Phasic Behaviour of Muscles

In Figure 2.11, you saw the EMG activity in a single muscle – a normal female's rectus femoris — plotted as a function of the gait cycle. One of the fascinating features of human gait, however, is that the central nervous system must control many muscles simultaneously. Figure 4.9 shows the normal EMG patterns for 28 of the most important muscles in the lower extremities plotted as functions of the gait cycle. When you consider that this graph is for one side of the body only and that there is another set of muscles on the other side which are half a cycle out of phase, you realise just how complex the human locomotor apparatus is!

The order of muscles in Figure 4.9 has been chosen so that there appears to be a wave of muscle action that flows from left to right, that is, from heel strike through to the next heel strike. Muscles with similar phasic activity have been grouped together. This applies both to muscles with similar actions (such as tibialis anterior and extensor digitorum longus), as well as those with no immediately apparent connection (such as rectus femoris and gluteus maximus).

Inman *et al*. (1981) introduced a novel method for illustrating the actions of leg muscles during the gait cycle. Wooden models of the pelvis and lower limbs were constructed and arranged in an expanded and sequential series depicting a single stride. Based on photographs of these models, drawings were made, and muscle groups were superimposed on the drawing of each model at each position. Then the level of the muscle activity was indicated by colour: red, highly active; pink, intermediate; and white, quiescent. We have adapted and extended their concept in this book. Figure 4.10 shows a gait cycle from two separate views, posterior and lateral; the events are indicated using the conventions described in Figure 2.5 and 2.7. The seven major muscle groups represented in Figure 4.10 are

1. gluteus maximus (posterior view);
2. gluteus medius (posterior and lateral views);
3. adductor magnus (posterior view);
4. quadriceps (lateral view);
5. hamstrings (posterior and lateral views); and
6. tibialis anterior (lateral view).

The shading indicates the degree of activity: black, most active; stippled, intermediate; and white, quiescent. The images in Figure 4.10 form part of the animation sequences that are the focus of Appendix A, where we will extend the concepts of Inman *et al.* (1981) and enable you to bring the human locomotor apparatus to life by fanning the pages of this book. In addition, these muscle activity sequences have been colour-coded and animated in *GaitLab*.

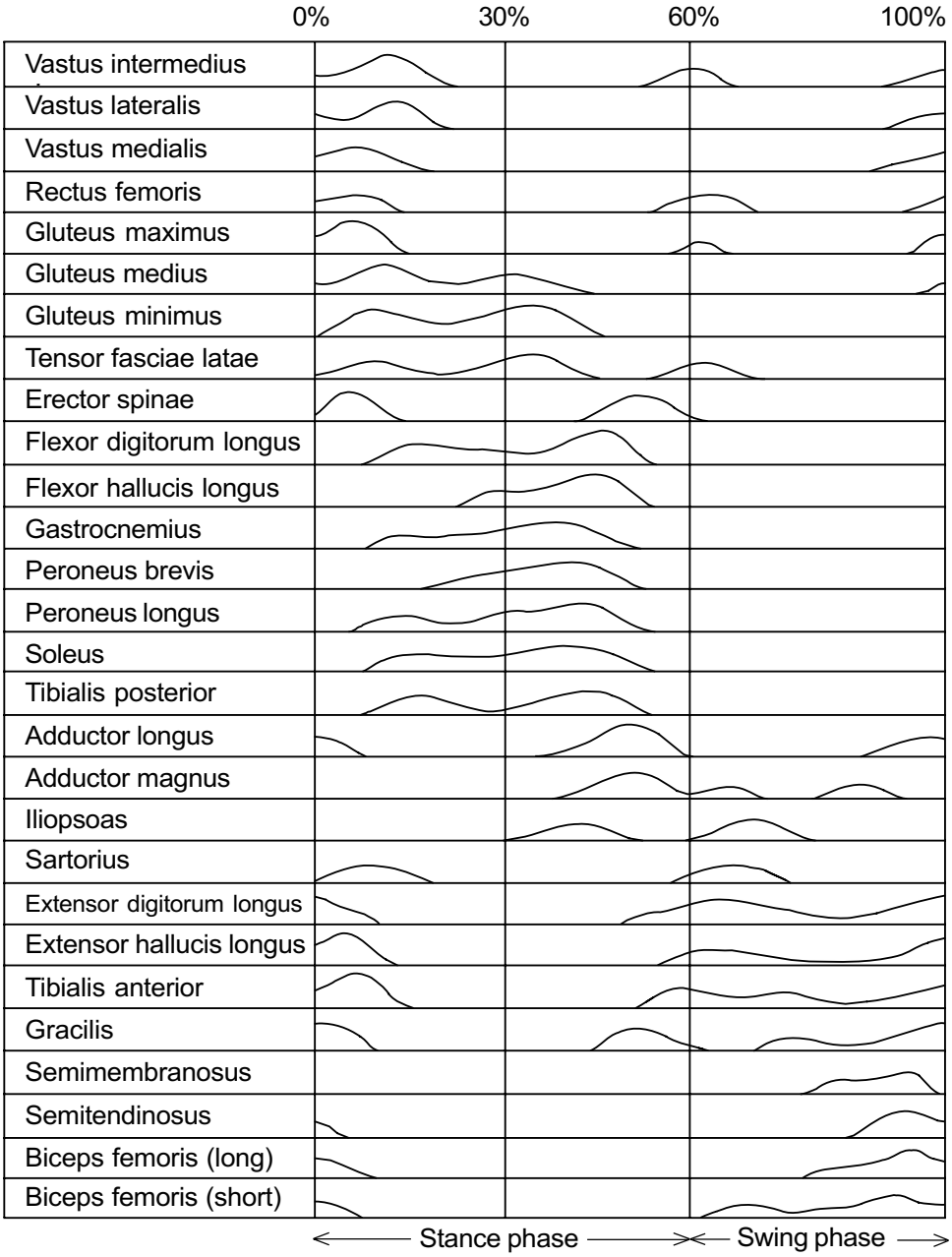

Figure 4.9 Normal EMG patterns for 28 of the major muscles in the lower extremities plotted as a function of the gait cycle. *Note*. Adapted from Bechtol (1975).

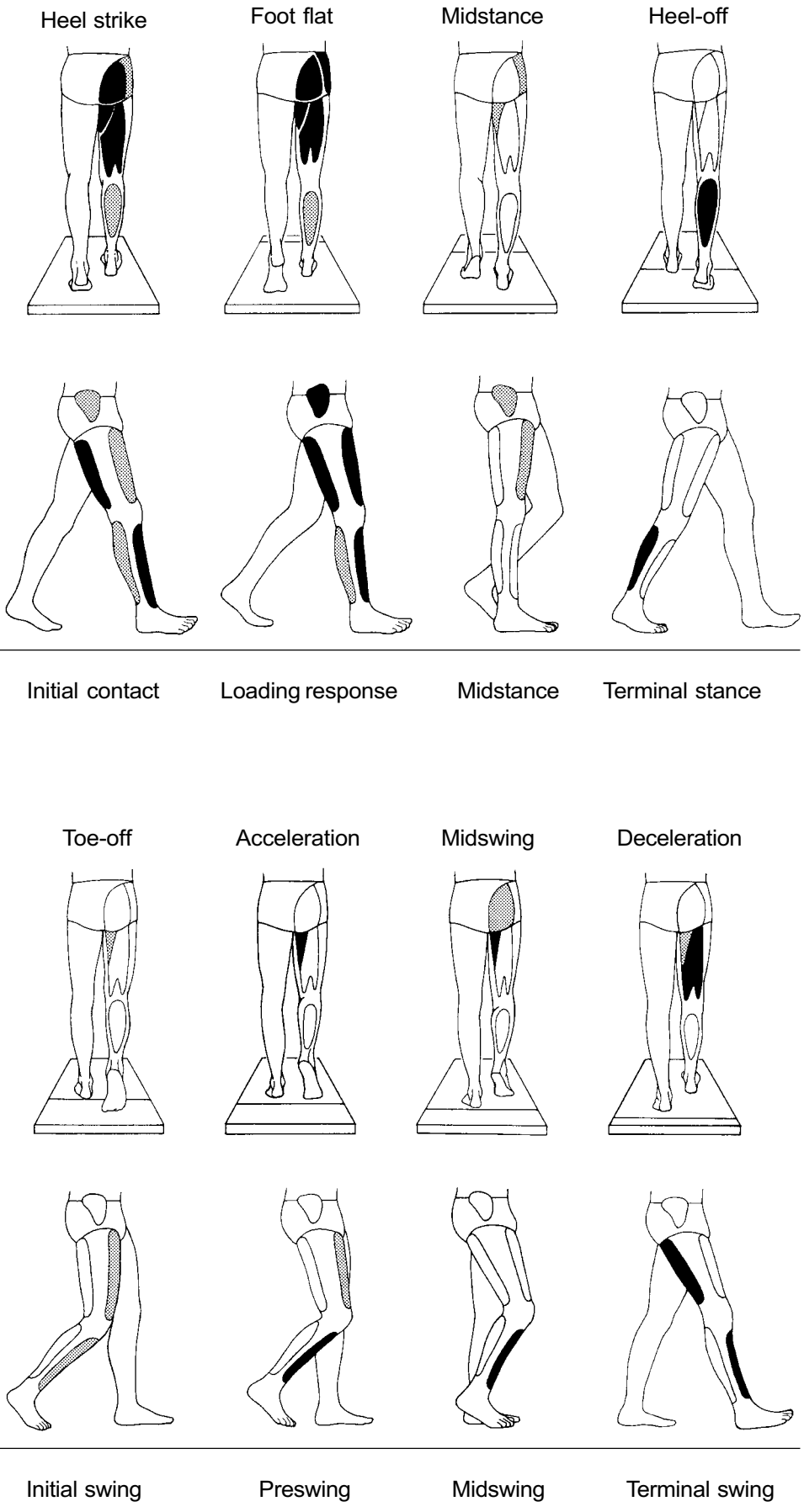

Figure 4.10 Posterior and lateral views of seven of the major muscles of the lower extremities, showing the activity of the muscles at key phases of the gait cycle.

A careful study of Figures 4.9 and 4.10 allow certain generalities to be made concerning the phasic behaviour of the muscles. Most of the major muscle groups are active at or around both heel strike and toe-off (*i.e.*, at the beginning and end of the stance and swing phases of the cycle). These are the periods of deceleration and acceleration of the legs, when body weight is transferred from one foot to the other. During midstance and midswing, most muscles (with the exception of gluteus medius and triceps surae during stance, and tibialis anterior during swing) are relatively quiescent. This is interesting because it is during these two periods (midstance and midswing) that the greatest observable movement takes place. During midstance, gluteus medius acts as a hip abductor to stabilise the pelvis as the contralateral leg swings through, while the triceps surae prevents excessive dorsiflexion of the ankle and then prepares to drive the person forward. During midswing, the tibialis anterior (as well as extensor digitorum longus and extensor hallucis longus) provides active dorsiflexion and thus prevents the toes from dragging on the ground. As a general rule, then, it appears that one of the principal actions of the muscles is to accelerate and decelerate the angular motions of the legs (Inman *et al*., 1981).