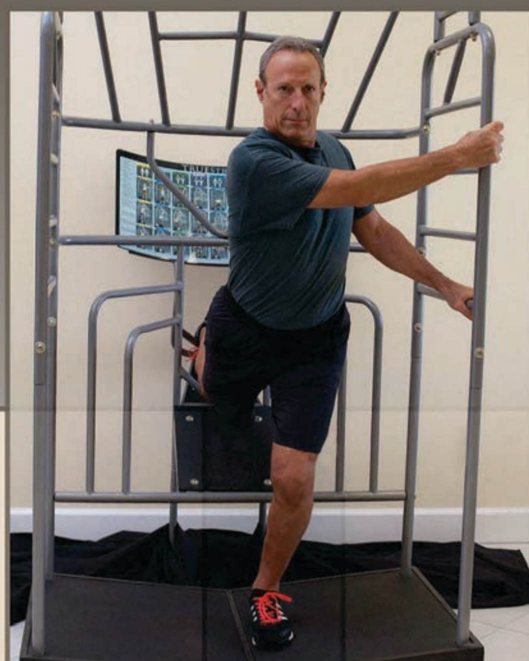
FOREWORD BY ROBERT MASSON, M.D.

INSIGHTS INTO FUNCTIONAL TRAINING

Principles, Concepts, and Application

CHUCK WOLF, MS, FAFS



"Chuck Wolf is an honest workman with decades of experience. Here he has assembled a simple to apply, solidly built program of connected exercise for the athlete who doesn't want hypo-movement in one part of the body to end up as hyper-movement—repetitive stress injury—in another. Train as a whole, until evenly strung like a good tennis racquet. Let this book help." **~ Tom Myers, author of Anatomy Trains**

INSIGHTS
INTO FUNCTIONAL TRAINING
PRINCIPLES, CONCEPTS, AND APPLICATION

Chuck Wolf, MS, FAFS

Foreword by Robert Masson, MD

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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.

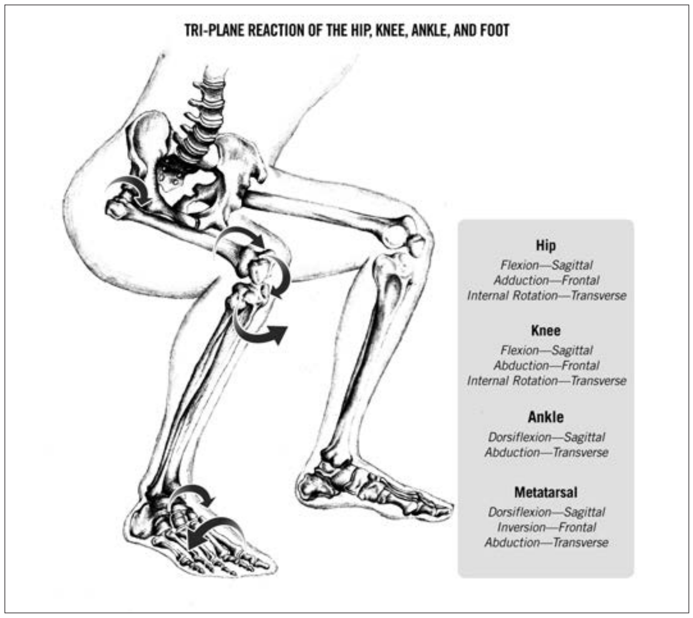

FIGURE 1.1 TRI-PLANE REACTION OF THE HIP, KNEE, ANKLE, AND FOOT

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.

MUSCLES OF THE FEET

There is no more of a synergistic nature of muscle tissue than in the foot. The 24 muscles are listed below with the origin and insertion. You will find frequent discussion of the four components of foot function throughout the book.

The loading or pronation is the deceleration phase, when all tissues lengthen to absorb force during calcaneal eversion and forefoot abduction. The transition from pronation to the acceleration or supination phase is when the muscles shorten to lock or close-pack the bones to create a more rigid environment for propulsion.

The following are the muscles affecting foot function.

Flexor Digitorum Brevis
Abductor Hallucis
Abductor Digiti Minimi
Flexor Hallucis Longus
Flexor Digitorum Longus
Extensor Digitorum Brevis
Extensor Hallucis Longus
Extensor Digitorum Longus

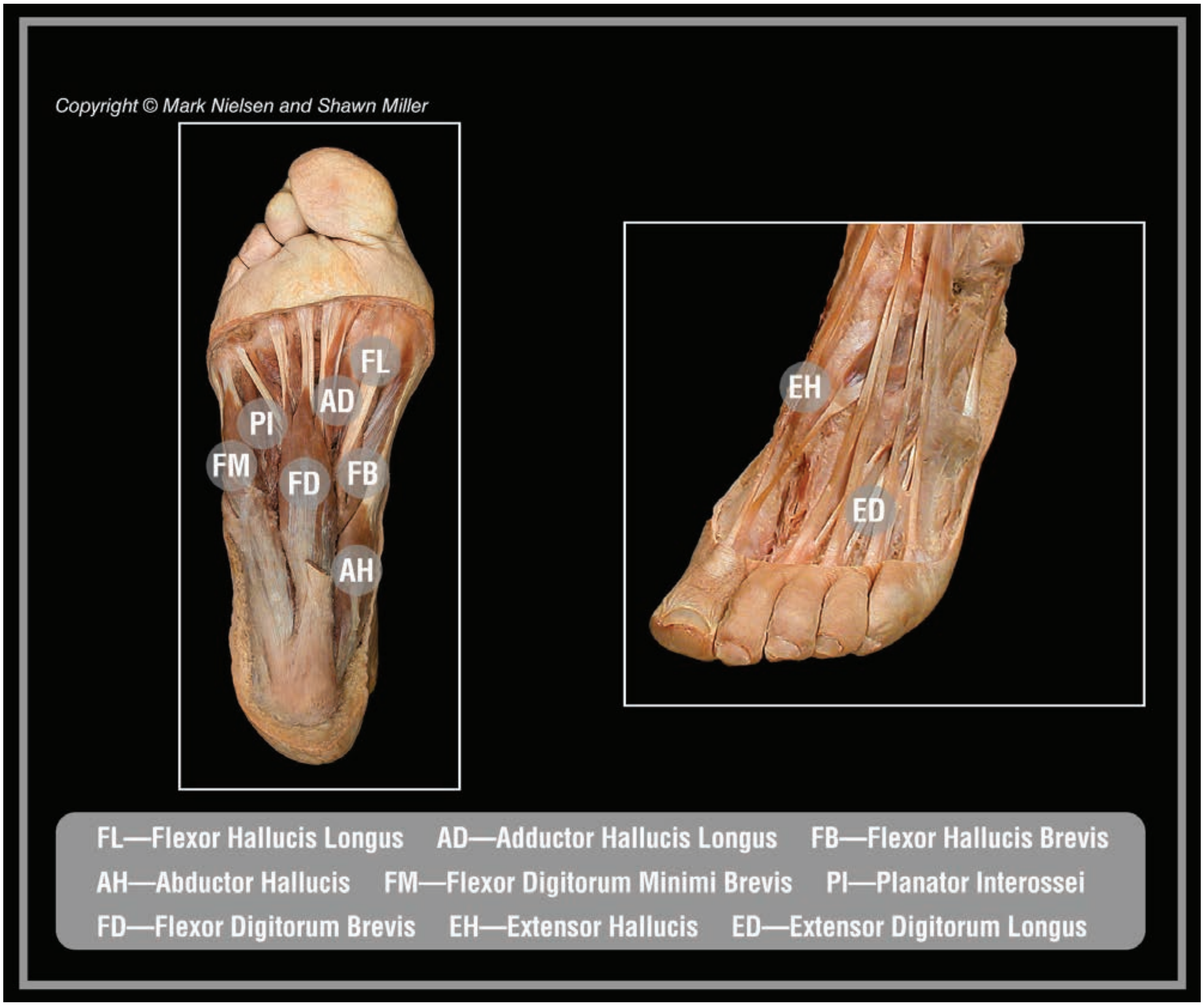

PHOTO 3.1 THE FOOT

FLEXOR DIGITORUM BREVIS

FUNCTIONAL ACTION	PHASE 1: DECELERATION	PHASE 2: TRANSITION	PHASE 3: ACCELERATION
SAGITTAL PLANE	Assists with deceleration of extension of toes two through four from heel strike through toe-off	Foot stabilization	Assists with acceleration of plantar flexion of toes two through four. However, think in terms of relative flexion of the toes prior to heel-off when they begin with deceleration of extension through toe-off.
FRONTAL PLANE	Foot stabilization in functional activities	Foot stabilization in functional activities	Foot stabilization in functional activities
TRANSVERSE PLANE	Foot stabilization in functional activities	Foot stabilization in functional activities	Foot stabilization in functional activities

ORIGIN	Medial aspect of calcaneal tuberosity and deep surface of the plantar aponeurosis
INSERTION	Middle phalanx behind flexor digitorum longus
BY THE BOOK	Flexion of toes two through four

ABDUCTOR HALLUCIS

FUNCTIONAL ACTION	PHASE 1: DECELERATION	PHASE 2: TRANSITION	PHASE 3: ACCELERATION
SAGITTAL PLANE	Assists with deceleration of the first metatarsophalange (MTP)	Synergistically assists with great toe stabilization	Assists with deceleration of great toe flexion during heel-off through toe-off
FRONTAL PLANE	Deceleration of great toe adduction of the first MTP	Synergistically assists with first MTP stabilization	Assists with acceleration of first MTP flexion and abduction during heel-off through toe-off
TRANSVERSE PLANE	Synergistically assists with first MTP stabilization	Synergistically assists with first MTP stabilization	Synergistically assists with first MTP stabilization during heel-off through toe-off

ORIGIN	Flexor retinaculum, medial aspect of calcaneal tuberosity, and deep surface of the plantar aponeurosis
INSERTION	Medial side of proximal phalanx of the first toe and medial sesamoid bone of the great toe
BY THE BOOK	Flexion and abduction of the first MTP

ABDUCTOR DIGITI MINIMI

FUNCTIONAL ACTION	PHASE 1: DECELERATION	PHASE 2: TRANSITION	PHASE 3: ACCELERATION
SAGITTAL PLANE	Assists with deceleration of fifth toe extension	Assists with fifth toe stability	Assists with acceleration of fifth toe relative flexion after toe-off
FRONTAL PLANE	Assists with fifth toe adduction	Assists with fifth toe stability	Assists with fifth toe abduction from heel-off through toe-off
TRANSVERSE PLANE	Dynamic stabilization of the fifth toe	Dynamic stabilization of the fifth toe	Dynamic stabilization of the fifth toe

ORIGIN	Inferior calcaneus
INSERTION	Lateral side of the fifth MTP
BY THE BOOK	Flexion and abduction of the fifth MTP

FLEXOR HALLUCIS LONGUS

FUNCTIONAL ACTION	PHASE 1: DECELERATION	PHASE 2: TRANSITION	PHASE 3: ACCELERATION
SAGITTAL PLANE	Assists with deceleration of great toe extension and ankle eversion at heel strike to mid-stance	Great toe and ankle stability during mid-stance	Assists with deceleration of great toe extension and ankle eversion during heel-off and toe-off
FRONTAL PLANE	Assists with great toe and foot stability during the entire gait cycle	Assists with great toe and foot stability during mid-stance	Assists with great toe and foot stability
TRANSVERSE PLANE	Assists with great toe and foot stability during the entire gait cycle	Assists with great toe and foot stability during mid-stance	Assists with great toe and foot stability

ORIGIN	Mid-posterior half of fibula
INSERTION	Distal phalanx of the first MTP on the plantar surface
BY THE BOOK	Assists in first toe flexion and foot and ankle inversion

FLEXOR DIGITORUM LONGUS

FUNCTIONAL ACTION	PHASE 1: DECELERATION	PHASE 2: TRANSITION	PHASE 3: ACCELERATION
SAGITTAL PLANE	Assists with deceleration of the four lesser toes as the toes reach the ground during heel strike to mid-stance	Synergistically assists with the four lesser toe stabilization	Assists with acceleration of flexion of the four lesser toes
FRONTAL PLANE	Assists in deceleration of ankle eversion during heel strike to mid-stance	Foot and ankle stability	Foot and ankle inversion and stability
TRANSVERSE PLANE	Foot and ankle stability	Foot and ankle stability	Foot and ankle stability

ORIGIN	Posterior middle tibia
INSERTION	Distal plantar surface of the lesser four toes
BY THE BOOK	Flexion of the four lesser toes and ankle inversion

EXTENSOR DIGITORUM BREVIS

FUNCTIONAL ACTION	PHASE 1: DECELERATION	PHASE 2: TRANSITION	PHASE 3: ACCELERATION
SAGITTAL PLANE	Assists with deceleration of flexion of MTPs two through four	Synergistically assists with stabilization of MTPs two through four	Assists with acceleration of extension of MTPs two through four at heel strike
FRONTAL PLANE	Dynamic stabilization of MTPs two through four and assists with deceleration of ankle inversion	Dynamic stabilization of MTPs two through four	Dynamic stabilization of MTPs two through four
TRANSVERSE PLANE	Dynamic stabilization of MTPs two through four	Dynamic stabilization of MTPs two through four	Dynamic stabilization of MTPs two through four

ORIGIN	Dorsal aspect of calcaneus
INSERTION	MTPs two through four
BY THE BOOK	Extension of MTPs two through four

EXTENSOR HALLUCIS LONGUS

FUNCTIONAL ACTION	PHASE 1: DECELERATION	PHASE 2: TRANSITION	PHASE 3: ACCELERATION
SAGITTAL PLANE	Assists with deceleration of first MTP extension and ankle plantar flexion	Synergistically assists with first MTP stabilization	Assists with deceleration of first MTP flexion at mid-stance prior to heel-off and toe-off
FRONTAL PLANE	Assists in deceleration of ankle eversion	Synergistically assists in first MTP stabilization	Assists in deceleration of ankle inversion
TRANSVERSE PLANE	Synergistically assists in first MTP stabilization	Synergistically assists in first MTP stabilization	Synergistically assists in first MTP stabilization

ORIGIN	Anterior fibula and interosseus membrane
INSERTION	Dorsal surface of distal phalanx of the first MTP
BY THE BOOK	First MTP extension, ankle inversion, and ankle dorsiflexion

EXTENSOR DIGITORUM LONGUS

FUNCTIONAL ACTION	PHASE 1: DECELERATION	PHASE 2: TRANSITION	PHASE 3: ACCELERATION
SAGITTAL PLANE	Assists with deceleration of flexion of MTPs two through five	Synergistically assists with stabilization of MTPs two through four	Assists with deceleration of flexion of MTPs two through four
FRONTAL PLANE	Dynamic stabilization of MTPs two through five	Dynamic stabilization of MTPs two through five	Assists in deceleration of ankle inversion
TRANSVERSE PLANE	Dynamic stabilization of MTPs two through five	Dynamic stabilization of MTPs two through five	Dynamic stabilization of MTPs two through five

ORIGIN	Lateral tibial condyle, proximal fibula
INSERTION	Lateral four lesser toes
BY THE BOOK	Extension of MTPs two through five and assists in ankle eversion

CHAPTER SIX

THE BIG MOVEMENT ROCKS—SIMPLY IMPORTANT

"Action is the foundational key to all success."

~ PABLO PICASSO

You will see the term "Big Movement Rocks" often in this book. These consist of the foot and ankle complex, the hips, and the thoracic spine.

Human movement is the culmination of a cascade of tri-plane motions resulting in a desired outcome whatever that may be. Efficient motion of the Big Movement Rocks improves efficiency of motion and will reduce the risk of injury.

Depending on which resources are cited, the top three injuries affecting people are low-back injury or pain, knee injury, followed by shoulder injury. My experiences over the last 37 years of practice have shown that repeated incidence of improper motion in the Big Movement Rocks significantly contributes to overuse and chronic injuries. Working closely with Dr. Robert Masson of the Neurospine Institute, I have seen many of his patients exhibit similar tendencies in movement. After evaluating their results from a gait-and-motion analysis, invariably we find tightness in the hips and thoracic spine in one or more planes of motion.

Anatomy shows us that the low back is "stuck" between the hips and thoracic spine. Chapter Two, *A Three-Dimensional Joint-by-Joint Approach to Movement* beginning on page 21, taught us that the hips are greatly affected by the foot and ankle complex and must be included within the scope of our assessments.

The knee is a victim of the foot and ankle complex and the hip. The tibia is greatly impacted by foot function and the femur is affected by hip motion, and so we see how the knee reacts to the structures above and below it. When people present with knee problems, the last place we look is the knee—we first assess the movement of the Big Movement Rocks below and above it.

The shoulder girdle involves the humerus, glenoid, clavicle, scapula, and thoracic spine. The scapula must glide over the ribs to provide proper and efficient movement of the shoulder joint. And the thoracic spine must move freely in all three planes of motion, especially in the transverse plane. If the thoracic spine has ample motion, the scapula will spontaneously glide over the ribs to allow the shoulder joint to function effectively.

However, the thoracic spine depends on freedom of motion in the hip complex, which is impacted by the foot and ankle actions. When viewing human movement, especially of a local joint, first look globally to get a perspective of gross overall tri-plane motion. Then move your assessment to the local joint action.

THE FOOT AND ANKLE COMPLEX

Often referred to as a mobile adapter, the foot must be able to absorb forces from gravity and ground-reaction forces when moving forward and back, side to side, and in rotation. It must be able to do these actions on firm, soft, level, and unleveled surfaces, as well as on a combination.

There is a predominance of one plane of motion in certain regions of the foot, yet those regions must have a subtle action of the other two planes of motion within them.

For example, the talocrural (ankle) joint is said to be primarily a sagittal-plane mover. As the tibia moves over the talus, the motion is in the sagittal plane. However, when the foot hits the ground, contact with the ground is usually at the lateral aspect of the calcaneus.

As the ankle plantarflexes and the foot lowers to the ground, the calcaneus everts five to seven degrees, resulting in a relative rotational movement of the midfoot and forefoot as the phalanges contact the ground. At this point, the tibia starts to rotate medially, as do the femur and hip.

To envision this, imagine viewing the foot from above as seen in Figure 6.1.

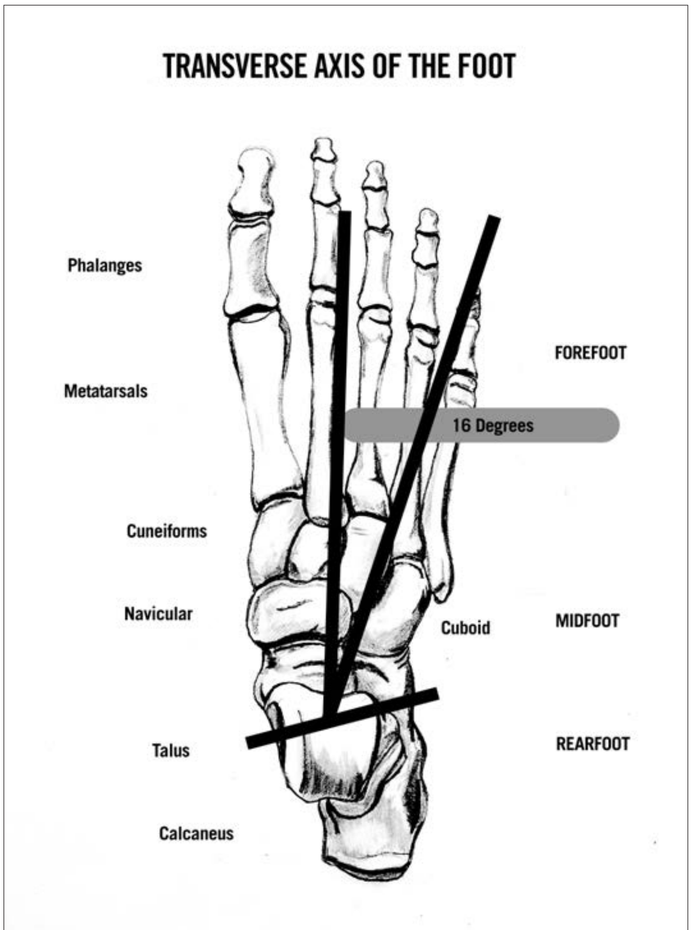

FIGURE 6.1 TRANSVERSE AXIS OF THE FOOT

Picture a line across the talus and have that line bisect both malleoli. Now add a line from the instep to a point between the fourth and fifth metatarsal bones. This represents an axis that passes through the talus at a 16-degree angle. This axis relates to the motion of the forefoot to the rearfoot when the foot is fully loaded in midstance.

The summation of ankle dorsiflexion in the sagittal plane, calcaneal eversion in the frontal plane, along with forefoot abduction through the transverse axis and tibia rotation in the transverse plane allows the foot and ankle complex to be loaded in three planes of motion.

For optimal foot and ankle function that will fully load the system, the following four components must occur:

- *Calcaneal eversion*
- *Tibial internal rotation*
- *Ankle dorsiflexion*
- *Forefoot abduction*

If any of these actions become limited, the entire system will be adversely affected and lack proper loading.

THE HIP COMPLEX

The hip complex is the conduit region that conjoins the lower extremities to the torso. It must possess mobility to ambulate in three planes of motion, along with stability to assist in absorbing and transmitting forces.

The hip is comprised of the spherical femoral head and the acetabulum. Often referred to as the body's powerhouse, the hip contains the densest, most powerful muscles in the body. Thirty-three muscles attach to the hip complex; many of them exhibit the body's highest power capacity. Among them are the gluteal complex, deep hip rotators such as the piriformis, gemellae and obturator groups, adductor group, and hamstrings to name those most commonly recognized.

Like all joints in the body, the hip moves in three planes of motion. In the sagittal plane, the flexion range of motion is between 100 to 120 degrees and extension is 15 to 20 degrees.

In the frontal plane, abduction ranges from 40 to 45 degrees, while adduction is approximately 25 degrees.

In the transverse plane, internal rotation range of motion varies from 35 to 40 degrees, with external rotation of 40 to 50 degrees. In standing single-leg balance, we have observed nearly 90 degrees of external rotation.

In addition to the tri-plane range of motion, pay attention to the femoral glide that must occur for successful motion. When the hip extends, the head of the femur glides or slides forward toward the anterior. When the hip flexes, the femoral head slides posterior toward the back.

In frontal-plane motion, the femoral head slides laterally during adduction of the hip and glides medially during hip abduction.

In the transverse plane, the head of the femur rotates backward with internal rotation and rotates forward during external rotation motion.

When the hip joint gets tight, the femoral head becomes somewhat compressed in the acetabulum, resulting not only in joint compression, but also with reduced range of motion in all three planes. Therefore, when stretching the hips in three planes, you will be more successful when applying a gentle, long axis distraction, pulling the distal bone from the proximal bone.

Considering the hip structure and its important role of force transmission, the mobility of the hip is critical for successful and efficient movement patterns. People with back pain invariably have a limitation of hip function within one and most often all three planes of motion.

The close relationship of the hip complex with the lumbo-pelvic complex greatly impacts the functioning of the lumbar spine. When the hip is limited, especially in the transverse and frontal planes, the lumbar spine compensates in these planes of motion. Over time, back injury to this region follows.

In static posture, anterior pelvic tilt alignment will influence the lumbar spine by increasing lordosis. Likewise, posterior pelvic tilt causes flexion of the lumbar spine. However, the lumbar spine can also influence pelvic tilt alignment, with increased lordosis causing anterior pelvic tilt and lumbar flexion often resulting in posterior pelvic tilt.

These issues need to be correlated to your strategies of corrective exercise when developing programs. For example, if a client has an anterior pelvic tilt with increased lordosis, you need to use caution when doing squats or spinal extension movements. The rationale is that the facets of L5/S1 are closer together than in a more neutral position lumbo-pelvic complex. When squatting or moving into an extended spinal movement, the facets may compress, causing discomfort.

A lunge program is an alternative to the squat in this situation, as the hip of the forward leg will move into a posterior position while the hip of the trail leg extends. In the majority of cases, this reduces the compressive force on the L5/S1 facets. The client will be able to work the legs and hips with more comfort and efficiency.

The interesting cascade reactions of the foot have significant impact upon the hips. These principles will be discussed further throughout this book.

The hip complex is a crucial big movement rock based on the alignment and proper motion of the hips, critical function of force transmission and mitigation, and the interrelationship with the lumbar spine.

THE THORACIC SPINE

Tri-plane motion of the thoracic spine is critical for successful and efficient movement. The span of 12 thoracic levels lends itself to be mobile in three planes of motion. The excellent book, *Low Back Disorder* by Stuart McGill, PhD, demonstrates the vast range of motion in all three planes. Cumulatively at all 12 levels, the thoracic spine averages 76 degrees in the sagittal plane of combined flexion and extension. In the frontal plane, the average range of cumulative motion is 78 degrees. In the transverse plane, the average is 74 degrees of combined left and right rotation.

Compare these ranges to the lumbar spine that totals 68 degrees of combined flexion and extension, 29 degrees of frontal plane motion, and 13 to 15 degrees in each direction of rotation.

The primary difference in the range of motion is due to the articulating facet structures of each region. The thoracic spine facets face more posterior and allow the ribs to have greater freedom of movement. The lumbar facets are aligned more obliquely and limit the movement in the transverse plane. Please refer to Figure 6.2 comparing the differences of the facet angulations between the thoracic and lumbar vertebra.

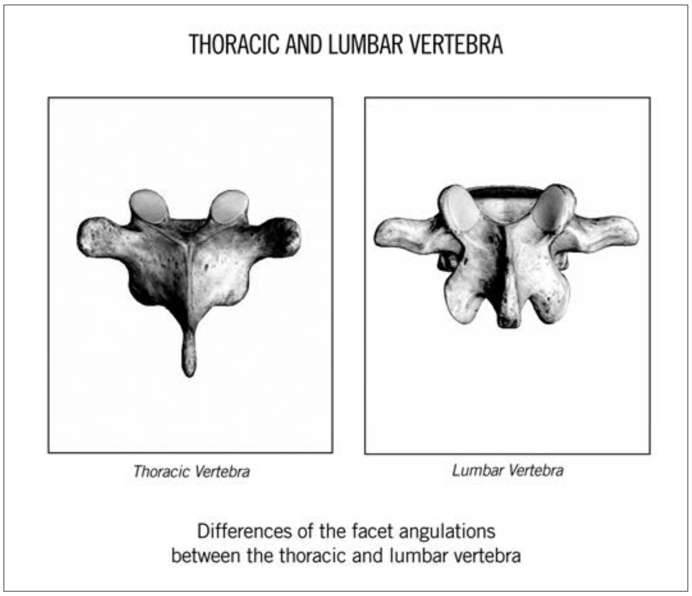

FIGURE 6.2 THORACIC AND LUMBAR FACET ANGULATIONS
PHOTO COPYRIGHT © 3D4MEDICAL

Figure 6.3 demonstrates the difference in articulation with adjacent vertebra in each region.

The thoracic spine simultaneously functions in three planes of motion. For example, when rotating to the right, the right transverse process moves posteriorly in the sagittal plane, while the vertebral body is rotating right in the transverse plane. This is often referred to as a "coupling effect." However, in many cases there is a slight lateral flexion to the side; therefore, the frontal plane is impacted and movement is occurring in three planes of motion.

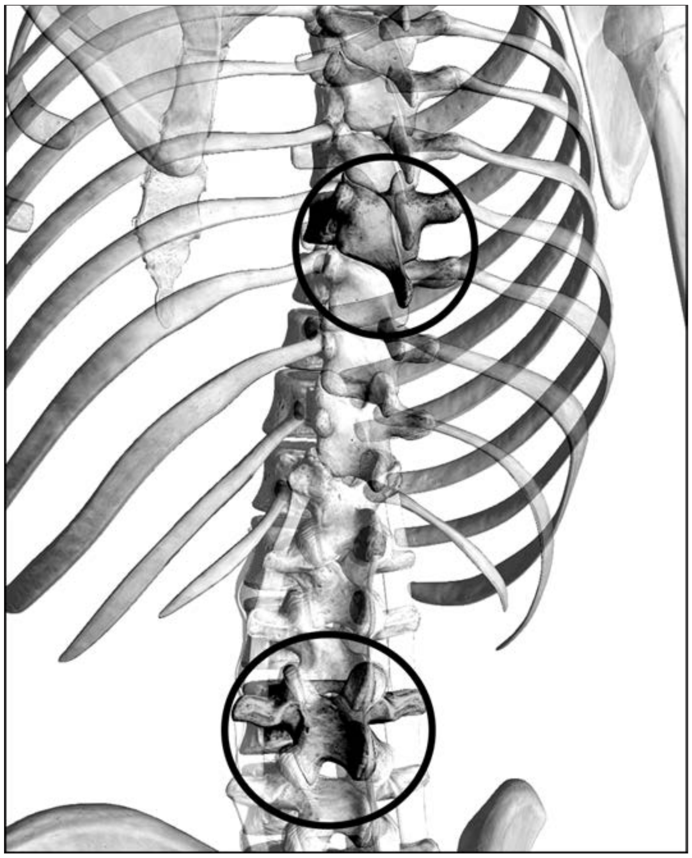

FIGURE 6.3 VERTEBRAL ARTICULATION
PHOTO COPYRIGHT © 3D4MEDICAL

There is greater motion in the upper thoracic spine from T1–T8 in the transverse plane. Farther down toward the lumbar spine, especially from T9–T12, the rotation becomes less as it approaches the thoracolumbar region. As the thoracic spine becomes more distal, the lumbar spine will influence it—it has less rotation, similar to the lumbar spine. The lumbar spine is conducive to flexion and extension, and the thoracic spine has more range of motion from T10–T12 than the level above it.

Frontal-plane motion is fairly consistent through the entire thoracic spine, as it is in the lumbar spine.

The articulation of the scapula with the thoracic spine is critical for healthy shoulder girdle and shoulder joint action. There must be good mobility in the thoracic spine to allow scapular gliding over the ribs.

This will enhance shoulder-joint mobility and create an environment for healthy shoulder movements.

SUCCESSFUL MOVEMENT DEPENDS ON THE BIG MOVEMENT ROCKS

Throughout this book, we will continue to discuss the Big Movement Rocks and their dependency on each other for successful movement. The synergistic cascade of reactions is necessary to allow a successful environment for efficient movement. If any part of these reactions becomes limited in motion, the entire system is affected and compensatory movement patterns will contribute to complete the task.

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APPENDIX THREE

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HUMAN MOTION ASSOCIATES HEALTH HISTORY

APPENDIX ONE

OVERVIEW OF THE SIX FLEXIBILITY HIGHWAYS

THE ANTERIOR FLEXIBILITY HIGHWAY

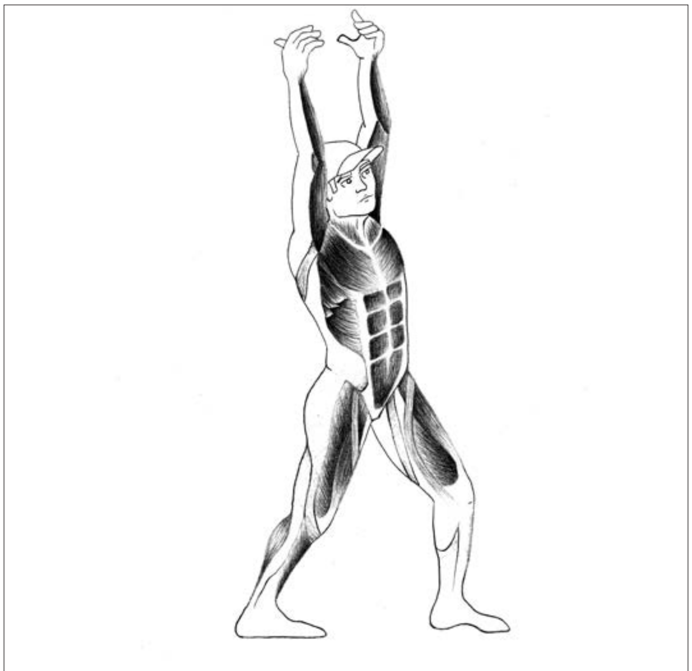

FIGURE A1.1 ANTERIOR FLEXIBILITY HIGHWAY

KEY INTERSECTIONS

- *Anterior tibialis to distal quads*
- *Proximal quads to distal hip flexor*
- *Proximal hip flexor to distal abdominals*
- *Proximal abdominals to distal pectorals*
- *Proximal pectorals to distal delts*
- *Opposite obliques to opposite shoulder*

STRETCHING THE ANTERIOR FLEXIBILITY HIGHWAY

LEVEL 1 LEVEL 2

PHOTO A1.1A AND B STRETCHING THE ANTERIOR FLEXIBILITY HIGHWAY

The Anterior Flexibility Highway runs from the south to the north—the bottom to the top of the body—or along the sagittal plane with flexion and extension movements occurring on this Highway.

The myofascial tissues of this Highway begin at the dorsal surface of the foot with the toe extensors, and interchange with the anterior compartment of the ankle and tibia. This runs from the anterior tibialis north, connecting to the distal quadriceps near the patellar tendon.

The next interchange north is the patellar tendon and the quadriceps attachment northward to the hip flexors. To enhance function of both the quadriceps and hip flexors, it is important to lengthen both structures together.

The hip flexors intersect with the abdominals that travel to the ribs, sternum, and the sternochondral fascia, and venture into the pectorals, anterior shoulder, and the sternocleidomastoid.

From there, an angular detour takes our journey to the mastoid process of the Anterior Flexibility Highway, which enhances extension moments.

POSTERIOR FLEXIBILITY HIGHWAY

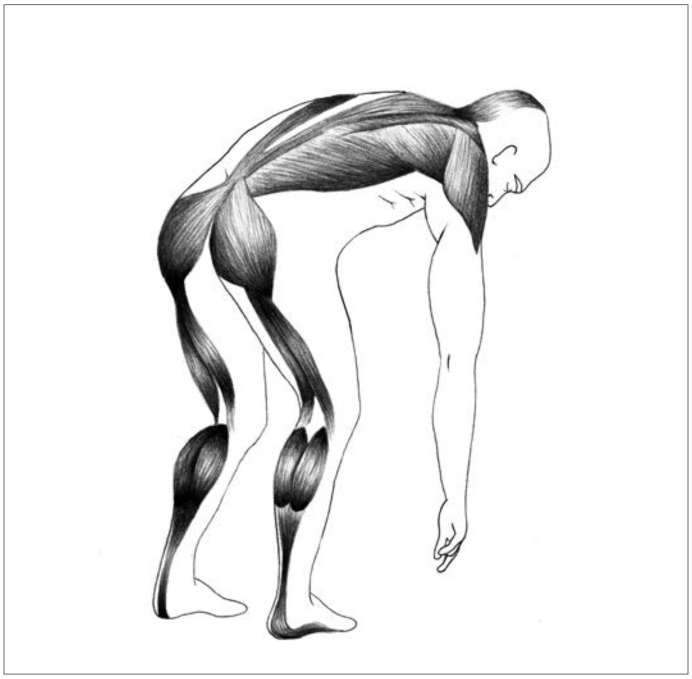

FIGURE A1.2 THE POSTERIOR FLEXIBILITY HIGHWAY

KEY INTERSECTIONS

- *Plantar fascia to calcaneus to Achilles*
- *Posterior calf to distal hams*
- *Proximal hams to distal glutes*
- *Proximal glutes to distal erector spinae*
- *Opposite glutes and lats*
- *Distal erector spinae to occipital to epicranial fascia*

STRETCHING THE POSTERIOR FLEXIBILITY HIGHWAY

PHOTO A1.2 STRETCHING THE POSTERIOR FLEXIBILITY HIGHWAY

The Posterior Flexibility Highway runs from the south to the north or along the sagittal plane with flexion movements occurring on this highway. The myofascia of this highway begins at the plantar surface of the foot from the toe flexors, moves through the posterior compartment of the ankle, and meets at the Achilles tendon. Through the posterior calf group of the gastrocnemius, soleus, and posterior tibialis northward, the knee interchange meets the hamstrings.

The gastrocnemius attaches at the femoral condyles and conjoins with the descending hamstrings that attach at the tibial condyles. In fact, the gastrocnemius and hamstrings connect with each other, forming the "trapeze artists of the body."

The hamstrings attach below and around the knee on the tibial condyles. The hamstrings run north, attaching at the ischial tuberosity, and merging into the sacrotuberous ligament. In this region, a major interchange emerges as the sacrotuberous ligament meets the lumbosacral fascia, and passes into the gluteal complex, as well as the erector spinae.

The erector group travels north to connect with the occiput and conjoins with the epicranial fascia to the forehead.

It is important to stretch the union of the gluteals and the erector spinae musculature in an integrated fashion, as any functional lumbar movement pattern includes the gluteals. The relationship of these structures should be developed together.

The final posterior journey terminates at the scalp fascia.

LATERAL FLEXIBILITY HIGHWAY

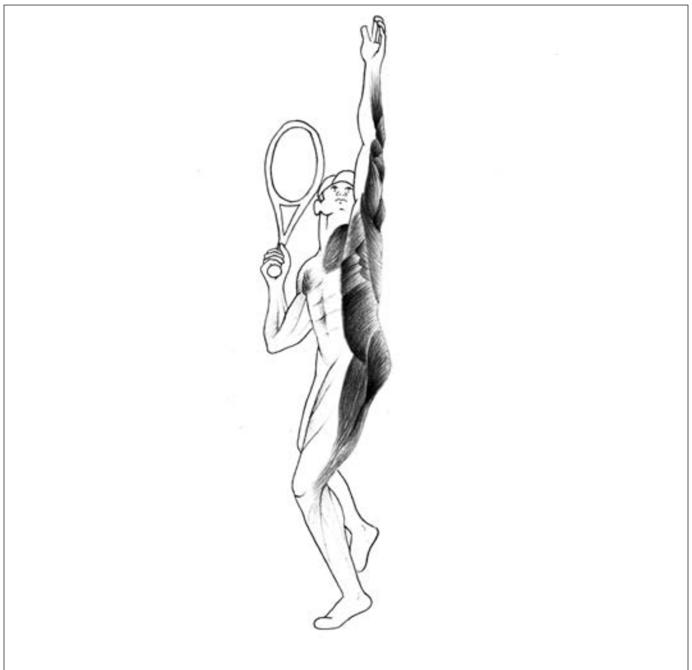

FIGURE A1.3 THE LATERAL FLEXIBILITY HIGHWAY

KEY INTERSECTIONS

- *Peroneals to ITB and TFL*
- *ITB and TFL to lateral gluteals*
- *Lateral gluteals to QL and obliques*
- *Obliques to opposite pectorals and shoulder*

STRETCHING LATERAL FLEXIBILITY HIGHWAY

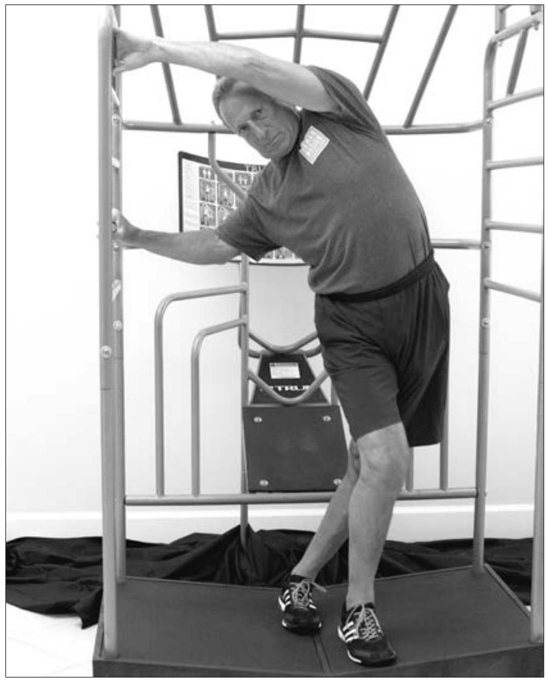

PHOTO A1.3 STRETCHING THE LATERAL FLEXIBILITY HIGHWAY

The Lateral Flexibility Highway is commonly overlooked in discussions on function. The Lateral Flexibility Highway runs from the south to the north along the frontal plane with abduction and adduction movements occurring along this line.

Running from the lateral ankle and the peroneal group, the Lateral Highway goes north to the lateral tibial condyle and the iliotibial band. Moving upward from this taut structure, the IT band merges with the tensor fascia lata, the gluteus medius and minimus, and then meets with the gluteus maximus.

When analyzing the multidirectional fibrous "routes" of the gluteal complex, we know to include these sections of the Highways with all Flexibility Highway stretching. The gluteals are the "command central" of our center of gravity, balance, and power. They are used in all functional movement patterns, and thus are the hub of tri-plane movement patterns.

Along the Lateral Flexibility Highway, the lateral gluteals are adjacent to the QL and then the obliques.

The obliques merge with the external and internal intercostals toward the anterior aspect and the latissimus dorsi in the posterior aspect. Additionally, these structures are close neighbors to the transverse abdominis by way of fascial anatomy.

From this point north, the lats will meet up with the posterior rotator cuff. There is a bypass at the junction of the latissimus dorsi and the trapezius group, whereby the journey northbound traverses through the trapezius group to the sternocleidomastoid.

THE ANTERIOR X-FACTOR

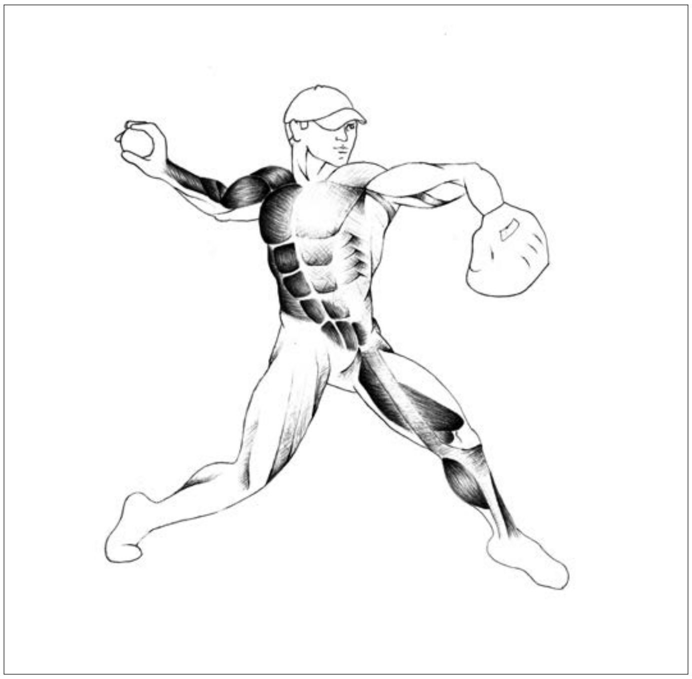

FIGURE A1.4 THE ANTERIOR X-FACTOR

KEY INTERSECTIONS

- *Opposite adductor to pubic ramus*
- *Pubic ramus to opposite obliques*
- *Obliques to serratus anterior to pectorals*
- *Pectorals to the shoulder*

STRETCHING THE ANTERIOR X-FACTOR

PHOTO A1.4 STRETCHING THE ANTERIOR X-FACTOR

All motions involving rotation and extension run along the Anterior X-Factor (AXF). When viewing the anatomy of the adductors to the opposite pectoral and shoulder region, there is a somewhat parallel line along these tissues. This Flexibility Highway runs from the adductor insertion on the linea aspera on the posterior femur and originates at the pubic ramus on the pelvis.

At this point, there is a close fascial relationship between the origin of the adductors to the rectus abdominis as it traverses along the abdominals to the opposite intercostals and obliques, upward to the serratus anterior, into the pectorals, and into the opposite shoulder complex. Therefore, any motion that involves extension and rotation of the opposite side runs along the AXF.

Additionally, when we abduct and extend an arm, similar to a throwing motion or a golfer's backswing, the tissue from the deltoid into the biceps and forearm is included in the AXF.

It is crucial to possess ample mobility in the adductors, abdominals, and pectoral regions to enhance motions through the AXF.

Likewise, it is important to maintain good range of motion in the hamstrings, as these tissues are the neighbor of the adductors, and highly affect them.

POSTERIOR X-FACTOR

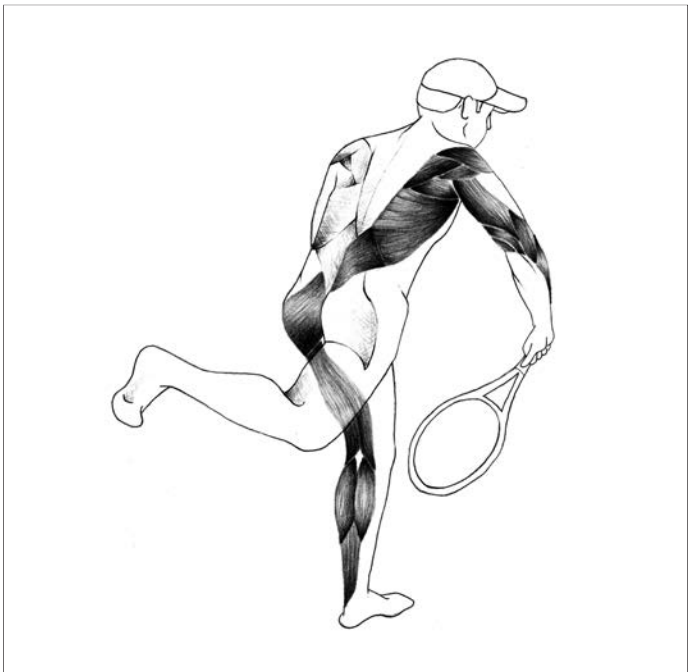

FIGURE A1.5 THE POSTERIOR X-FACTOR

KEY INTERSECTIONS

- *Calf to hamstrings*
- *Hamstrings to gluteals to sacrotuberous ligament to lumbar fascia*
- *Lumbar fascia to opposite latissimus dorsi to the shoulder*

STRETCHING THE POSTERIOR X-FACTOR

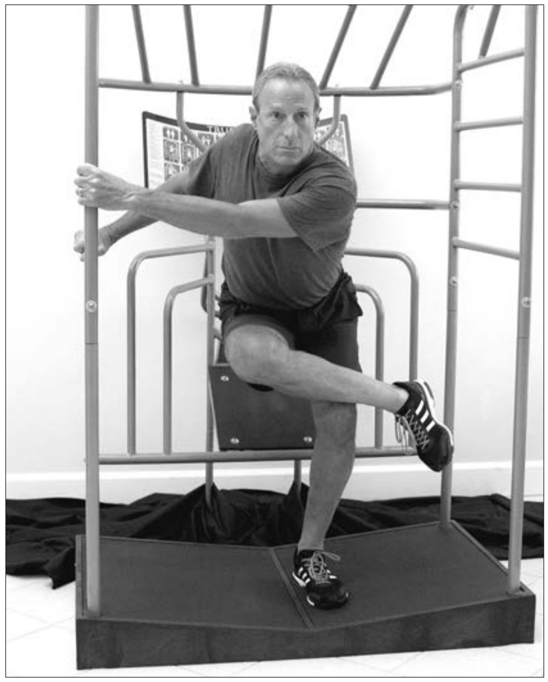

PHOTO A1.5 STRETCHING THE POSTERIOR X-FACTOR

As you view the posterior architecture of the soft tissue, the Posterior X-Factor (PXF), notice the nearly parallel line between the opposite gluteal complex and the latissimus dorsi. Both tissues entwine into the lumbosacral fascia, thereby joining the opposite hip and shoulder.

The importance of the PXF comes into play during flexion and rotational actions, such as the follow-through in a throw, the backswing during a golf swing, tennis swing follow-through, or simply picking up an object within reach and lateral to you.

THE TURNPIKE

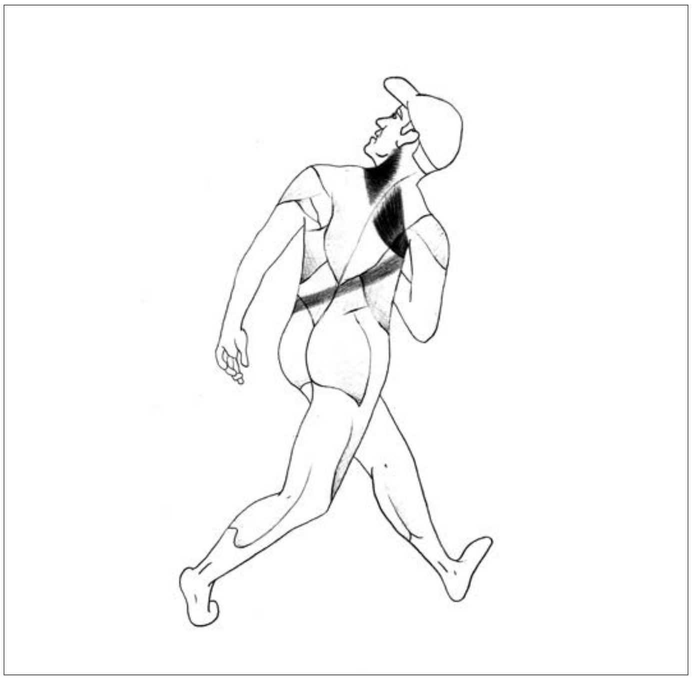

FIGURE A1.6 THE TURNPIKE

KEY INTERSECTIONS

- *Scalenes and cervicis capitis to the opposite rhomboid*
- *Rhomboid to subscapularis to serratus anterior*
- *Serratus anterior to external oblique to the opposite hip*

STRETCHING THE TURNPIKE

PHOTOS A1.6 A AND B STRETCHING THE TURNPIKE

This unique Highway system forms a relationship with the cervical spine and the hip via the opposite shoulder girdle. Running from the opposite scalene and capitis cervicis, these tissues conjoin with the rhomboids on the same side. The rhomboids attach to both scapulae, but due to the angulation of the rhomboid, these tissues attach to the opposite scapula. The rhomboid runs laterally to connect with the subscapularis approximately one-third from the medial border.

The subscapularis travels laterally to merge with the serratus anterior about 20 percent from the lateral border. The serratus anterior wraps around the side of the body, connecting with the pectorals and external obliques.

The external oblique runs on an angle toward the linea alba of the rectus abdominis to the opposite hip. This "turnpike" creates the indirect attachment from the same-side posterior cervical spine to the opposite shoulder, and diagonally back to the same-side hip on the anterior side.

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