CHAPTER 4

Motor Development

OBJECTIVES After reading this chapter, the student will be able to

1. Define the life span concept of development.
2. Understand the relationship of cognition and motivation to motor development.
3. Identify important motor accomplishments of the first 3 years of life.
4. Describe the acquisition and refinement of fundamental movement patterns during childhood.
5. Explain age-related changes in functional movement patterns across the life span.
6. Differentiate how age-related systems changes affect posture, balance, and gait in older adults.

INTRODUCTION

The Life Span Concept

Normal developmental change is typically presumed to occur in a positive direction; that is, abilities are gained with the passage of time. For the infant and child, aging means being able to do more. The older infant can sit alone, and the older child can run. With increasing age, a teenager can jump higher and throw farther than a school-age child. Developmental change can also occur in a negative direction. Speed and accuracy of movement decline after maturity. Assessing the ages of the gold medal winners in the last Olympics, it is apparent that motor performance peaks in early adolescence and adulthood. Older adults perform motor activities more slowly and take longer to learn new motor skills. Traditional views of motor development are based on the positive changes that lead to maturity and the negative changes that occur after maturity. This view of development can be visualized as a triangle, as in Figure 4-1. Others have described a leveling off of abilities during adulthood before the decline at old age, which can be defined as beginning at 65 years. This view is depicted in Figure 4-2.

A true life span perspective of motor development includes all motor changes occurring as part of the continuous process of life. This continuous process is not a linear one, as depicted in the previous figures, but rather is a circular process. Although the cycle of life is most often represented as a circle (Fig. 4-3) because it is continuous, a circle can represent only two dimensions and does not adequately depict Erikson’s view of life as an experience that is folded back on itself (Erikson, 1968). He sees the beginning and end of development as more closely related to each other than they are to the years that come in between. We offer a multidimensional representation of this concept of life being folded back on itself, not like an accordion folded back on itself, but as a three-dimensional Möbius strip. This folding back places older adulthood closer to infancy rather than farther away. When taking a strip of paper and merely putting the two ends together to make a circle, the circle will have an inner surface and an outer surface. However, by giving the strip a twist before attaching the ends, something that looks like an infinity sign is produced (∞) (Fig. 4-4). By placing the periods of development along the surface of the strip, it is easier to visualize this new relationship of the periods of development. Tracing along the surface of the strip, it has no break—the design represents one continuous surface, just the way life span development should be conceived. Continuity occurs from beginning to end. The three-dimensional Möbius strip is more reflective of the finding that movement occurs within three domains—physical, psychologic, and social.

The Five Characteristics of a Life Span Approach

Baltes (1987) recognized five characteristics that identify a theoretic approach as having a life span perspective:

- Development is life-long.
- Development is multidimensional.
- Development is plastic and flexible.
- Development is contextual.
- Development is embedded in history.

Although motor development meets all these criteria, not all developmental theories exhibit a life span approach. We have stated that motor skills change throughout a person’s lifetime, not just during the early years. Movement
fosters and supports the development of intelligence and social interaction and is therefore multidimensional. Motor skills are flexible and can change in response to cognitive and social requirements. Although early development usually follows a set sequence of skill acquisition, not every child learns to creep before learning to walk. The surroundings in which a person develops can make a difference in how the person develops. Context can refer to the psychologic, social, or physical surroundings. The time in which a person lives and the person’s life experiences and those of his or her family, friends, and teachers influence the person’s view of life and may affect the acquisition of motor skills. Cultural and child-rearing practices can also affect the developmental sequence.

**Life Span View of Motor Development**

The concept of motor development has been broadened to encompass any change in movement abilities that occurs across the span of life, so changes in the way a person moves after childhood are included. Motor development continues to elicit change from conception to death. Think of the classic riddle of the pharaohs: What creeps in the morning and walks on two legs in the afternoon and on three in the evening? The answer is a human in various stages as an infant who creeps, a toddler who walks alone throughout adulthood, and an older adult who walks with a cane at the end of life.

**DEVELOPMENTAL TIME PERIODS**

Age is the most useful way to measure change in development because it is a universally recognized marker of biologic, psychologic, and social progression. Infants become children, then adolescents, and finally adults at certain ages. Aging is a developmental phenomenon. Stages of cognitive development are associated with age, as are societal expectations regarding the ability of an individual to accept certain roles and functions. Defining these time periods gives everyone a common language when talking about motor development and allows comparison across developmental domains (physical, psychologic, and social). Everyone knows that a 3-year-old child is not an adult, but when does childhood stop and adolescence begin? When does an adult become an older adult? A list of commonly defined time periods that are used throughout the text is found in Table 4-1.

**Infancy**

Infancy is the first period of development and spans the initial 2 years of life following birth. During this time, the infant establishes trust with caregivers and learns to be autonomous.
The world is full of sensory experiences that can be sampled and used to learn about actions and the infant's own movement system. The infant uses sensory information to cue movement and uses movement to explore and learn about the environment. Therefore, home must be baby-proofed from the extremely curious and mobile infant or toddler.

### Childhood

Childhood begins at 2 years and continues until adolescence. Childhood fosters initiative to plan and execute movement strategies and to solve daily problems. The child is extremely aware of the surrounding environment, at least one dimension at a time. During this time, the child begins to use symbols such as language or uses objects to represent things that can be thought of but are not physically present. The blanket draped over a table becomes a fort, or pillows can become chairs for a tea party. Thinking is movement and uses movement to explore and learn about the environment. Therefore, home must be baby-proofed from the extremely curious and mobile infant or toddler.

### Adolescence

Adolescence covers the period right before, during, and after puberty, encompassing different age spans for boys and girls because of the time difference in the onset of puberty. Puberty (and, therefore, adolescence) begins at age 10 for girls and age 12 for boys. Adolescence is 8 years in length regardless of when it begins. Because of the age difference in the onset of adolescence, girls may exhibit more advanced social-emotional behavior than their male counterparts. In a classroom of 13-year-olds, many girls are completing puberty, whereas most boys are just entering it.

Adolescence is a time of change. The identity of the individual is forged, and the values by which the person will live life are embraced. Physical and social-emotional changes abound. The end result of a successful adolescence is the ability to know oneself, the journey ahead, and how to get there. The pursuit of a career or vocation assists the teenager in moving away from the egocentrism of childhood (Erikson, 1968). Cognitively, the teenager has moved into the formal operations stage in which abstract problems can be solved by inductive and deductive reasoning. These cognitive abilities help the individual to weather the adolescent identity crisis. Practicing logical decision making during this period of life prepares the adolescent for the rigors of adulthood, in which decisions become more and more complex.

### Adulthood

Adulthood is achieved by 20 years of age biologically, but psychologically it may be marked by as much as a 5-year transition period from late adolescence (17 years) to early adulthood (22 years). Levinson (1986) called this period the early adulthood transition because it takes time for the adolescent to mature into an adult. Research supports the existence of this and other transition periods. Although most of adulthood has been considered one long period of development, some researchers such as Levinson identify age-related stages. Middle adulthood (age 40) begins, with a 5-year transition from early adulthood, and it ends with a 5-year transition into older adulthood (age 60). Gerontologists, those researchers who study aging, use age 65 as the beginning of old age and further divide older adulthood into three periods: young-old (65 to 74 years); middle-old (75 to 84 years); and old-old (85 years and older) (Atchley, 1991).

### TABLE 4-1 Developmental Time Periods

<table>
<thead>
<tr>
<th>Period</th>
<th>Time Span</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infancy</td>
<td>Birth to 2 years</td>
</tr>
<tr>
<td>Childhood</td>
<td>2 years to 10 years (females)</td>
</tr>
<tr>
<td></td>
<td>2 years to 12 years (males)</td>
</tr>
<tr>
<td>Adolescence</td>
<td>10 years to 18 years (females)</td>
</tr>
<tr>
<td></td>
<td>12 years to 20 years (males)</td>
</tr>
<tr>
<td>Early adulthood</td>
<td>18 to 20 years to 40 years</td>
</tr>
<tr>
<td>Middle adulthood</td>
<td>40 years to 65 years</td>
</tr>
<tr>
<td>Older adulthood</td>
<td>65 years to death</td>
</tr>
<tr>
<td>Young-old</td>
<td>65 years to 74 years</td>
</tr>
<tr>
<td>Middle-old</td>
<td>75 years to 84 years</td>
</tr>
<tr>
<td>Old-old</td>
<td>85 years and older</td>
</tr>
</tbody>
</table>

### INFLUENCE OF COGNITION AND MOTIVATION

The three processes—motor development, motor control, and motor learning, which were discussed at length in the last chapter—are influenced to varying degrees by a person’s intellectual ability. Impairments in cognitive ability can affect an individual’s ability to learn to move. A child with mental retardation may not have the ability to learn movement skills at the same rate as a child of normal intelligence. The rate at which developmental change can be expected to occur is decreased in all domains—physical, psychologic, and social. The acquisition of motor skills is often as delayed as the acquisition of other knowledge.

Motivation to move comes from intellectual curiosity. Typically, developing children are innately curious about the movement potential of their bodies. Children move to be involved in some sports-related activities such as tee-ball or soccer. Adolescents often define themselves by their level of performance on the playing field, so a large part of their performance on the playing field, so a large part of their
Piaget's Stages of Cognitive Development

<table>
<thead>
<tr>
<th>Life Span Period</th>
<th>Stage</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infancy</td>
<td>Sensorimotor</td>
<td>Pairing of sensory and motor reflexes leads to purposeful activity</td>
</tr>
<tr>
<td>preschool</td>
<td>Preoperational</td>
<td>Unidimensional awareness of environment begins use of symbols solves problems with real objects classification, conservation induction, deduction</td>
</tr>
<tr>
<td>School age</td>
<td>Concrete operational</td>
<td>solves abstract problems</td>
</tr>
<tr>
<td>Pubescence</td>
<td>Formal operational</td>
<td></td>
</tr>
</tbody>
</table>

is visually depicted in Figure 4-5. A self-actualized person is self-assured, autonomous, and independent; is oriented to solving problems; and is not self-absorbed. Although Maslow’s theory may not appear to be embedded in history, it tends to transcend any one particular time in history by being universally applicable.

Erikson described stages that a person goes through to establish personality. These stages are linked to ages in the person’s life, with each stage representing a struggle between two opposing traits. For example, the struggle in infancy is between trust and mistrust. The struggle in adolescence is ego identity. Erikson’s theory as shown in Table 4-3 is an excellent example of a life span approach to development.

Although all three of these psychologists present important information that will be helpful to you when you work with people of different ages, it is beyond the scope of this text to go into further detail. The reader is urged to pursue more information on any of these theorists to add to an understanding of people of different ages and at different stages of psychologic development. A life span perspective can assist in an understanding of motor development by acknowledging and taking into consideration the level of intellectual development the person has attained or is likely to attain.

**DEVELOPMENTAL CONCEPTS**

Many concepts apply to human motor development, but we are going to present only a few of the more widely recognized ones here. These are not laws of development but merely guiding thoughts about how to organize information on motor development. Those to be explored include concepts related to the direction of change in the pattern of skill acquisition and concepts related to the type of movement displayed during different stages of development. The one overriding concept about which all developmentalists agree is the concept that development is sequential (Gesell et al., 1974). The developmental sequence is recognized by most developmental authorities. Areas of disagreement involve the composition of the sequence. Which specific skills are always part of the sequence is debated, and whether one skill in the sequence is a prerequisite for the next skill in the sequence has been questioned.

**Epigenesis**

Motor development is epigenetic. Epigenesis is a theory of development that states that a human being grows and develops from a simple organism to a more complex one through progressive differentiation. An example from the plant world is the description of how a simple, round seed becomes a beautiful marigold. Motor development occurs in an orderly sequence, based on what has come before; not like a tower of blocks, built one on top of the other, but like a pyramid, with a foundation on which the next layer overlaps the preceding one. This pyramid allows for growth and change to occur in more than one direction at the same time (Fig. 4-6). The developmental sequence is generally recognized to consist of the orderly development of head control, rolling, sitting, creeping, and walking. This sequence is

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**TABLE 4-3 **Erikson’s Eight Stages of Development

<table>
<thead>
<tr>
<th>Life Span Period</th>
<th>Stage</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infancy</td>
<td>Trust versus mistrust</td>
<td>Self-trust, attachment</td>
</tr>
<tr>
<td>Late infancy</td>
<td>Autonomy versus shame or doubt</td>
<td>Independence, self-control</td>
</tr>
<tr>
<td>Childhood (preschool)</td>
<td>Initiative versus guilt</td>
<td>Initiation of own activity</td>
</tr>
<tr>
<td>School age</td>
<td>Industry versus inferiority</td>
<td>Working on projects for recognition</td>
</tr>
<tr>
<td>Adolescence</td>
<td>Identity versus role confusion</td>
<td>Sense of self: physically, socially, sexually</td>
</tr>
<tr>
<td>Early adulthood</td>
<td>Intimacy versus isolation</td>
<td>Relationship with significant other</td>
</tr>
<tr>
<td>Middle adulthood</td>
<td>Generativity versus stagnation</td>
<td>Guiding the next generation</td>
</tr>
<tr>
<td>Late adulthood</td>
<td>Ego integrity versus despair</td>
<td>Sense of wholeness, vitality</td>
</tr>
</tbody>
</table>

known as the gross-motor milestones. The rate of change in acquiring each skill may vary from child to child within a family, among families, and among families of different cultures. Sequences may overlap as the child works on several levels of skills at the same time. For example, a child can be perfecting rolling while learning to balance in sitting. The lower-level skill does not need to be perfect before the child goes on to try something new. Some children even bypass a stage such as creeping and go on to another higher-level skill such as walking without doing themselves any harm developmentally (Long and Toscano, 2002).

**Directional Concepts of Development**

Development tends to proceed from cephalic to caudal, proximal to distal, mass to specific, and gross to fine.

**Cephalic to Caudal**
The concept of cephalocaudal development relates to the finding that head control is developed before control of the trunk and that, in general, upper extremity usage is mastered before skillful use of the lower extremities. However, this concept does not imply that head movements are perfected before body or trunk movements, because the infant develops as a linked structure, so when one part moves, other parts are affected by that movement. Cephalocaudal development is seen in the postnatal development of posture. Head control in infants begins with neck movements and is followed by development of trunk control. Postnatal postural development mirrors what happens in the embryo when the primitive spinal cord closes. Closure occurs first in the cervical area and then progresses in two directions at once, toward the head and the tail of the embryo (Martin, 1989). The infant develops head and neck and then trunk control. Overlap exists between the development of head and trunk control: Think of a spiral beginning around the mouth and spreading outward in all directions encompassing more and more of the body (Fig. 4-7).

**Proximal to Distal**
The second directional concept is that development occurs from proximal to distal in reference to the midline of the body. Because the body is a linked structure, the axis or midline of the body must provide a stable base for head, eye, and extremity movements to occur with any degree of control. The trunk is the stable base for head movement above and for limb movement distally. Imagine what would happen if you could not maintain an erect sitting posture without the use of your arms and you tried to use your arms to catch a ball thrown to you. You would have to use your arms for support, and if you tried to catch the ball, you would probably fall. Or imagine not being able to hold your head up. What chance would you have of being able to follow a moving object with your eyes? Early in development, the infant works to establish midline neck control by lifting the head from the prone position, then establishes midline trunk control by extending the spine against gravity, followed by establishing proximal shoulder and pelvic girdle stability through weight bearing. In some positions, the infant uses the external environment to support the head and trunk to move the arms and legs. Reaching with the upper extremities is possible early in development but only with external trunk support, as when placed in an infant seat in which the trunk is supported. Once again, the infant first controls the midline of the neck, then the trunk, followed by the shoulders and pelvis, before finally controlling the arms, legs, hands, and feet.

**Mass to Specific**
The third directional concept to be presented here is that development proceeds from mass movements to specific
movements or from simple movements to complex movements. This concept can be interpreted in several different ways. Mass can refer to the whole body, and specific can refer to smaller parts of the body. For example, when an infant moves, the entire body moves; movement is not isolated to a specific body part. Infant movement is characterized by the mass movements of the trunk and limbs. The infant learns to move the body as one unit, as in log rolling, before being able to move separate parts. The ability to separate movement in one body part from movement in another body part is called dissociation. Mature movements are characterized by dissociation, and typical motor development provides many examples. When an infant learns to turn her head in all directions without trunk movement, the head can be said to be dissociated from the trunk. Reaching with one arm from a prone on elbows position is an example of limb dissociation from the trunk. While the infant creeps on hands and knees, her limb movements are dissociated from trunk movement. Additionally, when the upper trunk rotates in one direction and the lower trunk rotates in the opposite direction during creeping (counterrotation), the upper trunk is dissociated from the lower trunk and vice versa.

**Gross to Fine**

This last directional concept involves the direction of overall change in movement skill acquisition, which is from gross, large muscle movement to fine, more discrete movement. Although this concept is similar to the previous one of mass movements coming before specific movements, it has relevance for the differentiation between gross-motor and fine-motor developmental sequences. Arm and leg thrusts occur in play before the infant reaches with a single limb. Mass grasp is possible before individual finger movements. Remember that the infant learns to move and respond on many levels at the same time. Not all gross-motor skills come before fine-motor skills.

**Reciprocal Interweaving**

Periods of stability and instability of motor patterns have been observed by many developmentalists. Gesell and colleagues (1974) presented the concept of reciprocal interweaving to describe the cyclic changes they observed in the motor control of children over the course of early development. Periods of equilibrium were balanced by periods of disequilibrium. Head control, which appears to be fairly good at one age, may seem to lessen at an older age, only to recover as the infant develops further. At each stage of development, abilities emerge, merge, regress, or are replaced. During periods of disequilibrium, movement patterns regress to what was present at an earlier time, but after a while, new patterns emerge with newfound control. At other times, motor abilities learned in one context, such as control of the head in the prone position, may need to be relearned when the postural context is changed, for example, when the child is placed in sitting. Some patterns of movement appear at different periods depending on need. The reappearance of certain patterns of movement at different times during development can also be referred to as reciprocal interweaving. One of the better examples of this reappearance of a pattern of movement is seen with the use of scapular adduction. Initially, this pattern of movement is used by the infant to reinforce upper trunk extension in the prone position. Later in development, the toddler uses the pattern again to maintain upper trunk extension when beginning to walk. This use in walking is described as a high guard position of the arms.

**Kinesiologic Concepts**

**Physiologic Flexion to Antigravity Extension to Antigravity Flexion**

The next concepts to be discussed are related to changes in the types of movement displayed during different stages of development. Some movements are easier to perform at certain times during development. Factors affecting movement include the biomechanics of the situation, muscle strength, and the level of neuromuscular maturation and control. Full-term babies are born with predominant flexor muscle tone (physiologic flexion). The limbs and trunk naturally assume a flexed position (Fig. 4-8). If you try to straighten or uncoil any extremity, it will return to its original position easily. It is only with the influence of gravity, the infant’s body weight, and probably some of the early reflexes that the infant begins to extend and lose the predisposition toward flexion. As development progresses, active movement toward extension occurs. This is an example of the concept of flexion moving toward extension. Antigravity extension is easiest to achieve early on because the extensors are in lengthened position from the effect of the newborn’s physiologic flexed posture. The extensors are ready to begin functioning before the shortened flexors. The infant progresses from being curled up in a fetal position, dominated by gravity, to exhibiting the ability to extend against gravity actively. Antigravity flexion is exhibited from the supine position and occurs later than antigravity extension.

**Kinesiologic Types of Movements**

Bly (1983) described the developmental process as a trend from random movements of the entire body to asymmetric movements to bilateral symmetric movements of the head.
and trunk against gravity in the prone, supine, and side-lying positions. Next she described alternating reciprocal movements of the limbs followed by unilateral symmetric movements of the head and trunk that result in lateral bending, with the final accomplishment of bilateral diagonal movements as in trunk rotation or limb action in creeping or walking. Once antigravity control of the head and trunk is accomplished, lateral trunk flexion and rotation can occur. Lateral flexion of the head and trunk is possible only if the extensor and flexor muscles of the head and trunk are equally strong and balanced. If either muscle group is stronger, pure lateral flexion will not be possible. Voluntary lateral trunk flexion is present developmentally before voluntary trunk rotation. The entire progression of change in movement patterns for the head and trunk is from physiologic flexion to antigravity extension to antigravity flexion to lateral flexion and, finally, to rotation. Movement patterns of the extremities change from flexion and adduction to extension and abduction.

**DEVELOPMENTAL PROCESSES**

Motor development is a result of three processes—growth, maturation, and adaptation.

**Growth**

_Growth_ is any increase in dimension or proportion. Examples of ways that growth is typically measured include size, height, weight, and head circumference. Infants’ and children’s growth is routinely tracked at the pediatrician’s office by use of growth charts (Fig. 4-9). Growth is an important parameter of change during development because some changes in motor performance can be linked to changes in body size. Typically, the taller a child grows, the farther she can throw a ball. Strength gains with age have been linked to increases in a child’s height and weight (Malina et al., 2004). Failure to grow or discrepancies between two growth measures can be an early indicator of a developmental problem.

**Maturation**

_Maturation_ is the result of physical changes that are due to preprogrammed internal body processes. Maturational changes are those that are genetically guided, such as myelination of nerve fibers, the appearance of primary and secondary bone growth centers (ossification centers), increasing complexity of internal organs, and the appearance of secondary sexual characteristics. Some growth changes, such as those that occur at the ends of long bones (epiphyses), occur as a result of maturation; when the bone growth centers, which are under genetic control, are active, length increases. After these centers close, growth is stopped, and no more change in length is possible.

**Adaptation**

_Adaptation_ is the process by which environmental influences guide growth and development. Adaptation occurs when physical changes are the result of external stimulation.

An infant adapts to being exposed to a contagion such as chickenpox by developing antibodies. The skeleton is remodeled during development in response to weight bearing and the muscular forces (Wolfe’s law) exerted on it during functional activities. As muscles pull on bone, the skeleton adapts to maintain the appropriate musculotendinous relationships with the bony skeleton for efficient movement. This same adaptability can cause skeletal problems if musculotendinous forces are abnormal (unbalanced) or misaligned and may thus produce a deformity.

**GROSS- AND FINE-MOTOR MILESTONES**

The motor milestones and the ages at which these skills can be expected to occur can be found in Tables 4-4 and 4-5. Remember the wide variation in time frames during which milestones are normally achieved. _Gross motor_ refers to large muscle movements, and _fine motor_ refers to small muscle movements.

**Gross-Motor Milestones**

**Head Control**

An infant should exhibit good head control by 4 months of age. The infant should be able to keep the head in line with the body (ear in line with the acromion) when pulled to sit from the supine position (Fig. 4-10). When the infant is held upright in a vertical position and is tilted in any direction, the head should tilt in the opposite direction. A 4-month-old infant, when placed in a prone position, should be able to lift the head up against gravity past 45 degrees (Fig. 4-11). The infant acquires an additional component of antigravity head control, the ability to flex the head from supine position, at 5 months.

**Segmental Rolling**

Rolling is the next milestone. Infants log roll (at 4 to 6 months) before they are able to demonstrate segmental rotation (at 6 to 8 months). When log rolling, the head and trunk move as one unit without any trunk rotation. Segmental rolling or rolling with separate upper and lower trunk rotation should be accomplished by 6 to 8 months of age. Rolling from prone to supine precedes rolling from supine to prone because extensor control precedes flexor control. The prone position provides some mechanical advantage because the infant’s arms are under the body and can push against the support surface. If the head, the heaviest part of the infant, moves laterally, gravity will assist in bringing it toward the support surface and will cause a change of position.

**Sitting**

This next milestone represents a change in functional orientation for the infant. Independent sitting is typically achieved by 8 months of age (Fig. 4-12). _Sitting independently_ is defined as sitting alone when placed. The back should be straight, without any kyphosis. No hand support is needed when an infant sits independently. The infant does not have
FIGURE 4-9. Growth chart. (Used with permission of Ross Products Division, Abbott Laboratories Inc., Columbus, OH 43216. From NCHS Growth Charts © 1982, Ross Products Division, Abbott Laboratories Inc.)
TABLE 4-4 Gross-Motor Milestones

<table>
<thead>
<tr>
<th>Milestone</th>
<th>Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head control</td>
<td>4 months</td>
</tr>
<tr>
<td>Rolling</td>
<td>6 to 8 months</td>
</tr>
<tr>
<td>Sitting</td>
<td>8 months</td>
</tr>
<tr>
<td>Creeping</td>
<td>9 months</td>
</tr>
<tr>
<td>Cruising</td>
<td>10 months</td>
</tr>
<tr>
<td>Walking</td>
<td>12 months</td>
</tr>
</tbody>
</table>

TABLE 4-5 Fine-Motor Milestones

<table>
<thead>
<tr>
<th>Milestone</th>
<th>Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>Palmar grasp reflex</td>
<td>Birth</td>
</tr>
<tr>
<td>Raking</td>
<td>5 months</td>
</tr>
<tr>
<td>Voluntary palmar grasp</td>
<td>6 months</td>
</tr>
<tr>
<td>Radial palmar grasp</td>
<td>7 months</td>
</tr>
<tr>
<td>Radial digital grasp</td>
<td>9 months</td>
</tr>
<tr>
<td>Inferior pincer grasp</td>
<td>9 to 12 months</td>
</tr>
<tr>
<td>Superior pincer grasp</td>
<td>12 months</td>
</tr>
<tr>
<td>Three-jaw chuck</td>
<td>12 months</td>
</tr>
</tbody>
</table>

FIGURE 4-10. Head in line with the body when pulled to sit.


FIGURE 4-12. Sitting independently.

to assume a sitting position but does have to exhibit trunk rotation while in the position. The ability to turn the head and trunk is important for interacting with the environment and for dynamic balance.

**Cruising and Creeping**

By 9 months of age, most infants are pulling up to stand and are cruising around furniture. **Cruising** is walking sideways while being supported by hands or tummy on a surface (Fig. 4-13). The coffee table and couch are perfect for this activity because they are usually the correct height to provide sufficient support to the infant. At the same time or within a month (by 10 months), infants begin to reciprocally creep forward on their hands and knees (Fig. 4-14). **Reciprocal** means that the opposite arm and leg move together and leave the other opposite pair of limbs to support the weight of the body.

**Walking**

The last major gross motor milestone is walking (Fig. 4-15). The new walker assumes a wide base of support, with legs abducted and externally rotated; exhibits lumbar lordosis; and holds the arms in high guard with scapular adduction. The traditional age range for this skill has been 12 to 18 months; however, an infant as young as 7 months may demonstrate this ability. As with any guidelines, these milestones are suggested times. The most important milestones are probably head control and sitting because if an infant is unable to
achieve control of the head and trunk, control of extremity movements will be difficult if not impossible. It is acceptable for a child to be ahead of typical developmental guidelines; however, delays in achieving these milestones are cause for concern.

**Fine-Motor Milestones**

Fine-motor milestones of development, as presented here, give the ages at which major changes occur in the development of prehension. These are listed in Table 4-5. *Prehension* is the act of grasping. To prehend or grasp an object, an individual must reach for it. Reaching patterns depend on the position of the shoulder. Reaching patterns influence the ability of the hand to grasp objects. Take a moment to try the following reaching pattern. Elevate your scapula and internally rotate your shoulder before reaching for the pencil on your desk. Do not compensate with forearm supination, but allow your forearm to move naturally into pronation. Although it is possible for you to obtain the pencil using this reaching pattern, it would be much easier to reach with the scapula depressed and the shoulder externally rotated.

**Hand Regard**

The infant first recognizes the hands at 2 months of age, when they enter the field of vision (Fig. 4-16). The asymmetric tonic neck reflex, triggered by head turning, allows the arm on the face side of the infant to extend and therefore is in a perfect place to be seen or regarded. Because of the predominance of physiologic flexor tone in the newborn, the hands are initially loosely fisted.

**Reflexive and Palmar Grasp**

The first type of grasp seen in the infant is reflexive, meaning that it happens in response to a stimulus, in this case, touch. In a newborn, touch to the palm of the hand once it opens, especially on the ulnar side, produces a reflexive palmar grasp. Reflexive grasp is replaced by a voluntary palmar grasp by 6 months of age. The infant is no longer compelled by the touch of an object to grasp but may grasp voluntarily. Palmar grasp involves just the fingers coming into the palm of the hand; the thumb does not participate.

**Evolution of Voluntary Grasp**

Once grasp is voluntary at 6 months, a progressive change occurs in the form of the grasp. At 7 months, the thumb begins to adduct, and this allows for a radial palmar grasp. The radial side of the hand is used along with the thumb to pick up small objects such as 1-inch cubes. Radial palmar...
grasp is replaced by radial digital grasp as the thumbs begin to oppose (Figs. 4-17 and 4-18). Objects can then be grasped by the ends of the fingers, rather than having to be brought into the palm of the hand. The next two types of grasp involve the thumb and index finger only and are called pincer grasps. In the inferior pincer grasp, the thumb is on the lateral side of the index finger, as if you were to pinch someone (Fig. 4-19). In the superior pincer grasp, the thumb and index finger are tip to tip, as in picking up a raisin or a piece of lint (Fig. 4-20). An inferior pincer grasp is seen between 9 and 12 months of age, and a superior pincer grasp is evident by 1 year. Another type of grasp that may be seen in a 1-year-old infant is called a three-jaw chuck grasp (Fig. 4-21). The wrist is extended, and the middle and index fingers and the thumb are used to grasp blocks and containers.
Release

As voluntary control of the wrist, finger, and thumb extensors develops, the infant is able to demonstrate the ability to release a grasped object (Duff, 2002). Transferring objects from hand to hand is possible at 5 to 6 months because one hand can be stabilized by the other. True voluntary release is seen around 7 to 9 months and is usually assisted by the infant’s being externally stabilized by another person’s hand or by the tray of a highchair. Mature control is exhibited by the infant’s being able to release an object into a container without any external support (12 months) or by putting a pellet into a bottle (15 months) (Boehme, 1988; Erhardt, 1982). Release continues to be refined and accuracy improved with ball throwing in childhood (Cliff, 1979).

TYPICAL MOTOR DEVELOPMENT

The important stages of motor development in the first year of life are those associated with even months 4, 6, 8, 10, and 12 (Table 4-6). Typical motor behavior of a 4-month-old infant is characterized by head control, support on arms and hands, and midline orientation. Symmetric extension and abduction of the limbs against gravity and the ability to extend the trunk against gravity characterize the 6-month-old infant. An 8-month-old infant demonstrates controlled rotation around the long axis of the trunk that allows segmental rolling, counterrotation of the trunk in crawling, and creeping. The 8-month-old sits alone. A 10-month-old balances in standing, and a 12-month-old walks independently. Although the even months are important because they mark the attainment of these skills, the other months are crucial because they prepare the infant for the achievement of the control necessary to attain these milestones.

Infant

Birth to Three Months

Newborns assume a flexed posture regardless of their position because physiologic flexor tone dominates at birth. Initially, the newborn is unable to lift the head from a prone position. The newborn’s legs are flexed under the pelvis and prevent contact of the pelvis with the supporting surface. If you put yourself into that position and try to lift your head, even as an adult, you will immediately recognize that the biomechanics of the situation are against you. With your hips in the air, your weight is shifted forward, thus making it more difficult to lift your head even though you have more muscular strength and control than a newborn. Although you are strong enough to overcome this mechanical disadvantage, the infant is not. The infant must wait for gravity to help lower the pelvis to the support surface and for the neck muscles to strengthen to be able to lift the head when in the prone position. The infant will be able to lift the head first unilaterally (Fig. 4-22), then bilaterally.

Over the next several months, neck and spinal extension develop and allow the infant to lift the head to one side, to lift and turn the head, and then to lift and hold the head in the midline. As the pelvis lowers to the support surface, neck and trunk extensors become stronger. Extension proceeds from the neck down the back in a cephalocaudal direction, so the infant is able to raise the head up higher and higher in the prone position. By 3 months of age, the infant can lift the head to 45 degrees from the supporting surface. Spinal extension also allows the infant to bring the arms from under the body into a position to support him-


TABLE 4-6 Important Stages of Development

<table>
<thead>
<tr>
<th>Age</th>
<th>Stage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1–2 months</td>
<td>Internal body processes stabilize</td>
</tr>
<tr>
<td></td>
<td>Basic biologic rhythms are established</td>
</tr>
<tr>
<td></td>
<td>Spontaneous grasp and release are established</td>
</tr>
<tr>
<td>3–4 months</td>
<td>Forearm support develops</td>
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<tr>
<td></td>
<td>Head control is established</td>
</tr>
<tr>
<td></td>
<td>Midline orientation is present</td>
</tr>
<tr>
<td>4–5 months</td>
<td>Antigravity control of extensors and flexors begins</td>
</tr>
<tr>
<td></td>
<td>Bottom lifting is present</td>
</tr>
<tr>
<td>6 months</td>
<td>Strong extension-abduction of limbs is present</td>
</tr>
<tr>
<td></td>
<td>Complete trunk extension is present</td>
</tr>
<tr>
<td></td>
<td>Pivots on tummy</td>
</tr>
<tr>
<td>7–8 months</td>
<td>Spontaneous trunk rotation begins</td>
</tr>
<tr>
<td></td>
<td>Trunk control develops along with sitting balance</td>
</tr>
<tr>
<td>9–10 months</td>
<td>Movement progression is seen in crawling,</td>
</tr>
<tr>
<td></td>
<td>creeping, pulling to stand, and cruising</td>
</tr>
<tr>
<td>11–12 months</td>
<td>Independent ambulation occurs</td>
</tr>
<tr>
<td>16–17 months</td>
<td>Carries or pulls an object while walking</td>
</tr>
<tr>
<td></td>
<td>Walks sideways and backward</td>
</tr>
<tr>
<td>20–22 months</td>
<td>Easily squats and recovers toy</td>
</tr>
<tr>
<td>24 months</td>
<td>Arm swing is present during ambulation</td>
</tr>
</tbody>
</table>

self on the forearms (Fig. 4-23). This position also makes it easier to extend the trunk. Weight bearing through the arms and shoulders provides greater sensory awareness to those structures and allows the infant to view the hands while in a prone position.

When in the supine position, the infant exhibits random arm and leg movements. The limbs remain flexed, and they never extend completely. In supine, the head is kept to one side or the other because the neck muscles are not yet strong enough to maintain a midline position. If you wish to make eye contact, approach the infant from the side because asymmetry is present. An asymmetric tonic neck reflex may be seen when the baby turns the head to one side (Fig. 4-24). The arm on the side to which the head is turned may extend and may allow the infant to see the hand while the other arm, closer to the skull, is flexed. This “fencing” position does not dominate the infant’s posture, but it may provide the beginning of the functional connection between the eyes and the hand that is necessary for visually guided reaching. Initially the baby’s hands are normally fisted, but in the first month they open. By 2 to 3 months, eyes and hands are sufficiently linked to allow for reaching, grasping, and shaking a rattle. As the eyes begin to track ever-widening distances, the infant will watch the hands explore the body.

When an infant is pulled to sit from a supine position before age 4 months, the head lags behind the body. Postural control of the head has not been established. The baby lacks sufficient strength in the neck muscles to overcome the force of gravity. Primitive rolling may be seen as the infant turns the head strongly to one side. The body may rotate as a unit in the same direction as the head moves. The baby can turn to the side or may turn all the way over from supine to prone or from prone to supine (Fig. 4-25). This turning as a unit is the result of a primitive neck righting reflex. A complete discussion of reflexes and reactions is presented following this section. In this stage of primitive rolling, separation of upper and lower trunk segments around the long axis of the body is missing.

**Four Months**

Four months is a critical time in motor development because posture and movement change from asymmetric to more symmetric. The infant is now able to lift the head in midline past 90 degrees in the prone position. When the infant is pulled to sit from a supine position, the head is in line with the body. Midline orientation of the head is present when the infant is at rest in the supine position (Fig. 4-26). The infant is able to bring her hands together in the midline and to watch them. In fact, the first time the baby gets both hands to the midline and realizes that her hands, to this point only viewed wiggling in the periphery, are part of her body, a real “aha” occurs. Initially, this discovery may result in hours of midline hand play. The infant can now bring objects to the mouth with both hands. Bimanual hand play is seen in all possible developmental positions. The hallmark motor behaviors of the 4-month-old infant are head control and midline orientation.

Head control in the 4-month-old infant is characterized by being able to lift the head past 90 degrees in the prone position, to keep the head in line with the body when the infant is pulled to sit, and to maintain the head in midline with the trunk when the infant is held upright in the vertical position (see Fig. 4-10) and is tilted in any direction (Fig. 4-27). Midline orientation refers to the infant’s ability...
to bring the limbs to the midline of the body, as well as to maintain a symmetric posture regardless of position. When held in supported sitting, the infant attempts to assist in trunk control. The positions in which the infant can independently move are still limited to supine and prone at this age. Lower extremity movements begin to produce pelvic movements. Pelvic mobility begins in the supine position when, from a hook-lying position, the infant produces anterior pelvic tilts by pushing on her legs and increasing hip extension, as in bridging (Bly, 1983). Active hip flexion in supine produces posterior tilting. Random pushing of the lower extremities against the support surface provides further practice of pelvic mobility that will be used later in development, especially in gait.

**Five Months**

Even though head control as defined earlier is considered to be achieved by 4 months of age, control of the head against gravity in a supine position is not achieved until 5 months of age. At 5 months, the infant exhibits the ability to lift the head off the support surface (antigravity neck flexion). Antigravity neck flexion may first be noted by the caregiver when putting the child down in the crib for a nap. The infant works to keep the head from falling backward when lowered toward the supporting surface. This is also the time when infants look as though they are trying to climb out of their car or infant seat by straining to bring the head forward. When the infant is pulled to sit from a supine position, the head now leads the movement with a chin tuck. The head is in front of the body. In fact, the infant often uses forward trunk flexion to reinforce neck flexion and to lift the legs to counterbalance the pulling force (Fig. 4-28).

As extension develops in the prone position, the infant may occasionally demonstrate a “swimming” posture (Fig. 4-29). In this position, most of the weight is on the tummy, and the arms and legs are able to be stretched out and held up off the floor or mattress. This posture is a further manifestation of extensor control against gravity. The infant plays between this swimming posture and a prone on elbows or prone on extended arms posture (Fig. 4-30). The infant makes subtle weight shifts while in the prone on elbows position and may attempt reaching. Movements at this stage show dissociation of head and limbs, as exemplified by the following movement sequences:

1. Bilateral arm and leg movements are present as compared with previous unilateral movements. The proximal joints, such as the shoulder and pelvic girdles, direct reaching and kicking movements. Just as the pattern of reaching is influenced by shoulder position, kicking can be changed by the position of the pelvis before and during the movement.

2. Pedaling is seen in the lower extremities. Starting with both hips flexed, the infant extends one leg, then the other, and then returns both legs to the original starting position. This leads to reciprocal kicking in which both legs continue to perform reciprocal alternating movements.

3. From a froglike position, the infant is able to lift her bottom off the support surface and to bring her feet into her visual field. This “bottom lifting” allows her to play with her feet and even to put them into her mouth for sensory awareness (Fig. 4-31). This play provides lengthening for the hamstrings and prepares the baby for long sitting. The lower abdominals also have a chance to work while the trunk is supported (Connor et al., 1978).

**Six Months**

A 6-month-old infant becomes mobile in the prone position by pivoting in a circle (Fig. 4-32). The infant is also able to shift
FIGURE 4-28. A, Use of trunk flexion to reinforce neck flexion as the head leads during a pull-to-sit maneuver. B, Use of leg elevation to counterbalance neck flexion during a pull-to-sit maneuver.

FIGURE 4-29. "Swimming" posture, antigravity extension of the body.

FIGURE 4-30. Prone on extended arms.

FIGURE 4-31. Bottom lifting.

FIGURE 4-32. Pivoting in prone.
weight onto one extended arm and to reach forward with the other hand to grasp an object. The reaching movement is counterbalanced by a lateral weight shift of the trunk that produces lateral head and trunk bending away from the side of the weight shift (Fig. 4-33). This lateral bending in response to a weight shift is called a righting reaction. Righting reactions of the head and trunk are more thoroughly discussed in the next section. Maximum extension of the head and trunk is possible in the prone position along with extension and abduction of the limbs away from the body. This extended posture is called the Landau reflex and represents total body righting against gravity. It is mature when the infant can demonstrate hip extension when held away from the support surface supported only under the tummy. The infant appears to be flying (Fig. 4-34). This final stage in the development of extension can occur only if the hips are relatively adducted. Too much hip abduction puts the gluteus maximus at a biomechanical disadvantage and makes it more difficult to execute hip extension. Excessive abduction is often seen in children with low muscle tone and increased range of motion such as in Down syndrome. These children have difficulty performing antigravity hip extension.

Segmental rolling is now present and becomes the preferred mobility pattern when rolling, first from prone to supine, which is less challenging, and then from supine to prone. Antigravity flexion control is needed to roll from supine to prone. The movement usually begins with flexion of some body part, depending on the infant and the circumstances. If enticed with a toy, the infant may reach up and over the body for the toy with the upper extremity. Another infant may lift one leg up and over the body and may allow the weight of the pelvis to initiate trunk rotation. Still another infant may begin the roll with head and neck flexion. Regardless of the body part used, segmental rotation is essential for developing transitional control (Fig. 4-35). Transitional movements are those that allow a change of position such as moving from prone to sitting, from the four-point position to kneeling, and from sitting to standing. Only a few movement transitions take place without segmental trunk rotation, such as moving from the four-point position to kneeling and from sitting to standing. Individuals with movement dysfunction often have problems making the transition from one position to another smoothly and efficiently. The quality of movement affects the individual’s ability to perform transitional movements.
The 6-month-old infant can sit up if placed and supported at the low back or pelvis. The typically developing infant can sit in the corner of a couch or on the floor if propped on extended arms. A 6-month-old cannot purposefully move into sitting from a prone position but may incidentally push herself backward along the floor. Coincidentally, while pushing, her abdomen may be lifted off the support surface, allowing the pelvis to move over the hips, with the end result of sitting between the feet. Sitting between the feet is called *W* sitting and should be avoided in infants with developmental movement problems because it can make it difficult to learn to use trunk muscles for balance. The posture provides positional stability, but it does not require active use of the trunk muscles. Concern also exists about the abnormal stress this position places on growing joints. Concern about this sitting posture in typically developing children is less because these children move in and out of the position more easily, rather than remaining in it for long periods of time.

Having developed trunk extension in the prone position, the infant can sit with a relatively straight back with the exception of the lumbar spine (Fig. 4-36). The upper and middle back are not rounded as in previous months, but the lumbar area may still demonstrate forward flexion. Although the infant’s arms are needed for support initially, with improving trunk control, first one hand and then both hands will be freed from providing postural support to explore objects and to engage in more sophisticated play. When balance is lost during sitting, the infant extends the arms for protection while falling forward. In successive months, this same upper extremity protective response will be seen in additional directions such as laterally and backward.

The pull-to-sit maneuver with a 6-month-old often causes the infant to pull all the way up to standing (Fig. 4-37). The infant will most likely reach forward for the caregiver’s hands as part of the task. A 6-month-old likes to bear weight on the feet and will bounce in this position when held. Back and forth rocking and bouncing in a position seem to be prerequisites for achieving postural control in a new posture (Thelen, 1979). Repetition of rhythmic upper extremity activities is also seen in the banging and shaking of objects during this period. Reaching becomes less dependent on visual cues as the infant uses other senses to become more aware of body relationships. The infant may hear a noise and may reach unilaterally toward the toy that made the sound (Connor et al., 1978; Duff, 2002).

Although complete elbow extension is lacking, the 6-month-old’s arm movements are maturing such that a mid–pronation-supination reaching pattern is seen. A position halfway between supination and pronation is considered neutral. Pronated reaching is the least mature reaching pattern and is seen early in development. Supinated reaching is the most mature pattern because it allows the hand to be visually oriented toward the thumb side, thereby increasing grasp precision (Fig. 4-38). Reaching patterns originate from the shoulder.
because early in upper extremity development, the arm functions as a whole unit. Reaching patterns are different from grasping patterns, which involve movements of the fingers.

**Seven Months**

Trunk control improves in sitting and allows the infant to free one hand for playing with objects. The infant can narrow her base of support in sitting by adducting the lower extremities as the trunk begins to be able to compensate for small losses of balance. Dynamic stability develops from muscular work of the trunk. An active trunk supports dynamic balance and complements the positional stability derived from the configuration of the base of support. The different types of sitting postures such as ring sitting, wide abducted sitting, and long sitting provide the infant with different amounts of support. Figure 4-39 shows examples of sitting postures in typically developing infants with and without hand support. Lateral protective reactions begin to emerge in sitting at this time (Fig. 4-40). Unilateral reach is displayed by the 7-month-old infant (Fig. 4-41), as is an ability to transfer objects from hand to hand.

**Eight Months**

Sitting is the most functional and favorite position of an 8-month-old infant. Because the infant’s back is straight, the hands are free to play with objects or extend and abduct to catch the infant if a loss of balance occurs, as happens less frequently at this age. Upper trunk rotation is demonstrated during play in sitting as the child reaches in all directions for toys (see Fig. 4-39, C). If a toy is out of reach, the infant can prop on one arm and reach across the body to extend the reach using trunk rotation and reverse the rotation to return to upright sitting. With increased control of trunk rotation, the body moves more segmentally and less as a whole. This trend of dissociating upper trunk rotation from lower trunk movement

![Figure 4-37. A and B, Pull-to-sit maneuver becomes pull-to-stand maneuver.](image1)

![Figure 4-38. Supinated reaching.](image2)
began at 6 months with the beginning of segmental rotation. Dissociation of the arms from the trunk is seen as the arms move across the midline of the body. More external rotation is evident at the shoulder (turning the entire arm from palm down, to neutral, to palm up) and allows supinated reaching to be achieved. By 8 to 10 months, the infant’s two hands are able to perform different functions such as holding a bottle in one hand while reaching for a toy with the other (Duff, 2002).

Now the infant can move into and out of sitting by deliberately pushing up from side lying. The infant may bear weight on hands and feet and may attempt to “walk” in this position (bear walking) after pushing backward while belly crawling. Some type of prewalking progression, such as belly crawling (Fig. 4-42), creeping on hands and knees (see Fig. 4-14), or sitting and hitching, is usually present by 8 months. Hitching in a sitting position is an alternative way for some children to move across the floor. The infant scoots on her bottom with or without hand support. We have already noted how pushing up on extended arms can be continued into pushing into sitting. Pushing can also be used for locomotion. Because pushing is easier than pulling, the first type of straight plane locomotion achieved by the infant in a prone position may be backward propulsion. Pulling is seen as strength increases in the upper back and

shoulders. All this upper extremity work in a prone position is accompanied by random leg movements. These random leg movements may accidentally cause the legs to be pushed into extension with the toes flexed and may thus provide an extra boost forward. In trying to reproduce the accident, the infant begins to learn to belly crawl or creep forward.

**Nine Months**

A 9-month-old is constantly changing positions, moving in and out of sitting, including side sitting (Fig. 4-43), and into the four-point position. The infant experiments more and more with the four-point position, rhythmically rocking back and forth and alternately putting weight on arms and legs. In this endeavor, the infant is aided by a new capacity for hip extension and flexion, other examples of the ability to dissociate movements of the pelvis from movements of the trunk. The hands and knees position, or quadruped position, is a less supported position requiring greater balance and trunk control. As trunk stability increases, simultaneous movement of an opposite arm and leg is possible while the infant maintains weight on the remaining two extremities. This form of reciprocal locomotion is called creeping. Creeping is often the primary means of locomotion for several months, even after the infant starts pulling to stand and cruising around furniture. Creeping provides fast and stable travel for the infant and allows for exploration of the environment.

Reciprocal movements used in creeping require counterrotation of trunk segments; the shoulders rotate in one direction while the pelvis rotates in the opposite direction.
Counterrotation is an important element of erect forward progression (walking), which comes later. Other major components needed for successful creeping are extension of the head, neck, back, and arms, and dissociation of arm and leg movements from the trunk. Extremity dissociation depends on the stability of the shoulder and pelvic girdles, respectively, and on their ability to control rotation in opposite directions.

When playing in the quadruped position, the infant may reach out to the crib rail or furniture and may pull up to a kneeling position. Balance is maintained by holding on with the arms rather than by fully bearing weight through the hips. The infant at this age does not have the control necessary to balance in a kneeling or half-kneeling (one foot forward) position. Even though kneeling and half-kneeling are used as transitions to pull to stand, only after learning to walk is such control possible for the toddler. Pulling to stand is a rapid movement transition with little time spent in either true knee standing or half-kneeling. Early standing consists of leaning against a support surface, such as the coffee table or couch, so the hands can be free to play. Legs tend to be abducted for a wider base of support, much like the struts of a tower. Knee position may vary between flexion and extension, and toes alternately claw the floor and flare upward in an attempt to assist balance. These foot responses are considered equilibrium reactions of the feet (Connor et al., 1978) (Fig. 4-44).

Once the infant has achieved an upright posture at furniture, weight shifting by moving from side to side is practiced. While in upright standing and before cruising begins in earnest, the infant practices dissociating arm and leg movements from the trunk by reaching out or backward with an arm while the leg is swung in the opposite direction. When side to side weight shift progresses to actual movement sideways, the baby is cruising. Cruising is done around furniture and between close pieces of furniture. This sideways “walking” is done with arm support and may be a means of working the hip abductors to ensure a level pelvis when forward ambulation is attempted. These maneuvers always make us think of a ballet dancer warming up at the barre before dancing. In this case, the infant is warming up, practicing counterrotation in a newly acquired posture, upright, before attempting to walk (Fig. 4-45). Over the next several months, the infant will develop better pelvic and hip control, to perfect upright standing before attempting independent ambulation.

**Toddler**

**Twelve Months**

The infant becomes a toddler at 1 year. Most infants attempt forward locomotion by this age. The caregiver has probably already been holding the infant’s hands and encouraging walking, if not placing the infant in a walker. Use of walkers has raised some safety issues (Walker et al., 1996); also, use of walkers too early does not allow the infant to sufficiently develop upper body and trunk strength needed for the progression of skills seen in the prone position. Typical first attempts at walking are lateral weight shifts from one widely abducted leg to the other (Fig. 4-46). Arms are held in high guard (arms held high with the scapula adducted, shoulders in external rotation and abducted, elbows flexed, and wrist and fingers extended). This position results in strong extension of the upper back that makes up for the lack of hip extension (Bobath and Bobath, 1962). As an upright trunk is more easily maintained against gravity, the arms are lowered to midguard (hands at waist level, shoulders still externally rotated), to low guard (shoulders more neutral, elbows extended), and finally to no guard.

The beginning walker keeps hips and knees slightly flexed to bring the center of mass closer to the ground. Weight shifts are from side to side as the toddler moves forward by total lower extremity flexion, with the hip joints remaining externally rotated during the gait cycle. Ankle movements are minimal, with the foot pronated as the whole foot contacts the ground. Toddlers take many small steps and walk slowly. The instability of their gait is seen in the short amount of time they spend in single-limb stance (Martin, 1989). As trunk stability improves, the legs come farther under the pelvis. As the hips and knees become more extended, the feet develop the plantar flexion needed for the pushoff phase of the gait cycle.

**Sixteen to Eighteen Months**

By 16 to 17 months, the toddler is so much at ease with walking that a toy can be carried or pulled at the same time. With help, the toddler goes up and down stairs, one step at

FIGURE 4-46. A and B, Independent walking.
a time. Without help, the toddler creeps up the stairs and may creep or scoot down on her buttocks. Most children will be able to walk sideways and backward at this age if they started walking at 12 months or earlier. The typically developing toddler comes to stand from a supine position by rolling to prone, pushing up on hands and knees or hands and feet, assuming a squat, and rising to standing (Fig. 4-47).

Most toddlers exhibit a reciprocal arm swing and heel-strike by 18 months of age, with other adult gait characteristics manifested later. They walk well and demonstrate a “running-like” walk. Although the toddler may still occasionally fall or trip over objects in her path because eye-foot coordination is not completely developed, the decline in falls appears to be the result of improved balance reactions in standing and the ability to monitor trunk and lower extremity movements kinesthetically and visually. The first signs of jumping appear as a stepping-off “jump” from a low object such as the bottom step of a set of stairs. Children are ready for this first step-down jump after being able to walk down a step while they hold the hand of an adult (Wickstrom, 1983). Momentary balance on one foot is also possible.

Two Years

The 2-year-old’s gait becomes faster, arms swing reciprocally, steps are bigger, and time spent in single-limb stance increases. Many additional motor skills emerge during this year. A 2-year-old can go up and down stairs one step at a time, jump off a step with a two-foot takeoff, stand on one foot for 1 to 3 seconds, kick a large ball, and throw a small one. Stair climbing and kicking indicate improved stability during shifting of body weight from one leg to the other (Connor et al., 1978). Stepping over low objects is also part of the child’s movement capabilities within the environment. True running, characterized by a “flight” phase when both feet are off the ground, emerges at the same time. Quickly starting to run and stopping from a run are still difficult, and directional changes by making a turn require a large area. As the child first attempts to jump off the ground, one foot leaves the ground, followed by the other foot, as if the child were stepping in air.

Fundamental Movement Patterns (Three to Six Years)

Fundamental movement patterns such as running and jumping are beginning to be perfected at 2 years, but it takes several years in some instances for these abilities to mature completely. Other fundamental motor skills such as hopping, skipping, throwing, catching, and striking develop over the next 4 years of life. Before discussing these skills, it is important to understand the development of postural control within the context of the two prevailing models of motor control. The reader may want to review Chapter 3. These theories affect how we view the development of postural control in the first 2 years of life and interpret the emergence of new motor skills and fundamental motor patterns in childhood.

Fundamental movement patterns are learned in early childhood and were defined by Wickstrom (1983) as basic motor skills with specific patterns. Running, jumping, galloping, skipping, throwing, catching, kicking, and striking are typically included in the category of fundamental skills. Each fundamental skill can be identified by a minimum standard of performance. The form used to meet the minimum standard of the movement is considered immature and can be improved on to acquire a mature form. Once walking, the child begins to try to walk faster and faster until running develops by age 2 years. The minimum standard for running mandates that the feet move forward alternately and that a brief period of nonsupport occurs after the support foot pushes off. The mature form of running is that of a sprint.

Three Years

The following gait characteristics indicate mature gait, which is usually developed by age 3 or 4 years: both arms and legs move reciprocally in synchrony with each other; out-toeing has been reduced; pelvic rotation and a double knee-lock pattern are present. This pattern refers to the two periods of knee extension in gait, one just before heelstrike and another as the body moves over the foot during stance phase. In between, at the moment of heelstrike, the knee is flexed to help absorb the impact of the body’s weight. A 3-year-old should exhibit heelstrike. By 4 years, 98 percent of toddlers exhibit mature gait characteristics according to Sutherland and co-workers (1988). However, Stout (2001) stated that gait is not mature until a child is 7 years of age.

Other reciprocal actions mastered by 3-year-olds are pedaling a tricycle and climbing a jungle gym or ladder. Locomotion can be started and stopped based on the demands of the environment or those of a task such as playing dodgeball on a crowded playground. A 3-year-old can make sharp turns while running and can balance on toes and heels in standing. Standing with one foot in front of the other, known as tandem standing, is possible, as is standing on one foot for up to 3 seconds. A reciprocal gait is used to ascend stairs; the child places one foot on each step in an alternating fashion but marks time (one step at a time) when descending.

Jumping begins with a step-down jump at 18 months of age and progresses to jumping off the floor with both feet at the same time when the child is 2 (Fig. 4-48). By the time a child is 3 years of age, jumping has continued to change, so the child can jump over an obstacle on the floor by leading with one foot. Types of jumps achieved by children in terms of progressive difficulty can be found in Table 4-7. One-foot jumps come before two-foot jumps, and one-foot landings come before two-foot landings. The time span between achieving various jumps varies greatly. Some possible ages of acquisition are also found in Table 4-7, but these ages vary for different individuals. Jumping skills progress, as evidenced by the ability of a 3½-year-old to jump over an obstacle by taking off with two feet and landing with two feet.

Once jumping off the floor with two feet is mastered, many other types of jumps become possible. At 3 years of age, a child may perform a running broad jump. The child runs and at some point jumps forward. The jump is from one foot,
but the landing is on two feet. Vertical jumps are possible, and the height of the jump increases with age (Fig. 4-49). Hopping on one foot is a special type of jump requiring balance on one foot and pushoff. It does not require a maximum effort. “Repeated vertical jumps from two feet can be done before true hopping can occur” (Wickstrom, 1983). Neither type of jump is seen at an early age. Hopping once or twice on the preferred foot may also be accomplished by 3½ years of age.

Four Years
A 4-year-old has better static and dynamic balance, as evidenced by an ability to stand on either foot for a longer
FIGURE 4-48. Types of jumps. A, First attempts at jumping involve a one-foot step-down. Then the child engages in a two-foot takeoff (B) and later becomes able to jump over obstacles with a one-foot (C) and later a two-foot takeoff and landing (D). (From Cratty BJ. Perceptual and Motor Development in Infants and Children, 2nd edition. Copyright © 1979 by Allyn & Bacon. Reprinted by permission.)

TABLE 4-7 Types of Jumps Achieved by Children in Terms of Progressive Difficulty

<table>
<thead>
<tr>
<th>Approximate Age</th>
<th>Type of Jump</th>
</tr>
</thead>
<tbody>
<tr>
<td>18 months</td>
<td>Jump down from one foot, land on the other foot</td>
</tr>
<tr>
<td>24 months</td>
<td>Jump up from two feet, land on two feet</td>
</tr>
<tr>
<td>26–28 months</td>
<td>Jump down from one foot, land on two feet</td>
</tr>
<tr>
<td>26–28 months</td>
<td>Jump down from two feet, land on two feet</td>
</tr>
<tr>
<td>29–31 months</td>
<td>Run and jump forward from one foot, land on the other foot</td>
</tr>
<tr>
<td>29–31 months</td>
<td>Jump forward from two feet, land on two feet</td>
</tr>
<tr>
<td>29–31 months</td>
<td>Run and jump forward from one foot, land on two feet</td>
</tr>
<tr>
<td>38–42 months</td>
<td>Jump over object from two feet, land on two feet</td>
</tr>
<tr>
<td>42 months</td>
<td>Jump from one foot to same foot rhythmically</td>
</tr>
</tbody>
</table>

period (4 to 6 seconds), than a 3-year-old. A child of 4 years can hop on one foot four to six times. Improved hopping ability is seen when the child learns to use the nonstance leg to help propel the body forward. Previously, all the work had been done by pushing off with the support foot. A similar pattern is observed in the arms, which are inactive at first, but then are used opposite the action of the moving leg. Gender differences for hopping are documented in the literature; girls perform better than boys (Wickstrom, 1983). This difference may be related to the finding that girls appear to have better balance than boys in childhood. Rhythmic relaxed galloping is possible for a 4-year-old. Galloping consists of a walk on the leading leg followed by a running step on the rear leg. Galloping is considered by some to be the first asymmetric gait seen in a young child and subsequently is also called unilateral skipping. Think of a child riding a stick horse as a visual example of galloping. Toddlers have been documented to gallop as early as 20 months after learning to walk (Whitall, 1989), but the movement is stiff, with arms held in high guard, as seen during beginning walking.

Four-year-olds can catch a small ball with outstretched arms if it is thrown to them, and they can throw a ball overhand for some distance. Throwing begins with an accidental letting go of an object at about 18 months of age. From 2 to 4 years of age, throwing is extremely variable, with underhand and overhand throwing observed. Gender differences are seen. A child of 2½ years can throw a large or small ball 5 feet (Fig. 4-50 and Table 4-8) (Wellman, 1937). The ball is not thrown more than 10 feet until the child is more than 4 years of age. The distance a child is able to propel an object has been related to a child’s height, as seen in Figure 4-51 (Cratty, 1979). Development of more mature throwing is related to using the force of the body and combining leg and shoulder movements to improve performance.

“Although throwing and catching have a close functional relationship, throwing is learned a lot more quickly than catching” (Wickstrom, 1977). Catching ability depends on many variables, the least of which is ball size, speed, arm position of the catcher, skill of the thrower, and age-related sensory and perceptual factors. Some of these perceptual factors involve the use of visual cues, depth perception, eye-hand coordination, and the amount of experience the catcher has had with playing with balls. Closing the eyes when an object is thrown toward one is a fear response common in children (Wickstrom, 1977) and has to be overcome to learn to catch or strike an object.

Precatching requires the child to interact with a rolling ball. Such interaction typically occurs while the child sits with legs outstretched and tries to trap the ball with legs or hands. Learning about time and spatial relationships of a moving object proceeds from this seated position to standing and chasing after a rolling or bouncing ball. The child tries to stop, intercept, and otherwise control his movements and to anticipate the movement of the object in space. Next, the child attempts to “catch” an object moving through the air. Before age 3 years, most children must have their arms prepositioned to have any chance of catching a ball thrown to them. Most of the time, the thrower, who is an adult, bounces the ball to the child, so the burden is on the thrower to calculate where the ball must bounce to land in the child’s outstretched arms. Figures 4-52 and 4-53 show two immature catchers, one 33 months old and the other 48 months old. As catching matures, the hands are used more, with less dependence on the arms and the body. The 4-year-old still has maturing to do in perfecting the skill of catching.

Striking, according to Wickstrom (1983), is the act of swinging and hitting an object. Developmentally, the earliest form of striking is for the child to use arm extension to hit something with her hand. When a child is holding an implement such as a stick or bat, the hand extension is increased by the implement but the form results in striking down on the object. Two- to 4-year-olds demonstrate this immature striking behavior. Without any special help, the child will progress slowly to striking more horizontally.
**Five Years**

At 5 years of age, a child can stand on either foot for 8 to 10 seconds, walk forward on a balance beam, hop 8 to 10 times on one foot, make a 2- to 3-foot standing broad jump, and skip on alternating feet. One motor test expects a 5-year-old to be able to hop 50 feet in 11 seconds (Stott et al., 1984). Skipping is a skill that requires coordination of both sides of the body. A 5-year-old should be able to hit a 2-foot square target from a distance of 5 feet, first by throwing underhand, then progressing to overhand, and finally by bouncing the ball to the target (Folio and Fewell, 2000). Half of all 5½-year-olds are able to catch a ball when their hands are initially at their sides. Different motor skills can be expected, depending on the child’s experiences and amount of practice.

Kicking is a special type of striking and one in which the arms play no direct role. Children most frequently kick a ball in spontaneous play and in organized games. A 2-year-old is able to kick a ball on the ground. The Peabody Developmental Motor Scales expect a child of 5 years to kick a ball rolled toward him 12 feet in the air and a child of 6 years to run and kick a rolling ball 4 feet (Folio and Fewell, 2000). Gesell (1940) expected a 5-year-old to

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**FIGURE 4-50.** Wellman graphs. **A,** Ball-catching skill is attained at a certain level of performance with the large ball before the same level of skill is achieved with the small ball. **B,** At 30 months, a small or large ball can be thrown 5 feet. It will take 10 more months for the child to be able to throw the large ball the same distance as the small ball. (Redrawn from Espanschade AS, Eckert HM. *Motor Development.* Columbus, OH, Charles E. Merrill, 1967.)
kicking a soccer ball 8 to 11½ feet and a 6-year-old to be able to kick a ball 10 to 18 feet. Measuring performance in kicking is difficult before age 4 years. Annual improvements begin to be seen at age 5 years (Gesell, 1940). Kicking requires good static balance on the stance foot and counterbalancing the force of the kick with arm positioning.

Hand preference, the tendency to use one particular hand, may be noted as early as a few days after birth to 4 months of age when the infant prefers to swipe or grasp objects with a particular hand. As the child learns to use more and more implements or tools, she experiments with using them in either hand. Hand preference develops because preschoolers practice skilled tasks such as eating with utensils and coloring. According to Levine (1987), hand preference is well established by 4 to 6 years of age. Hand dominance is the consistent use of one hand for tasks such as throwing a ball, writing with a pencil, and eating with a fork (Duff, 2002). Because the definitions of preference and dominance are often confused, the age at which true dominance is established remains controversial. Some sources say as early as 12 to 13 months (Fagard, 1990), others as late as 7 years. Five years of age is a time when confusion regarding dominance appears to be normal, even in a child who may have already shown a strong preference. The driving force behind hand dominance has always been considered to be the specialization of the cerebral hemispheres for specific purposes. This specialization process is complete by age 6 or 7 and results in laterality of brain functions. Laterality in hand usage means that one hand is

<table>
<thead>
<tr>
<th>Motor Age in Months</th>
<th>Distance of Throw (feet)</th>
<th>Small Ball (9.5 inch)</th>
<th>Large Ball (16.25 inch)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4–5</td>
<td>30</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>6–7</td>
<td>33</td>
<td>43</td>
<td></td>
</tr>
<tr>
<td>8–9</td>
<td>44</td>
<td>43</td>
<td></td>
</tr>
<tr>
<td>10–11</td>
<td>52</td>
<td>63</td>
<td></td>
</tr>
<tr>
<td>12–13</td>
<td>57</td>
<td>Above 72</td>
<td></td>
</tr>
<tr>
<td>14–15</td>
<td>65</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16–17</td>
<td>Above 72</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

consistently used to write with and is much better at the task than the other hand (Ayres, 1972; Murray, 1991). The majority of us are right-handed, meaning that the left cerebral hemisphere controls our hand movements.

Six Years

A 6-year-old is well coordinated in her movements. A child of this age can stand on either foot for 10 seconds or more with eyes open and with eyes closed. This ability is important to note because it indicates that vision can be ignored and balance maintained. A 6-year-old can throw and catch a small ball from 10 feet away, and walk on a balance beam forward, backward, and sideways without stepping off the beam. The child is able to use alternative forms of locomotion such as riding a bicycle or roller skating.

Between 6 and 10 years of age, children master the adult forms of running, throwing, and catching (Porter, 1989). Mature form in striking is usually not demonstrated until at least 6 years of age (Malina et al., 2004). Most of the studies on striking an object have been done with school-age children. Common patterns of striking are overhand, sidearm, and underhand. As the child progresses from striking down to a more horizontal striking (sidearm), more and more trunk rotation is seen as the child’s swing matures (Robertson and Halverson, 1977). A mature pattern of striking consists of taking a step, turning away, and then swinging (step-turn-swing) (Wickstrom, 1983).

Importance of Motor Skill Acquisition in Childhood

Understanding typical motor behavior is critical to understanding why and how we intervene therapeutically with individuals who exhibit movement dysfunction. Knowledge of normal motor development provides insights into movement dysfunction. The components of movement, the actual ways in which head, trunk, and limbs can move, are present by 6 months of age. It takes another 6 months for the infant to gain the postural control to attain and maintain upright standing needed for ambulation. Over the next year, movement in the upright position is refined, speeded up, and better controlled during stopping and starting. Three- to 6-year-olds develop fundamental patterns of movement that form the basis for later sports skills. Between 6 and 10 years of age, a child masters the adult forms of running, throwing, and catching (Porter, 1989). Throughout the process of changing motor activities and skills, the nervous and musculoskeletal systems are maturing, and the body is growing in height and weight. Although motor development continues to change throughout the life span, this section focuses on some of the significant changes that occur during the first 6 years.

Age-Related Differences in Movement Patterns Beyond Childhood

Many developmentalists have chosen to look only at the earliest ages of life when motor abilities and skills are being acquired. The belief that mature motor behavior is achieved by childhood led researchers to overlook the possibility that movement could change as a result of factors other than nervous system maturation. Although the nervous system is generally thought to be mature by age 10 years, changes in movement patterns do occur in adolescence and adulthood (VanSant, 1995). VanSant and her students studied the movement patterns used by people of different ages to accomplish a simple motor task.

VanSant and others studied the task of rising from supine to standing by describing the movement components for different regions of the body. Although an explanation of the method used in the many studies is beyond the scope of this text, a summary of the results is most appropriate.

Research shows a developmental order of movement patterns across childhood and adolescence with trends toward increasing symmetry with increasing age (Sabourin, 1989; VanSant, 1988a). VanSant (1988b) identified three common ways in which adults came to stand. These are shown in Figure 4-54. In this study, the most common way was to use upper extremity reach, symmetric push, forward head, neck and trunk flexion, and symmetric squat (see Fig. 4-54, A). The second most common way was identical, up to an asymmetric squat (see Fig. 4-54, B). The next most common way involved an asymmetric push and reach, followed by a half-kneel (see Fig. 4-54, C). In a separate study of adults in the third through fifth decades of life, the trend was toward increasing asymmetry with age (Ford-Smith and VanSant, 1993). Older adults were more likely to demonstrate the asymmetric patterns of movement seen in young children (VanSant, 1991). The asymmetry of movement in the older adult may reflect less trunk rotation resulting from stiffening of joints or lessening of muscle strength, factors that make it more difficult to come straight forward to sitting from a supine position.

Most recently, movement from supine to standing in older adults was studied by Thomas and colleagues (1998), who used VanSant’s component approach to movement...
In a group of community-dwelling elders with a mean age of 74.6 years, shorter time to rise was related to younger age, greater knee extension strength, and greater hip and ankle range of motion (flexion and dorsiflexion, respectively). “It appears that [older adults] who maintain their strength and flexibility may rise to standing faster and more symmetrically” (Thomas et al., 1998). The 70- and 80-year-old individuals in the study were more likely to use asymmetric patterns in the upper extremity and axial (trunk) regions, whereas the younger older adults demonstrated more symmetric patterns in the same body regions. Although the structures of the body are mature at the end of puberty, changes in movement patterns continue throughout a person’s entire life. Mature movement patterns have always been associated with efficiency and symmetry. Early in motor development, patterns of movement appear to be more homogenous and follow a fairly prescribed developmental sequence. As a person matures, movement patterns become more symmetric. With aging, movement patterns become more asymmetric. Less active middle-aged and older adults differ in movements used to come to stand (Green, 1989; Luehring, 1989). Because older people may exhibit different ways of moving and require more time to make the transition from one position to another, it is important to match our teaching to the individual’s usual patterns of movement.

**POSTURE, BALANCE, AND GAIT CHANGES WITH AGING**

**Posture**

The ability to maintain an erect aligned posture declines with advanced age. Figure 4-55 shows the difference in posture anticipated with aging. Humans have two primary spinal curves at birth, a forwardly flexed thoracic curve and a forwardly flexed sacral curve. During infancy, secondary cervical and lumbar curves develop with movement. These curves are...
convex forward. The emergence of secondary curves depends on the development of the intervertebral discs (Lowrey, 1986). With advanced age, the two secondary curves decrease and result in kyphosis and accentuated lordosis. The discs are known to lose water, become stiffer, and flatten with age (Moncur, 2000). In contrast, some older individuals demonstrate a flatter back as they age, rather than an increase in lordosis, if they sit for long periods during the day (Lewis, 2002). This may be a result of lack of movement rather than a pure aging effect. A forward-positioned head is often thought to be part of an older adult’s posture; however, it may be present before age 65 and may be further accentuated with aging as a compensation for thoracic kyphosis. Lack of cervical range may also be due to degenerative changes in the neck. Postural changes in older adults can be a result of aging or may be additionally related to a lack of movement from a sedentary lifestyle. Decreased activity can accentuate age-related postural changes (Moncur, 2000).

**Balance**

Older adult patients can have major problems with balance and falling. Whether an older person’s ability to balance while standing and walking always declines with age, however, is still undecided. Sensory information is needed to respond quickly to changes within the internal and external environments that signal the need for a postural response to maintain balance. Structural changes in the sensory receptors that provide information about the support surface, position of the arms and legs, and head movement are reported with age. A decline in structural integrity of these sensory receptors decreases the quality of the information relayed. The number of receptors also decreases. Awareness of vibration is lessened in older adults and has been related to an increase in postural sway during quiet stance. Because vision is a strong source of information for balance, any decline in this sensory system may be detrimental to balance. Age-related declines in visual acuity, depth perception, peripheral vision, and the ability to adapt to changes in light or dark environments can significantly affect an older person’s ability to detect threats to balance. Removal of visual information during balance testing in older adults has been shown to increase postural sway (Sheldon, 1963; Woollacott, 1990).

A dynamic postural response depends on the strength and range of motion available at a joint. The ankle has to have enough range to allow some sway. Loss of passive range of motion is seen with advancing age. Women seem to lose less range in the ankles than men, and the upper extremities remain more flexible than the lower extremities.
in both men and women (Bell and Hoshizaki, 1981). Isometric strength decreases by 30 to 40 percent over time, but because isometric strength does not relate highly to the ability to perform functional skills, this decrease may not be problematic. The ability to produce a concentric contraction also declines with age, but interestingly, the production of an eccentric or lengthening contraction is not as greatly affected by age and may even remain normal. Muscle strength declines with age beginning around age 50 years (Larsson, 1982). The reduction does not become functionally important until age 60 years (Vandervoort, 1995). By age 80 years, the decline in muscle strength accelerates (Vandervoort et al., 1990). The decline in strength can be related to the finding that older adults have less muscle mass. Another explanation could be that the ability of the nervous system to produce muscle excitation is impaired. This hypothesis has not yet been proven.

Gait
Numerous changes in gait can be expected to occur in an older population. Generally, the older adult is more cautious while walking. Cadence and velocity are decreased, as is stride length. Stride width increases to provide a wider base of support for better balance. Increasing the base of support and taking shorter steps means that an older adult spends more time in double-limb support than a young adult. Walking velocity slows as stride length decreases, and double-support time increases. Double-support time reflects how much time is spent with both feet on the ground. Winter and colleagues (1990) attributed these differences in gait to age alone. Those gait changes that cannot be linked to compensations for age-related musculoskeletal changes may be the result of the deterioration of the sensorimotor system (Olney and Culham, 1995).

Age-related changes in gait can create difficulties in other aspects of functional movement, such as stepping over objects and going up and down stairs. Chen and co-workers (1991) found that healthy older adults had more difficulty than healthy young adults in stepping over obstacles of increasing heights. Everyone slowed down and increased foot clearance as the height of the objects increased. However, the older adults used a significantly slower speed than the young adults and had less margin of error when clearing the obstacle. The decreased step length made it more likely for the older adult to step on the object and thereby increase her chance of falling. Stair climbing requires a period of single-limb stance while the swing leg is lifted up to the next step. Given the changes in gait with age already described, it is no surprise that older adults go up and down stairs more slowly.

Implications for Treatment
Age-related losses of range of motion, strength, and balance can be compounded in the older adult by a lack of habitual physical activity and can be intensified in the presence of neurologic deficits resulting from a stroke, spinal cord injury, or traumatic brain injury. The good news is that the decline in muscular strength and endurance can be partially reversed with an appropriate amount of resistive and endurance exercise. Precautions must always be considered in light of other preexisting disorders that would require modification of therapeutic intervention. The physical therapist is responsible for accurately documenting the patient’s present level of abilities, recognizing mitigating circumstances, and planning appropriate therapeutic interventions. The therapist should instruct the physical therapist assistant in how the patient’s exercise response should be monitored during treatment. If this information is not provided, the physical therapist assistant should request the information before treatment is initiated.

When the patient with a neurologic insult also has pulmonary or cardiac conditions, the physical therapist assistant should monitor the patient’s vital signs during exercise. Decline in cardiopulmonary reserve capacity resulting from age can be compounded by a loss of fitness and loss of conditioning. Probably no more deconditioned patient exists than one who is in the hospital. As the patient is being mobilized and acclimated to the upright position in preparation for discharge, the decline in reserve can affect the patient’s ability to perform normal activities of daily living. Walking can require up to 40 percent of the oxygen taken in by an individual. Therefore, an older person may need to slow down the speed of walking depending on how much oxygen is available. Measurements of heart rate, blood pressure, and respiratory rate are important, providing the supervising therapist with information about the patient’s response to exercise. More specific monitoring of oxygen saturation, rate of perceived exertion, level of dyspnea (shortness of breath), or angina may be indicated by the supervising physical therapist, but further discussion of these methods is beyond the scope of this text. The complexity of the patient’s condition may warrant limiting the involvement of the physical therapist assistant.

CHAPTER SUMMARY
Age and age-related changes in the structure and function of different body systems can significantly alter the functional movement expectations for any given individual. Functional tasks are defined by the age of the individual. An infant’s function is to overcome gravity and learn to move into the upright position. The toddler explores the world in the upright position and adds fundamental movement patterns of running, hopping, and skipping during childhood. Manipulation of objects is continually refined from finger feeding Cheerios to learning to write. Self-care skills are mastered by the time a child enters school. Sport skills build on the fundamental movement patterns and are important in childhood and adolescence. Work and leisure skills become important during late adolescence and adulthood. Every period of the life span has different functional movement expectations. The movement expectations are driven by the mover, the task, and the social and physical environments.
REVIEW QUESTIONS

1. What are the characteristics that identify a developmental theory as being life span in approach?
2. What theorist described a pyramid of needs that the individual strives to fulfill?
3. What is an example of a directional concept of development?
4. What three processes guide motor development?
5. When does a child typically achieve gross- and fine-motor milestones?
6. What are the typical postures and movements of a 4-month-old and a 6-month-old?
7. What motor abilities constitute fundamental motor patterns?
8. Why do motor patterns continue to change throughout the life span?
9. What role does decreased activity play in an older adult’s posture?
10. What gait changes can have an impact on functional abilities in older adults?

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