Stretching and Flexibility

Everything you never wanted to know

by Brad Appleton

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Introduction

This document is a modest attempt to compile a wealth of information in order to answer some frequently asked questions about stretching and flexibility. It is organized into chapters covering the following topics:

1. Physiology of Stretching
2. Flexibility
3. Types of Stretching
4. How to Stretch

Although each chapter may refer to sections in other chapters, it is not required that you read every chapter in the order presented. It is important, however, that you read the disclaimer before reading any other sections of this document. See [Disclaimer], page 1. If you wish to skip around, numerous cross references are supplied in each section to help you find the concepts you may have missed. There is also an index at the end of this document.

Disclaimer

I (Brad Appleton - the author of this document) do *not* claim to be any kind of expert on stretching, anatomy, physiology, or any other biological science. I am merely attempting to compile information that I have read in books or that has been presented to me by knowledgeable sources.

The techniques, ideas, and suggestions in this document are not intended as a substitute for proper medical advice! Consult your physician or health care professional before performing any new exercise or exercise technique, particularly if you are pregnant or nursing, or if you are elderly, or if you have any chronic or recurring conditions. Any application of the techniques, ideas, and suggestions in this document is at the reader's sole discretion and risk.

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In other words: "I'm not a doctor, nor do I play one on TV!" I can not be held liable for any damages or injuries that you might suffer from somehow relying upon information in this document, no matter how awful. Not even if the information in question is incorrect or inaccurate. If you have any doubt (and even if you don't) you should always check with your doctor before trying any new exercise or exercise technique.

Acknowledgements

Thanks to all the readers of the 'rec.martial-arts', 'rec.arts.dance' and 'misc.fitness' newsgroups on Usenet who responded to my request for questions (and answers) on stretching. Many parts of this document come directly from these respondents. Thanks in particular to Shawne Neeper for sharing her formidable knowledge of muscle anatomy and physiology.

Other portions of this document rely heavily upon the information in the following books:

Sport Stretch, by Michael J. Alter
(referred to as *M. Alter* in the rest of this document)

Stretching Scientifically, by Tom Kurz
(referred to as *Kurz* in the rest of this document)

SynerStretch For Total Body Flexibility, from Health For Life
(referred to as *SynerStretch* in the rest of this document)

The Health For Life Training Advisor, also from Health For Life
(referred to as *HFLTA* in the rest of this document)

Mobility Training for the Martial Arts, by Tony Gummerson
(referred to as *Gummerson* in the rest of this document)

Further information on these books and others, is available near the end of this document.
See Appendix A [References on Stretching], page 41.

About the Author

I am *not* any kind of medical or fitness professional! I do have over 6 years of martial arts training, and over 20 years of dance training in classical ballet, modern, and jazz. However, my primary "qualifications" to write this document are that I took considerable time and effort to read several books on the topic, and to combine the information that I read with the information supplied to me from many knowledgeable readers of Usenet news. I have tried to write this document for all audiences and not make it specific to any particular sport or art (such as dancing or martial arts). I have also tried to leave out any of my own personal opinions or feelings and just state the facts as related to me by the *real* experts.

If you have specific questions or comments about the specific content of one or more parts of the stretching FAQ, please email them to me at <'mailto:bradapp@enteract.com'>. However, **Please do not email me asking for any stretching advice!** I am a professional software developer of programming tools and environments. I simply am not qualified to dispense medical or fitness advice. You need to seek out a licensed/certified medical or fitness professional for that sort of thing. The information I have compiled here comes from various expert sources, and I certainly learned a lot when I researched the subject, but Im *not* an expert myself.

1 Physiology of Stretching

The purpose of this chapter is to introduce you to some of the basic physiological concepts that come into play when a muscle is stretched. Concepts will be introduced initially with a general overview and then (for those who want to know the gory details) will be discussed in further detail. If you aren't all that interested in this aspect of stretching, you can skip this chapter. Other sections will refer to important concepts from this chapter and you can easily look them up on a "need to know" basis.

1.1 The Musculoskeletal System

Together, muscles and bones comprise what is called the *musculoskeletal system* of the body. The bones provide posture and structural support for the body and the muscles provide the body with the ability to move (by contracting, and thus generating tension). The musculoskeletal system also provides protection for the body's internal organs. In order to serve their function, bones must be joined together by something. The point where bones connect to one another is called a *joint*, and this connection is made mostly by *ligaments* (along with the help of muscles). Muscles are attached to the bone by *tendons*. Bones, tendons, and ligaments do not possess the ability (as muscles do) to make your body move. Muscles are very unique in this respect.

1.2 Muscle Composition

Muscles vary in shape and in size, and serve many different purposes. Most large muscles, like the hamstrings and quadriceps, control motion. Other muscles, like the heart, and the muscles of the inner ear, perform other functions. At the microscopic level however, all muscles share the same basic structure.

At the highest level, the (whole) muscle is composed of many strands of tissue called *fascicles*. These are the strands of muscle that we see when we cut red meat or poultry. Each fascicle is composed of *fasciculi* which are bundles of *muscle fibers*. The muscle fibers are in turn composed of tens of thousands of thread-like *myofybrils*, which can contract, relax, and elongate (lengthen). The myofybrils are (in turn) composed of up to millions of bands laid end-to-end called *sarcomeres*. Each sarcomere is made of overlapping thick and thin filaments called *myofilaments*. The thick and thin myofilaments are made up of *contractile proteins*, primarily actin and myosin.

1.2.1 How Muscles Contract

The way in which all these various levels of the muscle operate is as follows: Nerves connect the spinal column to the muscle. The place where the nerve and muscle meet is called the *neuromuscular junction*. When an electrical signal crosses the neuromuscular junction, it is transmitted deep inside the muscle fibers. Inside the muscle fibers, the signal stimulates the flow of calcium which causes the thick and thin myofilaments to slide across one another. When this occurs, it causes the sarcomere to shorten, which generates force.

When billions of sarcomeres in the muscle shorten all at once it results in a contraction of the entire muscle fiber.

When a muscle fiber contracts, it contracts completely. There is no such thing as a partially contracted muscle fiber. Muscle fibers are unable to vary the intensity of their contraction relative to the load against which they are acting. If this is so, then how does the force of a muscle contraction vary in strength from strong to weak? What happens is that more muscle fibers are recruited, as they are needed, to perform the job at hand. The more muscle fibers that are recruited by the central nervous system, the stronger the force generated by the muscular contraction.

1.2.2 Fast and Slow Muscle Fibers

The energy which produces the calcium flow in the muscle fibers comes from *mitochondria*, the part of the muscle cell that converts glucose (blood sugar) into energy. Different types of muscle fibers have different amounts of mitochondria. The more mitochondria in a muscle fiber, the more energy it is able to produce. Muscle fibers are categorized into *slow-twitch fibers* and *fast-twitch fibers*. Slow-twitch fibers (also called *Type 1 muscle fibers*) are slow to contract, but they are also very slow to fatigue. Fast-twitch fibers are very quick to contract and come in two varieties: *Type 2A muscle fibers* which fatigue at an intermediate rate, and *Type 2B muscle fibers* which fatigue very quickly. The main reason the slow-twitch fibers are slow to fatigue is that they contain more mitochondria than fast-twitch fibers and hence are able to produce more energy. Slow-twitch fibers are also smaller in diameter than fast-twitch fibers and have increased capillary blood flow around them. Because they have a smaller diameter and an increased blood flow, the slow-twitch fibers are able to deliver more oxygen and remove more waste products from the muscle fibers (which decreases their "fatigability").

These three muscle fiber types (Types 1, 2A, and 2B) are contained in all muscles in varying amounts. Muscles that need to be contracted much of the time (like the heart) have a greater number of Type 1 (slow) fibers. When a muscle first starts to contract, it is primarily Type 1 fibers that are initially activated, then Type 2A and Type 2B fibers are activated (if needed) in that order. The fact that muscle fibers are *recruited* in this sequence is what provides the ability to execute brain commands with such fine-tuned tuned muscle responses. It also makes the Type 2B fibers difficult to train because they are not activated until most of the Type 1 and Type 2A fibers have been recruited.

HFLTA states that the the best way to remember the difference between muscles with predominantly slow-twitch fibers and muscles with predominantly fast-twitch fibers is to think of "white meat" and "dark meat". Dark meat is dark because it has a greater number of slow-twitch muscle fibers and hence a greater number of mitochondria, which are dark. White meat consists mostly of muscle fibers which are at rest much of the time but are frequently called on to engage in brief bouts of intense activity. This muscle tissue can contract quickly but is fast to fatigue and slow to recover. White meat is lighter in color than dark meat because it contains fewer mitochondria.

1.3 Connective Tissue

Located all around the muscle and its fibers are *connective tissues*. Connective tissue is composed of a base substance and two kinds of protein based fiber. The two types of fiber are *collagenous connective tissue* and *elastic connective tissue*. Collagenous connective tissue consists mostly of collagen (hence its name) and provides tensile strength. Elastic connective tissue consists mostly of elastin and (as you might guess from its name) provides elasticity. The base substance is called *mucopolysaccharide* and acts as both a lubricant (allowing the fibers to easily slide over one another), and as a glue (holding the fibers of the tissue together into bundles). The more elastic connective tissue there is around a joint, the greater the range of motion in that joint. Connective tissues are made up of tendons, ligaments, and the fascial sheaths that envelop, or bind down, muscles into separate groups. These fascial sheaths, or *fascia*, are named according to where they are located in the muscles:

endomysium
: The innermost fascial sheath that envelops individual muscle fibers.

perimysium
: The fascial sheath that binds groups of muscle fibers into individual fasciculi (see Section 1.2 [Muscle Composition], page 3).

epimysium
: The outermost fascial sheath that binds entire fascicles (see Section 1.2 [Muscle Composition], page 3).

These connective tissues help provide suppleness and tone to the muscles.

1.4 Cooperating Muscle Groups

When muscles cause a limb to move through the joint's range of motion, they usually act in the following cooperating groups:

agonists
: These muscles cause the movement to occur. They create the normal range of movement in a joint by contracting. Agonists are also referred to as *prime movers* since they are the muscles that are primarily responsible for generating the movement.

antagonists
: These muscles act in opposition to the movement generated by the agonists and are responsible for returning a limb to its initial position.

synergists
: These muscles perform, or assist in performing, the same set of joint motion as the agonists. Synergists are sometimes referred to as *neutralizers* because they help cancel out, or neutralize, extra motion from the agonists to make sure that the force generated works within the desired plane of motion.

fixators
: These muscles provide the necessary support to assist in holding the rest of the body in place while the movement occurs. Fixators are also sometimes called *stabilizers*.

As an example, when you flex your knee, your hamstring contracts, and, to some extent, so does your gastrocnemius (calf) and lower buttocks. Meanwhile, your quadriceps are inhibited (relaxed and lengthened somewhat) so as not to resist the flexion (see Section 1.6.4 [Reciprocal Inhibition], page 9). In this example, the hamstring serves as the agonist, or prime mover; the quadricep serves as the antagonist; and the calf and lower buttocks serve as the synergists. Agonists and antagonists are usually located on opposite sides of the affected joint (like your hamstrings and quadriceps, or your triceps and biceps), while synergists are usually located on the same side of the joint near the agonists. Larger muscles often call upon their smaller neighbors to function as synergists.

The following is a list of commonly used agonist/antagonist muscle pairs:

- pectorals/latissimus dorsi (pecs and lats)
- anterior deltoids/posterior deltoids (front and back shoulder)
- trapezius/deltoids (traps and delts)
- abdominals/spinal erectors (abs and lower-back)
- left and right external obliques (sides)
- quadriceps/hamstrings (quads and hams)
- shins/calves
- biceps/triceps
- forearm flexors/extensors

1.5 Types of Muscle Contractions

The contraction of a muscle does not necessarily imply that the muscle shortens; it only means that tension has been generated. Muscles can contract in the following ways:

isometric contraction

This is a contraction in which no movement takes place, because the load on the muscle exceeds the tension generated by the contracting muscle. This occurs when a muscle attempts to push or pull an immovable object.

isotonic contraction

This is a contraction in which movement *does* take place, because the tension generated by the contracting muscle exceeds the load on the muscle. This occurs when you use your muscles to successfully push or pull an object.

Isotonic contractions are further divided into two types:

concentric contraction

This is a contraction in which the muscle decreases in length (shortens) against an opposing load, such as lifting a weight up.

eccentric contraction

This is a contraction in which the muscle increases in length (lengthens) as it resists a load, such as pushing something down.

During a concentric contraction, the muscles that are shortening serve as the agonists and hence do all of the work. During an eccentric contraction the muscles that are lengthening serve as the agonists (and do all of the work). See Section 1.4 [Cooperating Muscle Groups], page 5.

1.6 What Happens When You Stretch

The stretching of a muscle fiber begins with the sarcomere (see Section 1.2 [Muscle Composition], page 3), the basic unit of contraction in the muscle fiber. As the sarcomere contracts, the area of overlap between the thick and thin myofilaments increases. As it stretches, this area of overlap decreases, allowing the muscle fiber to elongate. Once the muscle fiber is at its maximum resting length (all the sarcomeres are fully stretched), additional stretching places force on the surrounding connective tissue (see Section 1.3 [Connective Tissue], page 5). As the tension increases, the collagen fibers in the connective tissue align themselves along the same line of force as the tension. Hence when you stretch, the muscle fiber is pulled out to its full length sarcomere by sarcomere, and then the connective tissue takes up the remaining slack. When this occurs, it helps to realign any disorganized fibers in the direction of the tension. This realignment is what helps to rehabilitate scarred tissue back to health.

When a muscle is stretched, some of its fibers lengthen, but other fibers may remain at rest. The current length of the entire muscle depends upon the number of stretched fibers (similar to the way that the total strength of a contracting muscle depends on the number of recruited fibers contracting). According to *SynerStretch* you should think of "little pockets of fibers distributed throughout the muscle body stretching, and other fibers simply going along for the ride". The more fibers that are stretched, the greater the length developed by the stretched muscle.

1.6.1 Proprioceptors

The nerve endings that relay all the information about the musculoskeletal system to the central nervous system are called *proprioceptors*. Proprioceptors (also called *mechanoreceptors*) are the source of all *proprioception*: the perception of one's own body position and movement. The proprioceptors detect any changes in physical displacement (movement or position) and any changes in tension, or force, within the body. They are found in all nerve endings of the joints, muscles, and tendons. The proprioceptors related to stretching are located in the tendons and in the muscle fibers.

There are two kinds of muscle fibers: *intrafusal muscle fibers* and *extrafusal muscle fibers*. Extrafusil fibers are the ones that contain myofibrils (see Section 1.2 [Muscle Composition], page 3) and are what is usually meant when we talk about muscle fibers. Intrafusal fibers are also called *muscle spindles* and lie parallel to the extrafusal fibers. Muscle spindles, or *stretch receptors*, are the primary proprioceptors in the muscle. Another proprioceptor that comes into play during stretching is located in the tendon near the end of the muscle fiber and is called the *golgi tendon organ*. A third type of proprioceptor, called a *pacinian corpuscle*, is located close to the golgi tendon organ and is responsible for detecting changes in movement and pressure within the body.

When the extrafusal fibers of a muscle lengthen, so do the intrafusal fibers (muscle spindles). The muscle spindle contains two different types of fibers (or stretch receptors) which are sensitive to the change in muscle length and the rate of change in muscle length. When muscles contract it places tension on the tendons where the golgi tendon organ is located. The golgi tendon organ is sensitive to the change in tension and the rate of change of the tension.

1.6.2 The Stretch Reflex

When the muscle is stretched, so is the muscle spindle (see Section 1.6.1 [Proprioceptors], page 7). The muscle spindle records the change in length (and how fast) and sends signals to the spine which convey this information. This triggers the *stretch reflex* (also called the *myotatic reflex*) which attempts to resist the change in muscle length by causing the stretched muscle to contract. The more sudden the change in muscle length, the stronger the muscle contractions will be (plyometric, or "jump", training is based on this fact). This basic function of the muscle spindle helps to maintain muscle tone and to protect the body from injury.

One of the reasons for holding a stretch for a prolonged period of time is that as you hold the muscle in a stretched position, the muscle spindle habituates (becomes accustomed to the new length) and reduces its signaling. Gradually, you can train your stretch receptors to allow greater lengthening of the muscles.

Some sources suggest that with extensive training, the stretch reflex of certain muscles can be controlled so that there is little or no reflex contraction in response to a sudden stretch. While this type of control provides the opportunity for the greatest gains in flexibility, it also provides the greatest risk of injury if used improperly. Only consummate professional athletes and dancers at the top of their sport (or art) are believed to actually possess this level of muscular control.

1.6.2.1 Components of the Stretch Reflex

The stretch reflex has both a dynamic component and a static component. The static component of the stretch reflex persists as long as the muscle is being stretched. The dynamic component of the stretch reflex (which can be very powerful) lasts for only a moment and is in response to the initial sudden increase in muscle length. The reason that the stretch reflex has two components is because there are actually two kinds of intrafusal muscle fibers: *nuclear chain fibers*, which are responsible for the static component; and *nuclear bag fibers*, which are responsible for the dynamic component.

Nuclear chain fibers are long and thin, and lengthen steadily when stretched. When these fibers are stretched, the stretch reflex nerves increase their firing rates (signaling) as their length steadily increases. This is the static component of the stretch reflex.

Nuclear bag fibers bulge out at the middle, where they are the most elastic. The stretch-sensing nerve ending for these fibers is wrapped around this middle area, which lengthens rapidly when the fiber is stretched. The outer-middle areas, in contrast, act like they are filled with viscous fluid; they resist fast stretching, then gradually extend under prolonged tension. So, when a fast stretch is demanded of these fibers, the middle takes most of the stretch at first; then, as the outer-middle parts extend, the middle can shorten somewhat. So the nerve that senses stretching in these fibers fires rapidly with the onset of a fast stretch, then slows as the middle section of the fiber is allowed to shorten again. This is the dynamic component of the stretch reflex: a strong signal to contract at the onset of a rapid increase in muscle length, followed by slightly "higher than normal" signaling which gradually decreases as the rate of change of the muscle length decreases.

1.6.3 The Lengthening Reaction

When muscles contract (possibly due to the stretch reflex), they produce tension at the point where the muscle is connected to the tendon, where the golgi tendon organ is located. The golgi tendon organ records the change in tension, and the rate of change of the tension, and sends signals to the spine to convey this information (see Section 1.6.1 [Proprioceptors], page 7). When this tension exceeds a certain threshold, it triggers the *lengthening reaction* which inhibits the muscles from contracting and causes them to relax. Other names for this reflex are the *inverse myotatic reflex*, *autogenic inhibition*, and the *clasped-knife reflex*. This basic function of the golgi tendon organ helps to protect the muscles, tendons, and ligaments from injury. The lengthening reaction is possible only because the signaling of golgi tendon organ to the spinal cord is powerful enough to overcome the signaling of the muscle spindles telling the muscle to contract.

Another reason for holding a stretch for a prolonged period of time is to allow this lengthening reaction to occur, thus helping the stretched muscles to relax. It is easier to stretch, or lengthen, a muscle when it is not trying to contract.

1.6.4 Reciprocal Inhibition

When an agonist contracts, in order to cause the desired motion, it usually forces the antagonists to relax (see Section 1.4 [Cooperating Muscle Groups], page 5). This phenomenon is called *reciprocal inhibition* because the antagonists are inhibited from contracting. This is sometimes called *reciprocal innervation* but that term is really a misnomer since it is the agonists which inhibit (relax) the antagonists. The antagonists do *not* actually innervate (cause the contraction of) the agonists.

Such inhibition of the antagonistic muscles is not necessarily required. In fact, co-contraction can occur. When you perform a sit-up, one would normally assume that the stomach muscles inhibit the contraction of the muscles in the lumbar, or lower, region of the back. In this particular instance however, the back muscles (spinal erectors) also contract. This is one reason why sit-ups are good for strengthening the back as well as the stomach.

When stretching, it is easier to stretch a muscle that is relaxed than to stretch a muscle that is contracting. By taking advantage of the situations when reciprocal inhibition *does* occur, you can get a more effective stretch by inducing the antagonists to relax during the stretch due to the contraction of the agonists. You also want to relax any muscles used as synergists by the muscle you are trying to stretch. For example, when you stretch your calf, you want to contract the shin muscles (the antagonists of the calf) by flexing your foot.

However, the hamstrings use the calf as a synergist so you want to also relax the hamstrings by contracting the quadricep (i.e., keeping your leg straight).

2 Flexibility

Flexibility is defined by *Gummerson* as "the absolute range of movement in a joint or series of joints that is attainable in a momentary effort with the help of a partner or a piece of equipment." This definition tells us that flexibility is not something general but is specific to a particular joint or set of joints. In other words, it is a myth that some people are innately flexible throughout their entire body. Being flexible in one particular area or joint does not necessarily imply being flexible in another. Being "loose" in the upper body does not mean you will have a "loose" lower body. Furthermore, according to *SynerStretch*, flexibility in a joint is also "specific to the action performed at the joint (the ability to do front splits doesn't imply the ability to do side splits even though both actions occur at the hip)."

2.1 Types of Flexibility

Many people are unaware of the fact that there are different types of flexibility. These different types of flexibility are grouped according to the various types of activities involved in athletic training. The ones which involve motion are called *dynamic* and the ones which do not are called *static*. The different types of flexibility (according to *Kurz*) are:

dynamic flexibility
: Dynamic flexibility (also called *kinetic flexibility*) is the ability to perform dynamic (or kinetic) movements of the muscles to bring a limb through its full range of motion in the joints.

static-active flexibility
: Static-active flexibility (also called *active flexibility*) is the ability to assume and maintain extended positions using only the tension of the agonists and synergists while the antagonists are being stretched (see Section 1.4 [Cooperating Muscle Groups], page 5). For example, lifting the leg and keeping it high without any external support (other than from your own leg muscles).

static-passive flexibility
: Static-passive flexibility (also called *passive flexibility*) is the ability to assume extended positions and then maintain them using only your weight, the support of your limbs, or some other apparatus (such as a chair or a barre). Note that the ability to maintain the position does not come solely from your muscles, as it does with static-active flexibility. Being able to perform the splits is an example of static-passive flexibility.

Research has shown that active flexibility is more closely related to the level of sports achievement than is passive flexibility. Active flexibility is harder to develop than passive flexibility (which is what most people think of as "flexibility"); not only does active flexibility require passive flexibility in order to assume an initial extended position, it also requires muscle strength to be able to hold and maintain that position.

2.2 Factors Limiting Flexibility

According to *Gummerson*, flexibility (he uses the term *mobility*) is affected by the following factors:

- Internal influences
  - the type of joint (some joints simply aren't meant to be flexible)
  - the internal resistance within a joint
  - bony structures which limit movement
  - the elasticity of muscle tissue (muscle tissue that is scarred due to a previous injury is not very elastic)
  - the elasticity of tendons and ligaments (ligaments do not stretch much and tendons should not stretch at all)
  - the elasticity of skin (skin actually has some degree of elasticity, but not much)
  - the ability of a muscle to relax and contract to achieve the greatest range of movement
  - the temperature of the joint and associated tissues (joints and muscles offer better flexibility at body temperatures that are 1 to 2 degrees higher than normal)
- External influences
  - the temperature of the place where one is training (a warmer temperature is more conducive to increased flexibility)
  - the time of day (most people are more flexible in the afternoon than in the morning, peaking from about 2:30pm-4pm)
  - the stage in the recovery process of a joint (or muscle) after injury (injured joints and muscles will usually offer a lesser degree of flexibility than healthy ones)
  - age (pre-adolescents are generally more flexible than adults)
  - gender (females are generally more flexible than males)
  - one's ability to perform a particular exercise (practice makes perfect)
  - one's commitment to achieving flexibility
  - the restrictions of any clothing or equipment

Some sources also the suggest that water is an important dietary element with regard to flexibility. Increased water intake is believed to contribute to increased mobility, as well as increased total body relaxation.

Rather than discuss each of these factors in significant detail as *Gummerson* does, I will attempt to focus on some of the more common factors which limit one's flexibility. According to *SynerStretch*, the most common factors are: bone structure, muscle mass, excess fatty tissue, and connective tissue (and, of course, physical injury or disability).

Depending on the type of joint involved and its present condition (is it healthy?), the bone structure of a particular joint places very noticeable limits on flexibility. This is a common way in which age can be a factor limiting flexibility since older joints tend not to be as healthy as younger ones.

Muscle mass can be a factor when the muscle is so heavily developed that it interferes with the ability to take the adjacent joints through their complete range of motion (for example, large hamstrings limit the ability to fully bend the knees). Excess fatty tissue imposes a similar restriction.

The majority of "flexibility" work should involve performing exercises designed to reduce the internal resistance offered by soft connective tissues (see Section 1.3 [Connective Tissue], page 5). Most stretching exercises attempt to accomplish this goal and can be performed by almost anyone, regardless of age or gender.

2.2.1 How Connective Tissue Affects Flexibility

The resistance to lengthening that is offered by a muscle is dependent upon its connective tissues: When the muscle elongates, the surrounding connective tissues become more taut (see Section 1.3 [Connective Tissue], page 5). Also, inactivity of certain muscles or joints can cause chemical changes in connective tissue which restrict flexibility. According to *M. Alter*, each type of tissue plays a certain role in joint stiffness: "The joint capsule (i.e., the saclike structure that encloses the ends of bones) and ligaments are the most important factors, accounting for 47 percent of the stiffness, followed by the muscle's fascia (41 percent), the tendons (10 percent), and skin (2 percent)".

M. Alter goes on to say that efforts to increase flexibility should be directed at the muscle's fascia however. This is because it has the most elastic tissue, and because ligaments and tendons (since they have less elastic tissue) are not intended to stretched very much at all. Overstretching them may weaken the joint's integrity and cause destabilization (which increases the risk of injury).

When connective tissue is overused, the tissue becomes fatigued and may tear, which also limits flexibility. When connective tissue is unused or under used, it provides significant resistance and limits flexibility. The elastin begins to fray and loses some of its elasticity, and the collagen increases in stiffness and in density. Aging has some of the same effects on connective tissue that lack of use has.

2.2.2 How Aging Affects Flexibility

With appropriate training, flexibility can, and should, be developed at all ages. This does not imply, however, that flexibility can be developed at the same rate by everyone. In general, the older you are, the longer it will take to develop the desired level of flexibility. Hopefully, you'll be more patient if you're older.

According to *M. Alter*, the main reason we become less flexible as we get older is a result of certain changes that take place in our connective tissues. As we age, our bodies gradually dehydrate to some extent. It is believed that "stretching stimulates the production or retention of lubricants between the connective tissue fibers, thus preventing the formation of adhesions". Hence, exercise can delay some of the loss of flexibility that occurs due to the aging process.

M. Alter further states that some of the physical changes attributed to aging are the following:

- An increased amount of calcium deposits, adhesions, and cross-links in the body
- An increase in the level of fragmentation and dehydration
- Changes in the chemical structure of the tissues.
- Loss of *suppleness* due to the replacement of muscle fibers with fatty, collagenous fibers.

This does *not* mean that you should give up trying to achieve flexibility if you are old or inflexible. It just means that you need to work harder, and more carefully, for a longer period of time when attempting to increase flexibility. Increases in the ability of muscle tissues and connective tissues to elongate (stretch) can be achieved at any age.

2.3 Strength and Flexibility

Strength training and flexibility training should go hand in hand. It is a common misconception that there must always be a trade-off between flexibility and strength. Obviously, if you neglect flexibility training altogether in order to train for strength then you are certainly sacrificing flexibility (and vice versa). However, performing exercises for both strength and flexibility need not sacrifice either one. As a matter of fact, flexibility training and strength training can actually enhance one another.

2.3.1 Why Bodybuilders Should Stretch

One of the best times to stretch is right after a strength workout such as weightlifting. Static stretching of fatigued muscles (see Section 3.5 [Static Stretching], page 18) performed immediately following the exercise(s) that caused the fatigue, helps not only to increase flexibility, but also enhances the promotion of muscular development (muscle growth), and will actually help decrease the level of post-exercise soreness. Here's why:

After you have used weights (or other means) to overload and fatigue your muscles, your muscles retain a "pump" and are shortened somewhat. This "shortening" is due mostly to the repetition of intense muscle activity that often only takes the muscle through part of its full range of motion. This "pump" makes the muscle appear bigger. The "pumped" muscle is also full of lactic acid and other by-products from exhaustive exercise. If the muscle is not stretched afterward, it will retain this decreased range of motion (it sort of "forgets" how to make itself as long as it could) and the buildup of lactic acid will cause post-exercise soreness. Static stretching of the "pumped" muscle helps it to become "looser", and to "remember" its full range of movement. It also helps to remove lactic acid and other waste-products from the muscle. While it is true that stretching the "pumped" muscle will make it appear visibly smaller, it does not decrease the muscle's size or inhibit muscle growth. It merely reduces the "tightness" (contraction) of the muscles so that they do not "bulge" as much.

Also, strenuous workouts will often cause damage to the muscle's connective tissue. The tissue heals in 1 to 2 days but it is believed that the tissues heal at a shorter length (decreasing muscular development as well as flexibility). To prevent the tissues from healing at a shorter length, physiologists recommend static stretching after strength workouts.

2.3.2 Why Contortionists Should Strengthen

You should be "tempering" (or balancing) your flexibility training with strength training (and vice versa). Do not perform stretching exercises for a given muscle group without also performing strength exercises for that same group of muscles. Judy Alter, in her book *Stretch and Strengthen*, recommends stretching muscles after performing strength exercises, and performing strength exercises for every muscle you stretch. In other words: "Strengthen what you stretch, and stretch after you strengthen!"

The reason for this is that flexibility training on a regular basis causes connective tissues to stretch which in turn causes them to loosen (become less taut) and elongate. When the connective tissue of a muscle is weak, it is more likely to become damaged due to overstretching, or sudden, powerful muscular contractions. The likelihood of such injury can be prevented by strengthening the muscles bound by the connective tissue. *Kurz* suggests dynamic strength training consisting of light dynamic exercises with weights (lots of reps, not too much weight), and isometric tension exercises. If you also lift weights, dynamic strength training for a muscle should occur *before* subjecting that muscle to an intense weightlifting workout. This helps to pre-exhaust the muscle first, making it easier (and faster) to achieve the desired overload in an intense strength workout. Attempting to perform dynamic strength training *after* an intense weightlifting workout would be largely ineffective.

If you are working on increasing (or maintaining) flexibility then it is *very* important that your strength exercises force your muscles to take the joints through their full range of motion. According to *Kurz*, Repeating movements that do not employ a full range of motion in the joints (like cycling, certain weightlifting techniques, and pushups) can cause of shortening of the muscles surrounding the joints. This is because the nervous control of length and tension in the muscles are set at what is repeated most strongly and/or most frequently.

2.4 Overflexibility

It is possible for the muscles of a joint to become too flexible. According to *SynerStretch*, there is a tradeoff between flexibility and stability. As you get "looser" or more limber in a particular joint, less support is given to the joint by its surrounding muscles. Excessive flexibility can be just as bad as not enough because both increase your risk of injury.

Once a muscle has reached its absolute maximum length, attempting to stretch the muscle further only serves to stretch the ligaments and put undue stress upon the tendons (two things that you do *not* want to stretch). Ligaments will tear when stretched more than 6% of their normal length. Tendons are not even supposed to be able to lengthen. Even when stretched ligaments and tendons do not tear, loose joints and/or a decrease in the joint's stability can occur (thus vastly increasing your risk of injury).

Once you have achieved the desired level of flexibility for a muscle or set of muscles and have maintained that level for a solid week, you should discontinue any isometric or PNF stretching of that muscle until some of its flexibility is lost (see Section 3.6 [Isometric Stretching], page 19, and see Section 3.7 [PNF Stretching], page 20).

3 Types of Stretching

Just as there are different types of flexibility, there are also different types of stretching. Stretches are either dynamic (meaning they involve motion) or static (meaning they involve no motion). Dynamic stretches affect dynamic flexibility and static stretches affect static flexibility (and dynamic flexibility to some degree).

The different types of stretching are:

1. ballistic stretching
2. dynamic stretching
3. active stretching
4. passive (or relaxed) stretching
5. static stretching
6. isometric stretching
7. PNF stretching

3.1 Ballistic Stretching

Ballistic stretching uses the momentum of a moving body or a limb in an attempt to force it beyond its normal range of motion. This is stretching, or "warming up", by bouncing into (or out of) a stretched position, using the stretched muscles as a spring which pulls you out of the stretched position. (e.g. bouncing down repeatedly to touch your toes.) This type of stretching is not considered useful and can lead to injury. It does not allow your muscles to adjust to, and relax in, the stretched position. It may instead cause them to tighten up by repeatedly activating the stretch reflex (see Section 1.6.2 [The Stretch Reflex], page 8).

3.2 Dynamic Stretching

Dynamic stretching, according to *Kurz*, "involves moving parts of your body and gradually increasing reach, speed of movement, or both." Do not confuse dynamic stretching with ballistic stretching! Dynamic stretching consists of controlled leg and arm swings that take you (gently!) to the limits of your range of motion. Ballistic stretches involve trying to force a part of the body *beyond* its range of motion. In dynamic stretches, there are no bounces or "jerky" movements. An example of dynamic stretching would be slow, controlled leg swings, arm swings, or torso twists.

Dynamic stretching improves dynamic flexibility and is quite useful as part of your warm-up for an active or aerobic workout (such as a dance or martial-arts class). See Section 4.1 [Warming Up], page 25.

According to *Kurz*, dynamic stretching exercises should be performed in sets of 8-12 repetitions. Be sure to stop when and if you feel tired. Tired muscles have less elasticity which decreases the range of motion used in your movements. Continuing to exercise when you are tired serves only to reset the nervous control of your muscle length at the reduced range of motion used in the exercise (and will cause a loss of flexibility). Once you attain a maximal range of motion for a joint in any direction you should stop doing that movement during that workout. Tired and overworked muscles won't attain a full range of motion and the muscle's kinesthetic memory will remember the repeated shorted range of motion, which you will then have to overcome before you can make further progress.

3.3 Active Stretching

Active stretching is also referred to as *static-active stretching*. An active stretch is one where you assume a position and then hold it there with no assistance other than using the strength of your agonist muscles (see Section 1.4 [Cooperating Muscle Groups], page 5). For example, bringing your leg up high and then holding it there without anything (other than your leg muscles themselves) to keep the leg in that extended position. The tension of the agonists in an active stretch helps to relax the muscles being stretched (the antagonists) by reciprocal inhibition (see Section 1.6.4 [Reciprocal Inhibition], page 9).

Active stretching increases active flexibility and strengthens the agonistic muscles. Active stretches are usually quite difficult to hold and maintain for more than 10 seconds and rarely need to be held any longer than 15 seconds.

Many of the movements (or stretches) found in various forms of yoga are active stretches.

3.4 Passive Stretching

Passive stretching is also referred to as *relaxed stretching*, and as *static-passive stretching*. A passive stretch is one where you assume a position and hold it with some other part of your body, or with the assistance of a partner or some other apparatus. For example, bringing your leg up high and then holding it there with your hand. The splits is an example of a passive stretch (in this case the floor is the "apparatus" that you use to maintain your extended position).

Slow, relaxed stretching is useful in relieving spasms in muscles that are healing after an injury. Obviously, you should check with your doctor first to see if it is okay to attempt to stretch the injured muscles (see Section 4.12 [Pain and Discomfort], page 35).

Relaxed stretching is also very good for "cooling down" after a workout and helps reduce post-workout muscle fatigue, and soreness. See Section 4.2 [Cooling Down], page 28.

3.5 Static Stretching

Many people use the term "passive stretching" and "static stretching" interchangeably. However, there are a number of people who make a distinction between the two. According to *M. Alter*, *Static stretching* consists of stretching a muscle (or group of muscles) to its farthest point and then maintaining or holding that position, whereas *Passive stretching* consists of a relaxed person who is relaxed (passive) while some external force (either a person or an apparatus) brings the joint through its range of motion.

Notice that the definition of passive stretching given in the previous section encompasses *both* of the above definitions. Throughout this document, when the term *static stretching* or *passive stretching* is used, its intended meaning is the definition of passive stretching as described in the previous section. You should be aware of these alternative meanings, however, when looking at other references on stretching.

3.6 Isometric Stretching

Isometric stretching is a type of static stretching (meaning it does not use motion) which involves the resistance of muscle groups through isometric contractions (tensing) of the stretched muscles (see Section 1.5 [Types of Muscle Contractions], page 6). The use of isometric stretching is one of the fastest ways to develop increased static-passive flexibility and is much more effective than either passive stretching or active stretching alone. Isometric stretches also help to develop strength in the "tensed" muscles (which helps to develop static-active flexibility), and seems to decrease the amount of pain usually associated with stretching.

The most common ways to provide the needed resistance for an isometric stretch are to apply resistance manually to one's own limbs, to have a partner apply the resistance, or to use an apparatus such as a wall (or the floor) to provide resistance.

An example of manual resistance would be holding onto the ball of your foot to keep it from flexing while you are using the muscles of your calf to try and straighten your instep so that the toes are pointed.

An example of using a partner to provide resistance would be having a partner hold your leg up high (and keep it there) while you attempt to force your leg back down to the ground.

An example of using the wall to provide resistance would be the well known "push-the-wall" calf-stretch where you are actively attempting to move the wall (even though you know you can't).

Isometric stretching is *not* recommended for children and adolescents whose bones are still growing. These people are usually already flexible enough that the strong stretches produced by the isometric contraction have a much higher risk of damaging tendons and connective tissue. *Kurz* strongly recommends preceding any isometric stretch of a muscle with dynamic strength training for the muscle to be stretched. A full session of isometric stretching makes a lot of demands on the muscles being stretched and should not be performed more than once per day for a given group of muscles (ideally, no more than once every 36 hours).

The proper way to perform an isometric stretch is as follows:

1. Assume the position of a passive stretch for the desired muscle.
2. Next, tense the stretched muscle for 7-15 seconds (resisting against some force that will not move, like the floor or a partner).
3. Finally, relax the muscle for at least 20 seconds.

Some people seem to recommend holding the isometric contraction for longer than 15 seconds, but according to *SynerStretch* (the videotape), research has shown that this is not necessary. So you might as well make your stretching routine less time consuming.

3.6.1 How Isometric Stretching Works

Recall from our previous discussion (see Section 1.2.1 [How Muscles Contract], page 3) that there is no such thing as a partially contracted muscle fiber: when a muscle is contracted, some of the fibers contract and some remain at rest (more fibers are recruited as the load on the muscle increases). Similarly, when a muscle is stretched, some of the fibers are elongated and some remain at rest (see Section 1.6 [What Happens When You Stretch], page 7). During an isometric contraction, some of the resting fibers are being pulled upon from both ends by the muscles that are contracting. The result is that some of those resting fibers stretch!

Normally, the handful of fibers that stretch during an isometric contraction are not very significant. The true effectiveness of the isometric contraction occurs when a muscle that is already in a stretched position is subjected to an isometric contraction. In this case, some of the muscle fibers are already stretched before the contraction, and, if held long enough, the initial passive stretch overcomes the stretch reflex (see Section 1.6.2 [The Stretch Reflex], page 8) and triggers the lengthening reaction (see Section 1.6.3 [The Lengthening Reaction], page 9), inhibiting the stretched fibers from contracting. At this point, according to *SynerStretch*, when you isometrically contracted, some resting fibers would contract and some resting fibers would stretch. Furthermore, many of the fibers already stretching may be prevented from contracting by the inverse myotatic reflex (the lengthening reaction) and would stretch even more. When the isometric contraction is completed, the contracting fibers return to their resting length but the stretched fibers would remember their stretched length and (for a period of time) retain the ability to elongate past their previous limit. This enables the entire muscle to stretch beyonds its initial maximum and results in increased flexibility.

The reason that the stretched fibers develop and retain the ability to stretch beyond their normal limit during an isometric stretch has to do with the muscle spindles (see Section 1.6.1 [Proprioceptors], page 7): The signal which tells the muscle to contract voluntarily, also tells the muscle spindle's (intrafusal) muscle fibers to shorten, increasing sensitivity of the stretch reflex. This mechanism normally maintains the sensitivity of the muscle spindle as the muscle shortens during contraction. This allows the muscle spindles to habituate (become accustomed) to an even further-lengthened position.

3.7 PNF Stretching

PNF stretching is currently the fastest and most effective way known to increase static-passive flexibility. PNF is an acronym for *proprioceptive neuromuscular facilitation*. It is not really a type of stretching but is a technique of combining passive stretching (see Section 3.4 [Passive Stretching], page 18) and isometric stretching (see Section 3.6 [Isometric Stretching], page 19) in order to achieve maximum static flexibility. Actually, the term PNF stretching is itself a misnomer. PNF was initially developed as a method of rehabilitating stroke victims. PNF refers to any of several *post-isometric relaxation* stretching techniques in which a muscle group is passively stretched, then contracts isometrically against resistance while in the stretched position, and then is passively stretched again through the resulting increased range of motion. PNF stretching usually employs the use of a partner to provide resistance against the isometric contraction and then later to passively take the joint through its increased range of motion. It may be performed, however, without a partner, although it is usually more effective with a partner's assistance.

Most PNF stretching techniques employ *isometric agonist contraction/relaxation* where the stretched muscles are contracted isometrically and then relaxed. Some PNF techniques also employ *isometric antagonist contraction* where the antagonists of the stretched muscles are contracted. In all cases, it is important to note that the stretched muscle should be rested (and relaxed) for at least 20 seconds before performing another PNF technique. The most common PNF stretching techniques are:

the *hold-relax*
: This technique is also called the *contract-relax*. After assuming an initial passive stretch, the muscle being stretched is isometrically contracted for 7-15 seconds, after which the muscle is briefly relaxed for 2-3 seconds, and then immediately subjected to a passive stretch which stretches the muscle even further than the initial passive stretch. This final passive stretch is held for 10-15 seconds. The muscle is then relaxed for 20 seconds before performing another PNF technique.

the *hold-relax-contract*
: This technique is also called the *contract-relax-contract*, and the *contract-relax-antagonist-contract* (or *CRAC*). It involves performing two isometric contractions: first of the agonists, then, of the antagonists. The first part is similar to the hold-relax where, after assuming an initial passive stretch, the stretched muscle is isometrically contracted for 7-15 seconds. Then the muscle is relaxed while its antagonist immediately performs an isometric contraction that is held for 7-15 seconds. The muscles are then relaxed for 20 seconds before performing another PNF technique.

the *hold-relax-swing*
: This technique (and a similar technique called the *hold-relax-bounce*) actually involves the use of dynamic or ballistic stretches in conjunction with static and isometric stretches. It is **very** risky, and is successfully used only by the most advanced of athletes and dancers that have managed to achieve a high level of control over their muscle stretch reflex (see Section 1.6.2 [The Stretch Reflex], page 8). It is similar to the hold-relax technique except that a dynamic or ballistic stretch is employed in place of the final passive stretch.

Notice that in the hold-relax-contract, there is no final passive stretch. It is replaced by the antagonist-contraction which, via reciprocal inhibition (see Section 1.6.4 [Reciprocal Inhibition], page 9), serves to relax and further stretch the muscle that was subjected to the initial passive stretch. Because there is no final passive stretch, this PNF technique is considered one of the safest PNF techniques to perform (it is less likely to result in torn muscle tissue). Some people like to make the technique even more intense by adding the final passive stretch after the second isometric contraction. Although this can result in greater flexibility gains, it also increases the likelihood of injury.

Even more risky are dynamic and ballistic PNF stretching techniques like the hold-relax-swing, and the hold-relax-bounce. If you are not a professional athlete or dancer, you probably have no business attempting either of these techniques (the likelihood of injury is just too great). Even professionals should not attempt these techniques without the guidance of a professional coach or training advisor. These two techniques have the greatest potential for rapid flexibility gains, but only when performed by people who have a sufficiently high level of control of the stretch reflex in the muscles that are being stretched.

Like isometric stretching (see Section 3.6 [Isometric Stretching], page 19), PNF stretching is also not recommended for children and people whose bones are still growing (for the same reasons. Also like isometric stretching, PNF stretching helps strengthen the muscles that are contracted and therefore is good for increasing active flexibility as well as passive flexibility. Furthermore, as with isometric stretching, PNF stretching is very strenuous and should be performed for a given muscle group no more than once per day (ideally, no more than once per 36 hour period).

The initial recommended procedure for PNF stretching is to perform the desired PNF technique 3-5 times for a given muscle group (resting 20 seconds between each repetition). However, *HFLTA* cites a 1987 study whose results suggest that performing 3-5 repetitions of a PNF technique for a given muscle group is not necessarily any more effective than performing the technique only once. As a result, in order to decrease the amount of time taken up by your stretching routine (without decreasing its effectiveness), *HFLTA* recommends performing only one PNF technique per muscle group stretched in a given stretching session.

3.7.1 How PNF Stretching Works

Remember that during an isometric stretch, when the muscle performing the isometric contraction is relaxed, it retains its ability to stretch beyond its initial maximum length (see Section 3.6.1 [How Isometric Stretching Works], page 20). Well, PNF tries to take immediate advantage of this increased range of motion by immediately subjecting the contracted muscle to a passive stretch.

The isometric contraction of the stretched muscle accomplishes several things:

1. As explained previously (see Section 3.6.1 [How Isometric Stretching Works], page 20), it helps to train the stretch receptors of the muscle spindle to immediately accommodate a greater muscle length.
2. The intense muscle contraction, and the fact that it is maintained for a period of time, serves to fatigue many of the fast-twitch fibers of the contracting muscles (see Section 1.2.2 [Fast and Slow Muscle Fibers], page 4). This makes it harder for the fatigued muscle fibers to contract in resistance to a subsequent stretch (see Section 1.6.2 [The Stretch Reflex], page 8).
3. The tension generated by the contraction activates the golgi tendon organ (see Section 1.6.1 [Proprioceptors], page 7), which inhibits contraction of the muscle via the lengthening reaction (see Section 1.6.3 [The Lengthening Reaction], page 9). Voluntary contraction during a stretch increases tension on the muscle, activating the golgi tendon organs more than the stretch alone. So, when the voluntary contraction is stopped, the muscle is even more inhibited from contracting against a subsequent stretch.

PNF stretching techniques take advantage of the sudden "vulnerability" of the muscle and its increased range of motion by using the period of time immediately following the isometric contraction to train the stretch receptors to get used to this new, increased, range of muscle length. This is what the final passive (or in some cases, dynamic) stretch accomplishes.

4 How to Stretch

When done properly, stretching can do more than just increase flexibility. According to *M. Alter*, benefits of stretching include:

- enhanced physical fitness
- enhanced ability to learn and perform skilled movements
- increased mental and physical relaxation
- enhanced development of body awareness
- reduced risk of injury to joints, muscles, and tendons
- reduced muscular soreness
- reduced muscular tension
- increased suppleness due to stimulation of the production of chemicals which lubricate connective tissues (see Section 1.3 [Connective Tissue], page 5)
- reduced severity of painful menstruation (*dysmenorrhea*) in females

Unfortunately, even those who stretch do not always stretch properly and hence do not reap some or all of these benefits. Some of the most common mistakes made when stretching are:

- improper warm-up
- inadequate rest between workouts
- overstretching
- performing the wrong exercises
- performing exercises in the wrong (or sub-optimal) sequence

In this chapter, we will try to show you how to avoid these problems, and others, and present some of the most effective methods for realizing all the benefits of stretching.

4.1 Warming Up

Stretching is *not* warming up! It is, however, a very important part of warming up. Warming up is quite literally the process of "warming up" (i.e., raising your core body temperature). A proper warm-up should raise your body temperature by one or two degrees Celsius (1.4 to 2.8 degrees Fahrenheit) and is divided into three phases:

1. general warm-up
2. stretching
3. sport-specific activity

It is very important that you perform the general warm-up *before* you stretch. It is *not* a good idea to attempt to stretch before your muscles are warm (something which the general warm-up accomplishes).

Warming up can do more than just loosen stiff muscles; when done properly, it can actually improve performance. On the other hand, an improper warm-up, or no warm-up at all, can greatly increase your risk of injury from engaging in athletic activities.

It is important to note that active stretches and isometric stretches should *not* be part of your warm-up because they are often counterproductive. The goals of the warm-up are (according to *Kurz*): "an increased awareness, improved coordination, improved elasticity and contractibility of muscles, and a greater efficiency of the respiratory and cardiovascular systems." Active stretches and isometric stretches do not help achieve these goals because they are likely to cause the stretched muscles to be too tired to properly perform the athletic activity for which you are preparing your body.

4.1.1 General Warm-Up

The general warm-up is divided into two parts:

1. joint rotations
2. aerobic activity

These two activities should be performed in the order specified above.

4.1.1.1 Joint Rotations

The general warm-up should begin with joint-rotations, starting either from your toes and working your way up, or from your fingers and working your way down. This facilitates joint motion by lubricating the entire joint with synovial fluid. Such lubrication permits your joints to function more easily when called upon to participate in your athletic activity. You should perform slow circular movements, both clockwise and counter-clockwise, until the joint seems to move smoothly. You should rotate the following (in the order given, or in the reverse order):

1. fingers and knuckles
2. wrists
3. elbows
4. shoulders
5. neck
6. trunk/waist
7. hips
8. legs
9. knees
10. ankles
11. toes

4.1.1.2 Aerobic Activity

After you have performed the joint rotations, you should engage in at least five minutes of aerobic activity such as jogging, jumping rope, or any other activity that will cause a similar increase in your cardiovascular output (i.e., get your blood pumping). The purpose of this is to raise your core body temperature and get your blood flowing. Increased blood flow in the muscles improves muscle performance and flexibility and reduces the likelihood of injury.

4.1.2 Warm-Up Stretching

The stretching phase of your warmup should consist of two parts:

1. static stretching
2. dynamic stretching

It is important that static stretches be performed *before* any dynamic stretches in your warm-up. Dynamic stretching can often result in overstretching, which damages the muscles (see Section 4.12.3 [Overstretching], page 37). Performing static stretches first will help reduce this risk of injury.

4.1.2.1 Static Warm-Up Stretching

Once the general warm-up has been completed, the muscles are warmer and more elastic. Immediately following your general warm-up, you should engage in some slow, relaxed, static stretching (see Section 3.5 [Static Stretching], page 18). You should start with your back, followed by your upper body and lower body, stretching your muscles in the following order (see Section 4.8 [Exercise Order], page 33):

1. back
2. sides (external obliques)
3. neck
4. forearms and wrists
5. triceps
6. chest
7. buttocks
8. groin (adductors)
9. thighs (quadriceps and abductors)
10. calves
11. shins
12. hamstrings
13. instep

Some good static stretches for these various muscles may be found in most books about stretching. See Appendix A [References on Stretching], page 41. Unfortunately, not everyone has the time to stretch all these muscles before a workout. If you are one such person, you should at least take the time to stretch all the muscles that will be heavily used during your workout.

4.1.2.2 Dynamic Warm-Up Stretching

Once you have performed your static stretches, you should engage in some light dynamic stretching: leg-raises, and arm-swings in all directions (see Section 3.2 [Dynamic Stretching], page 17). According to *Kurz*, you should do "as many sets as it takes to reach your maximum range of motion in any given direction", but do not work your muscles to the point of fatigue. Remember – this is just a warm-up, the real workout comes later.

Some people are surprised to find that dynamic stretching has a place in the warm-up. But think about it: you are "warming up" for a workout that is (usually) going to involve a lot of dynamic activity. It makes sense that you should perform some dynamic exercises to increase your dynamic flexibility.

4.1.3 Sport-Specific Activity

The last part of your warm-up should be devoted to performing movements that are a "watered-down" version of the movements that you will be performing during your athletic activity. *HFLTA* says that the last phase of a warm-up should consist of the same movements that will be used during the athletic event but at a reduced intensity. Such *sport-specific activity* is beneficial because it improves coordination, balance, strength, and response time, and may reduce the risk of injury.

4.2 Cooling Down

Stretching is *not* a legitimate means of cooling down. It is only part of the process. After you have completed your workout, the best way to reduce muscle fatigue and soreness (caused by the production of lactic acid from your maximal or near-maximal muscle exertion) is to perform a light *warm-down*. This warm-down is similar to the second half of your warm-up (but in the reverse order). The warm-down consists of the following phases:

1. sport-specific activity
2. dynamic stretching
3. static stretching

Ideally, you should start your warm-down with about 10-20 minutes of sport-specific activity (perhaps only a little more intense than in your warm-up). In reality however, you may not always have 10-20 minutes to spare at the end of your workout. You should, however, attempt to perform at least 5 minutes of sport-specific activity in this case. The sport-specific activity should immediately be followed by stretching: First perform some light dynamic stretches until your heart rate slows down to its normal rate, then perform some static stretches. Sport-specific activity, followed by stretching, can reduce cramping, tightening, and soreness in fatigued muscles and will make you feel better.

According to *HFLTA*, "light warm-down exercise immediately following maximal exertion is a better way of clearing lactic acid from the blood than complete rest." Furthermore, if you are still sore the next day, a light warm-up or warm-down is a good way to reduce lingering muscle tightness and soreness even when not performed immediately after a workout. See Section 4.12 [Pain and Discomfort], page 35.

4.3 Massage

Many people are unaware of the beneficial role that massage can play in both strength training and flexibility training. Massaging a muscle, or group of muscles, immediately prior to performing stretching or strength exercises for those muscles, has some of the following benefits:

increased blood flow
: The massaging of the muscles helps to warm-up those muscles, increasing their blood flow and improving their circulation.

relaxation of the massaged muscles
: The massaged muscles are more relaxed. This is particularly helpful when you are about to stretch those muscles. It can also help relieve painful muscle cramps.

removal of metabolic waste
: The massaging action, and the improved circulation and blood flow which results, helps to remove waste products, such as lactic acid, from the muscles. This is useful for relieving post-exercise soreness.

Because of these benefits, you may wish to make massage a regular part of your stretching program: immediately before each stretch you perform, massage the muscles you are about to stretch.

4.4 Elements of a Good Stretch

According to *SynerStretch*, there are three factors to consider when determining the effectiveness of a particular stretching exercise:

1. isolation
2. leverage
3. risk

4.4.1 Isolation

Ideally, a particular stretch should work only the muscles you are trying to stretch. Isolating the muscles worked by a given stretch means that you do not have to worry about having to overcome the resistance offered by more than one group of muscles. In general, the fewer muscles you try to stretch at once, the better. For example, you are better off trying to stretch one hamstring at a time than both hamstrings at once. By isolating the muscle you are stretching, you experience resistance from fewer muscle groups, which gives you greater control over the stretch and allows you to more easily change its intensity. As it turns out, the splits is not one of the best stretching exercises. Not only does it stretch several different muscle groups all at once, it also stretches them in both legs at once.

4.4.2 Leverage

Having leverage during a stretch means having sufficient control over how intense the stretch becomes, and how fast. If you have good leverage, not only are you better able to achieve the desired intensity of the stretch, but you do not need to apply as much force to your outstretched limb in order to effectively increase the intensity of the stretch. This gives you greater control.

According to *SynerStretch*, the best stretches (those which are most effective) provide the greatest mechanical advantage over the stretched muscle. By using good leverage, it becomes easier to overcome the resistance of inflexible muscles (the same is true of isolation). Many stretching exercises (good and bad) can be made easier and more effective simply by adjusting them to provide greater leverage.

4.4.3 Risk

Although a stretch may be very effective in terms of providing the athlete with ample leverage and isolation, the potential risk of injury from performing the stretch must be taken into consideration. Once again, *SynerStretch* says it best: Even an exercise offering great leverage and great isolation may still be a poor choice to perform. Some exercises can simply cause too much stress to the joints (which may result in injury). They may involve rotations that strain tendons or ligaments, or put pressure on the disks of the back, or contain some other twist or turn that may cause injury to seemingly unrelated parts of the body.

4.5 Some Risky Stretches

The following stretches (many of which are commonly performed) are considered risky (*M. Alter* uses the term '`X`'-rated) due to the fact that they have a very high risk of injury for the athlete that performs them. This does not mean that these stretches should never be performed. However, great care should be used when attempting any of these stretches. Unless you are an advanced athlete or are being coached by a qualified instructor (such as a certified Yoga instructor, physical therapist, or professional trainer), you can probably do without them (or find alternative stretching exercises to perform). When performed correctly with the aid of an instructor however, some of these stretches can be quite beneficial. Each of these stretches is illustrated in detail in the section *X-Rated Exercises* of *M. Alter*:

the yoga plough
: In this exercise, you lie down on your back and then try to sweep your legs up and over, trying to touch your knees to your ears. This position places excessive stress on the lower back, and on the discs of the spine. Not to mention the fact that it compresses the lungs and heart, and makes it very difficult to breathe. This particular exercise also stretches a region that is frequently flexed as a result of improper posture. This stretch is a prime example of an exercise that is very easy to do incorrectly. However, with proper instruction and attention to body position and alignment, this stretch can be performed successfully with a minimal amount of risk and can actually improve spinal health and mobility.

the traditional backbend

In this exercise, your back is maximally arched with the soles of your feet and the palms of your hands both flat on the floor, and your neck tilted back. This position squeezes (compresses) the spinal discs and pinches nerve fibers in your back.

the traditional hurdler's stretch

This exercise has you sit on the ground with one leg straight in front of you, and with the other leg fully flexed (bent) behind you, as you lean back and stretch the quadricep of the flexed leg. The two legged version of this stretch is even worse for you, and involves fully bending both legs behind you on either side. The reason this stretch is harmful is that it stretches the medial ligaments of the knee (remember, stretching ligaments and tendons is *bad*) and crushes the meniscus. It can also result in slipping of the knee cap from being twisted and compressed.

straight-legged toe touches

In this stretch, your legs are straight (either together or spread apart) and your back is bent over while you attempt to touch your toes or the floor. If you do not have the ability to support much of your weight with your hands when performing this exercise, your knees are likely to hyperextend. This position can also place a great deal of pressure on the vertebrae of the lower lumbar. Furthermore, if you choose to have your legs spread apart, it places more stress on the knees, which can sometimes result in permanent deformity.

torso twists

Performing sudden, intense twists of the torso, especially with weights, while in an upright (erect) position can tear tissue (by exceeding the momentum absorbing capacity of the stretched tissues) and can strain the ligaments of the knee.

inverted stretches

This is any stretch where you "hang upside down". Staying inverted for too long increases your blood pressure and may even rupture blood vessels (particularly in the eyes). Inverted positions are especially discouraged for anyone with spinal problems.

4.6 Duration, Counting, and Repetition

One thing many people seem to disagree about is how long to hold a passive stretch in its position. Various sources seem to suggest that they should be held for as little as 10 seconds to as long as a full minute (or even several minutes). The truth is that no one really seems to know for sure. According to *HFLTA* there exists some controversy over how long a stretch should be held. Many researchers recommend 30-60 seconds. For the hamstrings, research suggests that 15 seconds may be sufficient, but it is not yet known whether 15 seconds is sufficient for any other muscle group.

A good common ground seems to be about 20 seconds. Children, and people whose bones are still growing, do not need to hold a passive stretch this long (and, in fact, *Kurz* strongly discourages it). Holding the stretch for about 7-10 seconds should be sufficient for this younger group of people.

A number of people like to count (either out loud or to themselves) while they stretch. While counting during a stretch is not, by itself, particularly important ... what is important is the setting of a definite goal for each stretching exercise performed. Counting during a stretch helps many people achieve this goal.

Many sources also suggest that passive stretches should be performed in sets of 2-5 repetitions with a 15-30 second rest in between each stretch.

4.7 Breathing During Stretching

Proper breathing control is important for a successful stretch. Proper breathing helps to relax the body, increases blood flow throughout the body, and helps to mechanically remove lactic acid and other by-products of exercise.

You should be taking slow, relaxed breaths when you stretch, trying to exhale as the muscle is stretching. Some even recommend increasing the intensity of the stretch only while exhaling, holding the stretch in its current position at all other times (this doesn't apply to isometric stretching).

The proper way to breathe is to inhale slowly through the nose, expanding the abdomen (not the chest); hold the breath a moment; then exhale slowly through the nose or mouth. Inhaling through the nose has several purposes including cleaning the air and insuring proper temperature and humidity for oxygen transfer into the lungs. The breath should be natural and the diaphragm and abdomen should remain soft. There should be no force of the breath. Some experts seem to prefer exhaling through the nose (as opposed to through the mouth) saying that exhaling through the mouth causes depression on the heart and that problems will ensue over the long term.

The rate of breathing should be controlled through the use of the glottis in the back of the throat. This produces a very soft "hm-m-m-mn" sound inside the throat as opposed to a sniffing sound in the nasal sinuses. The exhalation should be controlled in a similar manner, but if you are exhaling through the mouth, it should be with more of an "ah-h-h-h-h" sound, like a sigh of relief.

As you breathe in, the diaphragm presses downward on the internal organs and their associated blood vessels, squeezing the blood out of them. As you exhale, the abdomen, its organs and muscles, and their blood vessels flood with new blood. This rhythmic contraction and expansion of the abdominal blood vessels is partially responsible for the circulation of blood in the body. Also, the rhythmic pumping action helps to remove waste products from the muscles in the torso. This pumping action is referred to as the *respiratory pump*. The respiratory pump is important during stretching because increased blood flow to the stretched muscles improves their elasticity, and increases the rate at which lactic acid is purged from them.

4.8 Exercise Order

Many people are unaware of the fact that the order in which you perform your stretching exercises is important. Quite often, when we perform a particular stretch, it actually stretches more than one group of muscles: the muscles that the stretch is primarily intended for, and other supporting muscles that are also stretched but which do not receive the "brunt" of the stretch. These supporting muscles usually function as synergists for the muscles being stretched (see Section 1.4 [Cooperating Muscle Groups], page 5). This is the basis behind a principle that *SynerStretch* calls the *interdependency of muscle groups*.

Before performing a stretch intended for a particular muscle, but which actually stretches several muscles, you should first stretch each of that muscle's synergists. The benefit of this is that you are able to better stretch the primary muscles by not allowing the supporting muscles the opportunity to be a limiting factor in how "good" a stretch you can attain for a particular exercise.

Ideally, it is best to perform a stretch that isolates a particular muscle group, but this is not always possible. According to *SynerStretch*: "by organizing the exercises within a stretching routine according to the principle of interdependency of muscle groups, you minimize the effort required to perform the routine, and maximize the effectiveness of the individual exercises." This is what *Health For Life* (in all of their publications) calls *synergism*: "combining elements to create a whole that is greater than the mere sum of its parts."

For example, a stretch intended primarily for the hamstrings may also make some demands upon the calves and buttocks (and even the lower back) but mostly, it stretches the hamstrings. In this case, it would be beneficial to stretch the lower back, buttocks, and calves first (in that order, using stretches intended primarily for those muscles) before they need to be used in a stretch that is intended primarily for the hamstrings.

As a general rule, you should usually do the following when putting together a stretching routine:

- stretch your back (upper and lower) first
- stretch your sides after stretching your back
- stretch your buttocks before stretching your groin or your hamstrings
- stretch your calves before stretching your hamstrings
- stretch your shins before stretching your quadriceps (if you do shin stretches)
- stretch your arms before stretching your chest

4.9 When to Stretch

The best time to stretch is when your muscles are warmed up. If they are not already warm before you wish to stretch, then you need to warm them up yourself, usually by performing some type of brief aerobic activity (see Section 4.1.1 [General Warm-Up], page 26). Obviously, stretching is an important part of warming-up before (see Section 4.1 [Warming Up], page 25), and cooling-down after a workout (see Section 4.2 [Cooling Down], page 28).

If the weather is very cold, or if you are feeling very stiff, then you need to take extra care to warm-up before you stretch in order to reduce the risk of injuring yourself.

Many of us have our own internal body-clock, or *circadian rhythm* as, it is more formally called: Some of us are "early morning people" while others consider themselves to be "late-nighters". Being aware of your circadian rhythm should help you decide when it is best for you to stretch (or perform any other type of activity). *Gummerson* says that most people are more flexible in the afternoon than in the morning, peaking from about 2:30pm-4pm. Also, according to *HFLTA*, evidence seems to suggest that, during any given day, strength and flexibility are at their peak in the late afternoon or early evening. If this is correct then it would seem to indicate that, all else being equal, you may be better off performing your workout right after work rather than before work.

4.9.1 Early-Morning Stretching

On the other hand, according to *Kurz*, "if you need [or want] to perform movements requiring considerable flexibility with [little or] no warm-up, you ought to make early morning stretching a part of your routine." In order to do this properly, you need to first perform a general warm-up (see Section 4.1.1 [General Warm-Up], page 26). You should then begin your early morning stretching by first performing some static stretches, followed by some light dynamic stretches. Basically, your early morning stretching regimen should be almost identical to a complete warm-up (see Section 4.1 [Warming Up], page 25). The only difference is that you may wish to omit any sport-specific activity (see Section 4.1.3 [Sport-Specific Activity], page 28), although it may be beneficial to perform it *if* you have time.

4.10 Stretching With a Partner

When done properly, stretches performed with the assistance of a partner can be more effective than stretches performed without a partner. This is especially true of isometric stretches (see Section 3.6 [Isometric Stretching], page 19) and PNF stretches (see Section 3.7 [PNF Stretching], page 20). The problem with using a partner, however, is that the partner does not feel what you feel, and thus cannot respond as quickly to any discomfort that might prompt you to immediately reduce the intensity (or some other aspect) of the stretch. This can greatly increase your risk of injury while performing a particular exercise.

If you do choose to stretch with a partner, make sure that it is someone you trust to pay close attention to you while you stretch, and to act appropriately when you signal that you are feeling pain or discomfort.

4.11 Stretching to Increase Flexibility

When stretching for the purpose of increasing overall flexibility, a stretching routine should accomplish, at the very least, two goals:

1. To train your stretch receptors to become accustomed to greater muscle length (see Section 1.6.1 [Proprioceptors], page 7).

2. To reduce the resistance of connective tissues to muscle elongation (see Section 2.2.1 [How Connective Tissue Affects Flexibility], page 13).

If you are attempting to increase active flexibility (see Section 2.1 [Types of Flexibility], page 11), you will also want to strengthen the muscles responsible for holding the stretched limbs in their extended positions.

Before composing a particular stretching routine, you must first decide which types of flexibility you wish to increase (see Section 2.1 [Types of Flexibility], page 11), and which stretching methods are best for achieving them (see Chapter 3 [Types of Stretching], page 17). The best way to increase dynamic flexibility is by performing dynamic stretches, supplemented with static stretches. The best way to increase active flexibility is by performing active stretches, supplemented with static stretches. The fastest and most effective way currently known to increase passive flexibility is by performing PNF stretches (see Section 3.7 [PNF Stretching], page 20).

If you are very serious about increasing overall flexibility, then I recommend religiously adhering to the following guidelines:

- Perform early-morning stretching everyday (see Section 4.9.1 [Early-Morning Stretching], page 34).
- Warm-up properly before any and all athletic activities. Make sure to give yourself ample time to perform the complete warm-up. See Section 4.1 [Warming Up], page 25.
- Cool-down properly after any and all athletic activities. See Section 4.2 [Cooling Down], page 28.
- Always make sure your muscles are warmed-up before you stretch!
- Perform PNF stretching every other day, and static stretching on the off days (if you are overzealous, you can try static stretching every day, in addition to PNF stretching every other day).

Overall, you should expect to increase flexibility *gradually*. However, If you really commit to doing the above, you should (according to *SynerStretch*) achieve maximal upper-body flexibility within one month and maximal lower-body flexibility within two months. If you are older or more inflexible than most people, it will take longer than this.

Don't try to increase flexibility too quickly by forcing yourself. Stretch no further than the muscles will go *without pain*. See Section 4.12.3 [Overstretching], page 37.

4.12 Pain and Discomfort

If you are experiencing pain or discomfort before, during, or after stretching or athletic activity, then you need to try to identify the cause. Severe pain (particularly in the joints, ligaments, or tendons) usually indicates a serious injury of some sort, and you may need to discontinue stretching and/or exercising until you have sufficiently recovered.

4.12.1 Common Causes of Muscular Soreness

If you are experiencing soreness, stiffness, or some other form of muscular pain, then it may be due to one or more of the following:

torn tissue
: Overstretching and engaging in athletic activities without a proper warm-up can cause microscopic tearing of muscle fibers or connective tissues. If the tear is not too severe, the pain will usually not appear until one or two days after the activity that caused the damage. If the pain occurs during or immediately after the activity, then it may indicate a more serious tear (which may require medical attention). If the pain is not too severe, then light, careful static stretching of the injured area is supposedly okay to perform (see Section 3.5 [Static Stretching], page 18). It is hypothesized that torn fibers heal at a shortened length, thus decreasing flexibility in the injured muscles. Very light stretching of the injured muscles helps reduce loss of flexibility resulting from the injury. Intense stretching of any kind, however, may only make matters worse.

metabolic accumulation
: Overexertion and/or intense muscular activity will fatigue the muscles and cause them to accumulate lactic acid and other waste products. If this is the cause of your pain, then static stretching (see Section 3.5 [Static Stretching], page 18), isometric stretching (see Section 3.6 [Isometric Stretching], page 19), or a good warm-up (see Section 4.1 [Warming Up], page 25) or cool-down (see Section 4.2 [Cooling Down], page 28) will help alleviate some of the soreness. See Section 2.3.1 [Why Bodybuilders Should Stretch], page 14. Massaging the sore muscles may also help relieve the pain (see Section 4.3 [Massage], page 29). It has also been claimed that supplements of vitamin C will help alleviate this type of pain, but controlled tests using placebos have been unable to lend credibility to this hypothesis. The ingestion of sodium bicarbonate (baking soda) before athletic activity has been shown to help increase the body's buffering capacity and reduce the output of lactic acid. However, it can also cause urgent diarrhea.

muscle spasms
: Exercising above a certain threshold can cause a decreased flow of blood to the active muscles. This can cause pain resulting in a protective reflex which contracts the muscle isotonically (see Section 1.5 [Types of Muscle Contractions], page 6). The reflex contraction causes further decreases in blood flow, which causes more reflex contractions, and so on, causing the muscle to spasm by repeatedly contracting. One common example of this is a painful muscle cramp. Immediate static stretching of the cramped muscle can be helpful in relieving this type of pain. However, it can sometimes make things worse by activating the stretch reflex (see Section 1.6.2 [The Stretch Reflex], page 8), which may cause further muscle contractions. Massaging the cramped muscle (and trying to relax it) may prove more useful than stretching in relieving this type of pain (see Section 4.3 [Massage], page 29).

4.12.2 Stretching with Pain

If you are already experiencing some type of pain or discomfort before you begin stretching, then it is very important that you determine the cause of your pain (see Section 4.12.1 [Common Causes of Muscular Soreness], page 36). Once you have determined the cause of the pain, you are in a better position to decide whether or not you should attempt to stretch the affected area.

Also, according to *M. Alter*, it is important to remember that some amount of soreness will almost always be experienced by individuals that have not stretched or exercised much in the last few months (this is the price you pay for being inactive). However, well-trained and conditioned athletes who work-out at elevated levels of intensity or difficulty can also become sore. You should cease exercising immediately if you feel or hear anything tearing or popping. Remember the acronym *RICE* when caring for an injured body part. RICE stands for: Rest, Ice, Compression, Elevation. This will help to minimize the pain and swelling. You should then seek appropriate professional medical advice.

4.12.3 Overstretching

If you stretch properly, you should *not* be sore the day after you have stretched. If you are, then it may be an indication that you are overstretching and that you need to go easier on your muscles by reducing the intensity of some (or all) of the stretches you perform. Overstretching will simply increase the time it takes for you to gain greater flexibility. This is because it takes time for the damaged muscles to repair themselves, and to offer you the same flexibility as before they were injured.

One of the easiest ways to "overstretch" is to stretch "cold" (without any warm-up). A "maximal cold stretch" is not necessarily a desirable thing. Just because a muscle can be moved to its limit without warming up doesn't mean it is ready for the strain that a workout will place on it.

Obviously, during a stretch (even when you stretch properly) you are going to feel some amount of discomfort. The difficulty is being able to discern when it is too much. In her book, *Stretch and Strengthen*, Judy Alter describes what she calls *ouch! pain*: If you feel like saying "ouch!" (or perhaps something even more explicit) then you should ease up immediately and discontinue the stretch. You should definitely feel the tension in your muscle, and perhaps even light, gradual "pins and needles", but if it becomes sudden, sharp, or uncomfortable, then you are overdoing it and are probably tearing some muscle tissue (or worse). In some cases, you may follow all of these guidelines when you stretch, feeling that you are not in any "real" pain, but still be sore the next day. If this is the case, then you will need to become accustomed to stretching with less discomfort (you might be one of those "stretching masochists" that take great pleasure in the pain that comes from stretching).

Quite frequently, the progression of sensations you feel as you reach the extreme ranges of a stretch are: localized warmth of the stretched muscles, followed by a burning (or spasm-like) sensation, followed by sharp pain (or "ouch!" pain). The localized warming will usually occur at the origin, or point of insertion, of the stretched muscles. When you begin to feel this, it is your first clue that you may need to "back off" and reduce the intensity of the stretch. If you ignore (or do not feel) the warming sensation, and you proceed to the point where you feel a definite burning sensation in the stretched muscles, then you should ease up immediately and discontinue the stretch! You may not be sore yet, but you probably will be the following day. If your stretch gets to the point where you feel sharp pain, it is quite likely that the stretch has already resulted in tissue damage which may cause immediate pain and soreness that persists for several days.

4.13 Performing Splits

A lot of people seem to desire the ability to perform splits. If you are one such person, you should first ask yourself why you want to be able to perform the splits. If the answer is "So I can kick high!" or something along those lines, then being able to "do" the splits may not be as much help as you think it might be in achieving your goal. Doing a full split looks impressive, and a lot of people seem to use it as a benchmark of flexibility, but it will not, in and of itself, enable you to kick high. Kicking high requires dynamic flexibility (and, to some extent, active flexibility) whereas the splits requires passive flexibility. You need to discern what type of flexibility will help to achieve your goal (see Section 2.1 [Types of Flexibility], page 11), and then perform the types of stretching exercises that will help you achieve that specific type of flexibility. See Chapter 3 [Types of Stretching], page 17.

If your goal really is "to be able to perform splits" (or to achieve maximal lower-body static-passive flexibility), and assuming that you already have the required range of motion in the hip joints to even do the splits (most people in reasonably good health without any hip problems do), you will need to be patient. Everyone is built differently and so the amount of time it will take to achieve splits will be different for different people (although *SynerStretch* suggests that it should take about two months of regular PNF stretching for most people to achieve their maximum split potential). The amount of time it takes will depend on your previous flexibility and body makeup. Anyone will see improvements in flexibility within weeks with consistent, frequent, and proper stretching. Trust your own body, take it gently, and stretch often. Try not to dwell on the splits, concentrate more on the stretch. Also, physiological differences in body mechanics may not allow you to be very flexible. If so, take that into consideration when working out.

A stretching routine tailored to the purpose of achieving the ability to perform splits may be found at the end of this document. See Appendix B [Working Toward the Splits], page 49.

4.13.1 Common Problems When Performing Splits

First of all, there are two kinds of splits: front and side (the side split is often called a *chinese split*). In a Front split, you have one leg stretched out to the front and the other leg stretched out to the back. In a side split, both legs are stretched out to your side.

A common problem encountered during a side split is pain in the hip joints. Usually, the reason for this is that the split is being performed improperly (you may need to tilt your pelvis forward).

Another common problem encountered during splits (both front and side) is pain in the knees. This pain can often (but not always) be alleviated by performing a slightly different variation of the split. See Section 4.13.2 [The Front Split], page 39. See Section 4.13.3 [The Side Split], page 39.

4.13.2 The Front Split

For front splits, the front leg should be straight and its kneecap should be facing the ceiling, or sky. The front foot can be pointed or flexed (there will be a greater stretch in the front hamstring if the front foot is flexed). The kneecap of the back leg should either be facing the floor (which puts more of a stretch on the quadriceps and psoas muscles), or out to the side (which puts more of a stretch on the inner-thigh (groin) muscles). If it is facing the floor, then it will probably be pretty hard to flex the back foot, since its instep should be on the floor. If the back kneecap is facing the side, then your back foot should be stretched out (not flexed) with its toes pointed to reduce undue stress upon the knee. Even with the toes of the back foot pointed, you may still feel that there is to much stress on your back knee (in which case you should make it face the floor).

4.13.3 The Side Split

For side splits, you can either have both kneecaps (and insteps) facing the ceiling, which puts more of a stretch on the hamstrings, or you can have both kneecaps (and insteps) face the front, which puts more of a stretch on the inner-thigh (groin) muscle. The latter position puts more stress on the knee joints and may cause pain in the knees for some people. If you perform side splits with both kneecaps (and insteps) facing the front then you **must** be sure to tilt your pelvis forward (push your buttocks to the rear) or you may experience pain in your hip joints.

4.13.4 Split-Stretching Machines

Many of you may have seen an advertisement for a *split-stretching* machine in your favorite exercise/athletic magazine. These machines look like "benches with wings". They have a padded section upon which to sit, and two padded sections in which to place your legs (the machine should ensure that no pressure is applied upon the knees). The machine functions by allowing you to gradually increase the "stretch" in your adductors (inner-thigh muscles) through manual adjustments which increase the degree of the angle between the legs. Such machines usually carry a hefty price tag, often in excess of $100 (American currency).

A common question people ask about these machines is "are they worth the price?". The answer to that question is entirely subjective. Although the machine can certainly be of valuable assistance in helping you achieve the goal of performing a side-split, it is not necessarily any better (or safer) than using a partner while you stretch. The main advantage that these machines have over using a partner is that they give you (not your partner) control of the intensity of the stretch. The amount of control provided depends on the individual machine.

One problem with these "split-stretchers" is that there is a common tendency to use them to "force" a split (which can often result in injury) and/or to hold the "split" position for far longer periods of time than is advisable.

The most effective use of a split-stretching machine is to use it as your "partner" to provide resistance for PNF stretches for the groin and inner thigh areas (see Section 3.7 [PNF Stretching], page 20). When used properly, "split-stretchers" can provide one of the best ways to stretch your groin and inner-thighs without the use of a partner.

However, they do cost quite a bit of money and they don't necessarily give you a better stretch than a partner could. If you don't want to "cough-up" the money for one of these machines, I recommend that you either use a partner and/or perform the lying 'V' stretch described later on in this document (see Appendix B [Working Toward the Splits], page 49).

Appendix A References on Stretching

I don't know if these are *all* good, but I am aware of the following books and videotapes about stretching:

Stretch and Strengthen, by Judy Alter
Softcover, Houghton Mifflin Company (Publishers) 1986, 241 pages
$12.95 (US), ISBN: 0-395-52808-9
(also by Judy Alter: *Surviving Exercise*,
Softcover, Houghton Mifflin 1983, 127 pages, ISBN: 0-395-50073-7)

Sport Stretch, by Michael J. Alter
Softcover, Leisure Press (Publisher) 1990, 168 pages
$15.95 (US), ISBN: 0-88011-381-2
Leisure Press is a division of Human Kinetics Publishers, Inc.
in Champaign, IL and may be reached by phone at 1-800-747-4457

Science of Stretching, by Michael J. Alter
Clothcover, Leisure Press (Publisher) 1988, 256 pages
$35.00 (US), ISBN: 0-97322-090-0

Stretching, by Bob Anderson (Illustrated by Jean Anderson)
Softcover, Random House (Publisher) $9.95 (US), ISBN: 0-394-73874-8

Stretching For All Sports, by John E. Beaulieu
Athletic Press 1980, Pasadena, CA

Stretching Without Pain, by W. Paul Blakey
Softcover, Bibliotek Books (Publishers) 1994, 78 pages
$14.99 (US), ISBN: 1 896238 00 9

The Muscle Book, by W. Paul Blakey
Softcover, Bibliotek Books (Publishers) 1992, 48 pages
$10.99 (US), ISBN: 1 873017 00 6

Health & Fitness Excellence: The Scientific Action Plan,
by Robert K. Cooper, Ph.D.
Softcover, Houghton Mifflin Company (Publishers) 1989, 541 pages
$12.95 (US), ISBN 0-395-54453-X

Stretching for Athletics, by Pat Croce (2nd edition)
Softcover, Leisure Press (Publisher) 1984, 128 pages
$11.95 (US), ISBN: 0-88011-119-4

ExTension: The 20-minutes-a-day, Yoga-Based Program to Relax, Release, and Rejuvenate the Average Stressed-Out over-35-year-old body,
by Sam Dworkis with Peg Moline
Softcover, Poseidon Press (Publisher) 1994, 192 pages

$20 (US), ISBN: 0-671-86680-X

Jean Frenette's Complete Guide to Stretching, by Jean Frenette
Softcover, $10.95 (US), ISBN: 0-86568-145-7
(also by Jean Frenette, *Beyond Kicking: A Complete Guide to Kicking and Stretching*, $12.95 (US), ISBN: 0-86568-154-6)

Mobility Training for the Martial Arts, by Tony Gummerson
Softcover, A&C Black (Publishers) 1990, 96 pages
$15.95 (US), ISBN: 0 7136 3264 X

SynerStretch For Total Body Flexibility, from Health For Life
Softcover, 1984, 29 pages, $11.95 (US), ISBN: 0-944831-05-2
(A videotape which is an updated version of this same course is also available for $39.95 (US))
HFL can be reached by phone at 1-800-874-5339

Staying Supple: The Bountiful Pleasures of Stretching, by John Jerome
Softcover, Bantam Books 1987, 151 pages
ISBN: 0-553-34429-3

Light on Yoga, by B. K. S. Iyengar
NY Schocken Books 1979, 544 pages
$18 (US), ISBN: 0-8052-1031-8

Light on Pranayama, by B. K. S. Iyengar
Crossroad Publishers 1985, 200 pages
ISBN: 0-8245-0686-3

Ultimate Fitness through Martial Arts, by Sang H. Kim
[chapter 8 (pages 147-192) is devoted to flexibility]
Softcover, Turtle Press (Publishers) 1993, 266 pages
$16.95 (US), ISBN: 1-880336-02-2
(This book and other items may be ordered from Turtle Press by calling 1-800-77-TURTL in the United States)

Stretching Scientifically : a Guide to Flexibility Training, by Tom Kurz
3rd edition, completely revised
Softcover, Stadion (Publisher) 1994, 147 pages
$18.95 (US), ISBN: 0-940149-30-3
(also by Tom Kurz: *Science of Sports Training*, $26.95-Softcover, $39.95-Hardcover)
(A Videotape entitled *Tom Kurz' Secrets of Stretching* is also available from Stadion for $49.95 (US)).
Stadion can be reached by phone at 1-800-873-7117

Beyond Splits (Volume I and Volume II), by Marco Lala
Videotapes available from Marco Lala Karate Academy,

P.O. Box 979, Yonkers, NY USA 10704
the tapes are $39.95 each (Vol.I and Vol.II are separate tapes)

Facilitated Stretching: PNF Stretching Made Easy, by Robert E. McAtee
Softcover, Human Kinetics Publishers 1993, 96 pages
$16.00 (US), ISBN: 0-87322-420-5

The Woman's Stretching Book, by Susan L. Peterson
Softcover, Leisure Press (Publisher) 1983, 112 pages
$11.95 (US), ISBN: 0-88011-095-3

The Health For Life Training Advisor, edited by Andrew T. Shields
Softcover, Health for Life 1990, 320 pages
$29.95 (US), ISBN: 0-944831-22-2

Yoga the Iyengar Way, by Silva, Mira and Shyam Mehta
Knopf Publishers
$20 (US), ISBN: 0-679-72287-4.

Stretch!, by Ann Smith
Acropolis Books 1979

The Book About Stretching, by Dr. Sven-A Solveborn, M.D.
Japan Publications, 1985

Stretching the Quick and Easy Way, by Sternad & Bozdech
Softcover, $9.95 (US), ISBN: 0-8069-8434-1

Complete Stretching, by Maxine Tobias and John Patrick Sullivan
Softcover, Knopf (Publisher), $17.95 (US), ISBN: 0-679-73831-2
(also by Maxine Tobias: *Stretch and Relax*)

A.1 Recommendations

My best recommendations are for *Sport Stretch* and *Stretching Scientifically*, followed by *Health & Fitness Excellence*, *SynerStretch*, or *Stretch and Strengthen*. *Mobility Training for the Martial Arts* also has quite a bit of valuable information and stretches. *The Health for Life Training Advisor* has a *lot* of information about stretching and muscle physiology, but it is not strictly about stretching and contains a *ton* of other information about all aspects of athletic training and performance (which I find to be invaluable). If you don't want to get into too much technical detail and are looking for a quick but informative read, then I recommend *Stretching Without Pain*. If you really want to delve into all the technical aspects of stretching, including physiology, neurophysiology, and functional anatomy, then you must get *Science of Stretching*. If you want to know more about PNF stretching, then *Facilitated Stretching* is the book to get. If you are looking for yoga or active stretches you simply must take a look at *ExTension* (also your local library probably has quite a few books and/or videotapes of yoga exercises). If you want to know more about muscle anatomy and physiology but don't have a lot of technical interest or background in those two fields, *The Muscle Book* is highly recommended.

Many of the other books don't have as much detail about stretching and what happens to your muscles during a particular stretch, they just present (and illustrate) a variety of different exercises. Also, most of the stretches presented in these books are to be performed alone. *Sport Stretch*, *SynerStretch* (both the videotape and the book), and *Mobility Training for the Martial Arts* present stretches that you can perform with the assistance of a partner.

In general, *Health For Life* (also known as *HFL*) and *Human Kinetics Publishers* have a tremendously wide variety of technical, no-nonsense, exercise related books and videotapes. I would highly recommend contacting both organizations and asking for their free catalogs:

> *Human Kinetics Publishers*
> 1607 North Market Street
> P.O. Box 5076
> Champaign, IL USA 61825-5076
> 1-800-747-4457 (US)
> 1-800-465-7301 (Canada)
>
> *Health For Life*
> 8033 Sunset Blvd., Suite 483
> Los Angeles, CA USA 90046
> 1-800-874-5339

A.2 Additional Comments

Here is a little more information about some of the references (I haven't actually read or seen all of them so I can't comment on all of them):

Sport Stretch
: This book has a very thorough section on all the details about how stretching works and what different stretching methods to use. It also contains over 300 illustrated stretches as well as various stretching programs for 26 different sports and recreational activities. Each stretching program takes about 20 minutes and illustrates the 12 best stretches for that activity. In my humble opinion, this is the most complete book I was able to find on the subject of stretching (however, *Science of Stretching*, by the same author, is even more comprehensive). Some of you may prefer Kurz' book to this one, however, since it is more devoted to increasing flexibility.

Science of Stretching
: This book explains the scientific basis of stretching and discusses physiology, neurophysiology, mechanics, and psychology as they all relate to stretching. The book makes thorough use of illustrations, charts, diagrams, and figures,

and discusses each of its topics in great detail. It then presents guidelines for developing a flexibility program, including over 200 stretching exercises and warm-up drills. I suppose you could think of this book as a "graduate-level version" of *Sport Stretch*.

Stretching Scientifically

This is an excellent book that goes into excruciating detail on just about everything you want to know about stretching. It also contains a variety of stretches and stretching programs and is geared towards achieving maximal flexibility in the shortest possible amount of time. The only problem I found in this book is that some of the discussion gets very technical without giving the reader (in my opinion) sufficient background to fully understand what is being said. I believe that *Sport Stretch* does a better job of explaining things in a more comprehensible (easily understood) fashion.

Facilitated Stretching

Most of the reading material that is devoted to PNF stretching is highly technical. This book attempts to break that trend. It tries to explain the history and principles of PNF without getting too technical, and shows how to perform PNF techniques that are appropriate for healthy people (complete with illustrations and easy-to-follow instructions). This book also contains a chapter which discusses the role of PNF techniques during injury rehabilitation. According to the publisher:

> The stretches in *Facilitated Stretching* are known as CRAC (contract-relax, antagonist-contract) stretches. CRAC stretches are the safest PNF stretches because there is no passive movement – the athlete performs all of the stretching. *Facilitated Stretching* contains 29 CRAC stretches, which address most of the major muscle groups: 18 are single-muscle stretches, and 11 use the spiral-diagonal patterns that are the heart of PNF stretching. Once readers have learned these stretching techniques, they will be able to design additional stretches for almost any muscle or muscle group. The book also features many self-stretching techniques that athletes can use to maintain their gains in range of motion.

SynerStretch

This is a "course" from HFL which claims that you can achieve "total body flexibility in just 8 minutes a day." It explains and presents two excellent stretching routines: one for increasing flexibility and one for maintaining flexibility. It was the only work that I found which discusses the importance of performing certain stretches in a particular order. It is important to note that there is a significant difference between the printed and videotape versions of this course (aside from price): The printed version has a much more thorough discussion of theory, exercise selection, and exercise order; whereas the stretching routines presented in the videotape are better explained, and more "up to date".

Stretch and Strengthen

This is very good, but the author makes a few mistakes in some places (in particular, she seems to equate the stretch reflex, reciprocal inhibition, and PNF with one another). The book is devoted to static stretching and to performing strengthening exercises of the muscles stretched. Each exercise explains what to do, what not to do, and why. There is also a separate section for diagnosing and correcting some problems that you may encounter during a particular stretch.

Health & Fitness Excellence
Simply put, this is one of the best books available on overall health and fitness. It has two chapters devoted to flexibility training that explain and provide several static and PNF stretches (although it refers to the PNF stretches as *tighten-relax* stretches). This is *not* a "fad" book! It uses sound, proven, scientific principles and research (explained in simple terms) to present programs for: reducing stress, strength and flexibility training, nutritional wellness, body fat control, postural vitality, rejuvenation and living environments design, and mind and life unity. I highly recommend this book.

ExTension This is a fantastic book of yoga exercises. Each exercise is very well explained along with instructions on what to do if you don't seem to feel the stretch, or think you are feeling it in the wrong place. It is chock-full of useful information and is very well written.

Stretching Without Pain
The author, W. Paul Blakey, is a practicing Osteopath, and former international ballet dancer. The book is very similar in format and content to this document, only it has well over a hundred illustrations, and also covers some additional material not found in this document (such as mental and emotional aspects to stretching and "stretching warzones"). It is one of the best quick, easy, and up-to-date stretching introductions that you will find. I can't think of any other book that is under a hundred pages that covers as much as this book does (including isometric and PNF stretches). For more information about this book, contact Twin Eagles Educational and Healing Institute at '`http://www.sunshine.net/www/0/sn0016`'. You can also reach the author by e-mail at '`TEEHI@sunshine.net`'.

The Muscle Book
The author, Paul Blakey, is a practicing Osteopath, and former international ballet dancer. He has written and illustrated this book to help everyone who needs to know more about their own muscles, and how to look after them. The book clearly identifies the major surface muscles of the human body, and shows how they work. For each muscle there is straightforward information about first aid by massage, and an indication of particular dangers to watch for. All students of physique, and in particular dancers and gymnasts should find this book useful. For more information about this book, contact Twin Eagles Educational and Healing Institute at '`http://www.sunshine.net/www/0/sn0016`'. You can also reach the author by e-mail at '`TEEHI@sunshine.net`'.

Mobility Training for the Martial Arts
This book is also quite good and quite comprehensive, but not as good (in my personal opinion) as *Sport Stretch* or *Stretching Scientifically*.

Staying Supple
: This book is a little old but is wonderfully written (although it could be organized a bit better). It contains information at just about every level of detail about stretching, increasing and maintaining suppleness, and preventing the loss of suppleness. There is also a glossary of terms and concepts near the end of the book.

Stretching
: A lot of people like this one. It presents a wide variety of stretches and stretching routines and does a good job of explaining each one. It does not go into too much detail about stretching other than just to present the various stretches and routines.

Appendix B Working Toward the Splits

The following stretching routine is tailored specifically to the purpose of achieving the ability to perform both front splits and side splits. It consists of the following exercises:

1. lower back stretches
2. lying buttock stretch
3. groin & inner-thigh stretch
4. seated calf stretch
5. seated hamstring stretch
6. seated inner-thigh stretch
7. psoas stretch
8. quadricep stretch
9. lying 'V' stretch

Don't forget to warm-up your body before performing any of these exercises. See Section 4.1.1 [General Warm-Up], page 26.

Warning: This stretching routine contains exercises that, depending on your physical condition, may be hazardous to your health. Consult with your doctor before attempting any of these exercises. It is also important that you use great caution when performing these exercises since improper performance could result in injury.

Perform these stretches at your own risk! I cannot be held responsible for any injury which may result from you performing any of these exercises! See [Disclaimer], page 1.

The details on how to perform each of the stretches are discussed in the following sections. Each section describes how to perform a passive stretch, and an isometric stretch, for a particular muscle group. On a given day, you should either perform only the passive stretches, or perform only the PNF stretches, in the order given (see Chapter 3 [Types of Stretching], page 17). If you perform the PNF stretches, don't forget to rest 20 seconds after each PNF stretch, and don't perform the same PNF stretch more than once per day (see Section 3.7 [PNF Stretching], page 20). The isometric stretches described do not require the assistance of a partner, but you may certainly use a partner if you so desire. The order in which these exercises are performed is important because the entire routine attempts to employ the principle of synergism by stretching a muscle fully before using that muscle as a "supporting muscle" in another stretch (see Section 4.8 [Exercise Order], page 33).

As with all stretches, you should *not* stretch to the point of intense pain! A tolerable amount of discomfort should be more than sufficient. You do *not* want to pull (or tear) your muscles, or be very sore the next day.

B.1 lower back stretches

These stretches work mostly the lower back, but also make some demands on your abdominals, and your external obliques (sides).

Lying down with your back on the floor, straighten one leg, while bending the knee of the other leg, and try to bring the thigh of your bent leg as close as possible to your chest. Hold it there for 10-15 seconds. Then cross your bent leg over your straight leg and try to touch your knee to the floor (while trying to keep both shoulders on the ground). Repeat this same procedure with the other leg. Then, bend both knees and bring both thighs up against your chest (keeping your back on the floor). Hold that for 10-15 seconds. Then, put both feet on the ground but keep the knees bent. While trying to keep both shoulders on the ground, roll your legs over to one side and try to get your knees to touch the floor beside you. Hold for about 10-15 seconds and then do the same thing on the other side. Now repeat the same stretch, but this time begin with your feet off the floor so that your leg is bent at the knee at about a 90 degree angle.

As for isometric stretches for the back, I don't recommend them.

B.2 lying buttock stretch

This mainly stretches your buttocks (gluteal muscles) but also makes some demands on your groin and upper inner-thigh area. You must be very careful *not* to apply any stress to the knee joint when performing this stretch. Otherwise, serious injury (such as the tearing of cartilage) may occur.

Lie on your back again with both knees bent and in the air and with your feet on the floor. Take your right foot in your left hand (with your hand wrapping under your foot so that the fingertips are on its outside edge) and hold your leg (with your knee bent) in the air about 1-3 feet above your left breast (relax, we haven't started to stretch the buttocks just yet). The leg you are holding should be in much the same position as it is when you start your groin stretch in the next exercise, only now it is in the air because you are on your back (see Section B.3 [groin and inner-thigh stretch], page 51). Exhale and slowly pull your foot over to the side and up (toward your head) as if you were trying to touch your outstretched leg about 12 inches to the outside of your left shoulder. You should feel a good stretch in your buttocks about now. If you feel any stress at all on your knee then stop at once. You are probably pulling "up" too much and not enough to the side. You may wish to use your free hand to support your knee in some way. Hold this stretch for about 20 seconds (and stop if you feel any stress in the knee joint). Now repeat this same stretch with the other leg (using the other hand). Remember that the leg you are *not* holding should have the sole of its foot on the floor with the knee bent and in the air.

To make an isometric stretch out of this, when you are performing the passive stretch (above) and feel the stretch in your buttocks, continue trying to pull your foot to the outside of your shoulder while at the same time resisting with your leg so that it pushes agains your hand. No actual leg motion should take place, just the resistance. Stop immediately if you feel any undue stress to your knee.

B.3 groin and inner-thigh stretch

This mainly stretches your groin and upper inner-thigh area, but also makes some demands on your lower back. It is often called the *butterfly stretch* or *frog stretch* because of the shape that your legs make when you perform it.

Sit down with your back straight up (don't slouch, you may want to put your back against a wall) and bend your legs, putting the soles of your feet together. Try to get your heels as close to your groin as is *comfortably* possible. Now that you are in the proper position, you are ready to stretch. For the passive stretch, push your knees to the floor as far as you can (you may use your hands to assist but do *not* resist with the knees) and then hold them there. *This can be hard on the knees so please be careful.* Once you have attained this position, keep your knees where they are, and then exhale as you bend over, trying to get your chest as close to the floor as possible. Hold this stretch for about 20 seconds.

The isometric stretch is almost identical to the passive stretch, but before you bend over, place your hands on your ankles and your elbows in the crooks of your knees. As you bend over, use your elbows to "force" your knees closer to the floor while at the same time pushing "up" (away from the floor) with your thighs to resist against your arms. Once again, please be careful since this can place considerable strain on the knees.

B.4 seated leg stretches

These include three different stretches performed for the calves, hamstrings, and inner-thighs, but they are all performed in very similar positions and I do all three stretches (in the order given) for one leg before performing them for the other leg. You will need an apparatus for this stretch: a bench, or a firm bed or couch (or you could use two chairs with your butt on one chair and the heel of your foot on the other) that is at least 12 inches off the ground (but not so high that you can't sit on it with out your knees bent and the sole of your foot solidly on the floor). The bench should be long enough to accommodate the full length of your leg. Sit on the bench and have your leg comfortably extended out in front of you (your heel should still be on the bench) and the other leg hanging out to the side with the leg bent and the foot flat on the ground.

B.4.1 seated calf stretch

With your leg extended directly in front of you, face your leg and bend it slightly. Place your hands around the ball of your foot and gently pull back so that you force yourself to flex your foot as much as possible. Hold this stretch for about 20 seconds (don't forget to breathe).

Now for the isometric stretch: in this same position, use your hands to try and force the ball (and toes) of your foot even further back toward you while at the same time using your calf muscles to try and straighten your foot and leg. You should be resisting enough with your hands so that no actual foot (or leg) motion takes place.

B.4.2 seated hamstring stretch

Now that our calf is stretched, we can get a more effective hamstring stretch (since inflexibility in the calf can be a limiting factor in this hamstring stretch). Still sitting on the bench in the same position, straighten your leg out while trying to hold onto your outstretched leg with both hands on either side as close as possible to your heel. Starting up with your back straight, slowly exhale and try to bring your chest to the knee of your outstretched leg. You should feel a "hefty" stretch in your hamstring and even a considerable stretch in your calf (even though you just stretched it). Hold this stretch for about 20 seconds.

Now for the isometric stretch: when you have gotten your chest as close as you can to your knee, try and put both hands under the bench by your heel (or both hands on opposite sides of your heel). Now grab on tight with your hands and try to physically push your heel (keeping your leg straight) downward "through" the bench, the bench will provide the necessary resistance, and should prevent any leg motion from occurring.

B.4.3 seated inner-thigh stretch

You should still be sitting on the bench with your outstretched leg in front of you. Now turn on the bench so that your leg is outstretched to your side, and you are facing the leg that is bent. You may perform this next stretch with either your toe pointing up toward the ceiling or with the inside edge of your foot flat on the bench with your toe pointing forward (but flexed), or you may try this stretch both ways since you will stretch some slightly different (but many of the same) muscles either way. I prefer to keep my toe pointed towards the ceiling because I personally feel that the other way applies to much stress to my knee, but you can do whatever feels comfortable to you.

Note: If you are using two chairs instead of a bench, the first thing you need to do is to make sure that one of the chairs supports your outstretched leg somewhere between the knee and the hip. If the support is being provided below the knee and you try to perform this stretch, there is a good chance that you will injure ligaments and/or cartilage.

Place your hands underneath the bench directly under you (or you may keep one hand under the portion of the bench that is below the knee of your outstretched leg) and pull yourself down and forward (keeping your back straight) as if you were trying to touch your chest to the floor. You should be able to feel the stretch in your inner-thigh. Hold this for about 20 seconds.

For the isometric stretch, do the same thing you did with the hamstring stretch: keep both hands underneath you as before and try to force your foot downward "through" the bench.

B.5 psoas stretch

This stretch is sometimes called the *runner's start* because the position you are in resembles that of a sprinter at the starting block. It mainly stretches the psoas muscle located just above the top of the thigh.

Crouch down on the floor with both hands and knees on the ground. Put one leg forward with your foot on the floor so that your front leg is bent at the knee at about a 90 degree angle. Now extend your rear leg in back of you so that it is almost completely straight (with just an ever so slight bend) and so that the weight of your rear leg is on the ball of your rear foot with the foot in a forced arch position. Now we are in the position to stretch (notice that your rear leg should be in pretty much the same position that it would assume if you were performing a front split).

Keeping your back straight and in line with your rear thigh, exhale and slowly try to bring your chest down to the floor (you shouldn't need to bend much further than the line your front knee is on). You should feel the stretch primarily in the upper thigh of your rear leg but you should also feel some stretch in your front hamstring as well. Hold this position for at least 15 seconds. If you wish to also stretch your rear quadricep from this position, you can shift your weight back so that your rear leg makes a right angle with your knee pointing toward the floor (but don't let it touch the floor). Now, without bending your rear leg any further, try to force your rear knee straight down to the floor.

Now repeat the same stretch(es) with your other leg in front.

For an isometric stretch, you can do this same stretch in front of a wall and instead of putting your hands on the floor, put them in front of you against the wall and then push against the wall with the ball of your foot (without decreasing the "stretch" in your psoas).

B.6 quadricep stretch

For this stretch you will need one (or two) pillows or soft cushions to place between your knee and the floor. You must be very careful when performing this stretch because it can be hard on the knees. Please be advised to take it easy (and not overdo) while performing this exercise. If you have problems with your knees, you may be better off *not* performing this stretch at all.

Put the pillow under your rear knee and let your knee rest on the floor. Lift up your rear foot and grab onto your foot with the opposite hand (grab the instep if possible, but if you can only reach the heel, that is okay). If you have trouble grabbing your foot, then you may need to sit (or shift) back onto your rear leg so that you can grab it, and then shift forward into the starting position (with your hand now holding your foot). Now, exhale and very gently, but steadily, pull your foot toward its buttock (butt-cheek) and lean toward your front foot (you may also wish to twist your waist and trunk towards the foot you are holding). You should feel a tremendous stretch in the quadricep (top right thigh) of the foot that you are pulling. If you begin to feel stress in your knee, then discontinue the exercise (but let your foot down slowly – not all at once). Hold this stretch for about 15 seconds. When you are finished, shift your weight slowly back onto your rear leg and let your foot down while you are still holding onto it. Do not just let go and let your foot snap back to the ground – this is bad for your knee.

Now for the isometric stretch: Get into the same position as for the passive quadricep stretch, but as you lean forward and pull on your foot, resist with the leg you are holding by trying to push your instep back down to the ground and out of the grip of your hand (but no actual movement should take place).

Now do the same stretch with your other leg in front.

Stop the stretch immediately if you feel pain or discomfort in your knee.

B.7 lying 'V' stretch

This stretch is very good for working toward a side (chinese) split (see Section 4.13.3 [The Side Split], page 39). This exercise should be performed *after* you have stretched each of these areas individually with prior stretches (like the ones mentioned above).

Start by lying down with your back flat on the ground and your legs straight together in the air at a 90 degree angle. Try to have your legs turned out so that your knees are facing the side walls more than they are facing your head. Slowly bring your legs down to the sides, keeping your legs straight and turned out. When you reach the point where you cannot bring them down any further into this "lying" side split position, leave them there.

Now for the stretch: With your feet both flexed or both pointed (your choice) use your arms to reach in and grab your legs. Each arm should grab the leg on the same side. Try to get a hold of the leg between the ankle and the knee (right at the beginning portion of the calf that is closest to the ankle is almost perfect). Now, exhale and use your arms to gently but steadily force your legs down further and wider (keeping the legs straight) getting closer to the lying side-split position (where, ideally, your kneecaps would be "kissing" the floor). Hold this position and keep applying steady pressure with your arms for about 20 seconds.

For the isometric stretch, you do the same thing as the passive stretch except that, as you use your arms to force your legs wider, use your inner and outer thigh muscles to try and force your legs back up together and straight (like a scissors closing), but apply enough resistance with your arms so that no motion takes place (this can be tough since your legs are usually stronger than your arms). You may find that you get a much better stretch if you use a partner (rather than your own arms) to apply the necessary resistance.

Appendix C Normal Ranges of Joint Motion

According to *Kurz*, the following tables indicates the normal ranges of joint motion for various parts of the body:

C.1 Neck

Flexion: 70-90 degrees
Touch sternum with chin.

Extension: 55 degrees
Try to point up with chin.

Lateral bending: 35 degrees
Bring ear close to shoulder.

Rotation: 70 degrees left & right
Turn head to the left, then right.

C.2 Lumbar Spine

Flexion: 75 degrees
Bend forward at the waist.

Extension: 30 degrees
Bend backward.

Lateral bending: 35 degrees
Bend to the side.

C.3 Shoulder

Abduction: 180 degrees
Bring arm up sideways.

Adduction: 45 degrees
Bring arm toward the midline of the body.

Horizontal extension: 45 degrees
Swing arm horizontally backward.

Horizontal flexion: 130 degrees
Swing arm horizontally forward.

Vertical extension: 60 degrees
Raise arm straight backward.

Vertical flexion: 180 degrees
Raise arm straight forward.

C.4 Elbow

Flexion: 150 degrees
Bring lower arm to the biceps

Extension: 180 degrees
Straighten out lower arm.

Supination: 90 degrees
Turn lower arm so palm of hand faces up.

Pronation: 90 degrees
Turn lower arm so palm faces down.

C.5 Wrist

Flexion: 80-90 degrees
Bend wrist so palm nears lower arm.

Extension: 70 degrees
Bend wrist in opposite direction.

Radial deviation: 20 degrees
Bend wrist so thumb nears radius.

Ulnar deviation: 30-50 degrees
Bend wrist so pinky finger nears ulna.

C.6 Hip

Flexion: 110-130 degrees
Flex knee and bring thigh close to abdomen.

Extension: 30 degrees
Move thigh backward without moving the pelvis.

Abduction: 45-50 degrees
Swing thigh away from midline.

Adduction: 20-30 degrees
Bring thigh toward and across midline.

Internal rotation: 40 degrees
Flex knee and swing lower leg away from midline.

External rotation: 45 degrees
Flex knee and swing lower leg toward midline.

C.7 Knee

Flexion: 130 degrees
Touch calf to hamstring.

Extension: 15 degrees
Straighten out knee as much as possible.

Internal rotation: 10 degrees
Twist lower leg toward midline.

C.8 Ankle

Flexion: 45 degrees
Bend ankle so toes point up.

Extension: 20 degrees
Bend ankle so toes point down.

Pronation: 30 degrees
Turn foot so the sole faces in.

Supination: 20 degrees
Turn foot so the sole faces out.

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