Walking uses a repetitious sequence of limb motion to move the body forward while simultaneously maintaining stance stability. For the new support site, then the limbs reverse their roles. For the source of support while the other limb advances, itself is a two support system. One limb serves as a mobile floor contact pattern.

**Reciprocal Floor Contact Patterns**

As the body moves forward, one limb moves forward, one limb serves as mobile floor contact pattern.

W

**Gait Cycle**

Chapter 1
Gait Analysis

When two feet are not in contact with the ground. This series of events is repeated by each limb with reciprocal timing until the person's destination is reached. A single sequence of these functions by one limb is called a gait cycle (GC). With one action flowing smoothly into the next, there is no specific starting or ending point. Hence, any event could be selected as the onset of the gait cycle. Because the moment of initial contact is the most readily defined event, double cycle support is generally used to describe the entire period during which both feet are on the floor. Although double limb support is the preferred term in the literature, it implies an equal sharing of body weight by the two feet, which is not true during most of the double stance. Initial double stance begins with initial contact, or, the moment when the two feet first touch the floor. Double stance is subdivided into three intervals according to the sequence of floor contact by the two feet (Figure 1.2). Both the start and end of double stance involve a portion of stance plus one foot contact (reverse I.C.).

Stance is the entire period during which one foot is on the floor. Stance begins with initial contact (Figure 1.1). Stance is subdivided into two periods, stance and swing. Swing begins as the foot is lifted from the floor (toe-off). Stance is subdivided into three intervals according to the sequence of floor contact by the two feet (Figure 1.2). Both the start and end of stance involve a period of bilateral foot contact with the floor (double stance), while the middle portion of stance begins with initial contact with the floor and ends when the foot contacts the floor again. The foot is lifted off the floor and begins the swing phase.

Cycle Divisions

Each gait cycle is divided into two periods, stance and swing. The foot is lifted from the floor (toe-off) when the foot is lifted off the floor (toe-off). The word swing applies to the time the foot is in the air for limb advancement. Swing begins with initial contact with the floor (Figure 1.1). Swing continues until the foot contacts the floor again.

Each gait cycle is divided into two periods, stance and swing. Stance begins with initial contact with the floor and ends when the foot contacts the floor again. Swing begins when the foot is lifted off the floor (toe-off). The foot is lifted off the floor (toe-off) and begins the swing phase.

Figure 1.1: Divisions of the gait cycle. Clear bar represents the duration of stance. Shaded bar is the duration of swing. Stance is subdivided into three periods according to the sequence of floor contact by the two feet.
The gait cycle consists of two limbs being in contact with the floor at different times. The stance phase is when both feet are in contact with the floor, and the swing phase is when one foot is off the floor and the other is in contact. The subdivisions of stance are initial double limb stance, single limb support, and terminal double limb stance.

- **Initial Double Limb Stance**: Both feet are in contact with the floor.
- **Single Limb Support**: One foot is in contact with the floor while the other is off.
- **Terminal Double Limb Stance**: The second foot comes into contact with the floor, ending the gait cycle.

The duration of these phases varies with walking speed. At a speed of 50% of normal walking speed, 60% of the time is spent in stance and 40% in swing. As walking speed increases, the stance and swing times decrease inversely. The total gait cycle time is approximately 60% for stance and 40% for swing.

The gait cycle is crucial for understanding the mechanics of locomotion. The changes in stance and swing times with speed can be attributed to the body's efficiency in distributing weight and maintaining balance during movement.
As speed slows, the subdivisions of stance change to different relationships and shorten the two double stance intervals. This pattern of change is curvilinear. Having an interval when both feet are in contact with the ground is a basic characteristic of walking. When double stance is omitted, the person has entered the running mode of locomotion.

### Table 1.1

<table>
<thead>
<tr>
<th>Floor Contact Periods</th>
<th>Swing</th>
<th>Single Limb Support</th>
<th>Single Limb Double Stance</th>
<th>Initial Double Stance</th>
<th>Terminal Double Stance</th>
</tr>
</thead>
<tbody>
<tr>
<td>%</td>
<td>10%</td>
<td>%</td>
<td>40%</td>
<td>10%</td>
<td>60%</td>
</tr>
</tbody>
</table>

**Stride and Step**

Stride is the equivalent of a gait cycle. It is based on the actions of one limb. Occasionally the word step is used, but this is inappropriate (Figure 1.3).

The gait cycle also has been identified by the descriptive term stride.

**Figure 1.3** A step versus a stride. Step length is the interval between initial contact of each foot. Stride length continues until there is a second contact by the same foot.
The duration of a stride is the interval between two sequential initial floor contacts by the same limb (i.e., right IC and the next right IC).

Step refers to the timing between the two limbs. There are two steps in each stride (or gait cycle). At the conclusion of one stride, the other foot contacts the ground to begin its next stance period. The interval between an initial contact by each foot is a step (i.e., left IC and then right IC). The same offset in timing will be repeated in reciprocal fashion throughout the walk.

The duration of a stride is the interval between two sequential initial floor contacts by the same limb (i.e., right IC and the next right IC).
In order to provide the basic functions required for ambulation, the foot and the supporting body and the supporting foot undergo a series of movements that involve altering the angle of alignment required for development of the gait cycle. The foot provides opposition for the ankle joint and the knee joint, while the hip joint provides support to the body. The foot is crucial in maintaining balance and posture. The body is supported by the foot and the supporting body and the supporting foot undergo a series of movements that involve altering the angle of alignment required for development of the gait cycle. The foot provides opposition for the ankle joint and the knee joint, while the hip joint provides support to the body. The foot is crucial in maintaining balance and posture.

Phases of Gait
Gait Analysis/ Perry customarily has been called heel strike; yet the heel of a paralytic patient may never contact the ground or do so much later in the gait cycle. Similarly initial floor contact may be by the whole foot (foot flat), rather than having forefoot contact occur later, after a period of heel-only support. This latter fact adds to the complexities of gait analysis.

Each of the eight gait phases has a functional objective and a critical pattern of selective synergistic motion to accomplish this goal. The sequential combination of the phases also enables the limb to accomplish three basic tasks. These are weight acceptance (WA), single limb support (SLS) and limb advancement (LA) (Table 2.1).

<table>
<thead>
<tr>
<th>Divisions of the Gait Cycle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Contact</td>
</tr>
<tr>
<td>Loading Response</td>
</tr>
<tr>
<td>Mid Stance</td>
</tr>
<tr>
<td>Single Limb Support</td>
</tr>
<tr>
<td>Terminal Stance</td>
</tr>
<tr>
<td>Swing</td>
</tr>
<tr>
<td>Swing</td>
</tr>
<tr>
<td>Swing</td>
</tr>
</tbody>
</table>

Table 2.1

<table>
<thead>
<tr>
<th>Divisions of the Gait Cycle</th>
<th>Tasks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Contact</td>
<td>WA</td>
</tr>
<tr>
<td>Loading Response</td>
<td>SLS</td>
</tr>
<tr>
<td>Mid Stance</td>
<td>WA</td>
</tr>
<tr>
<td>Single Limb Support</td>
<td>SLS</td>
</tr>
<tr>
<td>Terminal Stance</td>
<td>WA</td>
</tr>
<tr>
<td>Swing</td>
<td>SLS</td>
</tr>
<tr>
<td>Swing</td>
<td>SLS</td>
</tr>
<tr>
<td>Swing</td>
<td>SLS</td>
</tr>
</tbody>
</table>
**Phases of Gait**

The gait cycle is divided into two main phases: initial contact and loading response. These two phases are followed by single limb support, which consists of midstance and terminal stance. Limb advancement begins in the final phase of stance (pre-swing) and continues through the three phases of swing (initial swing, midswing, and terminal swing).

### Task A: Weight Acceptance

This task is the most demanding task in the gait cycle. It involves three functional patterns: shock absorption, weight-bearing stability, and progression of movement. The challenge is the abrupt transfer of body weight onto a limb that has just finished swinging and is in an unstable alignment. Two gait phases are involved: initial contact and loading response (Table 2.1).

<table>
<thead>
<tr>
<th>Phase 1 - Initial Contact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Objective:</td>
</tr>
<tr>
<td>Describe the joint positions when the foot first touches the ground (Figure 2.1). The phase begins with the initial double stance period (Figure 2.2).</td>
</tr>
<tr>
<td>Interval: 0-2% GC</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Phase 2 - Loading Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Objective:</td>
</tr>
<tr>
<td>Describe the moment when the limb is positioned to start stance with a heel rocker (Figure 2.3).</td>
</tr>
<tr>
<td>Interval: 0-10% GC</td>
</tr>
</tbody>
</table>

### Task B: Single Limb Support

Lifting the other foot for swing begins the single limb support interval for the stance limb. This continues until the opposite foot again contacts the floor. During this time, one limb has the total responsibility for weight-bearing in both the sagittal and coronal planes while the supporting body weight is maintained in both the sagittal and coronal planes. Two gait phases are involved: initial contact and loading response (Table 2.2). This is the most demanding task in the gait cycle. Three functional patterns are needed: shock absorption, initial limb stability, and progression of movement.

<table>
<thead>
<tr>
<th>Phase 1 - Initial Contact</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Terminal swing)</td>
</tr>
<tr>
<td>(continued from previous phase)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Phase 2 - Loading Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>(continued from previous phase)</td>
</tr>
</tbody>
</table>

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**Table 2.1: Initial Contact**

<table>
<thead>
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<tr>
<td>Interval: 0-2% GC</td>
</tr>
</tbody>
</table>

**Table 2.2: Loading Response**

<table>
<thead>
<tr>
<th>Phase 2 - Loading Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Objective:</td>
</tr>
<tr>
<td>Describe the moment when the limb is positioned to start stance with a heel rocker (Figure 2.3).</td>
</tr>
<tr>
<td>Interval: 0-10% GC</td>
</tr>
</tbody>
</table>
Figure 2.1 Initial Contact. The hip is fixed, the knee is extended, the ankle is dorsiflexed to neutral. Floor contact is made with the heel. Shading indicates the reference limb. The other limb (clear) is at the end of terminal stance.

Phase 1—Initial Contact

Interval: 0-10% GC

This phase is the first half of the single-limb support interval (Figure 2.3). It begins as the other foot is lifted and continues until body weight is aligned with the foot. Shading indicates the reference limb. The other limb (clear) is at the end of terminal stance.

Objectives:
- Progression of the body beyond the supporting foot
- Limb stability

Figure 2.2 Loading Response. Body weight is transferred onto the forward limb (shaded). Using the heel as a rocker, the knee is flexed for shock absorption. Ankle plantar flexion limits the heel rocker by forefoot contact with the floor. The opposite limb (clear) is in its pre-stance phase.

Interval: 10-30% GC

This is the first half of the single-limb support interval (Figure 2.3), it begins as the other foot is lifted and continues until body weight is aligned over the forefoot.

Objectives:
- Progression over the stationary foot
- Limb and trunk stability

Figure 2.3 Mid Stance

Interval: 30-50% GC

This phase completes single-limb support (Figure 2.4). It begins with heel rise and continues until the other foot strikes the ground. Throughout this phase body weight moves ahead of the forefoot.

Objectives:
- Progression of the body beyond the supporting foot
- Weight shift

Figure 2.4 Terminal Stance

Interval: 30-50% GC

This phase completes single-limb support (Figure 2.4). It begins with heel rise and continues until the other foot strikes the ground. Throughout this phase body weight moves ahead of the forefoot.

Objectives:
- Progression of the body beyond the supporting foot
- Weight shift
Figure 2.3 Mid Stance. In the first half of single limb support, the limb (shaded) advances over the stationary foot by ankle dorsiflexion (ankle rocker) while the knee and hip extend. The opposite limb (clear) is advancing in its mid swing phase.

**Task C: Limb Advancement**

**Phase 2—Pre-Swing**

Pre-swing (end of stance) includes swing and stance and terminal swing.

**Phase 3—Terminal Stance**

Task C: Limb Advancement

Terminal stance. During the second half of stance, the limb is in terminal stance position. The other limb (clear) is in terminal swing position. The goal is to reposition the body and prepare for the next swing phase.
Figure 2.5 Pre-Swing. Floor contact by the other limb (dear) has started terminal double support. The refer. once limb (shaded) responds with increased ankle plantar flexion, greater knee flexion and loss of hip extension. The opposite (dear) limb is in Loading Response.

Figure 2.6 Initial Swing. The foot is lifted and limb advanced by hip flexion and increased knee flexion. The ankle only partially dorsiflexes. The other limb (clear) is in early mid stance.

Initial Swing

**Objective:**
Position the limb for swing

**Interval:** 60-73% GC

This first phase is approximately one-third of the swing period (Figure 2.6). It begins with lift of the foot from the floor and ends when the swinging

**Initial Swing**

**Objective:**
Position the limb for swing

**Response:**
Extension of the opposite (clear) limb is in loading, the ankle plantar flexion, the other limb (shaded) responds with increased knee flexion, hip flexion and increased knee flexion. The foot is in early mid stance. The other limb (clear) has started terminal double support. The refer. once limb (shaded) has started terminal double support. The other limb (shaded) has started terminal double support.
Mid Swing

Figure 2.7 Mid Swing. Advancement of the limb anterior to the body weight is gained by further hip flexion. The knee is allowed to extend in response to gravity while the ankle continues to dorsiflex into neutral. The other limb (dear) is in late mid stance.

Terminal Swing

Figure 2.8 Terminal Swing. Advancement is completed as the foot moves ahead of the thigh. (shank) moves ahead of the thigh. The foot clearance from the floor is completed as the leg begins to lift. (shank) moves ahead of the thigh. The foot clearance from the floor is completed as the leg begins to lift. (shank) moves ahead of the thigh. The foot clearance from the floor is completed as the leg begins to lift. (shank) moves ahead of the thigh. The foot clearance from the floor is completed as the leg begins to lift. (shank) moves ahead of the thigh. The foot clearance from the floor is completed as the leg begins to lift. (shank) moves ahead of the thigh. The foot clearance from the floor is completed as the leg begins to lift. (shank) moves ahead of the thigh. The foot clearance from the floor is completed as the leg begins to lift. (shank) moves ahead of the thigh. The foot clearance from the floor is completed as the leg begins to lift. (shank) moves ahead of the thigh. The foot clearance from the floor is completed as the leg begins to lift. (shank) moves ahead of the thigh. The foot clearance from the floor is completed as the leg begins to lift. (shank) moves ahead of the thigh. The foot clearance from the floor is completed as the leg begins to lift. (shank) moves ahead of the thigh. The foot clearance from the floor is completed as the leg begins to lift. (shank) moves ahead of the thigh. The foot clearance from the floor is completed as the leg begins to lift. (shank) moves ahead of the thigh. The foot clearance from the floor is completed as the leg begins to lift. (shank) moves ahead of the thigh. The foot clearance from the floor is completed as the leg begins to lift. (shank) moves ahead of the thigh. The foot clearance from the floor is completed as the leg begins to lift. (shank) moves ahead of the thigh. The foot clearance from the floor is completed as the leg begins to lift. (shank) moves ahead of the thigh. The foot clearance from the floor is completed as the leg begins to lift. (shank) moves ahead of the thigh. The foot clearance from the floor is completed as the leg begins to lift. (shank) moves ahead of the thigh. The foot clearance from the floor is completed as the leg begins to lift. (shank) moves ahead of the thigh. The foot clearance from the floor is completed as the leg begins to lift.
Objectives:
1. Complete limb advancement
2. Prepare the limb for stance

Reference:
Pathokinesiology & Physical Therapy Department, Professional Staff Association of Rancho Los Amigos Medical Center, 1990.


Figure 17.4b Strobe photography at a slower rate (5 frames/sec) portrays the disability of hemiplegia, swing showing failure to extend the limb and the inhibition of progression by ankle immobility. Terminal stance flexion is rapidly reversed to knee extension.
Gait Analysis

Figure 1.1 Divisions of the gait cycle. Clear bar represents the duration of stance. Shaded bar is the duration of swing. Limb segments show the onset of stance with initial contact, end of stance by roll-off of the toes, and end of swing by floor contact again.
Gait Analysis

**Initial Contact**
- Figure 2.1 Initial Contact. The hip is flexed, the knee is extended, and the ankle is dorsiflexed and plantarflexed. Floor contact is made with the heel, indicating the presence of a break. The other limb (close) is at the end of terminal stance.

**Loading Response**
- Figure 2.2 Loading Response. Body weight is transferred to the forward limb (shaded). Using the heel as a contact, the knee is flexed for shock absorption. Anterior plantar flexion foot and the heel contact with the floor. The opposite limb (close) is in its pre-swing phase.

**Mid Stance**
- Figure 2.3 Mid Stance. In the first half of single limb support, the foot (shaded) advances over the stationary foot by ankle dorsiflexion (ankle protraction) while the knee and hip extend. The opposite limb (close) is advancing in the mid-swing phase.

**Terminal Stance**
- Figure 2.4 Terminal Stance. During the second half of single limb support, the lead stance and the limb (shaded) advances over the terminal stance. The knee increases its excursion and then just begins to flex slightly. Increased hip extension puts the limb in a more trailing position. The other limb (close) is in terminal swing.

**Pre-Swing**
- Figure 2.5 Pre-Swing. Floor contact by the other limb (close) has started terminal double support. The forward limb (shaded), exchanges with increased ankle plantar flexion, greater knee flexion and some of hip extension. The opposite limb (close) is in Loading Response.

**Initial Swing**
- Figure 2.6 Initial Swing. The foot is flexed and limb accelerated by hip flexion and increased knee flexion. The ankle only partially dorsiflexes. The other limb (close) is in early mid-swing.

**Mid Swing**
- Figure 2.7 Mid Swing. Anticipation of the limb (shaded) anterior to the body weight line is gained by better hip flexion. The knee is allowed to extend in response to gravity while the ankle continues dorsiflexing to neutral. The other limb (close) is in late mid-swing.

**Terminal Swing**
- Figure 2.8 Terminal Swing. Limb advancement is completed by hip extension. The hip maintains its opposite stance, and the ankle remains dorsiflexed to neutral. The other limb (close) is in terminal stance.

Jacquelin Perry
Figure 1.2 The subdivisions of stance and their relationship to the bilateral floor contact pattern. Vertical dark bars are the periods of double limb stance (right and left feet). Horizontal shaded bar is single limb support (single stance). Total stance includes three intervals: the initial double stance, single limb support and the next (terminal) double stance. Swing is the clear bar that follows terminal double stance. Note that right single limb support is the same time interval as left swing. During right swing there is left single limb support. The third vertical bar (double stance) begins the next gait cycle.