NERVE AND MUSCLE CHARTS

MUSCLE INNERVATIONS, SPINAL NERVES, AND MUSCLE CHARTS

The recording of test results is an important component of muscle examinations. Records are valuable from the standpoints of diagnosis, treatment, prognosis, and progress. An examination performed without recording the details can be of value at the moment, but one has an obligation to the patient, to the institution (if one is involved), and to oneself to record the findings.

Charts used for recording the findings of muscle examinations should permit complete tabulation of test results. In addition, the arrangement of the information should facilitate its interpretation. There are two charts in this category provided by Florence Kendall: one for the neck, diaphragm, and upper extremity and the other for the trunk and lower extremity. These charts have been designed especially for use as an aid in the differential diagnosis of lesions of the spinal nerves (Box 1-2). The motor involvement, as determined by manual muscle tests, can aid in determining whether a lesion of the nerve exists at the root, plexus, or peripheral level. The charts may also be useful in determining the level of a spinal cord lesion.

Box 1-2

Use of Charts in Differential Diagnosis

- Muscle strength grades are recorded in the column to the left of the muscle names. The grade symbols may be numerals or letters. Grades can be translated as indicated on the *Key to Grading Symbols* .
- After the grades have been recorded, the nerve involvement is plotted, when applicable, by circling the dots under peripheral supply or outlining the numbers under spinal segment distribution that corresponds with each involved muscle (see Chapters 6 and 7).
- The involvement of peripheral nerves and/or parts of the plexus is ascertained from the encircled dots by following the vertical lines upward to the top of the chart or the horizontal to the left margin. When evidence of involvement at spinal segment level exists, the level of the lesion may be indicated by a heavy black line drawn vertically to separate the involved from the uninvolved spinal segments.
- As a rule, muscles graded as good (i.e., 8) or above may be considered as not being involved from a neurological standpoint. This degree of weakness may be the result of factors such as inactivity, stretch weakness, or lack of fixation by other muscles. It should be remembered, however, that a grade of good might indicate a deficit of a spinal segment that minimally innervates the muscle.
- Weakness with grades of fair or less may be the result of inactivity, disuse atrophy, immobilization, or neurological problems. Faulty posture of the upper back and shoulders may cause weakness of the middle and lower trapezius. It is not uncommon to find bilateral weakness of these muscles with grades as low as fair–. A neurological problem with involvement of the spinal accessory nerve is unlikely in cases of isolated weakness of these muscles, unless there is also involvement of the upper trapezius.

Use of the *Spinal Nerve and Muscle Charts* is illustrated by the case studies in Chapters 6 and 7 .

In the upper and lower extremity charts, the names of the muscles appear in the left column and are grouped, as indicated by heavy black lines, according to their innervations, which are listed to the left of the muscle names. The space between the column of muscle names and the nerves is used to record the grade of muscle strength. Following is a brief description of a few sections of these extremity charts.

Peripheral Nerves

Peripheral nerves and their segmental origins are listed across the top of the center of the chart and follow the order of proximal-distal branching insofar as possible. For the peripheral nerves that arise from cords of the brachial plexus, the appropriate cord is indicated. The key at the top of the charts explains the abbreviations used.

Below this section, in the body of the chart, the dots indicate the peripheral nerve supply to each muscle (see Appendix D for sources of material for this section.)

Spinal Segment

In this section, a number denotes the spinal segment origin of nerve fibers innervating each of the muscles listed in the left column (see Appendix D for sources for material for this section).

In the accompanying spinal nerve and muscle charts and subsequent text, distribution is indicated by numbers. Major distribution is indicated by a number in bold type, a small distribution by a number in regular type, and a possible or infrequent distribution by a number in parenthesis.

Sensory

On the right side of the charts are diagrams showing the dermatomes and the distribution of cutaneous nerves for the upper extremity on one and for the trunk and lower extremity on the other (17 , 22).

It is possible to use the illustrations for charting areas of sensory involvement by shading or using a colored pencil to outline the areas of the involvement for any given patient. Only drawings of the right extremity are used on the extremity charts, but labeling can indicate, when necessary, that the recorded information pertains to the left side.

Neck, Diaphragm, and Upper Extremity

See Figure 1-10 for grading muscle strength of the neck, diaphragm, and upper extremity.

Muscle	Spinal Segment
HEAD & NECK EXTENSORS	1 2 3 4 5 6 7 8 1
INFRAHYOID MUSCLES	1 2 3
RECTUS CAP ANT. & LAT.	1 2
LONGUS CAPITIS	1 2 3 (4)
LONGUS COLLI	2 3 4 5 6 (7)
LEVATOR SCAPULAE	3 4 5
SCALENI (A. M. P.)	3 4 5 6 7 8
STERNOCLEIDOMASTOID	(1) 2 3
TRAPEZIUS (U. M. L.)	2 3 4
DIAPHRAGM	3 4 5
SERRATUS ANTERIOR	5 6 7 8
RHOMBOIDS MAJ & MIN	4 5
SUBCLAVIUS	5 6
SUPRASPINATUS	4 5 6
INFRASPINATUS	(4) 5 6
SUBSCAPULARIS	5 6 7
LATISSIMUS DORSI	6 7 8
TERES MAJOR	5 6 7
PECTORALIS MAJ (UPPER)	5 6 7
PECTORALIS MAJ (LOWER)	6 7 8 1
PECTORALIS MINOR	(6) 7 8 1
TERES MINOR	5 6
DELTOID	5 6
CORACOBRACHIALIS	6 7
BICEPS	5 6
BRACHIALIS	5 6
TRICEPS	6 7 8 1
ANCONEUS	7 8
BRACHIALIS (SMALL PART)	5 6
BRACHIORADIALIS	5 6
EXT CARPI RAD L	5 6 7 8
EXT CARPI RAD B	5 6 7 8
SUPINATOR	5 6 (7)
EXT DIGITORUM	6 7 8
EXT DIGITI MINIMI	6 7 8
EXT CARPI ULNARIS	6 7 8
ABD POLLICIS LONGUS	6 7 8
EXT POLLICIS BREVIS	6 7 8
EXT POLLICIS LONGUS	6 7 8
EXT INDICIS	6 7 8
PRONATOR TERES	6 7
FLEX CARPI RADIALIS	6 7 8
PALMARIS LONGUS	(6) 7 8 1
FLEX DIGIT SUPERFICIALIS	7 8 1
FLEX DIGIT PROF I & II	7 8 1
FLEX POLLICIS LONGUS	(6) 7 8 1
PRONATOR QUADRATUS	7 8 1
ABD POLLICIS BREVIS	6 7 8 1
OPPONENS POLLICIS	6 7 8 1
FLEX POLL BREV (SUP. H)	6 7 8 1
LUMBRICALES I & II	(6) 7 8 1
FLEX CARPI ULNARIS	7 8 1
FLEX DIGIT. PROF. III & IV	7 8 1
PALMARIS BREVIS	(7) 8 1
ABD DIGITI MINIMI	(7) 8 1
OPPONENS DIGITI MINIMI	(7) 8 1
FLEX DIGITI MINIMI	(7) 8 1
PALMAR INTEROSSEI	8 1
DORSAL INTEROSSEI	8 1
LUMBRICALES III & IV	(7) 8 1
ADDUCTOR POLLICIS	8 1
FLEX POLL BREV. (DEEP H.)	8 1

Key to peripheral nerves:
D. = Dorsal Prim. Ramus
V. = Vent. Prim. Ramus
P.R. = Plexus Root
S.T. = Superior Trunk
P. = Posterior Cord
L. = Lateral Cord
M. = Medial Cord

Dermatomes redrawn from Keegan and Garrett Anat Rec 102. 409. 437. 1948
Cutaneous Distribution of peripheral nerves redrawn from *Gray's Anatomy of the Human Body.* 28th ed

FIGURE 1-10: Grading muscle strength: neck, diaphragm, and upper extremity. © 1993 Florence P. Kendall.

Trunk and Lower Extremity

See Figure 1-11 for grading muscle strength of the trunk and lower extremity.

underlying influences and implementing a program of positive and preventive educational measures. Both require an understanding of the mechanics of the body and its response to the stresses and strains imposed on it.

Inherent in the concept of good body mechanics are the inseparable qualities of alignment and muscle balance. Examination and treatment procedures are directed toward restoration and preservation of ideal body mechanics in posture and movement. Education and therapeutic exercises to strengthen weak muscles and stretch tight muscles are the chief means by which muscle balance is restored. Ideal body mechanics requires that range-of-joint motion be adequate but not excessive. Normal flexibility is an attribute; excessive flexibility is not. A basic principle regarding joint movements can be summarized as follows: the more flexibility, the less stability; the more stability, the less flexibility. A problem arises, however, because skilled performance in a variety of sport, dance, and acrobatic activities requires excessive flexibility and muscle length. *Although "the more, the better" may apply to improving performance, it may adversely affect the well-being of the performer* .

The following definition of posture was included in a report by the Posture Committee of the American Academy of Orthopedic Surgeons (7). It is so well stated that it bears repeating:

> Posture is usually defined as the relative arrangement of the parts of the body. Good posture is that state of muscular and skeletal balance which protects the supporting structures of the body against injury or progressive deformity, irrespective of the attitude (erect, lying, squatting, or stooping) in which these structures are working or resting. Under such conditions the muscles will function most efficiently, and the optimum positions are afforded for the thoracic and abdominal organs. Poor posture is a faulty relationship of the various parts of the body which produces increased strain on the supporting structures and in which there is less efficient balance of the body over its base of support.

POSTURE AND PAIN

Complaints of pain related to faulty body mechanics are so common that most adults have examples of their own that impact their daily life. Painful lower backs have been the most frequent complaints, although cases of neck, shoulder, arm, foot, and knee pain have become increasingly prevalent (1 , 3 , 5 , 8 , 9).

When discussing pain in relation to postural faults, questions are often asked about why many cases of faulty posture exist without symptoms of pain, and why seemingly mild postural defects give rise to symptoms of mechanical and muscular strain. The answer to both depends on the constancy of the fault and the individual it affects.

A posture may appear to be very faulty, yet the individual may be flexible and the position of the body may change readily, thus limiting the amount of time they spend in the position. Alternatively, a posture may appear to be good, but stiffness or muscle tightness may so limit mobility that the position of the body cannot change readily. The lack of mobility, which is not apparent as an alignment fault but which is detected in tests for flexibility and muscle length, may be the more significant factor.

Basic to an understanding of pain in relation to posture is the concept that the cumulative effects of constant or repeated small stresses over long periods of time can give rise to the same kind of difficulties that occur with a sudden, severe stress. Cases of postural pain are extremely variable in the manner of onset and in the severity of symptoms. In some cases, only acute symptoms appear, usually as a result of an unusual stress or injury. Other cases have an acute onset and develop chronically painful symptoms. Still others exhibit chronic symptoms that later become acute.

Symptoms associated with an acute onset can be focal or widespread. Measures to relieve pain are indicated for these patients. Only after acute symptoms have subsided can tests for underlying faults in alignment and muscle balance be done and specific therapeutic measures be instituted.

Important differences exist between treatment of an acutely painful condition and that of a chronic one. A given procedure may be recognized and accepted as therapeutic if it is applied at the proper time. Applied at the wrong time, this same procedure may be ineffective or even harmful.

Just like an injured neck, shoulder, or ankle, an injured back may need support. Nature's way of providing protection is by protective muscle spasm or muscle guarding, in which the back muscles hold the back rigid to prevent painful movements. Muscles can become secondarily involved, however, when they are overburdened by the work of protecting the back. Use of an appropriate support to immobilize the back can temporarily relieve the muscles of this function, permit healing of the underlying injury, and lead to a decrease in pain.

Immobilization is often a necessary expedient for the relief of pain, but prolonged immobilization can lead to adaptive shortening of the surrounding soft tissue. Stiffness of the body part is not a desirable outcome. The patient should understand that a transition from the acute stage to the recovery stage requires moving from immobilization to restoration of normal motion. Continuing use of a support that should have been discarded can perpetuate a problem that might otherwise resolve. See Box 2-1 for the principles of alignment, joints, and muscles.

Box 2-1

Principles of Alignment, Joints, and Muscles

Evaluating and treating postural problems requires an understanding of the basic principles relating to alignment, joints, and muscles:
- Faulty alignment results in undue stress and strain on bones, joints, ligaments, and muscles.
- Joint positions indicate which muscles appear to be elongated and which appear to be shortened.
- A relationship exists between alignment and muscle test findings if posture is habitual.
- Muscle shortness holds the origin and insertion of the muscle closer together.
- Adaptive shortening can develop in muscles that remain in a shortened condition.
- Muscle weakness allows separation of the origin and insertion of the muscle.

THE STANDARD POSTURE

Posture is a composite of the positions of all the joints of the body at any given moment, and static postural alignment is best described in terms of the positions of the various joints and body segments. This chapter provides basic but essential information for analyzing postural alignment. One must have a clear understanding of the anatomical position as described previously in Chapter 1 . Posture may also be described in terms of muscle balance. This chapter describes the muscle balance or imbalance associated with static postural positions.

As is true in all testing, there must be a standard when evaluating postural alignment. It is essential that the standard be met if the whole system of posture training that is built around it is to be sound. Basmajian and DeLuca states that "among mammals, man has the most economical of antigravity mechanisms once the upright posture is attained. The expenditure of muscular energy for what seems to be a most awkward position is actually extremely economical" (10).

In the *standard position* , the spine presents the normal curves and the bones of the lower extremities are in ideal alignment for weight bearing. The neutral position of the pelvis is conducive to good alignment of the abdomen and trunk and of the extremities below. The chest and thoracic spine are in a position that favors optimal function of the respiratory organs. The head is erect and in a well-balanced position that minimizes stress on the neck musculature (Figure 2-1).

Slightly posterior to apex of coronal suture

Through external auditory meatus

Through odontoid process of axis

Midway through the shoulder

Through bodies of lumbar vertebrae

Through sacral promontory

Slightly posterior to center of hip joint

Slightly anterior to axis of knee joint

Slightly anterior to lateral malleolus

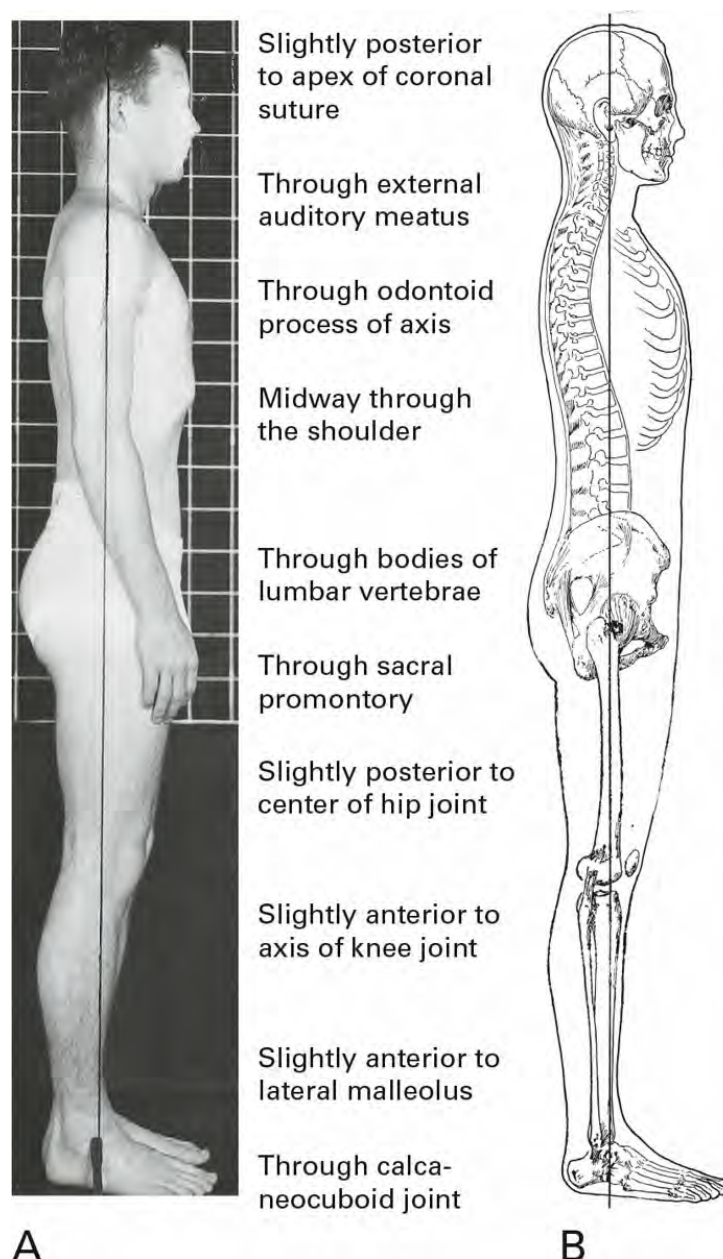Through calcaneocuboid joint

A   B

FIGURE 2-1: Postural examination landmark alignment.

The body contour in illustrations of standard posture shows the relationship of skeletal structures to surface outline in ideal alignment. Variations occur in body type and size, and the shape and proportions of the body are factors in weight distribution. Variations in contour are correlated, to some degree, with variations in skeletal alignment (11 , 12). This is essentially true regardless of body build. An experienced observer should be able to estimate the position of the skeletal

structures by observing the contours of the body (13 , 14).

The intersection of the midsagittal and coronal planes of the body forms a line that is analogous to the *gravity line* (15). Around this line, the body is hypothetically in a position of equilibrium. Such a position implies a balanced distribution of weight and a stable position of each joint.

Various machines are available for use in evaluating postural alignment. These complicated machines, which may be cost prohibitive to most clinics, often introduce variables that are difficult to control. Whitmore and Berman (1996) noted that "[c]ommercially available movement/posture evaluation systems require extensive data collection procedures, rigid camera calibrations, and referencing points" (16). Fortunately, accurate postural examinations can be done with simple equipment at minimal cost. See Table 2-1 for body regions, postural views, and lines of reference.

TABLE 2-1 Body Regions, Postural Views, and Lines of Reference

Body Region	Sagittal View	Posterior View
	Line of Reference	*Line of Reference*
Head and Neck	• Lobe of the ear (through the external auditory meatus)	• Midline of the head Cervical spinous processes
Thoracic Spine		• Thoracic spinous processes
Upper Extremity	• Midway through the glenohumeral joint	
Pelvis and Lumbar Spine	• Posterior to the axis of the hip joint	• Sacral crest, Lumbar spinous processes
Hips and Knees	• Anterior to the axis of the knee joint	

Head and Neck

The ideal alignment of the head and neck is one in which the head is in a well-balanced position that is maintained with minimal muscular effort. The head is not tilted upward or downward, and it is not tilted sideways or rotated. The chin is not retracted.

Good alignment of the thoracic spine is essential for good alignment of the head and neck; faulty alignment of the thoracic spine adversely affects the alignment of the head and neck. If the thoracic spine slumps into a rounded position when sitting or standing, a compensatory change will occur in the position of the head and neck.

If the head position were to remain fixed with the neck held in normal lordosis as the thoracic spine flexed into hyperkyphosis, the head would be inclined forward and downward. However, "eyes seek eye level," and the head must be raised from that position by extending the cervical spine. In normal extension of the cervical spine, there is an approximation of the occiput and the seventh cervical vertebra. As the head is raised to seek eye level, the distance between the occiput and the seventh cervical vertebra is reduced remarkably. Compared with the separation between the two points in ideal alignment, there may be as much as 2 or 3 inches of difference between the two positions.

The forward head position is one in which the neck extensors are in a shortened position and are strong, and the potential exists for the development of adaptive shortening in these muscles. The anterior vertebral neck flexors are in an elongated position and give evidence of weakness when tested for strength. See Figures 2-2 through 2-7 .
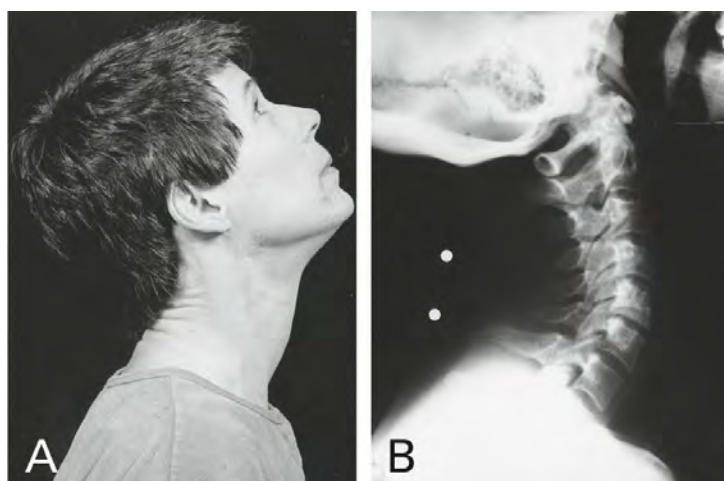

FIGURE 2-2: Subject with normal flexibility was photographed and x-rayed in five neck positions. Markers were placed at the hairline and at C7. The photograph shows cervical spine extension by tilting the head in a posterior direction. Note the approximation of the markers on the x-ray.

FIGURE 2-3: Cervical spine extension in a typical forward-head posture.
Note the similarity in the curve and the positions of the markers to those in Figure 2-2 . Often, this slumped posture is mistakenly referred to as flexion of the lower cervical spine and extension of the upper cervical spine. However, the extension is more pronounced in the lower than in the upper cervical region.
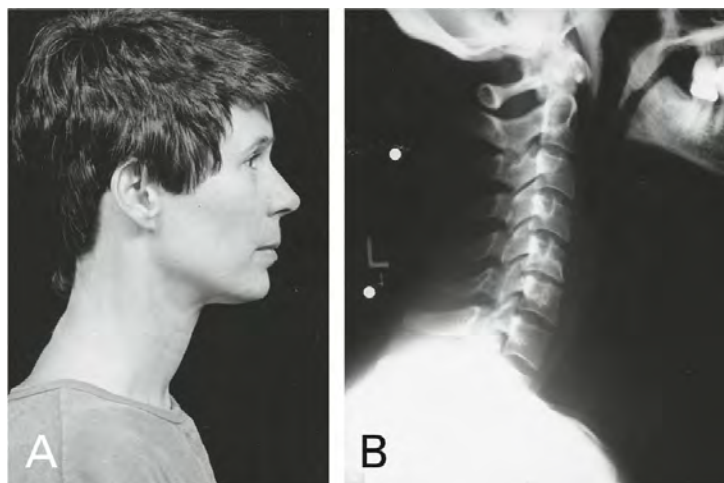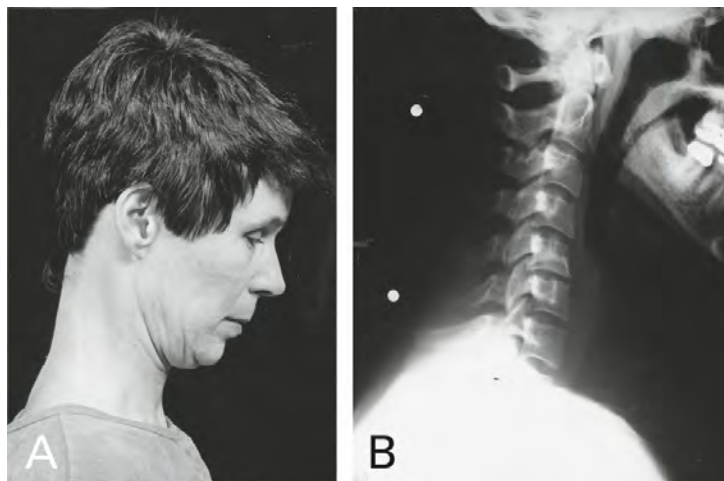

FIGURE 2-4: Good alignment of the cervical spine.

FIGURE 2-5: Flexion (flattening) of the cervical spine by tilting the head in an anterior direction.
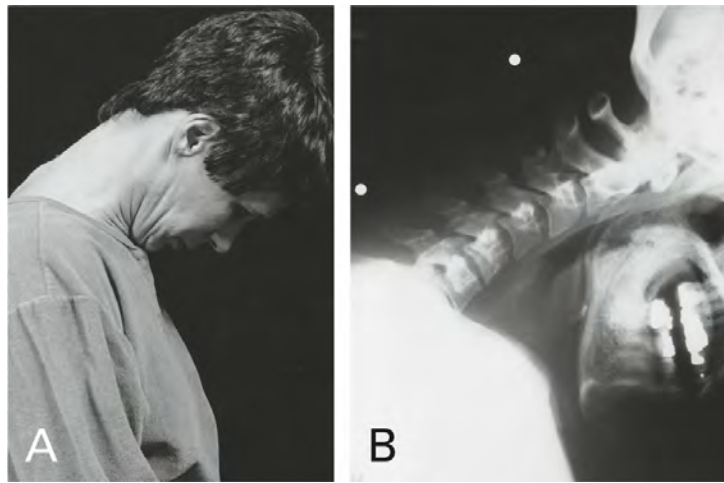
FIGURE 2-6: Flexion of both the cervical spine and the upper thoracic spine occurs when the chin is brought toward the chest.
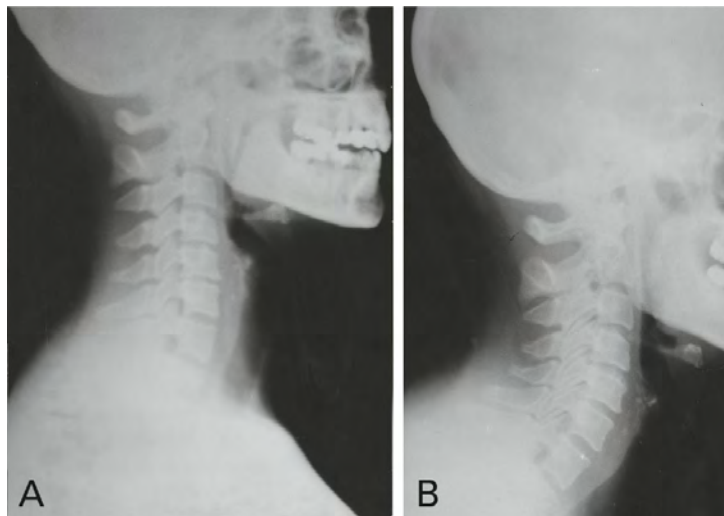

FIGURE 2-7: Cervical spine, good and faulty positions. For the x-ray in **A,** the subject sat erect, with the head and upper trunk in good alignment. For the x-ray in **B,** the same subject sat in a typically slumped position, with a round upper back and a forward head. As illustrated, the cervical spine is in extension.

Thoracic Spine

In ideal alignment, the thoracic spine curves slightly in a posterior direction (kyphosis). Just as the positions of the head and neck are affected by the position of the thoracic spine, the thoracic spine is affected by the positions of the lumbar spine and pelvis. With the pelvis and lumbar spine in ideal alignment, the thoracic spine can assume the ideal position. If a normally flexible individual assumes a position of increased lordosis of the lumbar spine (i.e., increased anterior curve), the thoracic spine tends to straighten, decreasing the normal posterior curve. On the other hand, habitual positions and repetitive activities may give rise to the development of a lordotic-kyphotic posture, in which one tends to compensate for the other. For example, in a sway-back posture, the position of increased posterior curvature of the thoracic spine compensates for a forward deviation of the pelvis (see Figure 2-17 later in this chapter).

Upper Extremity

The position of the arm and shoulder depends on the positions of the scapulae and thoracic spine. In ideal alignment, the scapulae lie flat against the thoracic spine approximately between the second and seventh thoracic vertebrae, and approximately 4 inches apart (more or less depending on the size of the individual). Faulty positions of the scapulae adversely affect the position of the shoulder, and malalignment of the glenohumeral joint can predispose to injury and chronic pain. The elbow will typically rest in slight flexion, the radioulnar joint in slight pronation, the wrist in neutral, and fingers (metacarpophalangeal and interphalangeal joints) in slight relaxed flexion.

Pelvis and Lumbar Spine

The relationship of the pelvis to the line of reference is determined to a great extent by the relationship of the pelvis to the hip joints. Because the sagittal view line of reference represents the plane passing slightly posterior to the axis of the hip joint of the viewed side, the pelvis will be intersected at the acetabula. However, these points of reference are not sufficient to establish the position of the pelvis, because the pelvis can tilt either anteriorly or posteriorly about the axis through the hip

joint.

It is therefore necessary to define the **neutral position of the pelvis** in the standard posture. The neutral position used as the standard in this text is one in which the anterior-superior iliac spine is in the same horizontal plane and in which the anterior-superior iliac spines and the symphysis pubis are in the same vertical plane. From the standpoint of the action of muscles attached to the anterior iliac spine and the symphysis pubis, opposing groups of muscles have an equal mechanical advantage in a straight line of pull. The rectus abdominis, with its attachment on the pubis, extends upward to the sternum, and the rectus femoris, sartorius, and tensor fasciae latae, with their attachments on the anterior iliac spines, extend downward to the thigh.

Because of the structural variations of the pelvis, it is not practical to describe a neutral position on the basis of a specific anterior point and a specific posterior point being in the same horizontal plane. The anterior-superior iliac spines and the posterior-superior iliac spines are approximately in the same plane, however. In neutral position of the pelvis, there is a normal anterior curve (lordosis) in the low back. In anterior tilt of the pelvis, there is a hyperlordosis. In posterior tilt of the pelvis, there is a flat back.

Without minimizing the importance of proper foot positions that establish the base of support, it may be said that the position of the pelvis is the key to good or faulty postural alignment. The muscles that maintain good alignment of the pelvis anteriorly, posteriorly, and laterally are of utmost importance in maintaining good overall alignment. Imbalance between muscles that oppose each other in the standing position changes the alignment of the pelvis and adversely affects the posture of the body parts both above and below.

Hips and Knee

The standard sagittal-view line of reference through the lower extremities passes slightly posterior to the center of the hip joint and slightly anterior to the axis of the knee joint and represents a stable position of the hip and knee joints.

If the center of the hip and knee joints coincides with the line of gravity, there is an equal tendency for those joints to flex or to extend. However, this on-center position of the joint is not a stable one for weight bearing. The slightest force exerted in either direction will cause it to move off center unless it is stabilized by constant muscular effort. If the body must call on muscular effort to maintain a stable position, energy is expended unnecessarily.

If the hip joint and knee joint moved freely in extension as well as in flexion, there would be no stability, and constant effort would be required to resist movement in both directions. A stable off-center position for a joint is dependent on limitation of joint motion in one direction. For the hip and knee, extension is limited. Ligamentous structures, strong muscles, and tendons are the restraining forces preventing hyperextension. Stability in the standing position is obtained by this normal limitation of joint motion.

Exercises or manipulations that tend to hyperextend the knee or hip joint or that excessively stretch muscles such as hamstrings should be scrutinized carefully. The normal restraining influence of the ligaments and muscles helps to maintain good postural alignment with a minimum of muscular effort. When muscles and ligaments fail to offer adequate support, the joints exceed their normal range, and posture can become faulty with respect to the positions of knee and hip hyperextension.

Ankle

The standard line of reference passes slightly anterior to the lateral malleolus and approximately through the apex of the arch, designated laterally by the calcaneocuboid joint. In the standard position, dorsiflexion at the ankle with the knee extended is approximately 10°. This means that standing barefoot with feet in a position of slight out-toeing and with knees straight, the lower leg cannot sway forward on the foot more than about 10°. Forward deviation of the body (dorsiflexion at the ankle) is checked by the restraining tension of strong posterior muscles and ligaments. However, this element of restraint is materially altered with changes in heel height that place the ankle in varying degrees of plantar flexion, and it is appreciably altered if the knees are flexed.

Feet

In the standard posture, the position of the feet is one in which the heels are separated approximately 3 inches and the forepart of the feet are separated so that the angle of out-toeing is approximately 8–10° from the midline on each side, making a total of 20° or less. This position of the feet refers only to the static and barefoot position. Both elevation of the heels and motion affect the position of the feet.

In establishing a standard position of the feet—and in determining where, if at all, out-toeing should occur—it is necessary to consider the foot in relation to the rest of the lower extremity. The out-toeing position cannot occur at the knee, because there is no rotation in extension. In ideal alignment, the axis of the extended knee joint is in a frontal plane. With the knee joint in this plane, out-toeing cannot take place from the knee-joint level. There can be a position of out-toeing as a result of external rotation of the hip. In this case, however, the entire extremity would be externally rotated, and the degree of out-toeing would be exaggerated. This makes the question of whether there should be rotation of the foot into an out-toeing position dependent on the relationship of the foot to the ankle joint. The ankle joint permits dorsiflexion and plantarflexion primarily; it does not permit appreciable rotation. The ankle joint is not positioned entirely in the frontal plane. According to anatomists, it is in a slightly oblique plane. The line of obliquity is such that it extends from slightly anterior at the medial malleolus to slightly posterior at the lateral malleolus. The angle at which the axis of the ankle joint deviates from the frontal plane suggests that the foot is normally in a position of slight out-toeing in relation to the lower leg.

The foot is not a rigid structure. Movements of the subtalar and transverse tarsal joints permit pronation and supination of the foot as well as abduction and adduction of the forefoot. The combination of pronation and forefoot abduction is seen as

eversion of the foot and the combination of supination and forefoot adduction as inversion. Passive or active movements of the foot and ankle reveal that the foot tends to move outward as it moves upward and to move inward as it moves downward.

In the standing position, the foot is not fully dorsiflexed on the leg, nor is it in full eversion. However, the person who stands with flexed knees and marked out-toeing of the feet will be in dorsiflexion and eversion—a position that results in stress and strain on the foot and leg. When influenced by shoes with heels, the standing position represents varying degrees of plantar flexion of the foot, dependent on the heel height. As heel height increases, the tendency toward a parallel position of the feet, or in-toeing, also increases.

The relationship of heel height to out-toeing or in-toeing of the foot is analogous to the position of the foot in standing, walking, and running. When standing barefoot, a slight degree of out-toeing is natural. Standing with heels raised or walking fast, the feet tend to become parallel. As speed increases from walking to sprinting, the heels do not contact the ground, and the weight is borne on the anterior part of the foot entirely. There is then a tendency for the print of the forefoot to show in-toeing.

SECTION II

ALIGNMENT

In the study of body mechanics, **plumb lines** represent the vertical planes. With the anatomical position of the body as the basis, positions and movements are defined in relation to these planes. **Body mechanics** analyzes the static and dynamic forces acting on the body. It is not an exact science, but to the extent that it is possible and meaningful, standards and precision must be incorporated in its study. The ideal alignment of the body is the standard.

When viewing a standing posture, a plumb line is used as a line of reference. The plumb line is a cord with a plumb bob attached to provide an absolute vertical line. The point in line with which a plumb line is suspended must be a standard fixed point. Because the only fixed point in the standing posture is at the base, where the feet are in contact with the floor, the point of reference must be at the base. A movable point is not acceptable as a standard. The position of the head is not stationary; therefore, using the lobe of the ear as a point in line with which to suspend a plumb line is not appropriate.

The plumb line test is used to determine whether the points of reference of the individual being tested are in the same alignment as the corresponding points in the standard posture. The deviations of the various points of reference from the plumb line reveal the extent to which the subject's alignment is considered faulty.

For the purpose of testing, subjects step up to a suspended plumb line. In posterior view, they stand with the feet equidistant from the line. In lateral view, a point just in front of the lateral malleolus is in line with the plumb line.

Deviations from the plumb alignment are described as slight, moderate, or marked rather than in terms of inches or degrees. During routine examinations, it is not practical to determine exactly how much each point of reference deviates from the plumb line.

The standing position may be regarded as a composite alignment of a subject from four views: anterior, posterior, sagittal right, and sagittal left side.

With ideal alignment as the standard, the positions of the head, neck, upper extremities, thoracic spine, lumbar spine, pelvis, and lower extremities are described and illustrated on the following pages.

IDEAL ALIGNMENT: ANTERIOR VIEW

Figure 2-8 shows an anterior view of the ideal alignment.