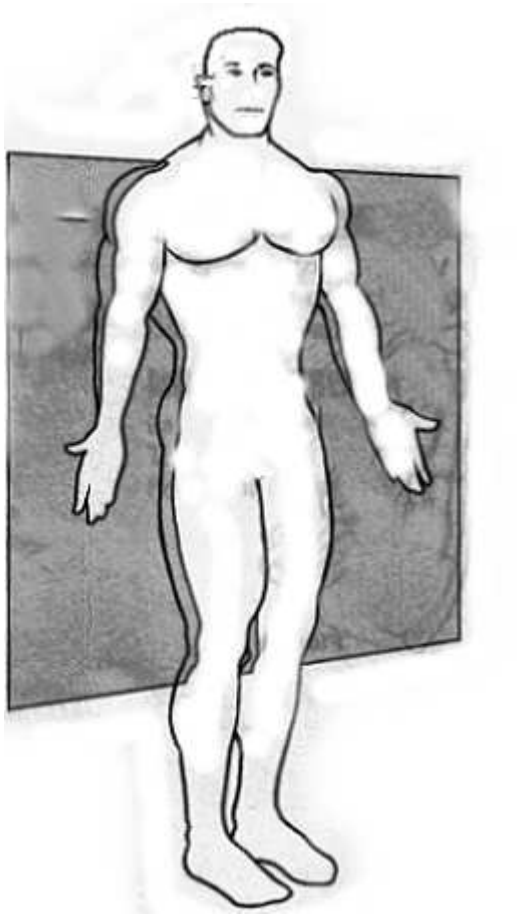
MUSCLES OF ELBOW EXTENSION
Triceps long head
Triceps lateral head
Triceps medial head
Anconeus

MUSCLES OF WRIST FLEXION
Wrist flexors

MUSCLES OF WRIST EXTENSION
Wrist extensors

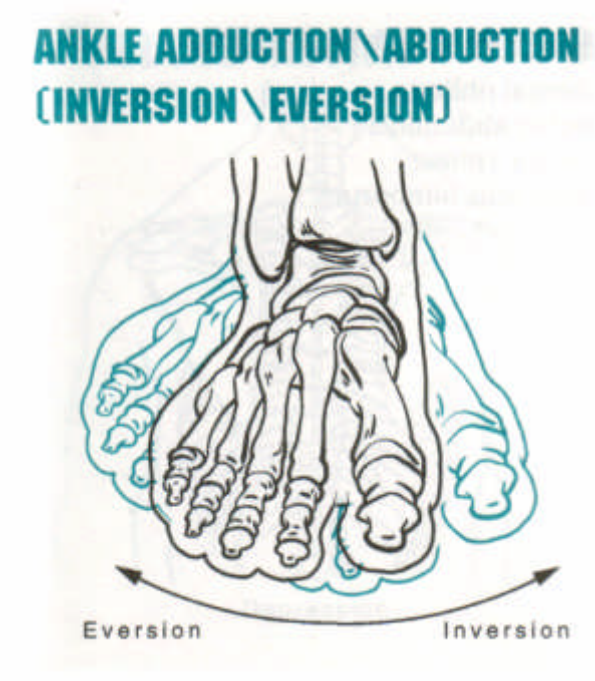
II. Joint Motions of the Frontal Plane

The frontal plane (also known as the coronal plane) divides the body into anterior and posterior halves. Joint motions distinctive to the frontal plane are referred to as adduction and abduction. Lateral flexion of the neck and trunk are the other joint motions that also take place in the frontal plane.



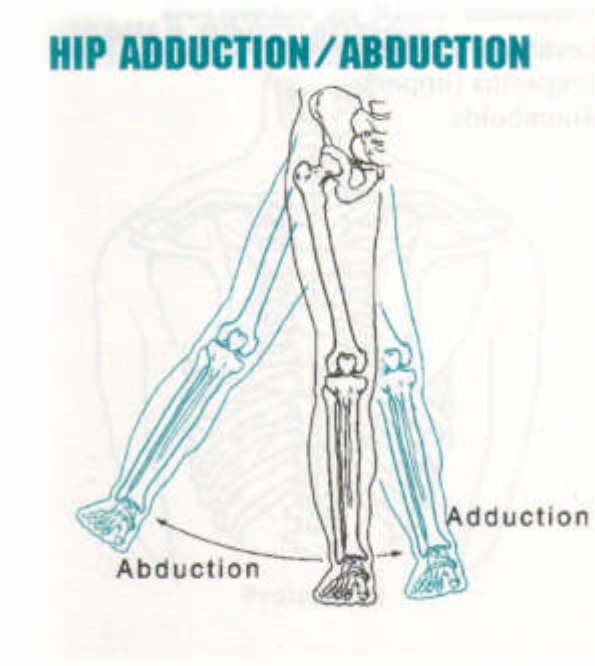
The Frontal Plane

Joint Motions of the Frontal Plane



MUSCLES OF ANKLE ADDUCTION
Extensor hallucis longus
Tibialis anterior
Tibialis posterior
Flexor digitorum longus
Flexor hallucis longus
Triceps surae

MUSCLES OF ANKLE ABDUCTION
Peroneus longus, brevis
Peroneus tertius
Extensor digitorum longus (lateral part)

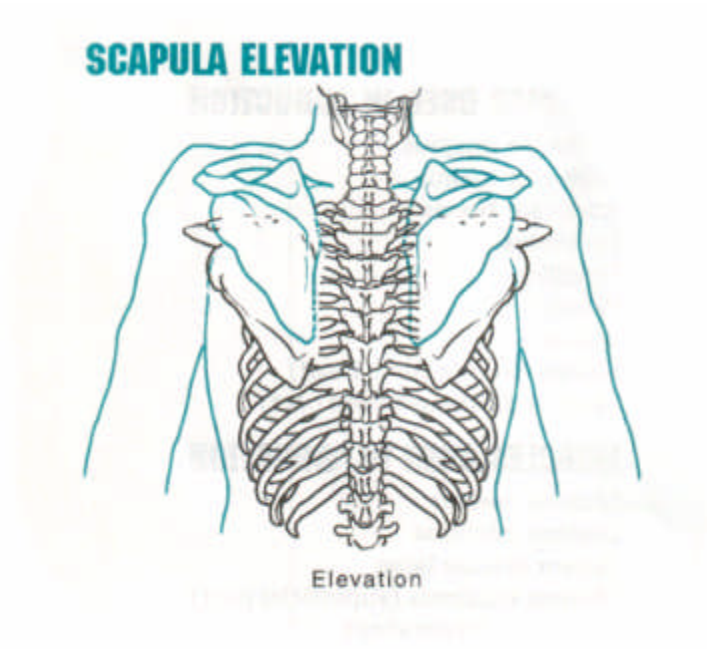


MUSCLES OF HIP ADDUCTION
Adductor magnus
Adductor longus
Adductor brevis
Pectineus
Gracilis
Psoas
Illacus
Biceps femoris (long head)
Gluteus maximus (deep part)

MUSCLES OF HIP ABDUCTION
Gluteus medius
Gluteus minimus
Tensor fasciae latae
Gluteus maximus (superficial part)
Piriformis (accessory)
Obturators (accessory)
Gemelli (accessory)
Sartorius (accessory)

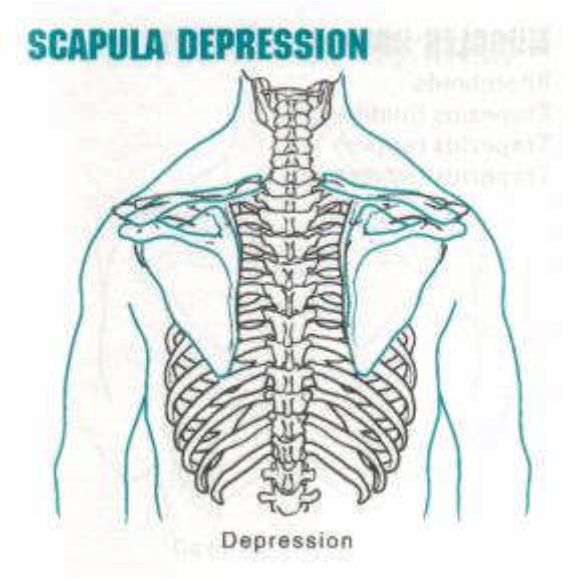
Joint Motions of the Frontal Plane

MUSCLES OF TRUNK LATERAL FLEXION
Internal oblique
Rectus abdominis
Erector spinae
Quadratus lumborum

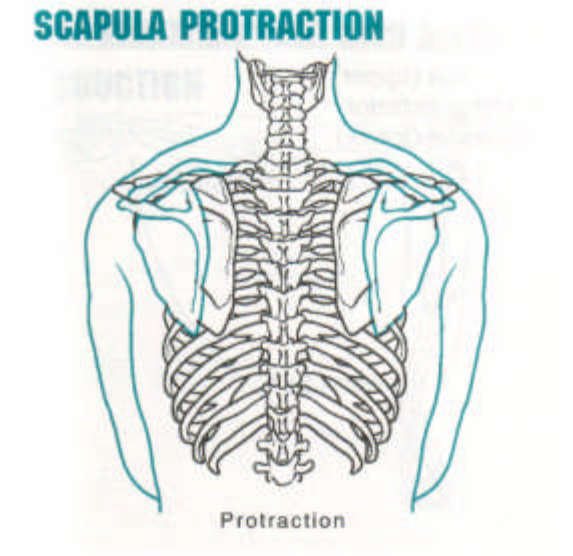


MUSCLES OF SCAPULAR ELEVATION
Levator scapulae
Trapezius (upper)
Rhomboids

Joint Motion of the Frontal Plane

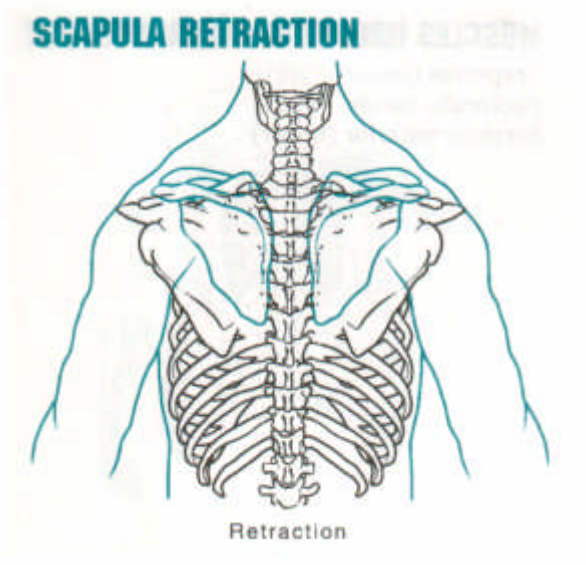


MUSCLES OF SCAPULAR DEPRESSION
Trapezius (lower)
Pectoralis minor
Serratus anterior (lower)

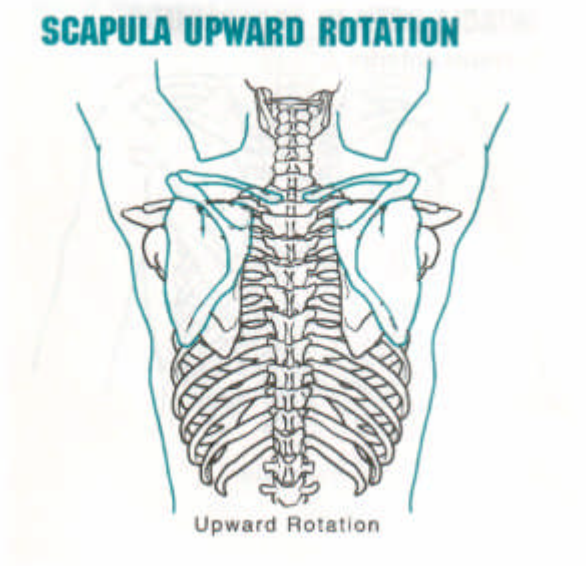


MUSCLE OF SCAPULAR PROTRACTION
Serratus anterior

Joint Motion of the Frontal Plane

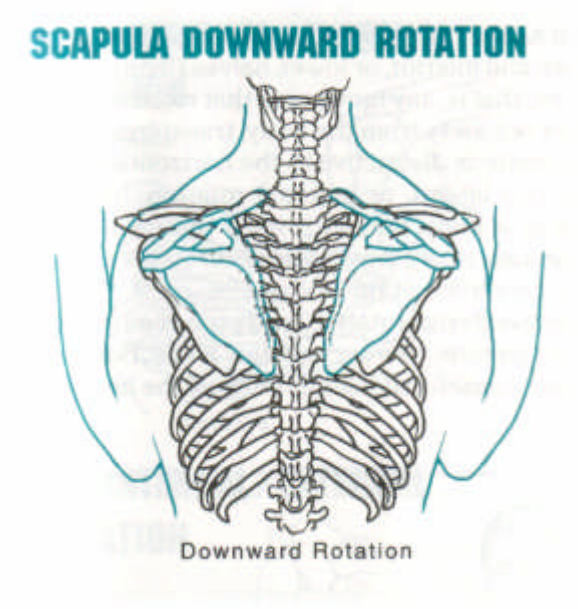


MUSCLES OF SCAPULAR RETRACTION
Rhomboids
Trapezius (middle)
Trapezius (upper)
Trapezius (lower)

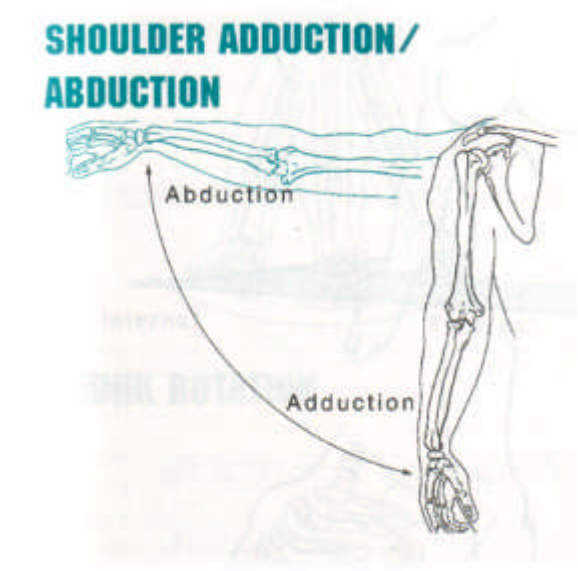


MUSCLES OF SCAPULAR UPWARD ROTATION
Trapezius (upper)
Serratus anterior
Trapezius (lower)

Joint Motion of the Frontal Plane



MUSCLES OF SCAPULAR DOWNWARD ROTATION
Rhomboids
Levator scapulae

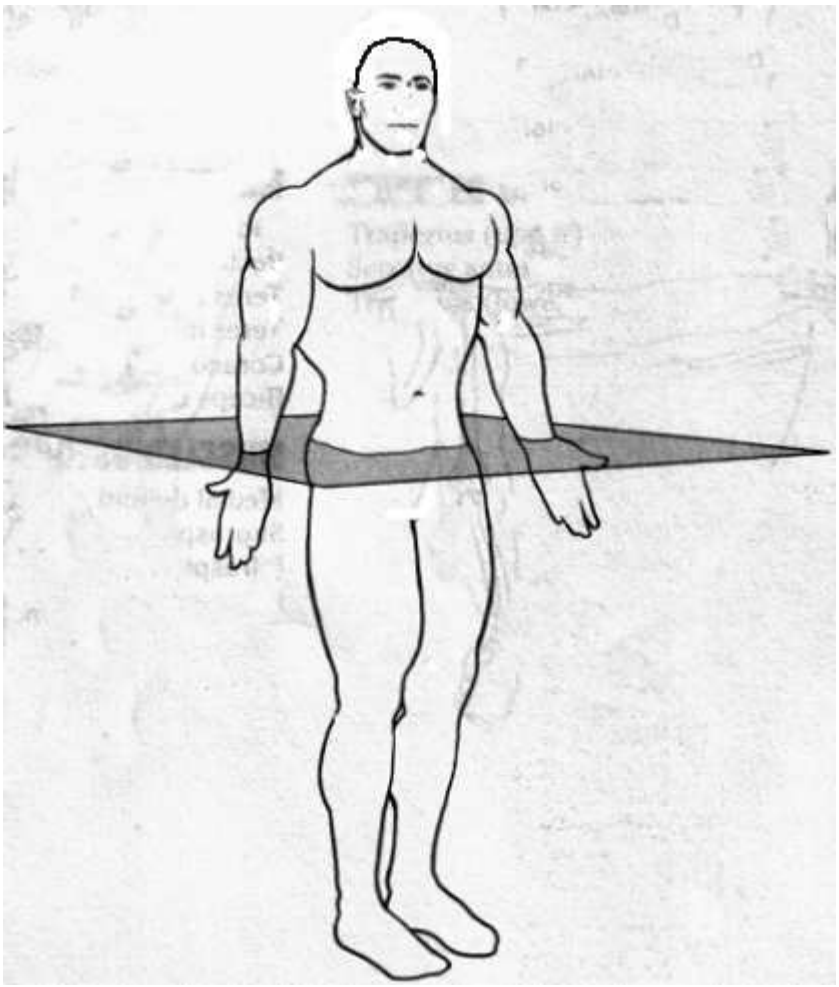


MUSCLES OF SHOULDER ADDUCTION
Latissimus dorsi
Pectoralis major
Teres major
Teres minor (accessory)
Coracobrachialis (accessory)
Biceps brachii short head (accessory)

MUSCLES OF SHOULDER ABDUCTION
Medial deltoid
Supraspinatus
Infraspinatus (accessory)
Biceps brachii long head (accessory)

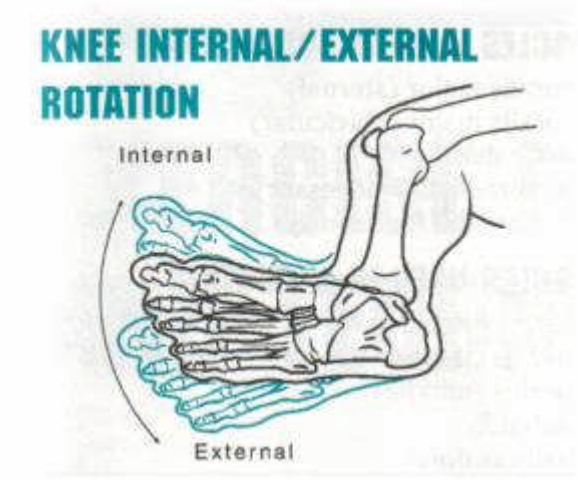
III. Joint Motions of the Horizontal Plane

- The horizontal plane (also known as the transverse plane) divides the body horizontally into superior and inferior halves. Joint motions distinctive to the horizontal plane are internal rotation, and external rotation.
- Supination (which is similar to external rotation) and pronation (which is similar to internal rotation) of the forearm occur in the horizontal plane. Additionally, horizontal adduction and abduction are joint motions of the horizontal plane.



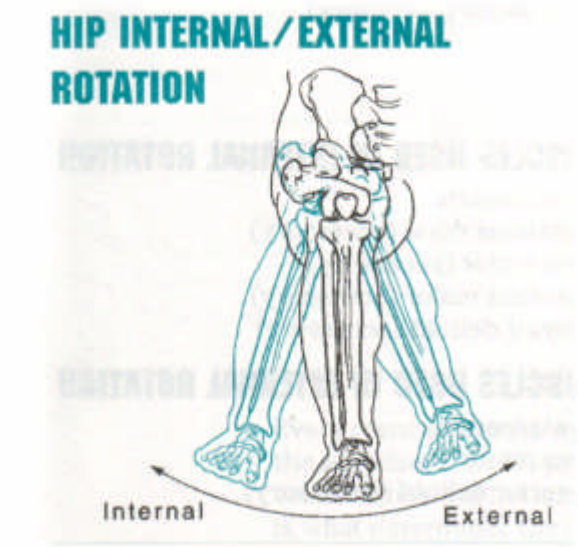
The Horizontal Plane

Joint Motions of the Horizontal Plane



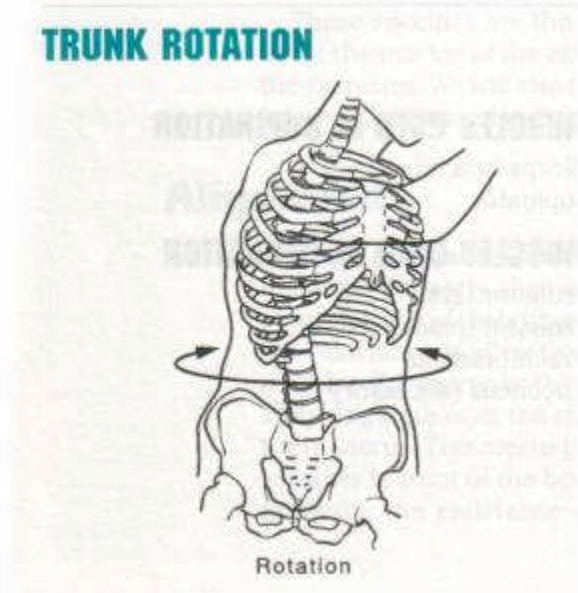
KNEE MUSCLES OF INTERNAL ROTATION
Sartorius
Semitendinosus
Gracilis
Popliteus

KNEE MUSCLES OF EXTERNAL ROTATION
Tensor fasciae latae
Gluteus maximus (superficial part)
Biceps femoris (long and short head)



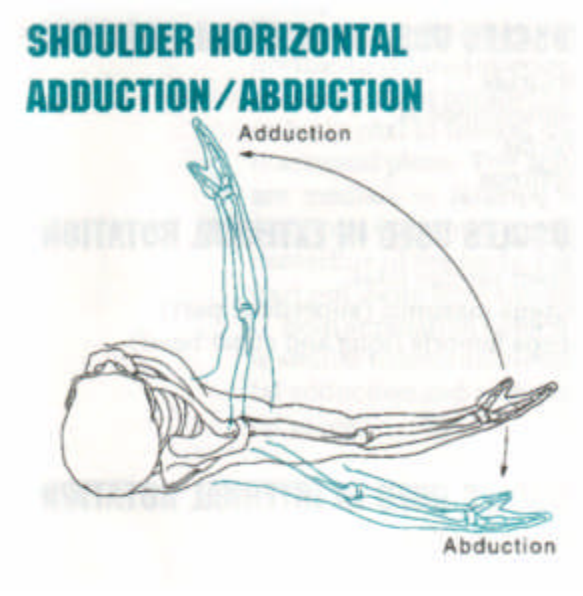
HIP MUSCLES OF INTERNAL ROTATION
Gluteus medius
Gluteus minimus
Tensor fasciae latae

HIP MUSCLES OF EXTERNAL ROTATION
Gluteus maximus
Piriformis
Obturators
Gemelli
Quadratus femoris
Biceps femoris
Adductors



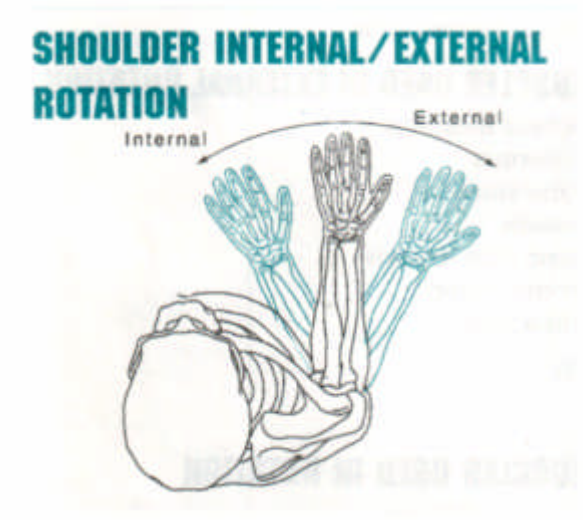
TRUNK MUSCLES OF ROTATION
External oblique
Rectus abdominis
Erector spinae

Joint Motions of the Horizontal Plane



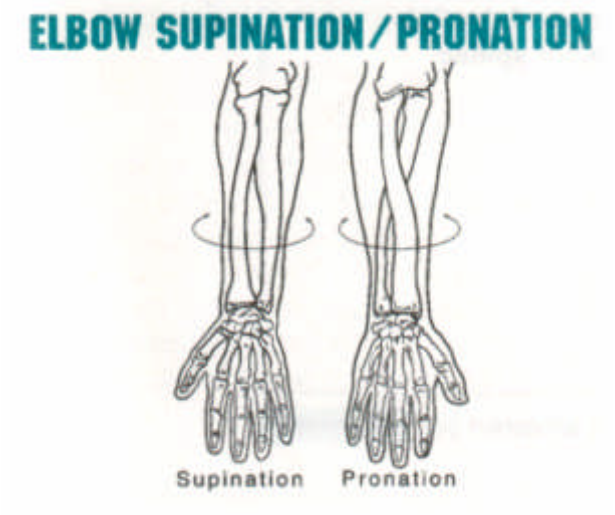
SHOULDER MUSCLES OF ADDUCTION
Pectoralls major (sternal)
Pectoralis major (clavicular)
Anterior deltoid
Coracobrachialis (accessory)
Biceps brachi! (accessory)

SHOULDER MUSCLES OF ABDUCTION
Posterior deltoid
Trapezius (upper)
Trapezius (middle)
Rhomboids
Latissimus dorsi
Teres major (accessory)



SHOULDER MUSCLES OF INTERNAL ROTATION
Subscapularis
Latissimus dorsi (accessory)
Teres major (accessory)
Pectoralis major (accessory)
Anterior deltoid (accessory)

SHOULDER MUSCLES OF EXTERNAL ROTATION
Infraspinatus
Teres minor
Posterior deltoid (accessory)



ELBOW MUSCLES OF SUPINATION
Biceps brachi
Supinator

ELBOW MUSCLES OF PRONATION
Pronator teres
Pronator quadratus
Brachioradialis
Anconeus (accessory)

Overview of the Three Body Types (Somatotypes)

Ectomorph - The entire body is slender and sparsely built. The bone structure is small, subcutaneous fat is almost nonexistent and the muscles are small and flat. The joints of the body have loose ligaments. Ranges of motion may be 15-30% greater than what is considered the normal ranges. The arms and legs are long and spindly. The neck is long, the Adam's apple prominent and the head is often carried forward creating the "military neck". The lateral spinal curves are often more dramatic with a lordotic lumbar curve coupled with a kyphotic thoracic curve. Scoliosis is more common in this body type. With exercise training they can develop strength that is surprising. As weight is the main determinant of oxygen utilization, their light frame can afford them good endurance.

Endomorph - The entire body is heavy and can be obese without proper diet and exercise. The bone structure is heavy and the bones are dense. Subcutaneous fat is plentiful. There is considerable muscle bulk and the muscles are short. The joints of the body are large and the ligaments are tight and very thick and strong. The joints may not reach full extension. Range of motion may be 10-20% less than the "normal" found in the intermediate, mesomorph type.
The increased body mass demands greater oxygen consumption. The endomorph does well in "spurt" activity, or explosive efforts but is poorly suited for endurance.
The endomorph is strong and can be very powerful, even when appearing to be excessively obese.

Mesomorph - The mesomorph, also known as the intermediate type, is the classic example of form and anatomy. Generally, they are of "average" height, 5'7" to 5'1O" and they have classic proportions, i.e., total arm span equal to body length, total trunk length is approximately equal to limb length and the Law of Thirds apply, i.e., the arm length is three times the length of the outstretched hand, the leg length is three times the length of the foot, and the height of the head is one third the length of the torso.
The mesomorph has good muscle development, body fat percentage is 13-22% depending on sex and age, and their connective tissues are strong and durable.

Ectomorph Susceptibilities

1. Lax ligaments leading to misalignment or dislocation.
2. Extra lumbar vertebra creating a weak, easily destabilized low back and poor posture.
3. A higher incidence of developmental deformities such as tropism and scoliosis.
4. Low blood pressure and congestive heart condition.
5. Scapular "winging" or Sprengles deformity.
6. Susceptibility to upper respiratory tract infections, and lung congestion. This includes colds, flu, acute bronchitis, allergies and sinus problems.
7. Depression / Anxiety / Neurotic behavior / Endocrine excesses.
8. Slower healing with muscle or ligamentous injury necessitating longer rehab periods.

Endomorph Susceptibilities

1. Myocardial infarction, coronary vessel blockage, myocardial degeneration and arteriosclerosis.
2. Emphysema.
3. Osteoarthritis and DJD.
4. High blood pressure / Diabetes / Gout.

5. Liver, kidney, gall bladder dysfunction.
6. Chronic low back pain / Obesity.
7. Rapid healing for most structural injuries with good return of strength.

Dietary Recommendations According to Body Type

Body Type	Goals	Dietary Strategies
Ectomorph - tall, slender, high metabolism	Increase body weight, and lean body mass, decrease body fat.	Increase calorie intake by 350 - 400 Kcal per day / Eat larger portions / eat 5 to 7 times per day / Increase protein to 1.5 - 2 grams per kg body weight.
Mesomorph - naturally muscular, long torso, full chest	Increase body weight, and lean body mass, decrease body fat.	Consume 60% of calories from carbohydrates / 1 to 1.5 grams of protein per Kg of body weight / Keep fat intake around 30% of total calories.
Endomorph - stocky build, slower metabolism	Decrease body weight, increase lean body mass, decrease body fat.	Decrease calorie intake by 500 Kcal per day / Consume low fat high fiber foods / Eat smaller more frequent meals.

Energy

Energy--is the capacity to do work. The human body has three basic systems to produce energy for exercise;Oxygen,Lactic Acid and the ATP--PC systems.

The Oxygen System--through complex changes, the muscle stores of carbohydrates and fats can enter the Krebs cycle, an array of enzymes that modify the structure of carbohydrates and fats, so they can release energy. Glucose and free fatty acids may enter the cell from the bloodstream. When carbohydrates and fats eventually combine with oxygen, large amounts of A T P (adenosine triphosphate) may be produced. A T P is a high energy phosphate compound found in the body and is one of the major forms of energy available for immediate use. In low levels of activity, such as rest and slow, long distance running lasting longer than four or five minutes the oxygen system predominates. The oxygen system produces A T P at a slow rate but can sustain production for a longer period of time than either the lactic acid or A T P--P C energy systems.

The Lactic Acid System--muscle glycogen can be broken down without the utilization of oxygen. This process is called anaerobic glycolysis. A T P is produced rapidly with lactic acid being the end product. Lactic acid is a major cause of fatigue in the muscle. The lactic acid system is utilized during exercise bouts of very high intensity conducted at maximal rates for about one to two minutes, such as running a fast 400 meter race.

The A T P--P C Energy System—A T P and P C (phosphocreatine) are high energy phosphates stored in muscle that can provide energy very rapidly. This system is utilized for quick, maximal exercises, such as sprinting or the performance of power squats, lasting one to six seconds. ATP is stored in muscle in limited amounts and can be used for many body processes, such as muscle contraction.ATP stores are used for fast, all out bursts of energy that last about 1 second. It then must be replenished from other sources in order for muscle contraction to continue. Phosphocreatine is also stored in the muscle in limited amounts and can be used to rapidly synthesize ATP.

Characteristics of Human Energy Systems

Characteristic	ATP-PC	Lactic Acid	Oxygen
Aerobic/anaerobic	Anaerobic	Anaerobic	Aerobic
Rate of ATP production	Fast	Fast	Slow
Time limits for maximal exercise	4-5 seconds	1-2 minutes	Hours
Capacity for ATP production	Low	Low	High
Lactic acid production	No	Yes	No
Fatigability	High	High	Low
Energy Source	ATP-PC	Carbohydrate	Carbohydrate, fat
Track event	100 meters	400-800 meters	5 kilometers

4

Aerobic Exercise

VO_2 Max

Maximal oxygen uptake is the most important measure of aerobic fitness. Another important measure is the ability to sustain exercise at a high percentage of VO_2 Max. To measure VO_2Max directly, monitor oxygen consumption with a gas analyzer while the individual exercises to exhaustion on a treadmill or bicycle ergometer. VO_2Max is partially dependent upon body weight. The larger the individual, the greater the potential VO_2Max. VO_2 Max is a measure of milliliters of oxygen per kilogram of body weight that the body metabolizes in one minute of exercise.

- During endurance exercise your muscles use oxygen to burn fat and carbohydrates to produce energy.
- The higher your VO_2 Max, the longer and more effortlessly you can perform.
- To increase your VO_2 Max - train at 85%-95% of your maximum heart rate. This will increase the size and strength of the heart, thereby allowing it to pump more blood with less effort on every stroke.
- Distance runners have been known to have resting heart rates of 30 beats per minute and a VO_2 Max of 60-80 milliliters per kilogram of body weight per minute of exercise.

Intensity of exercise is the most important component of the stimulus period. In order to receive optimal benefits from aerobic exercise, you must attain a **threshold stimulus**, which is the minimal stimulus intensity that will produce a training effect. Heart rate is usually used to determine the threshold level of exercise intensity.

To obtain the resting heart rate per minute;

1. Count the pulse rate for six seconds and add a 0.
2. Count the pulse rate for ten seconds and multiply the count by six.
3. Count the pulse rate for 30 seconds and multiply by two.

To calculate an individuals heart rate maximum, subtract the persons age from 220.

The heart rate range needed to elicit a training effect is called the **target heart rate range.**

- Determining Your Target Heart Rate

Step 1 - Determine your resting heart rate (number of heartbeats in one minute).
Step 2 - Subtract your age from 220.
Step 3 - Subtract your resting heart rate from the number above.
Step 4 - Multiply this number by .75.
Step 5 - Add this number to the number for your resting heart rate.

Estimating Your Maximum Heart Rate (MHR)

If you can carry on a conversation during the exercise, you are working aerobically (at 60 - 80 percent of MHR); if you can't, you are working anaerobically.

Metabolic Specific Training

Aerobic Training -

- Usually large-muscle group rhythmic activities such as walking, jogging, rowing, cycling, swimming, etc.
- Events greater than 90 seconds.
- In training, the activity should be performed continuously for 15-20 minutes at 70-90% of the maximal heart rate.
- Minimum of 3 training sessions per week.
- Athletes requiring higher aerobic fitness may train 4-6 *days* per *week* and may train for 20-30 minutes.
- Training can increase aerobic power 10-20%. Endurance athletes should train 5-7 days per week, 1-2 hours duration. Healthy individuals should train 3-5 days per week, 15-60 minutes duration.
- Cardiovascular ability is being able to maintain a sustained activity (like running), for a relatively long time (15 minutes or more).
- Aerobic training, unlike anaerobic training, utilizes oxygen and helps to metabolize fat.[5]

Over Training

Aerobic Over Training -

- Muscle size and strength may not be effected.
- Decreased total testosterone.
- Decreased pituitary secretion or growth hormone due to impaired hypothalamic function.[6]

Anaerobic Exercise

Anaerobic Muscular Endurance-- is the ability of a muscle or muscle group to repeatedly exert force by use of the anaerobic energy systems (the lactic acid and ATP-PC systems). Anaerobic endurance differs from aerobic endurance in that fatigue usually occurs in a relatively short period of time when utilizing anaerobic energy systems. For example, lifting your body weight in a pull--up may lead to fatigue rapidly because the small muscle groups in your arms are not able to produce ATP at a rate to meet the demand.

Anaerobic Training - relating to energy processes that occur in the absence of oxygen.

- For activities of less than 2 minutes duration involving utilization of phosphagen (ATP-PC) and lactic acid energy sources. Definitions:
- Phosphorous - Chemical element needed to digest protein, calcium and glucose. A lack of phosphorous can cause weight loss, anemia and abnormal growth. Needed to make ATP (adenosine triphosphate), a major source of body energy for the breakdown of sugar (glycolysis).
- Lactic Acid - organic acid normally present in tissue. Found in muscle and blood as a byproduct of the transformation of carbohydrates, glucose and glycogen into energy during strenuous physical exercise.
- Events under 6 seconds are almost exclusively using the phosphagen system. Ex. Weightlifting such as dead lift etc.
- Events lasting 30-90 seconds rely heavily on lactic acid.

Anaerobic Threshold

To raise your anaerobic threshold, do shorter intervals at 80% of your MHR. Recover for 15 minutes between intervals. Your ability to add speed to endurance is limited by your ability to tolerate the lactic acid that accumulates in your blood during intense exercise.

Anaerobic Over Training

Athletes engaged in anaerobic activities are more susceptible to over training - may occur in as little as 2 weeks.

Markers of Over Training.

- Decreased performance.
- Decreased percentage of body fat.
- Increased muscle soreness.
- Decreased total testosterone concentration.
- Increased heart rate[7].

The Over Training Syndrome

Emotional Warning Signs

- Increase in nervousness or depression.
- Inability to relax.
- Desire to quit training, skip training sessions or quit during competition.
- A drop in academic performance or in job performance.

Body Warning Signs

- Extreme *muscle* soreness *and* stiffness the day after *a hard training* session.
- A gradual increase in muscle soreness from training session to training session.
- Inability to complete a training session.
- Lowered general physical resistance as shown by continuous colds, headaches, etc.
- Loss of appetite.
- Unexplained drop in athletic performance.

When signs of over training are present it is advisable to suspend training for one or several days or to decrease the intensity and/or duration of training for one or several days. If strong signs of over training are present, it is possible that the athlete may have to spend days or possibly weeks at a decreased level of strenuous training.[8]

Detraining - Effects on Endurance and Strength

Endurance

- Rapid decline in maximum oxygen consumption (VO_2) after 2-4 weeks of cessation of training.
- A decrease in stroke volume and cardiac output appears to be one of the contributing factors to the loss of endurance capability in the initial 2-4 weeks of detraining. Stroke volume (the amount of blood pumped with each heartbeat) decreases as soon as training is stopped. A 10% decline can be noticed in 12 days. The decrease is relative to lower blood and plasma volume.
- Decreased plasma volume in well-trained endurance athletes. After 2-4 weeks of detraining - plasma volume is decreased by 9%, stroke volume by 12%, VO_2 max 6%.

Strength Detraining

- **Skeletal muscle changes:** After 3 month detraining, 12% decrease in Type II A and B (fast twitch) muscle fibers.
- Swimmers declined 13.6% in maximal arm power on an exercise machine after 4 weeks of inactivity.

- At a training frequency of 1 / week muscle strength can be maintained.[9]

According to the American College of Sports Medicine, the minimum amount of exercise for aerobic fitness is an intensity level of 60 to 90 percent of ones maximum heart rate reserve, for a duration of 20 to 60 minutes, at a frequency of three to five times per week.[10]

Types of Exercises

1) **Isometric Exercise** - muscle contraction against immovable resistance, performed without producing joint motion. Ideal in cases where you have less than 15-20% of normal range of motion, however it is not the best way to achieve muscle strength. Isometrics can be performed by contracting the desired muscle against some immovable object. Isometric contraction can be submaximal, exerting 65% or less of maximum force potential, or maximal, 85% or more of maximal force potential. Submaximal contractions are usually tolerated well early on in rehabilitation, followed by maximal contractions where there are no signs of aggravation. Once maximal contractions are possible the rule is to perform 10 second contractions, 10 seconds of rest, 10 repetitions, and 10 sets per day. (Isometric Rule of 10)

The best results with isometric "sets" are achieved in the first four weeks. Beyond that time period better results *can* be achieved by other exercises. Isometrics are not the best way to produce strength. They do not change a *muscle's* ability to exert a force rapidly. They provide only a limited stimulus for hypertrophy and, lastly, they do not improve endurance in dynamic activities. Isometric contractions help maintain tone, they can be used to strengthen a particular weak angle in the full range of motion, and they limit atrophy.

2) **Isotonic Exercise** is a form of exercise that produces joint movement and is the most common form of exercise in rehabilitation. Isotonic exercise is a muscle contraction through a range of motion using a constant resistance weight. Initially limb weight is used. This can progress to limb, wrist or ankle weights, barbells, and/or machines, or tubing.

General Rules of Isotonic Exercise

- The initial weight utilized is merely the weight of the body part itself against gravity. This progresses to tubing, free weights etc.
- When using free weights, initially use light weight and low repetitions.
- In upper extremity strength training, perform 3 sets of 12 repetitions using the maximum weight that will create mild burning in the muscle but will not allow a full third set using strict form. When the third set of 12 repetitions can be performed with strict form increase the weight 5 to 10 percent.
- In the lower extremities use 3 sets of 12-15 repetitions.
- For endurance increase the number of sets and repetitions used. This may necessitate a reduction in the amount of weight used.
- For muscle mass, increase the weight and decrease the repetitions.
- An isotonic exercise schedule frequency of 3 to 5 times per week is optimum.

3) **Isokinetic Exercise** This type of exercise involves contraction against a variable resistance in which the speed is held constant. An example would include the Cybex machine. Isokinetic machines allow for the performance of exercise at speeds higher than those attainable with free weights. However, it is questionable whether greater exercise speed has any significant effect on performance or reaction time. Also there is no significant difference between isotonic and isokinetic exercise in the development of muscle strength and endurance.

- **Goal Setting**--Exercise goals should be realistic and attainable. Determine present physical fitness status; write a measurable statement of the exercise goals or objectives; identify the exercise mode, intensity, frequency and duration required to reach the goal; and perform periodic physical fitness status assessments. Examples of goals would include, increasing muscular strength and endurance, increasing cardiovascular endurance, increasing flexibility, body composition alterations, weight gain and weight loss.
- Vary the exercise mode and intensity.
- Utilize the overload principle.
- Perform core, compound exercises such as squats.
- Use a system of training consistent with your goals.
- Record your progress.

General Rehabilitation Exercise Progression

Step 1- Depending upon patient tolerance, range of motion exercises and stretching should be introduced during the acute phase of healing. Mobilization will prevent scar tissue adhesions and spinal fixation. Range of motion and stretching can be utilized through out the entire course of care.
Step 2 - Progress to isometric exercise if you have less than 15% to 20% of normal range of motion in a joint.
Step 3 - If you have normal range of motion in a joint progress to isotonic exercise using limb weight only.
Step 4 - Progress to isotonic exercise using resistance weight.

- Initially utilize light weight, 3 sets of 15 - 20 repetitions for muscle endurance for a period of 1-2 weeks.
- Progress to 3 sets of 12-15 repetitions using weight that will allow completion of the third set. Subsequently increase the weight 5% to 10% (this may require a decrease in the number of repetitions to accommodate the increased weight). This regimen may last for 8-12 weeks.

Step 5 - The ultimate goal and progression is a 1 repetition maximum lift of ones body weight or better, one session per week, and moderate lifting intensity (3 sets, 8-10 repetitions, incrementally increasing the weight each set) on other training days.

How To Arrange Exercises

- Exercise large muscle groups first such as the chest, thigh and upper back.
- Alternate upper body with lower. Ex. Bench press (chest) followed by lunges (thigh & hip), bicep curls (arm), knee extensions (anterior thigh) standing press (shoulder) and leg curl (posterior thigh).
- Alternate push with pull exercises. Ex. Bench press (push), Lat pull-down (pull), Seated press (push), Bicep curl (pull), Tricep extension (push), Leg curl (pull), Knee extension (push).

Classification of Common Exercises

Single-Joint Movements

Exercise	Joint	Primary Muscle
Biceps Curl	Elbow	Biceps
Triceps Pressdown	Elbow	Triceps
Front Raise	Shoulder	Anterior Deltoid
Lateral Raise	Shoulder	Lateral Deltoid
Bent-Over Lateral Raise	Shoulder	Posterior Deltoid
Flye	Shoulder	Pectoralis Major
Back Extension	Hip	Spinal Erectors
Crunch	Hip	Abdominals
Leg Extension	Knee	Quadriceps

Leg Curl	Knee	Hamstrings
Standing Calf Raise	Ankle	Gastrocnemius

Multiple-Joint Movements

Exercise	Joint	Primary Muscle
Squat	Hip Knee	Spinal Erectors, Hamstrings Quadriceps
Deadlift (Bent-Leg)	Hip Knee	Spinal Erectors, Hamstrings Quadriceps
Leg Press	Hip Knee	Hamstrings Quadriceps
Bench Press	Shoulder Elbow	Pectoralis Major Triceps
Military Press	Shoulder Elbow	Deltoid Triceps
Lat Pull-Down	Shoulder Elbow	Latissimus Dorsi Biceps
Bent-Over Row	Shoulder Elbow	Latissimus Dorsi Biceps
Seated Cable Row	Shoulder Elbow	Latissimus Dorsi Biceps

Single-Joint vs. Multiple-Joint Movements: A Comparison

Multiple-joint movements before single-joint movements

Advantages

- Greater overall muscle mass is stimulated.
- Heavier weights can be used.
- Muscles are fatigued faster.
- More work can be done in less time.
- Provides good warm-up for smaller muscle groups and single-joint movements.

Disadvantages

- Secondary muscles may tire before the target muscle group.
- Injury is more likely in the absence of proper warm-up.

Single-joint movements before multiple-joint movements

Advantages

- Pre-exhaustion is effective in maximally fatiguing a given muscle group.
- Can be effective in stimulating new growth in stubborn muscle groups.
- Useful for isolating muscle groups.
- Stretches and warms joint muscles in preparation for multiple-joint movements.
- Often helpful in developing symmetry.

Disadvantages

- Requires the use of lighter weights.
- Fatigues muscles, preventing the use of maximal weights for multiple-joint movements.
- Can be dangerous if pre-exhausted muscle group fails during multiple-joint movement.

Beginner Exercise Program Fundamentals

- Starting out a strength and conditioning program too aggressively can lead to injury, excessive delayed muscle soreness, and psychological maladjustment to training.
- Underestimate physical abilities rather than overestimate when prescribing exercise for beginners.
- Evaluate and upgrade the program weekly in order to maintain exercise stimulus.
- Perform 10-12 repetitions.
- Progress from 1 to 3 sets.
- Exercise large muscle groups first, gradually adding small muscle group exercises.
- Perform upper extremity exercises before lower extremity exercises. This differs from the experienced lifter who performs lower extremity exercises first then upper extremity exercises.
- Rest 3-4 minutes between sets and 48 hours between body parts.
- Inexperienced trainees have been reported to make strength gains with loads as low as 45% of their 1 repetition maximum lifting capability.
- Elite athletes require a load of at least 80% of a 1 repetition maximum lift for strength gains.

Beginner Program

Frequency: 2-3 days per week
Duration: 60 minutes (30 cardiovascular/warm-up, 30 resistance training/stretching)
Recovery: 60-90 seconds between sets
48-72 hours between workouts

Exercise	Volume (Sets-Repetitions)
Warm-up stationary bike - 10 min	•
Squats	1 –3 x 10 – 12 reps
Leg press	1 –3 x 10 – 12 reps
Hamstring flexion	1 –3 x 10 – 12 reps
Hip abduction	1 –3 x 10 – 12 reps
Leg raise	1 –3 x 10 – 12 reps
Seated lat row	1 –3 x 10 – 12 reps
Bench press	1 –3 x 10 – 12 reps
Side deltoid abduction	1 –3 x 10 – 12 reps
Shoulder internal rotation	1 –3 x 10 – 12 reps
Shoulder external rotation	1 –3 x 10 – 12 reps
Trunk extensions	1 –3 x 10 – 12 reps
Cardiovascular stationary bike - 10 min	•
Stretching 5- 10 min	•

Advanced Exercise Program

Frequency: 2-3 days per week
Duration: 90 minutes (30 cardiovascular/warm-up, 60 resistance training/stretching)
Recovery: 60-90 seconds between sets or active recovery (supersets)
48-72 hours between training sessions
Volume: Depends on goals. For muscle endurance use light weight and high repetitions (10-17 reps). For muscle strength use heavy weight and low repetitions (4 – 6 reps) to muscle failure.

Exercise	Volume Sets
Warm-up stationary bike – 5 min	
Lunges	3 sets
Squats	3 sets
Calf raises	3 sets
Leg flexion / extension	3 sets
Leg press	3 sets
Bicep curl	3 sets
Tricep extension	3 sets
Bench press	3 sets
Lat pull down	3 sets
Deltoid rows	3 sets
Bike or treadmill - 30—45 min	.
Stretching - 5—10min	.

Developing Muscular Strength

Strength development is dependent upon the ability to recruit more motor units, the amount of lean body mass (fat free mass), age, sex and hormones. A strength program should:

1. Utilize the set system with adequate rest between sets.
2. Perform 2--4 repetitions per set.
3. Perform 3--5 sets per exercise.
4. Utilize heavy resistance.
5. Keep the intensity high and the volume low.
6. Keep the number of different exercises low.
7. Perform 1 repetition maximum lifts on the heavy lifting day.

Developing Muscular Endurance--muscular endurance, the ability to perform repeated movements without experiencing premature fatigue, is probably more important in daily life than possessing a high level of strength. A muscular endurance training program should:

1. Utilize circuit training or super sets keeping rest to a minimum between sets.
2. Perform three, 10--30 repetition, sets.
3. Keep the intensity low and the volume high utilizing light resistance.

Developing Power--power is the ability to generate force very quickly and is a combination of strength and speed. Speed is developed by performing the desired skill as fast as possible. A power training program should include the strength developing program listed above, speed training and plyometrics.

Manual Resistance Exercise-- can be performed alone or may include cooperative efforts between partners to develop strength. No equipment is required, many different muscle groups can be worked and the speed of movements can be controlled.

Power

- Power is an explosive combination of strength and speed. The ability to move large amounts of weight very rapidly.
- Power = Force x Velocity.
- Olympic lifting actions trigger your central nervous system to whip your fast - twitch (Type II) muscle fibers into quick action.
- Powerful athletes get from point A to point B quicker, and exert more force when they get there. These attributes are essential in all sports.

Power: Take the Test

The classic test of power is the standing vertical jump. Warm up, then cover the finger-tips of your right hand with chalk and, standing perpendicular to a wall with your feet flat, make a mark at the top of your reach. Then jump as high as you can and touch the wall. Don't take a step or swing your arms. Record the difference in inches between the low and high marks in the best of three jumps.

How do you measure up?

Age	**20-29**	**30-39**	**40-49**	**50-59**	**60-69**
Excellent	>21	>19	>16	>14	>12
Good	15-21	14-19	12-16	11-14	9-12
Average	11-14	10-13	9-11	8-10	6-8
Fair	8-10	7-9	6-8	5-7	4-5
Poor	<8	<7	<6	<5	<4

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Children and Resistance Training

Children need to develop cardiovascular fitness, flexibility, motor skills and strength.
Training sessions should not be longer than 30-60 minutes and conducive to safety and enjoyment.
Use moderate resistance (a 10 repetition maximum weight). Never allow maximal 1 RM lifts until 16 years old so as not to damage epiphyseal plates.

1. Before starting a weight -training program, children should have an examination by a physician.
2. Weight - training should be supervised.
3. Two to three training sessions per week on nonconsecutive days beginning with one set of 10 repetitions using light weights.
4. Perform 6-8 basic exercises per training session such as leg extension, leg curl, chest press, latissimus dorsi pull down, bicep curl and tricep extension.
5. For strength gains, progressively increase the weight and decrease the repetitions to 6-10 reps. A 2-3 pound increase in weight is consistent with a 5%-10% increase in training intensity. Progress can also be achieved by increasing the repetitions.
6. Weight training can begin at approximately 13-15 years old.

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Exercise Protocols for Children

I. Use of Body Weight for Resistance

Exercise	Sets and repetitions
Push up	3 x 10-20
Bent leg sit up	3 x 15-30
Squats	3 x 10-20
Toe Raises	3 x 20 - 30
Self resistance arm curls	10 - Contractions of 6 seconds duration
Partner resisted lateral arm raise	10 - Contractions of 6 seconds duration
Back hyperextension	3 x 10-15

II. Resistance With Machines or Free Weights

Exercise	Sets and repetitions
Leg Press	3 x 10
Bench Press	3 x 10
Leg curls	3 x 10
Arm curls	3 x 10
Leg extensions	3 x 10
Military press	3 x 10

Exercise Equipment

Exercise Equipment--there is a large assortment of pieces of exercise equipment including, but not limited to,free weights (barbells and dumbells), machine weights (Universal, Nautilus, etc.), tubing, flex bands, exercise and medicine balls.

Free Weights-- allow for constant resistance exercises in which the load remains the same throughout the exercise. However, the relative load changes during the lift at different angles. For example, during a bicep curl, the resistance is greater at the start of the lift and lessons as the range of motion nears its completion.

Machine Weights--allow for variable resistance exercises in which the load increases throughout the exercise and results in a more even resistance distribution during the complete range of motion. Advanced,isokinetic machines control the speed of the muscle contraction during the exercise.

Exercise Technique Fundamentals

Types of Grips

- Pronated grip - a.k.a. overhand grip - palms down - used in upright rowing.
- Supinated grip - a.k.a. underhand grip - palms up - used in bicep curl.
- Alternated grip - One hand pronated, one hand supinated-used in dead lifts.
- Hook grip - Similar to the pronated grip except the thumb is under the index and middle fingers--used in the snatch.

Grip Width - Wide, medium and narrow grips depending upon the exercise being performed.

Stance

- Feet slightly wider than shoulder-width or hip-width apart.
- Heels and balls of feet should be in contact with floor.
- Move through the entire range of motion at a controlled velocity. This maximizes the value of the exercise and maintains or improves flexibility.
- Repetitions should be done slow and controlled to insure full ROM.

- Inhale and exhale at the proper time - Exhale through the sticking point (the most strenuous time during the exercise).
- For exercises that require lifting a barbell or dumbbell from the floor to the shoulders or overhead, keep the back flat, the bar close and let the leg muscles do the work.

Exercise Speed – The speed of one repetition should be approximately 7 seconds. The positive portion of the exercise is 2-3 seconds. The negative portion is 4 seconds.

Exercise Safety

1. Learn to breathe properly. Associated with prolonged breath holding is a response known as the Valsalva phenomenon (holding your breath causes your epiglottis to close over your windpipe and the pressure in your chest and abdominal area rises rapidly causing resistance to blood flow to the heart and brain resulting in a possible blackout).
2. Use spotters.
3. Use lock collars on the bar ends when lifting with - partner.
4. When exercising alone, do not use lock collars on the bar ends when performing the bench press with heavy weight.
5. Warm up and cool down properly.
6. Lower weights slowly.
7. Use proper lifting form.
8. Avoid exercises that aggravate low back pain.

Exercise Basics

Variability--exercise programs should be varied with respect to the exercises performed and the intensity at which they are performed. Substitute different exercises. For example, instead of the bench press, perform the incline bench press or flyes. Vary the intensity of the workouts. On a light intensity workout day perform 8--10 repetitions; medium intensity workout perform 6--8 repetitions; and on a heavy intensity day perform 2--4 repetitions.

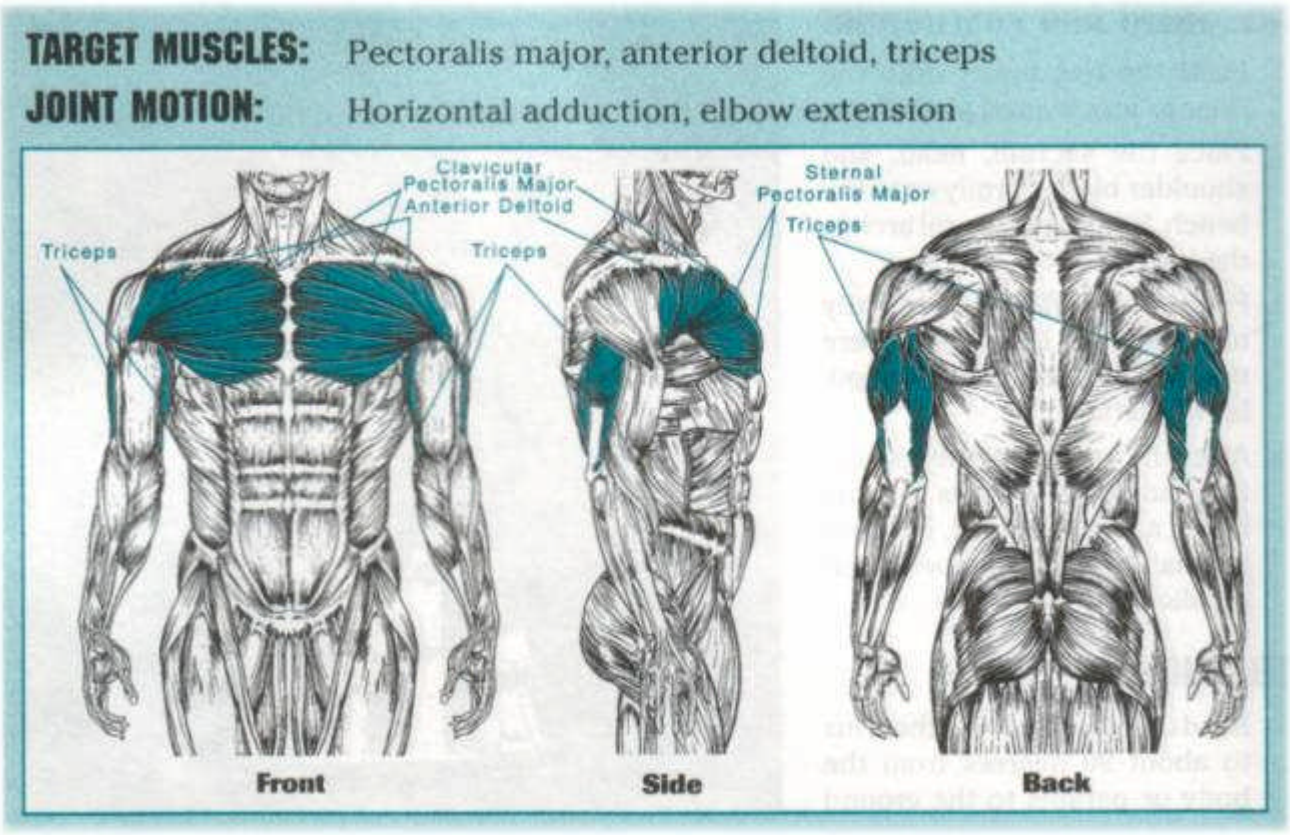
Progressive Resistance--exercise programs must be progressive (regularly increasing the load) to achieve muscle strength.

The Bodies Response to Exercise--the bodies initial response is one of shock. This period lasts one to two weeks and is characterized by muscle soreness. This effect can be minimized by beginning with a single set of approximately 10 repetitions utilizing light weight for two or three training days. After a week or two the body adapts to the imposed exercise stress. This adaptive stage lasts six to ten weeks during which time the muscles increase in size and strength due to progressive increases in the resistance utilized. Progressive resistance over training may lead to a fatigue stage which may necessitate a brief rest period during which time other forms of physical activity, such as calisthenics, are performed.

Common Types of Exercise

Chest Exercises--bench press; incline/decline bench press; flyes; dips; pullovers and cable cross--overs.

BENCH PRESS

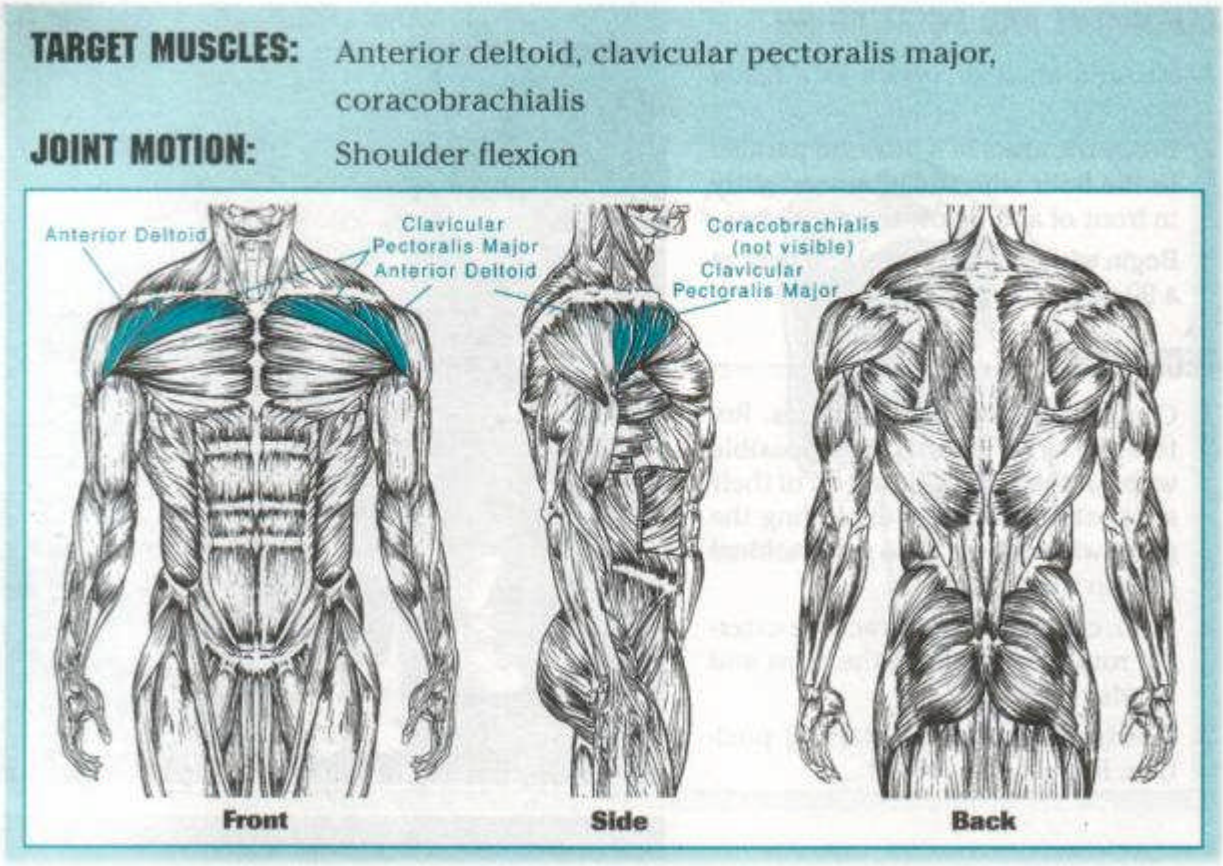


BENCH PRESS EXERCISE FUNDAMENTALS

- Keep the feet planted flat, and the head and sacrum pressed firmly against the bench.
- Remove weight from the weight rack , inhale and lower the arms parallel to the floor.
- Keep the shoulder blades down and together and a natural arch in the lower back throughout the exercise.
- Exhale and bring arms back to starting position.

Shoulder Exercises-- front deltoid raises; lateral deltoid raises; bent--over lateral raises, overhead press; seated press behind the neck; upright row.

Front Deltoid Raises

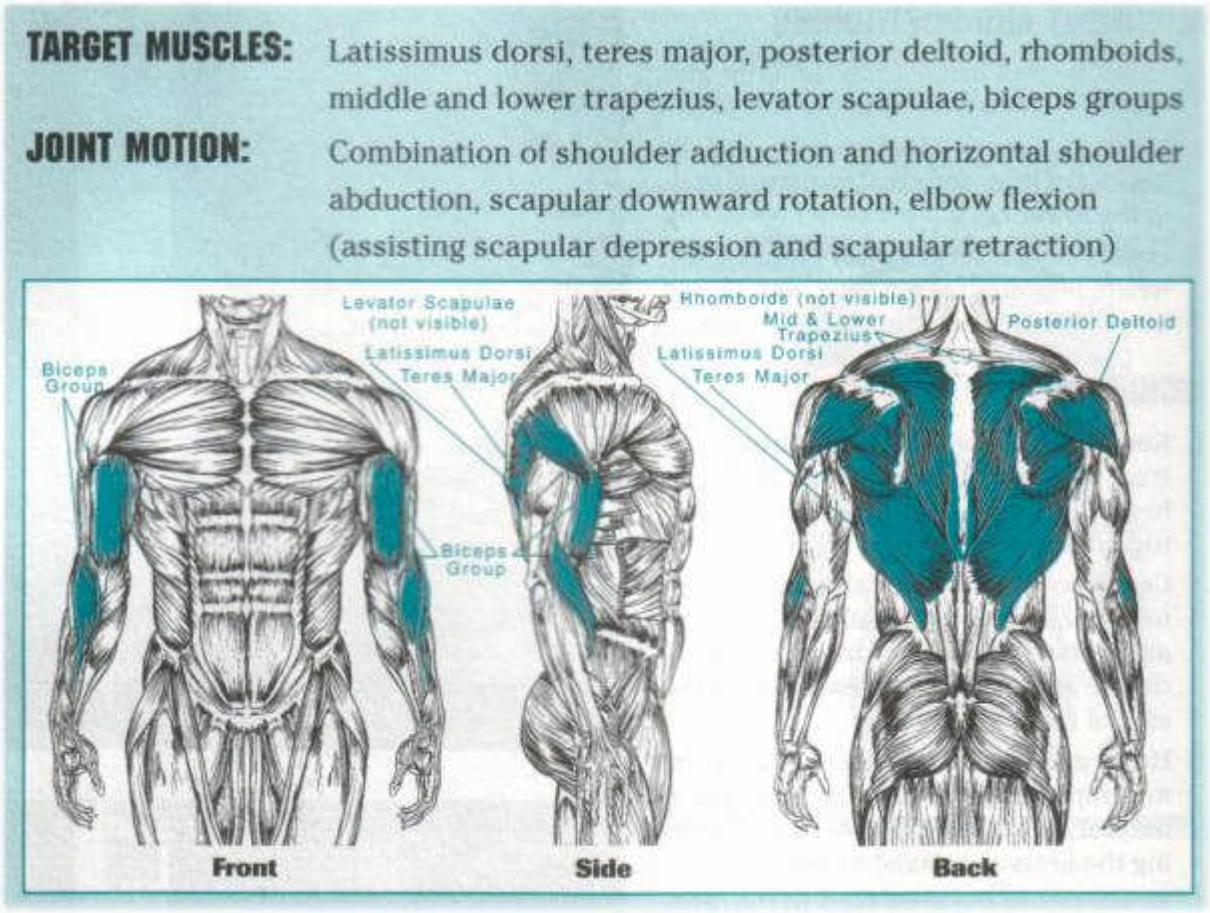


FRONT DELTOID RAISE EXERCISE FUNDAMENTALS

- Stand in a ready position with the feet about shoulder-width apart and the knees and hips slightly bent.
- Hold the dumbbells parallel to the body with the elbows pointing back and slightly bent.
- Contract the anterior deltoids. Pull the arms up and out, relax the hands and keep the elbows bent.
- Raise the arms up and out until they are approximately parallel to the floor.
- Slowly lower the arms back to their original starting position.

Back Exercises-- lat pull downs, upright rows; shrugs; bent--over rows; seated rows; pull--ups; extensions; and extensions.

Latissimus Dorsi (Lat) Pull Down



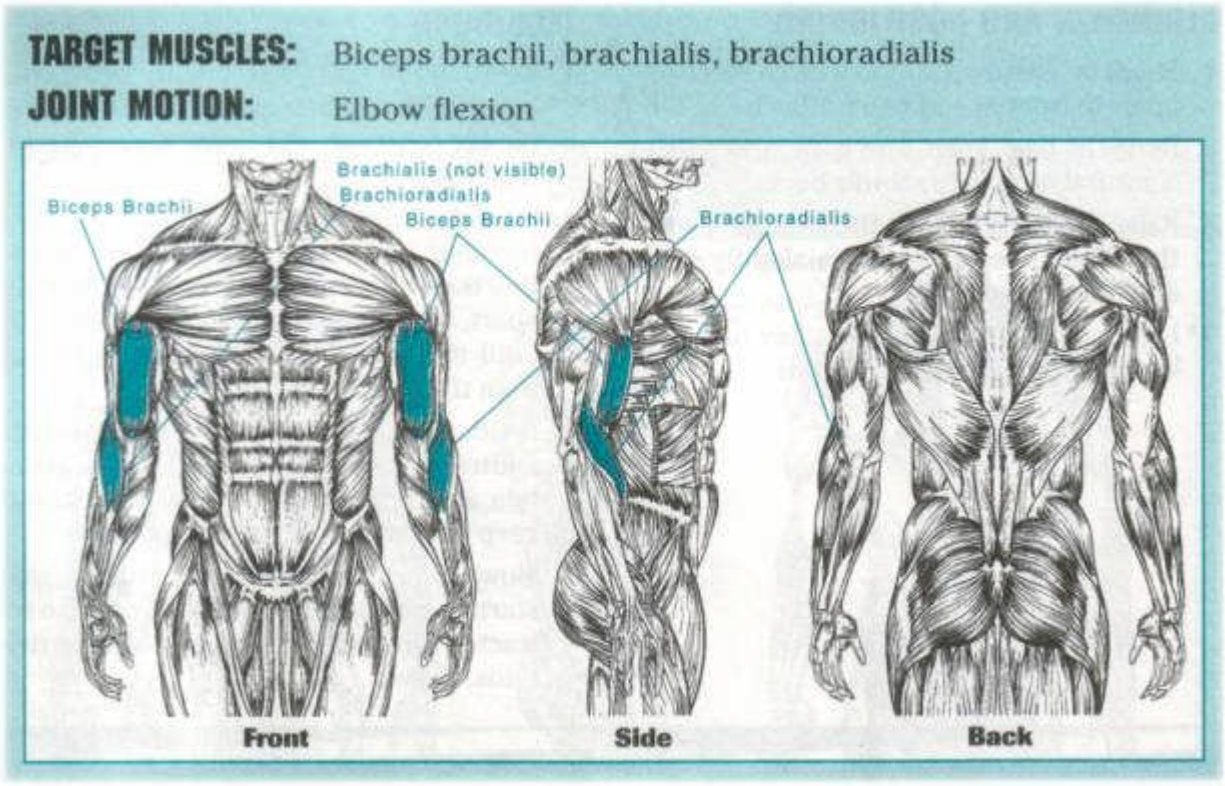
LATISSIMUS DORSI PULL DOWN EXERCISE FUNDAMENTALS

- Place the hands onto the bar so that when the upper arms are parallel to the floor, they will form an approximate 90-degree angle with the forearms.
- Lean back approximately 15 to 45 degrees.
- Contract the latissimus dorsi, bend the elbows, and begin to pull the arms out and down until the upper arms are parallel to the floor.
- Keep the scapulae depressed and retracted, the spine stabilized, and a natural arch in the lower back.
- Let the arms back up slowly to the original starting position keeping tension in the latissimus dorsi.

Warning – Avoid pulling the bar down behind the head and striking the cervico thoracic junction.

Arm Exercises--curls (dumbell, preacher, concentration and E--Z); tricep press, extension and pushdowns; reverse curls and wrist curls; chin-ups.

BICEPS CURL



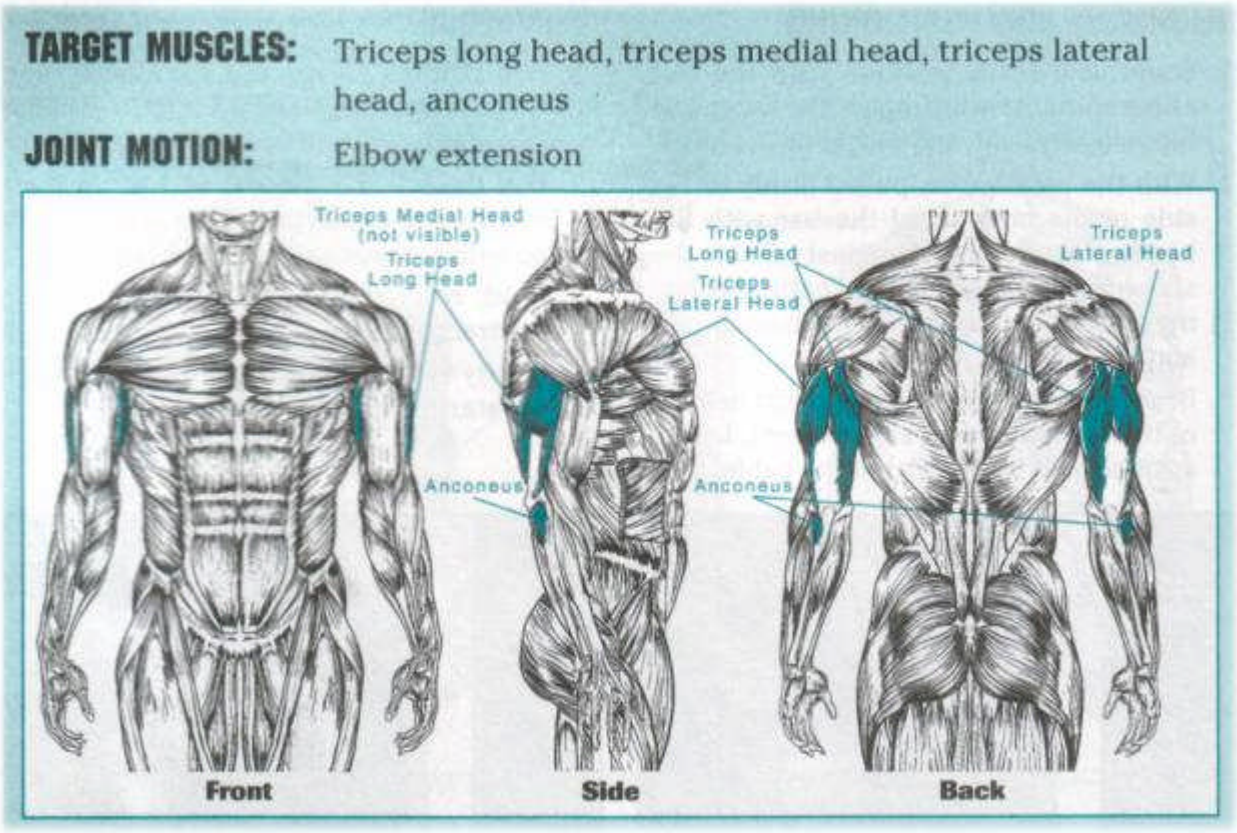
EXERCISE MOVEMENT

- If the forearm is supinated and the palm is up, the biceps brachii is most active. When the forearm is neutral or in a pronated position the brachialis and brachioradialis become more active.

BICEPS CURL EXERCISE FUNDAMENTALS

- Stand with the feet shoulder-width apart, the knees and hips slightly bent, and weight on the heels.
- With the upper arms pulled firmly to the side of the body, hold the dumbbells with the lower arm neutral, or in a partially pronated position, depending on which portion of the biceps you wish to target.
- Begin with the elbows aligned under the shoulders and slightly bent.
- Contract the biceps and flex the elbows as far as they will go.
- Hold, relax the hands, and continue to contract the biceps.
- Slowly lower the arms back to their original starting position keeping tension on the biceps.

TRICEPS EXTENSION



EXERCISE MOVEMENT

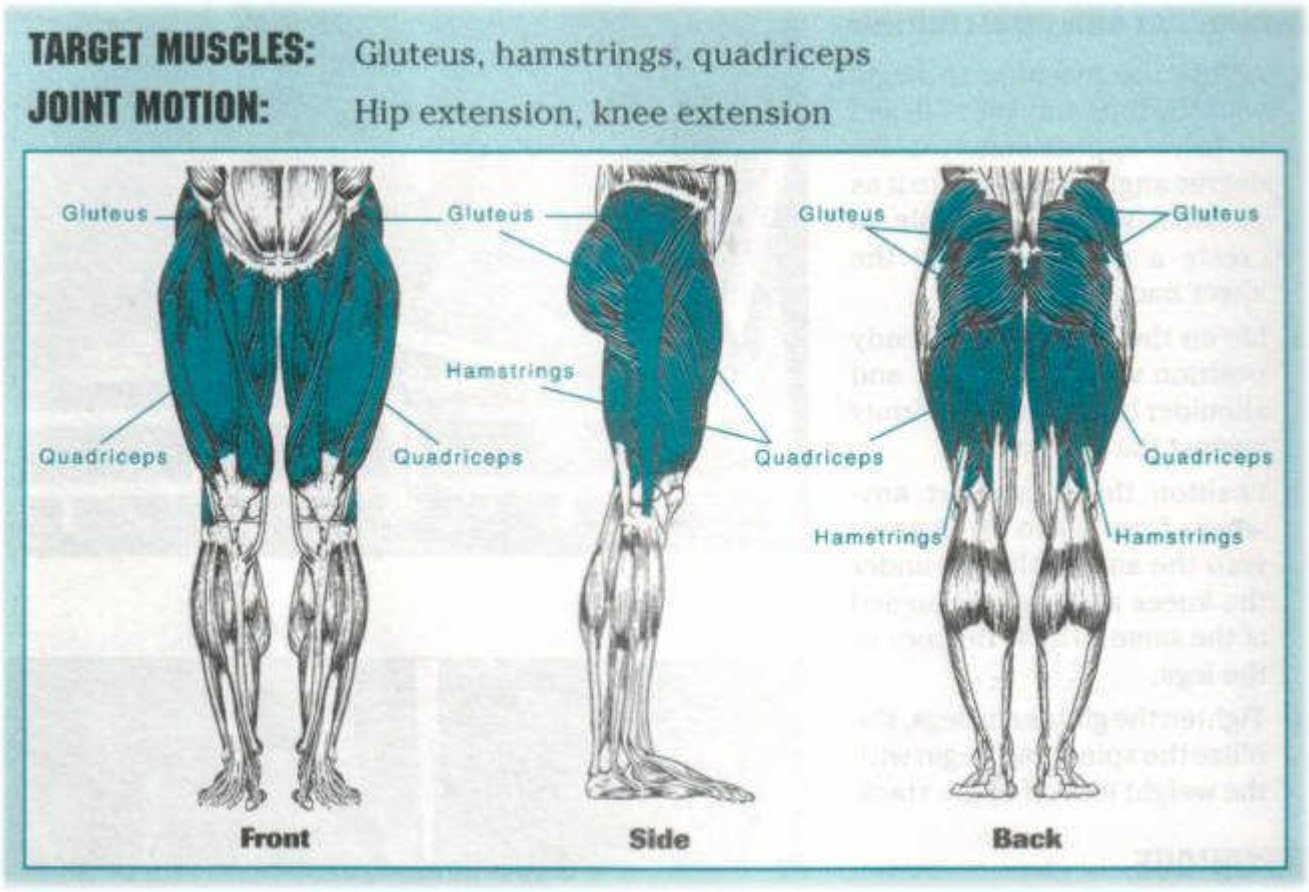
Changing the focus of the resistance to a different portion of the triceps is accomplished by setting the shoulder in different degrees of flexion or extension. The higher the degree of flexion, the more the muscle fibers of the triceps long head will be recruited and the less the triceps lateral head will assist.

TRICEP EXTENSION EXERCISE FUNDAMENTALS

- Plant the feet firmly on the floor or an elevated platform.
- Place the sacrum, shoulder blades, and head firmly against the bench. Maintain a natural arch in the lower back.
- Position the arms straight up at approximately 90 degrees of flexion.
- Lower the forearms, keeping them in line until they form an approximate 90-degree angle.
- Hold, continue to contract the triceps, and return to the starting position.

Leg Exercises--squats; lunges; leg press; leg extension; leg curl and calf raises.

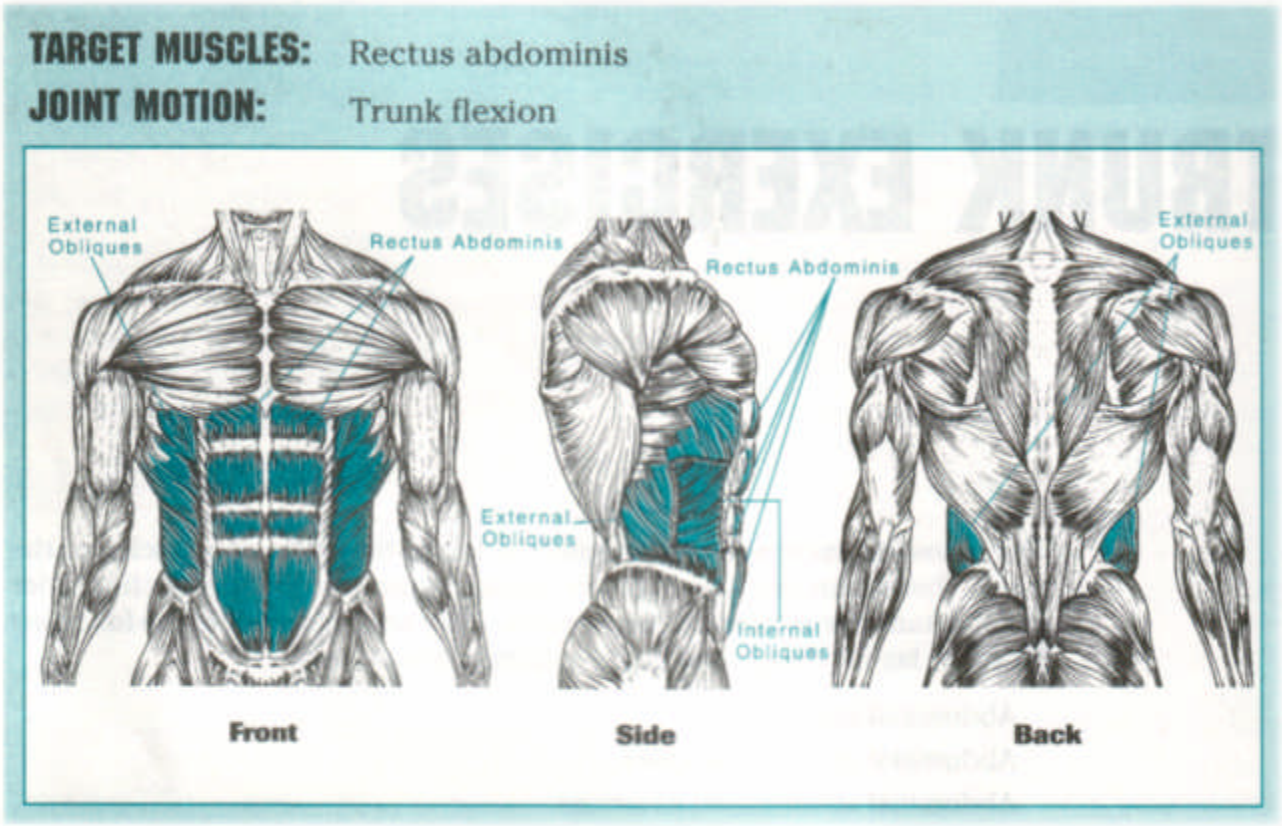
Lunges



LUNGE EXERCISE FUNDAMENTALS

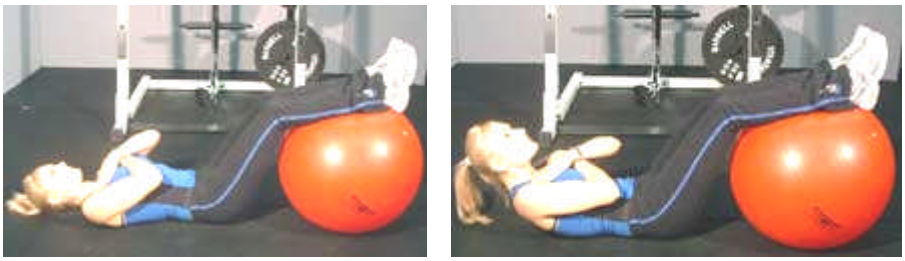
- Stand in a ready position with legs aligned directly under the hips, feet pointed forward, and knees slightly flexed.
- Take a long stride forward with the lead leg landing softly on the heel.
- Lower the body, keeping the trail leg straight and the knee slightly flexed.
- Keep the weight over the ankle of the lead leg and the knee aligned with the foot.
- Contract the glutes, quads, and hamstrings.
- Keeping the weight over the ankle of the lead leg, pull the trail leg and body back up and forward to your original starting position.

Crunches / Trunk Flexion



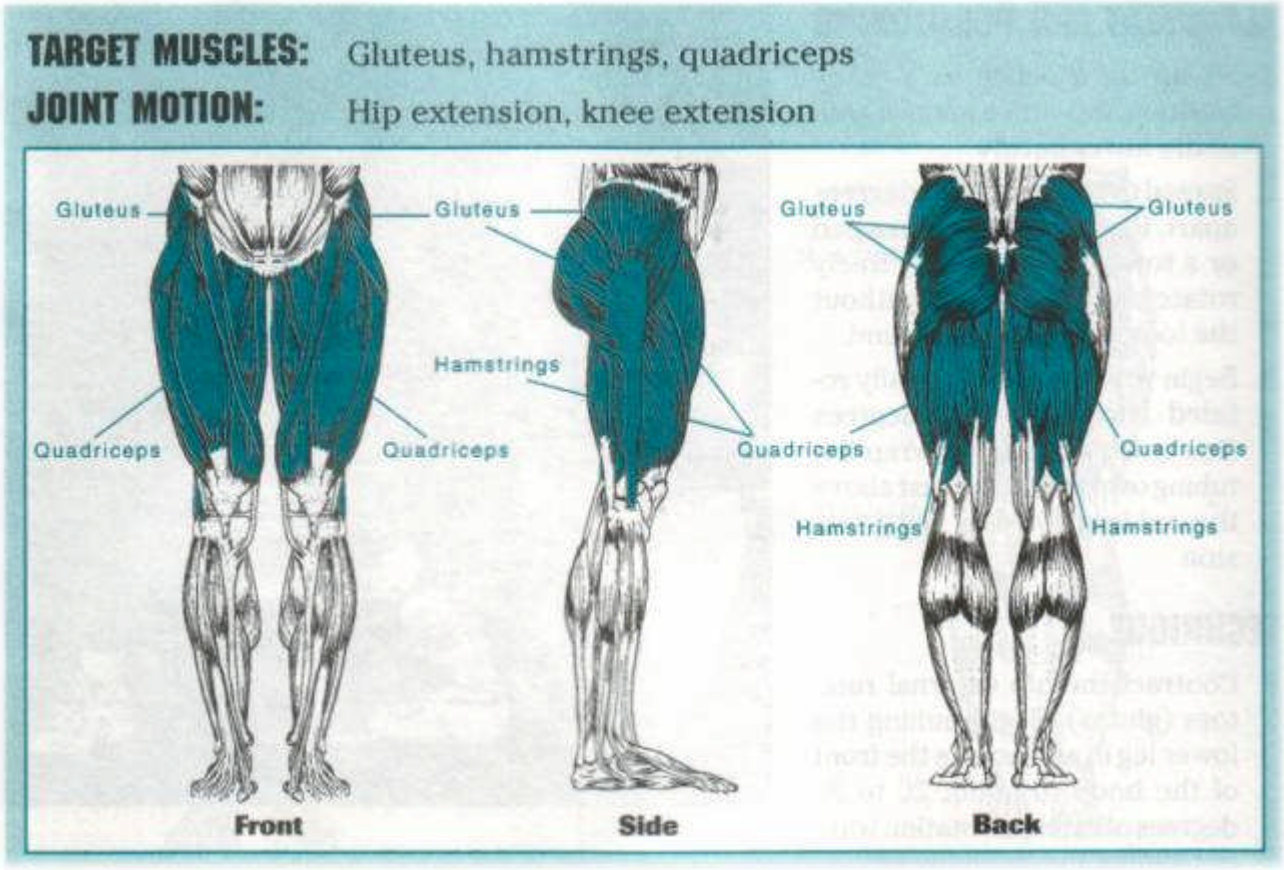
CRUNCH EXERCISE FUNDAMENTALS

- Lie on an inclined, flat, or declined bench or floor with the back flat.
- Place the legs on a chair, bench, or any object or brace the feet against a wall to create about a 45-90 degree angle between the trunk and legs.
- Spread the legs apart in order to limit hip flexor involvement.
- Cross the arms over the chest.
- Contract the abdominals moving only one vertebra at a time keeping the sacrum pressed against the pad.
- Hold, continue to contract the abdominals, and breathe out any remaining air.
- Lower the trunk one vertebra at a time back to its original starting position.



Whole Body Exercises--squats; power cleans (the clean is the movement of the barbell from the floor to a position across the lifter's upper chest while in a standing position); clean and jerk(the jerk portion of the movement is an overhead press) and deadlifts.

Body Weight Squats



SQUAT EXERCISE FUNDAMENTALS

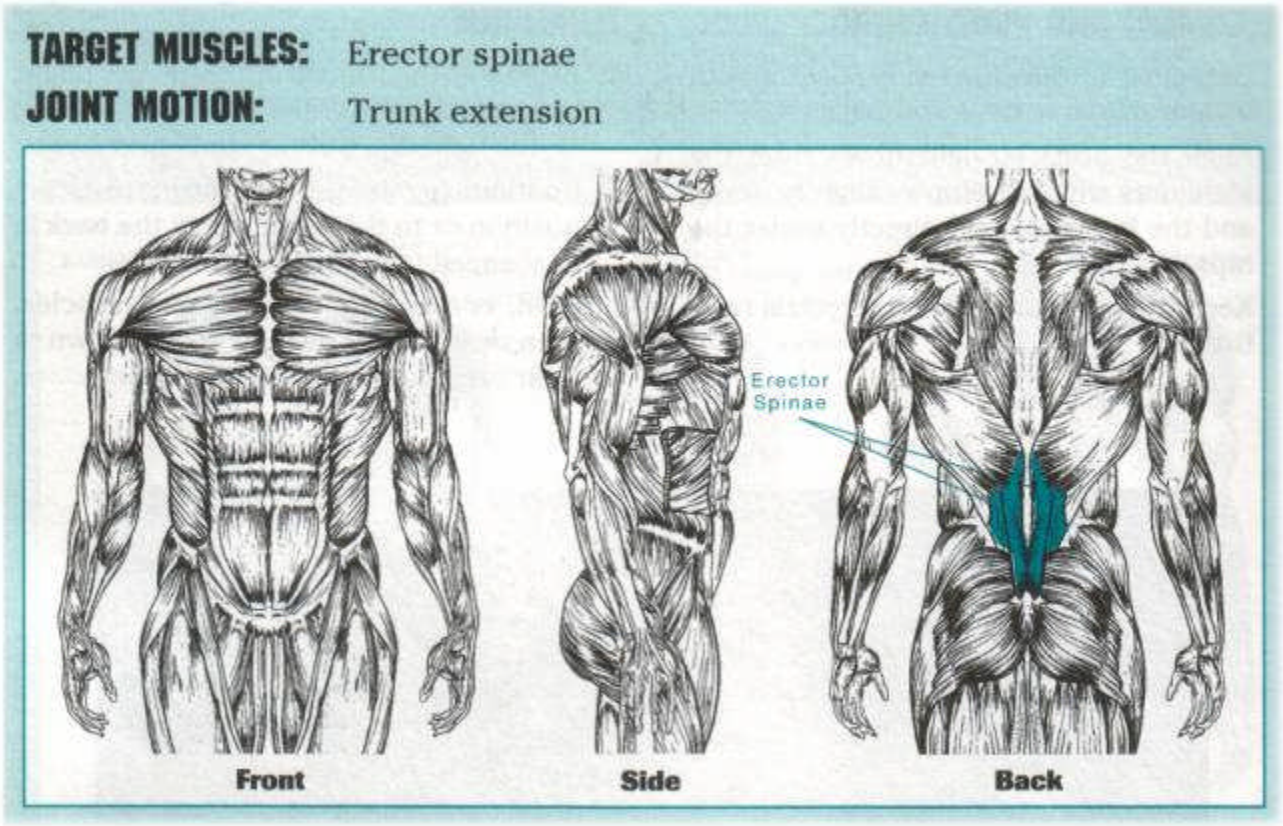
- Position the legs slightly greater than shoulder width and rotate hips and feet out about 20 to 30 degrees.
- Begin with the hips and knees flexed, trunk in a slight forward lean, the spine in a ready position, and weight over the ankles.
- Tilt the pelvis.
- Bend the knees. Slowly begin to lower the body to a point where the legs form an approximate 90-degree angle.
- Contract the glutes, quads, and hamstrings.
- Extend the legs back up to their original starting position.

Calisthenic Exercises--use the weight of the body for resistance. Resistance is adjusted by performing more repetitions or by changing body position. These exercises can be used in conjunction with other forms of resistance exercise or aerobic exercise and are excellent for children, and beginning or advanced exercisers.

Upper--Body Exercises--Straight--leg, bent--knee and assorted modified push--ups; pull--ups and chin--ups.

Back Exercises--Back extensions, and opposite arm and leg raises.

Trunk Extension (Lower Back)



LOWER BACK EXERCISE FUNDAMENTALS

- Lie prone on an inclined, flat, or declined bench or floor.
- Place the arms next to the body, off to the side, or overhead, depending on the desired resistance.
- Begin with the head and chest raised slightly off of the bench to provide tension on the lower-back muscles.
- Contract the erector spinae. Slowly raise the trunk.
- Continue to extend the back slowly, one vertebra at a time, to the point where the erector spinae is fully contracted without any spinal discomfort.
- Hold, continue to contract the erector spinae, then slowly lower the trunk back to its original starting position.

Exercise Training Systems

Single Set System

One of the oldest resistance training programs first espoused in 1925. Consists of a single set of each exercise(8-10 reps) with 5 minute rest between exercises.

Multiple Set System

Consists of two or three warm-up sets of increasing resistance followed by several sets at the same resistance. Became popular in the 1940's.

Bulk System

Multiple set system of three sets of *5-6* repetitions per exercise (increase weight with each set). The bulk system is one of the most effective systems in bringing about increases in static strength of the back and legs and therefore, may be a valuable system for increasing general leg and back strength.

Light-to-Heavy System

Progressing from light to heavy resistances. This system became popular in the 1930's and 1940's among Olympic lifters. It consists of performing a set of three to five reps with light resistance. 5 lbs. are added and another set of 3-5 reps are performed. This is continued until only one repetition can be performed.

The DeLorme Method - three sets of ten reps with resistance progressing from 50%-66%-100% of 10 RM is effective for increasing static leg and back strength.

Heavy-to-Light System

After a brief warm-up, the heaviest set is performed first and for each succeeding set the weight is lowered.

-The Oxford technique is a reversal of the DeLorme system. Research favors a heavy-to-light system over the light-to-heavy for producing strength gains.

Triangle or Pyramid Program

Used by many power lifters. Starts with a light resistance set of 10-20 reps. The resistance is then increased over several sets so that fewer and fewer reps can be performed until a 1 RM. can be performed. Then, over several sets the resistance is decreased in the reverse manner it was increased until a set of 10-12 reps.

Super Set System (2 types)

- One program uses several sets of two exercises for the same body part but two groups of antagonistic muscles (arm curls immediately followed by tricep extensions).
- Second type uses one set of several exercises in rapid succession for the same muscle group or body part. An example is a lat pull-down followed by seated rows followed by bent-over rowing.
- Both types involve sets of 8-10 reps with little or no rest between sets. Popular among body builders and benefits muscular hypertrophy.

Circuit Program

Consists of a series of resistance training exercises that are performed one after the other with minimal rest (15-20 seconds) between exercises. Performing 10-15 reps for each exercise at 40-60% of 1 RM. One major goal of circuit training is to improve cardiovascular conditioning.

Cheat System

Popular among body builders. Involves cheating or breaking of strict form of the exercise. Usually done with barbell curls. The body swing allows the trainee to lift 10-20lbs. more than when following strict form.

Split Routine

Various body parts are trained on alternating days. A typical split routine entails training arms, legs and abdomen on Monday, Wednesday, and Friday, and chest, shoulders and back on Tuesday, Thursday, and Saturday. Sufficient recovery of groups between training sessions is possible because body parts are not trained on successive days. Allows for higher intensity training of a particular body part. The higher intensity should result in greater strength gains.

Forced Repetition System
After a set of exhaustion has been performed, training partners assist the lifter just enough to force out 3-4 reps. Increases local muscle endurance by forcing the muscle to produce force when it is partially fatigued.

Components of Training an Athlete

I. Warm-up

The purpose of the warm up period is to raise the body's temperature and make muscles more pliable. Dynamic flexibility movements should be utilized from the head to the feet. The warm up period should last approximately 15 minutes.

II. Plyometrics

Plyometrics are a series of explosive hopping, skipping, and bounding drills that were originally developed by the Soviets in the 1960's for their high jumpers. The main focus of these drills is to develop the ability to create force very quickly.

- Plyometric drills are an excellent way of improving ones capacity to create explosion which in turn will correlate to improved running speed. Plyometrics have long been considered the best method of training to enhance power, which is basic to all sports.
- The purpose of plyometrics is to develop explosiveness (power) in the muscles that are responsible for movement. This type of training shocks the neuromuscular system so that the athlete is able to accelerate quicker, jump higher, hit harder, run faster, etc. These drills make it possible for the athlete to transfer and use the strength that they have developed in the weight room to the playing field.
- In all plyometric drills (example - bounding, hopping, skipping, etc.) the athlete must think of switching from the yielding (absorbing) contraction to an overcoming (positive) contraction as quickly as possible. When we talk about plyometrics, we are talking about the three R's: RECEIVE, RESIST and REPEL. The KEY to all plyometric drills is to reduce the amount of time on the ground.

Lower Body Plyometrics

- Double Leg Hops - done in multiples of three to five jumps.
- Standing Jump over a barrier such as jumping over a cone or hurdle.
- Stadium Step Hops.
- Basketball Rim Jumps - jump continuously reaching with alternating hands and attempt to reach the rim on every jump.
- Multiple jumps or hops.
- Bounding - exaggeration of normal running 10-100 meters.

Upper Body Plyometrics
Medicine Ball Drills

- Medicine ball push pass to a partner or against a wall.
- Trunk Rotations / Underhand Throw / Overhead Throw / Pullover Pass
- Power Drop - Partner stands and drops a medicine ball to a person lying supine who catches the ball and pushes it back upward to the partner.
- Hands on ball push ups

Push ups – one hand push ups and hand clapping push ups.
Plyometric Volume - The number of foot contacts per work out.
80-100 contacts per session for beginners.
100-120 contacts per session for intermediates.
120-140 contacts per session for advanced athletes.

- Rest Periods - In-depth jumps may consist of 5-10 seconds of rest between repetitions and 2-3 minutes of rest between sets.
- Drills should be thought of as speed training and not conditioning.

- Recovery must be adequate (2-4 days depending on sport and time of year) to prevent over training and injury.

Plyometric Power Building Exercises

Can be added to your exercise regimen approximately 6 weeks after beginning a lifting program and building a solid base of strength.

1. **Standing Long Jump** - Stand in a semi-squat, feet shoulder-width apart. With a big arm swing, jump forward as far as possible. Immediately, jump again.
2. **Two-Footed Box Jump** - Stand next to a box about 12 inches wide, and 30 inches deep. With both feet, jump onto the box, back to the ground on the other side, and then back onto the box again. Try for one touch per second, and continue for the time specified below.
3. **Clapping Push-Up** - Perform a standard push-up, keeping your body straight, but push your body off the floor enough to clap your hands once before landing.
4. **Medicine-Ball Sit-Up** - Sit on the floor with your knees flexed 90 degrees and your upper body leaning slightly backward. Have a partner toss a medicine ball straight toward your chest. Catch the ball, absorbing the impact with your arms as you rock backward. As soon as your lower back hits the floor, sit up and throw the ball straight forward.

III. Speed Training

Speed: the ability of the athlete to go from point A to point B in the shortest amount of time. Although many people feel you are either born with or without speed, many athletes can improve their running speed by improving their running mechanics and techniques.

A normal speed workout will last about 15 - 20 minutes. The athlete should run each repetition only when he feels rested or "fresh."

Speed Improvement Essentials

- **Sprinting must be done year round!**

If you lift weights without working on your sprint speed you will be slow until your body adjusts to the sprinting motion. It may require as long as one month for your body to adapt to sprinting at 100%.

- **Full Recovery Between Sets:**

In order to work on explosive speed, distances must be short 10 to 50 yards, with 100% effort and rest between sets. If an athlete tries to sprint when the body is still recovering from the last sprint, speed enhancement stops and running endurance development begins.

- **Errors in Running Technique**

Head sway - Do not let the head sway in any direction, but maintain a relaxed upright position.

Arm swing - Arm swing should be forward and backward with minimal lateral movement (or horizontal adduction) Lateral movement causes a slight rotation at the shoulders, which decreases running speed. The elbows should be flexed at about 90^{o} and held in this position. Arm swing should come from the shoulder and not involve excessive flexion and extension of the arm itself. In general, the hands should not cross the midline of the body and go no higher than the armpits.

Rear heel kick action - The greater the speed, the higher the heel should kick up. This is a product of pushing off the ground and is known as heel recovery. Improper height of the rear heel kick action will hinder speed of proper leg turnover rate.

Upper body lean - The upper body should have a slight forward lean after the start. The lean should be approximately 45^{o}.

Foot placement - The feet should point straight ahead and should not pronate excessiyely during the support phase. Foot contact should be ball-heel-ball, not on the balls of the foot only.

Relaxation - The runner must be able to relax the body during maximal or near-maximal sprint speed. Hands should not be clenched and the jaw should be relaxed and loose.

- Warm-up and stretch well before the workout.

- Gradually build into top running speed.
- Master short distances before long distances.
- Work on a level surface and use a good pair of shoes.
- Warm down after the workout to facilitate recovery.

Speed Program

- Sprint for 10 yards, 5 repetitions and 3 sets (10 second rest between repetitions and 2 minute rest between sets).
- Sprint for 20 yards, 3 repetitions and 3 sets (same rest intervals as above).
- For maximal speed perform "Flying 50 yard drills", (20 yard jog then 30 yard sprint), 3 repetitions and 2 sets (2 minute rest between repetitions and 4 minute rest between sets).

IV. Torso Exercises

- Abdominal exercises and functional torso exercises to prevent back injury and facilitate the transmission of forces between the upper and lower body.

V. Weight Training

- The athlete must perform explosive lifting movements such as the squat and the clean lifts. These maneuvers cause triple extension of the ankle, knee and hip to occur at one time which facilitates both strength and balance. Performing slow lifting movements is not recommended for an athlete (lift slow to be slow).
- **Lower Body Training** – Sports are leg dominated activities. Athletes with strong legs are less prone to injury. Train to develop the pyramid shaped athlete. Many body builders posses an inverted pyramid shaped body which possesses a higher risk of injury. Lower body training should be performed in the frontal, sagittal, and transverse movement planes.
- **Upper Body Training** – Emphasis should be placed on multiple joint exercise movements.
- **Sets and Reps –** Body builders will typically perform high repetition exercises (10 to 15 repetitions) with low weight and rest periods of approximately one minute. Power lifters will perform low repetition exercises (4 to 6 repetitions) with heavy weight and rest periods of approximately five minutes between sets. For the athlete, nervous system development (muscle memory and neural adaptation) is essential. Athletes should perform explosive exercises utilizing heavy weight and low repetitions.

VI. Cool Down

Perform slow movements for approximately 5 minutes.

Flexibility

Flexibility is the range of possible movement in a joint and its surrounding muscles.

1. Perform general warm-up before stretching.
2. Use slow deliberate movements.
3. Hold static stretches for 10 - 15 seconds.
4. Never bounce while performing static stretches.

Benefits of stretching:

1. Warms the muscles before strenuous training.
2. Lubricates the joints.
3. Decreases chances of injury.

Types of Stretching

Dynamic – Flexibility during sport specific movements. Ex. - high knees for sprinters. Dynamic stretching involves moving parts of your body and gradually increasing reach, speed of movement, or both. Dynamic stretching is performed prior to competition.
Static – Static stretching involves holding a stretched position. Stretch to the farthest point and hold the stretch for approximately 10 to 60 seconds. Static stretching is performed after workouts only.
Ballistic – Ballistic stretching uses the momentum of a moving body or a limb in an attempt to force it beyond its normal range of motion. May produce injury to the muscle or connective tissue.

Dynamic Flexibility

An increasing number of sports scientists believe the classic static stretch before a game or workout is counterproductive. In one study, athletes who stretched statically before a vertical-jump test couldn't jump as high as athletes who did no warm-up at all. In another, runners who performed static stretches were substantially slower than peers who went out of the blocks cold. Dynamic flexibility exercises raise your body temperature and increase your range of motion.

Dynamic Flexibility Exercises

Complete the following dynamic flexibility exercises every Monday, Wednesday, and Friday before doing strength and power exercises.

1. **Windmill** - Stand with your feet shoulder-width apart, arms out to the sides and parallel to the ground. Turn your arms in small forward circles, gradually making wider circles until your arms are nearly perpendicular to the ground. Do one set of 20 repetitions; repeat in the opposite direction.
2. **Prone Push-Up** - Lie face down with your hands planted by your shoulders. Slowly press your upper body up and look toward the ceiling, keeping your hips and lower body flat on the ground. Return to the starting position. Do one set of ten.
3. **High Knee** - March forward, starting with your left foot. Lift your knee as high as it will go on each step (all the way to your chest, if possible), keeping your foot parallel with the ground and your back straight. Do one set of 20 repetitions.

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