CHAPTER TWO

A THREE-DIMENSIONAL JOINT-BY-JOINT APPROACH TO MOVEMENT

"We work because it is a chain reaction, each subject leads to the next."

~ CHARLES EAMES

A concept recently permeated the fitness, sports performance, and rehabilitation fields describing the body and its movement as a series of alternating joint levels of mobility-stability-mobility patterns. This systematized arrangement of movement idea is good, but the common description of it was incomplete. The simplistic version looked at motion in one dimension, when in reality every muscle and joint works in three planes of motion. There must be an adequate range of motion in all three planes to allow an efficient, economical, and successful chain reaction of synchronized movement.

In this section, we will discuss the principles and concepts of movement, expression of relative motion of joints, basic foot mechanics, and will then delve into the lower extremity, knee, and hip. Later, we will explore the complexity of the lumbar and thoracic spine and of the shoulder girdle.

DISTAL AND PROXIMAL

First, we need to set the premise for our discussion. As covered in the previous chapter, we describe "movement" as *the relationship of bone segments that comprise the joints*. When discussing motion away from the spine, we look at the position of the distal bone in relation to the proximal bone.

Our discussion will begin at the foot, move through the subtalar joint, and proceed up the chain to the cervical spine. However, let's take a few minutes to make sure the concepts of distal and proximal are clear.

For example, in Photo 2.1 we see the open-chain position of hip adduction with the femur medial to the ilium. In Photo 2.2, we also see the closed-chain, integrated position of hip adduction, even though the foot is not moving in space the way it is in an open-chain action.

In July 2002, the late Dr. Mel Siff wrote an article for *PTontheNET* called "Closed Versus Open Kinetic Chain Exercise." In the article, he quoted Dr. Arthur Steindler, who coined the terms "open and closed kinetic chain."

"We designate an open kinetic chain a combination in which the terminal joint is free. A closed kinetic chain, on the other hand, is one in which the terminal joint meets with some considerable external resistance which prohibits or restrains its free motion." ~ Kinesiology of the Human Body under Normal and Pathological Conditions, Springfield, 1955

For the rest of the article, visit:
http://www.ptonthenet.com/articles/Closed-Versus-Open-Kinetic-Chain-Exercise-1692

In actuality, integrated human movements are a constant alternation of open and closed chain events that produce efficient outcomes of a desired task.

PHOTO 2.1 HIP ADDUCTION, OPEN CHAIN

PHOTO 2.2 HIP ADDUCTION, CLOSED CHAIN

In both pictures, the femur—the distal bone—is medial or adducted to the proximal bone, the ilium. For the sake of consistency, "distal" references *any point below a point of attachment.* In this case, the femur is below the ilium.

"Medial" refers to *any point closer to the midline* from a referenced starting point. Here, the femur is closer to the midline of the body as related to the ilium.

In the spine, however, the description of "spinal movement" is *the proximal bone in relation to the distal bone.*

In Photo 2.3, we see rotation of the cervical spine to the left with the chin somewhat over the left shoulder. The proximal segments of the cervical spine are rotated farther left than the distal cervical segments.

PHOTO 2.3 C-SPINE ROTATION TO LEFT, OPEN CHAIN

When viewing the integrated action as shown in Photo 2.4, there is still left cervical rotation even though the body is rotated right—the proximal cervical segments are left of the distal segments.

PHOTO 2.4 C-SPINE ROTATION TO LEFT, CLOSED CHAIN

In Photo 2.4, the lower segment of the cervical spine and the thoracic spine are rotated right. However, the proximal segments are rotated to the relative left to the distal segments. Therefore, this is still left cervical rotation.

UNDERSTANDING THE SYNERGISTIC RELATIONSHIP FOR MOVEMENT EFFICIENCY

Historically, the majority of exercise training programs have been created in an isolated environment, such as machines in a gym. There are benefits to isolation in training, such as hypertrophy development or to increase isolated strength. These issues are necessary, especially considering a person who is rehabilitating an injury or a postsurgical issue.

However, when we use an isolated movement pattern, it is concentric in nature, in one plane of motion, and is isolated. You can readily see this as opposite of how the body actually moves as described in the earlier section, *Characteristics of Human Motion* beginning on page 14.

Functional, efficient movement is eccentric before concentric, is a tri-plane action, and integrated for successful movement. It is not isolated.

Next, you will see a diagram showing the integrated, synergistic reactions that occur in normal, healthy movements when loading the musculoskeletal system. As you can see, all joints move in three planes of motion. This is the roadmap to keep in mind as you observe a person's gait or during a motion analysis. It is a roadmap you can use to create an environment for a client's success, as these reactions must transpire to allow optimal, efficient motion.

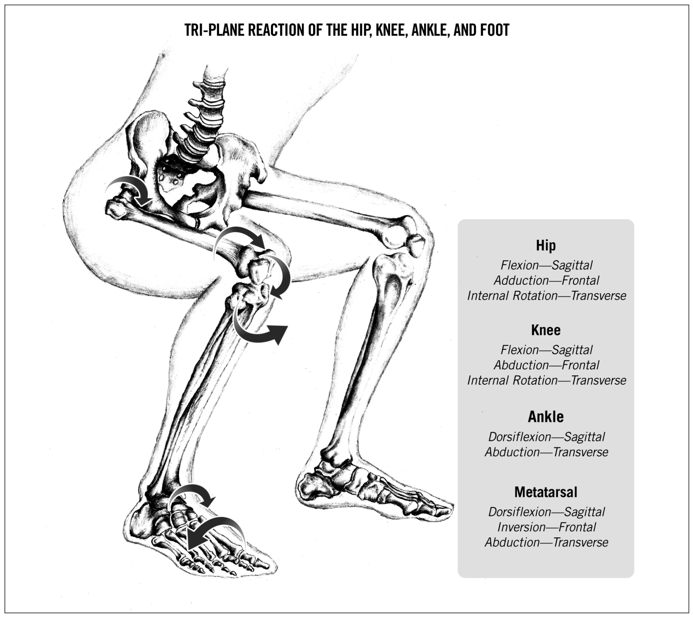

FIGURE 1.1 TRI-PLANE REACTION OF THE HIP, KNEE, ANKLE, AND FOOT

There must be adequate range of motion in all three planes to allow an efficient, economical, and successful chain reaction of synchronized movement. There is a predominance of a particular plane of motion in each joint. However, we still expect the presence of the other two cardinal planes of motion during any integrated, functional movement.

For example, the knee moves predominantly in the sagittal plane. But, consider again the principle of motion away from the spine, where movement is defined as the distal bone in relation to the proximal bone. Under normal, healthy conditions, as the knee flexes, the tibia internally rotates, resulting in knee internal rotation. Likewise, as the knee flexes and rotates, the distal end of the tibia is usually lateral to the distal end of the femur. Under these movement principles, the knee is abducted when considering the distal bone in relation to the proximal bone.

Figure 1.1 shows the concomitant tri-plane actions that occur at each joint, as well as the necessary reactions that must transpire to make all joints and movements successful. Notice how the knee flexes in the sagittal plane, abducts in the frontal plane, and internally rotates in the transverse plane. The majority of anatomy and kinesiology books do not discuss these reactions; they only discuss knee flexion. Take a few minutes to ponder this concept if it is new to you.

Many reactions occur in other regions of the body to allow the knee to have efficient motion. For example, the ankle must dorsiflex for the knee to successfully move.

We will discuss ankle dorsiflexion and the important role it plays in allowing an efficient system to move well when we get to the section on foot function beginning on page 29. For now, we will keep our focus on how the ankle must dorsiflex to allow the knee to flex, abduct, and internally rotate in normal actions.

To get a feel of this, please stand and perform a squat, paying close attention to ankle dorsiflexion. If you have good ankle dorsiflexion, the knee will track somewhere close to over the shoelaces. If you have the ability to achieve this necessary function of the ankle, you should feel a smooth squat action.

Now, attempt the squat again, but this time do not dorsiflex the ankle and do not allow the knee to track over your shoelaces. Most often, people feel awkward and may lose balance; they feel the weight more toward the heels, feel more quadriceps recruitment, and—the biggest compensation—they flex more at the hip. Some feel tension in the low back.

Many people who have had a previous ankle, foot, or calf injury who squat or lunge in this manner are at risk of hip, knee, low back, or sacroiliac joint dysfunction or even injury. We will discuss this in more depth when we explore common limitations, compensations, and injury, beginning on page 137.

Referring back to the earlier movement illustration in Figure 1.1, you will see the necessary chain reaction for optimal performance, whatever that may be:

- *Adequate ankle dorsiflexion must be accompanied by adequate subtalar joint eversion and forefoot abduction to allow the tibia to internally rotate.*
- *This causes the knee to internally rotate, abduct, and flex.*
- *With this successful reaction, the femur will follow the tibia and rotate inward.*
- *As the knee is abducted, it "pulls" the femur, thereby causing the femur to be medial to the ilium.*
- *Following the principle of distal bone in relation to the proximal bone, the femur is now adducted to the ilium, resulting in hip adduction.*
- *Likewise, as the femur moves slightly forward of the ilium, the hip is flexed in the sagittal plane.*
- *As a result, a successful hip action loads the gluteal complex in three planes of motion. The hip is flexed in the sagittal plane, adducted in the frontal plane, and internally rotated in the transverse plane.*

We started this global journey from the foot and ankle complex, through the knee and into the hip. If any component becomes locally limited in motion, it will impact successful global reactions.

Remember, if there is a limitation, it will create a compensation. Compensation often results in an injury or a dysfunctional issue, but that typically is not the *cause* of the problem. It is quite possible—and common—to see the cause of a dysfunction be one or two joint levels away from the site of the compensation or injury.

Therefore, we must look globally prior to looking locally to understand and assess the cause of a problem.

That movement graphic looks complex. To make it more understandable, get in front of a mirror and follow the illustration as you start moving in all planes of motion. Stop in a different position after each movement to analyze each of your joint positions and look at the relationship of the distal bone to the proximal bone.

Once you have internalized these concepts, you will begin to more fully appreciate human movement and be better able to unravel the complexities of each motion. When you understand how the body moves and where the motion is limited rather than where it should be coming from, the possibilities of working with and training clients become endless.

We will expand our explorations into the movement of various regions as we delve into each specific area.