Most joints fall into the category of freely movable joints held together by synovial membranes. The elbow and knee joints are essentially hinge joints. The structure of joints surfaces and the strong lateral and medial ligaments limit sideways movements, and posterior ligaments and muscles limit extension. Hence, there is stability and strength in the extended position. In contrast, the shoulder joint is movable in all directions and have less stability.

| **CLASSIFICATION OF JOINTS According to type of** | | | | |
|---|---|---|---|---|
| **Tissue** | **Joint** | | **Movement** | **Example** |
| **Fibrous** | Synarthrosis | Syndesmosis | Immovable | Tibiofibular (distal) |
| | | Sutura | Immovable | Sutura of skull |
| | | Gomphosis | Immovable | Tooth in bony socket |
| **Cartilaginous** | Amphiarthrosis | Synchondrosis | Slightly movable | First sternocostal |
| | | Symphysis | Slightly movable | Symphysis pubis |
| **Synovial** | Diarthrosis | Spheroid or ball-and-socket | All joint movements | Shoulder (2) and hip |
| | | Ginglymus | Flexion and extension | Elbow |
| | | Modified ginglymus | Flexion, extension, and slightly rotation | Knee and ankle |
| | | Ellipsoid or condyloid | All except rotation and opposition | Metacarpophalangeal and metatarsophalangeal |
| | | Trochoid or pivot | Supination, pronation and rotation | Atlantoaxial and radioulnar |
| | | Plane or gliding | Gliding | Head of fibula with lateral condyle of tibia |
| | | Combined ginglymus and gliding | Flexion, extension, and gliding | Temporomandibular |

## TYPES OF STRUCTURE

The gross structure of muscle helps to determine muscle action and affects the way that a muscle responds to stretching. Muscle fibers are arranged in bundles called **fasciculi.** The arrangement of fasciculi and their attachments to tendons varies anatomically. Two main divisions are found in gross structure: fusiform (or spindle) and pennate. A third arrangement, fan-shaped, is probably a modification of the other two but has a distinct significance clinically. In fusiform structure, fibers are arranged essentially parallel to line from origin to insertions, and the fasciculi terminate at both ends of the muscle in flat tendons. In **pennate** structure, fibers are inserted obliquely into the tendon or tendons that extend the length of the muscle on one side (i.e., unipennate) or through the belly of the muscle (i.e., bipennate).

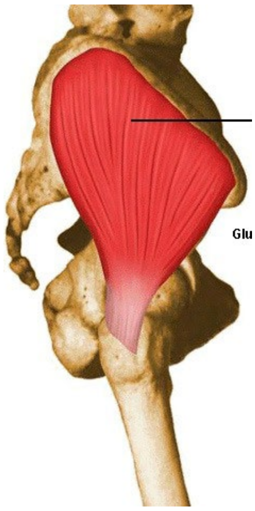
Probably, the long fusiform muscle is the most vulnerable to stretch. The joint motion is in the same direction as the length of the fiber, and each longitidinal component is dependent on every other one.

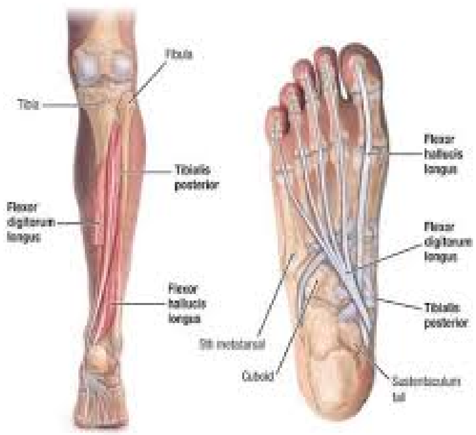
The pennate muscles are probably the least vulnerable to stretch, both because the muscle fiber is oblique to the direction of joint motion and because the fibers and fasciculi are short and parallel and, thereby, are not dependent on other segments for continuity in action.

The fan-shaped muscle has advantages and disadvantage of both. It might be thought of as a group muscles arranged side by side to form a fan-shaped unit. Each segment is independent in that it has its own origin with a common insertion. For example, in the fan-shaped pectoralis major, the clavicular part may be unaffected, but the sternal part paralyzed in a spinal cord lesion.

According to Gray's Anatomy, the "arrangement of fasciculi is correlated with the power of the muscles. those with comparatively few fasciculi, extending the length of the muscle, have a greater range of motion but not as much power. Penniform muscles, with many fasciculi disrupted along their tendons, have grater power but smaller range of motion" (14).

**FUSIFORM** **FAN-SHAPED** **PENNATE**



# RANGE OF JOINT MOTION AND RANGE OF MUSCLE LENGTH

The phrases “range of joint motion” and “range of muscle length have specific meanings. Range of joint motion refers to the number of degrees of motion that are present in a joint. Descriptions of joints and the joint measurements charts included references to normal ranges of joint motion. Range of muscle length, also expressed in terms of degrees of joint motion, refers to the length of the muscle.

For muscles that pass over one joint only, the range of joint motion and range of muscle length will measure the same. Both may be normal, limited, or excessive.

In some instances, when measuring range of joint motion, it is necessary to allow the muscle to be slack over one joint to determine the full range of joint motion in the other. For example, when measuring the range of knee joint flexion, the hip is flexed to allow the rectus femoris to be slack over the hip joint and permit full range of joint motion at the knee. When measuring range of hip joint flexion, the knee is flexed to allow the hamstrings to be slack over the knee joint and permit full range of joint motion at the hip.

## MEASURING JOINT MOTION AND MUSCLE LENGTH

It is easier and more accurate to use a measuring device that permits the stationary arm of caliper to rest on the table and examiner to place the movable arm in line with or parallel to the axis of humerus or femur as the case may be. The fulcrum will be shifted to permit this change, but the angle will remain the same- as if the stationary arm were held parallel to table along the trunk in line with the shoulder joint or hip joint.

## CORRELATION BETWEEN JOINT RANGE AND MUSCLE LENGTH

An interesting correlation exits between total range of joint motion and the range of muscle length chosen as a standard for hamstring and hip flexor length tests. In each case, the muscle length adopted as a standard is approximately %80 the total range of joint motion of two joints over which the muscles pass.

The following are joint ranges considered to be normal:

Hip - 10° extension, 125° flexion, for a total of 135°.

Knee- 0° extension, 140° flexion, for a total of 140°.

Total of both joint- 275°.

**Hip Flexor Length Test Used a Standard:** Supine, with the low back and sacrum flat on table, hip joint extended, and hip flexors elongated 135° over the hip joint. With the knee flexed over the end of table at an angle of 80°, the two-joint hip flexors are elongated 80° over the joint, for a total of 215°. Thus, 215° divided by 275° is 78.18%, and range of muscle length is 78% of total joint range.

Hamstring Length Test Used as a Standard: Supine, with low back and sacrum flat on table and straight-leg raising to an 80° angle with table. Hamstring are elongated 140° over the knee by full extension and 80° over the hip joint by the straight-leg raising, for a total of 220°. Thus, 220° divided ve 275° is 80%, and range of muscle length is 80% of total joint range.

## MUSCLE LENGTH TESTS

Muscle length test are performed to determine whether the range of muscle length is normal, limited, or excessive. Muscles that are excessive in length are usually weak and allow adaptive shortening of opposing muscles; muscles that are too short are usually strong and maintain opposing muscles in a lengthened position.

Muscle length testing consisting of movements that increase the distance between origin and insertion, thereby elongating muscles in directions opposite those of the actions.

Accurate muscles length testing usually requires that the bone of origin be in a fixed position while the bone of insertion moves in the direction of lengthening the muscle. Length tests use passive or active-assisted movements to determine the extent to which a muscle can be elongated.

## PASSIVE INUFFICIENCY

As defined O'Connell and Gardner:

> Passive insufficiency of a muscle is indicated whenever a full range of motion of any joint or joints that the muscle crosses is limited by that the muscle's length, rather than by the arrangement of ligaments or structures of the joint itself (12).

As defined by Kendall et al.

Passive insufficiency. Shortness of a two-joint (or multijoint) muscle; the length of the muscle is not sufficient to permit normal elongation over both joints simultaneously, e.g., short hamstrings (13).

***Note:*** *By both definitions, the term* ***passive insufficiency*** *refers to lack of muscle length. In contrast, the term* ***active insufficiency*** *refers to lack of muscle strength.*

## ACTIVE INSUFFICIENCY

As defined by O'Connell and Gardner:

If a muscle which crosses two or more joints produces simultaneously movement at all the joints that it crosses, it soon reaches a length at which it can no longer generate a useful amount force. Under these conditions, the muscle is said to be actively insufficiency. An example of such insufficiency occurs when one tries to achieve full hip extension with maximal knee flexion. The two-joint hamstrings are incapable of shortening sufficiently to produce a complete range of motion of both joints simultaneously (12).

As defined by Kendall at al.:

Active insufficiency. The inability of a Class III or IV two-joint (or multijoint) muscle to generate an effective force when placed in a fully shortened position. The same meaning is implied by expression "the muscle has been put on a slack" (13).

## TEST FOR STRENGTH – CLASS I & II: AT END RANGE WITH SHORTENING OF MUSCLE

### Class I

One-joint muscles that **actively shorten** (i.e., concentric contraction) through range to completion of joint motion and exhibit maximal strength at completion of range (i.e., short, and strong).

Examples: Triceps, medial and lateral heads; deltoid; pectoralis major; three one-joint thumb muscles; gluteus maximus; iliopsoas; and soleus.

### Class II

Two-joint and multijoint muscles that act like one-joint muscles by **actively shortening** over both or all joints simultaneously and exhibiting maximal strength at competition of range (i.e., short, and strong).

## TEST FOR STRENGTH- CLASS III & IV: AT MIGRANGE OF OVERALL LENGTH OF MUSCLE

### Class III

Two-joint muscles that shorten over one-joint and lengthen over the other to provide midrange of overall muscle length for maximal contraction and strength (as represented by the length-tension curve).

**Examples:** Rectus femoris, hamstrings, and gastrocnemius.

### Class IV

Two-joint or multijoint muscles that physiologically act in one direction but are prevented from overshortening by the coordinated action of synergic muscles.

**Example of Two-Joint Muscles:** The biceps act to flex the shoulder joint and elbow joint. If acting to flex both joints simultaneously, the muscle would become overshortening. To prevent this, the shoulder extensors, as synergist, extend the shoulder joint, thereby lengthening the biceps over the shoulder joint when the elbow is maximally flexed by the biceps.

**Examples of Multijoint Muscle:** İf acting in one direction by flexing the wrists and fingers simultaneously, the finger flexors and extensors would overshorten and become actively insufficient. Nature, however, prevents this from happening. In forceful flexion of fingers, such as when making a fist, the flexors shorten over the finger joints but are prevented from shortening over their entire length by synergic action of wrist extensors that hold the wrist in moderate extension, thereby lengthening the flexors over wrist joint for them to forcefully shorten over the finger joints.

**BASIC RULES OF PROCEDURE THAT APPLY TO MUSCLE STRENGTH TESTING**

Place the subject in a position that offers the best fixation of the body as a whole (usually supine, prone, side-lying).

Stabilize the part proximal to tested part or, as in the case of hand, adjacent to the tested part. Stabilization is necessary for specificity in testing.

Place the part to tested in precise antigravity test position, whenever appropriate, to help elicit the desired muscle action and aid in grading.

Use test movements in the horizontal plane when testing muscles that are too weak to function against gravity. Use test movements in antigravity positions for most trunk muscle tests in which body weight offers sufficient resistance.

Apply pressure directly opposite the line of pull of the muscle or the muscle segment being tested. Like antigravity position, the direction of pressure helps to elicit the desired muscle action.

Use a long lever whenever possible, but not too slowly, unless contraindicated. The length of lever is determined by the location of pressure along the lever arm. Better discriminated by the location of strength for purpose of grading is obtained trough use of a long lever.

The order in which muscles are tested is largely a matter of choice, but it generally is arranged to avoid frequent and unnecessary changes of position for the subject. Muscles that are closely related in position or action tend to appear in a testing order in sequence to distinguish test differences. As a rule, length testing precedes strength testing. When the specific order of tests is important, it is so indicated in the text (See suggested order of muscles test, p. 18).

## TERM USED IN DESCRIPTION OF MUSCLE STRENGTH TESTS

Description of the muscle tests in Chapter 4 through 7 are presented under headings of Patient, Fixation, Test, and Pressure. This capture discusses each of these topics in detail to point out its significance in relation to accurate muscle testing.

### Patient

In the description of each muscle test, this heading is followed by position in which the patient is placed to accomplish the desired test. The position is important in relation to the test in two respects. First, insofar as practical, the position of body should permit function against gravity for all muscles in which gravity is a factor in grading. Second, the body should be placed in such a position that the parts not being tested will remain as stable as possible (This point is discussed further under Fixation).

In all muscle testing, the comfort to the patient and the intelligent handling of affected muscle are important factors. In some instances, the comfort of the patient or the condition of affected muscles will necessitate some modification of the test position. For example, insisting on an antigravity position may result in absurd positioning of a patient. Side-lying, which offers the best test position for several muscles, may be uncomfortable and result in strain of other muscles.

## Fixation

This heading refers to the firmness or stability of the body or body part, which is necessary to insure an action accurate test of a muscle or muscle group. Stabilization (i.e., holding steady or holding down), support (i.e., holding up), and counterpressure (i.e., equal and opposite pressure) are all included under fixation, which implies holding firm. Fixation will be influenced by the firmness of table, body weight, and in some test, the muscles that furnish fixation.

Adequate fixation depends, to a great extent, on the firmness of the examining table, which offers much of the necessary support. Testing and grading of strength will not be accurate if the table on which the patients lies has a thick, soft pad or soft mattress that “gives” as the examiner applies pressure.

Body weight may furnish the necessary fixation. Because the weight of the body is an important factor in offering stability, the horizontal position, whether supine, prone, or side-lying, offers the best fixation for most tests. In the extremities, the body part that proximal to the tested part must be stable. The examiner may stabilize the proximal part in tests of finger, wrist, toe and foot muscles, but in other tests, the body weight should help to stabilize the proximal part. In some instances, the examiner may offer fixation in addition to weight of the proximal part. There may be a needed to hold a part firmly down on the table so that the pressure applied on the distal part (plus the weight of that part) does not displace the weight of the proximal part. In rotation tests, it is necessary for examiner to apply counterpressure to ensure exact test performance (See pp. 321, 322, 429, 431).

In some tests, muscles furnish fixation. The muscles that furnish fixation do not cross the same joint or joints as the muscle being tested. The muscles that stabilize the scapula during arm movements and pelvis during leg movements are referred to as fixation muscles. They do not enter directly into the test movement, but they do stabilize the movable scapula to trunk or pelvis to thorax, and thereby, make it possible for the tested muscle to have a firm origin from which to pull. In the same way, anterior abdominal muscles fix thorax to the pelvis as anterior neck flexors act to lift the head forward in flexion from supine position (See p. 180 regarding action of opposite hip flexors in stabilizing the pelvis during hip extension.). muscle that have an agonistic action give fixation by preventing excessive joint movement. This principle is illustrated by the fixation that the lumbricales and interossei provide in restricting hyperextension at the metacarpophalangeal joint during finger extension. In the presence of weak lumbricales and interossei, the pull of a strong extensor digitorum results in hyperextension of these joints and passive flexion of the interphalangeal joints. This hyperextension does not occur, however, and the fingers can be extended normally if the examiner prevents hyperextension of the metacarpophalangeal joints by fixation equivalent to that of the lumbricales and interossei (See bottom, p. 274).

When the fixation muscles are either too weak or too strong, the examiner can stimulate the normal stabilization by assisting or restricting movement of the part in question. The examiner must be able to differentiate between the normal action of these muscles in fixation and the abnormal actions that occur when substitution or muscle imbalance is present.

## Strength testing

In muscle testing, weakness must be distinguished from restriction of range of motion. Frequently, a muscle can does not complete the normal range of joint motion. It may be that the muscle is too weak to complete the movement, or it may be that range of motion is restricted because of shortness of the muscles, capsule, or ligamentous structures, the body part that is proximal to the tested part must be stable. The examiner should passively carry the part through the range of motion to determine whether any restriction exists. If no restriction is present, then failure by subject to hold the test position may be interpreted as weakness unless joint or tendon laxity is present.

When testing one-joint muscles in which the ability to hold the part at completion of range of motion is excepted, the examiner mush distinguish between muscle weakness and tendon insufficiency. For example, the quadriceps may be strong but unable to fully extend the knee because the patellar tendon or quadriceps tendon has been stretched.

Muscles examinations should consider such superimposed factors as relaxed, unstable joints. The degree of actual muscles weakness is difficult to judge in such cases. From the standpoint of function, the muscle is weak and should be so graded. When the muscle exhibits a strong contraction, however, it is important to recognize this as potential for improvement. In a muscle that fails to function because of joint instability rather than because of weakness of the muscle itself, treatment should be directed at correcting the joint problem and relieving strain on the muscle. Instances are not uncommon in which the deltoid muscle shows a “fullness” of contraction throughout the muscle belly yet cannot begin to lift the weight of the arm. Such a muscle should be protected from strain by application of an adequate support for the express purpose of allowing the joint structures to shorten to their normal position. Failure to distinguish between real and apparent muscle weakness resulting from joint instability may deprive a patient of adequate follow-up treatment.