Exercise Physiology and Biomechanics for the Sport Yoga Instructor
Part II
Modules 3 and 4

✓ Introduction: The Importance of Understanding Physiology for the Sport Yoga Instructor

✓ Health Benefits of Yoga

✓ Biomechanics

✓ Intro to Muscle Structure and Function

✓ Intro to Joint Structure and Function

✓ Summary
Introduction:

The Importance of Understanding Physiology for the Sport Yoga Instructor.

The foundations of yoga (and hence Sport Yoga) go back thousands of years (some theorize as much as 5000 years). When done properly, Sport Yoga will bring together the mind and body, bringing oneself to new levels of body awareness. Put in more scientific terms, yoga has both psychological and physiological benefits. One of Sport Yoga’s most important physiological benefits (and the initial goal for many new to Sport Yoga) is an increase in musculoskeletal flexibility and range of motion. However, when done wrong, with improper instruction, yoga can do damage to joints and connective tissues. That’s why it’s vital that a Sport Yoga Instructor have a fundamental understanding of musculoskeletal anatomy and physiology. That’s what this section of your program is all about.
Health Benefits of Yoga

by Trisha Lamb


Two of the most common inquiries we receive from professional members preparing presentations on Yoga and from journalists and students writing about Yoga are:

What are the health benefits of Yoga?
How does Yoga differ from conventional exercise?

Following are answers drawn from various sources and provided in a succinct format. I wish to especially thank the following three individuals: First, A. Malathi, M.D. (amalathi@vsnl.net), for her presentation in November 2000 on the benefits of Yoga at Sutter Medical Center in Santa Rosa, California. Her paper “Promotive, Prophylactic Benefits of Yogic Practice in Middle Aged Women” furnishes research results and explanations for many of the benefits noted below. Thanks also to IAYT member Matra Majmundar (matra@post.com) for her presentation on Yoga physiology at the Integrating Yoga Therapeutics into Rehabilitation seminar at San Francisco Memorial Hospital in April 2000. Her book, tentatively titled Physiology of Yoga Therapeutics, is in preparation. I also would like to thank Arpita for her article “The Physical and Psychological Benefits of Yoga,” which appeared in the 1991 issue of The Journal of The International Association of Yoga Therapists. Bibliographic details for these and other references are provided at the end of this article.

Health Benefits

This information is grouped into three categories—physiological benefits, psychological benefits, biochemical effects—and is based on the regular practice of traditional āsana, prānāyāma, and meditation. Please note that while pulse rate, etc., may increase during the practice of various āsanas, some forms of prānāyāma, and some stages of meditation, but overall benefits to general health are as listed below. For information on the physiological changes that occur during the practice of specific āsanas, etc., please see James Funderburk’s Science Studies Yoga and other resources cited at the end of this article.

Physiological Benefits

- Stable autonomic nervous system equilibrium, with a tendency toward parasympathetic nervous system dominance rather than the usual stress-induced sympathetic nervous system dominance
- Pulse rate decreases
- Respiratory rate decreases
- Blood pressure decreases (of special significance for hyporeactors)
- Galvanic Skin Response (GSR) increases
- EEG - alpha waves increase (theta, delta, and beta waves also increase during various stages of meditation)
- EMG activity decreases
✓ Cardiovascular efficiency increases
✓ Respiratory efficiency increases (respiratory amplitude and smoothness increase, tidal volume increases, vital capacity increases, breath-holding time increases)
✓ Gastrointestinal function normalizes
✓ Endocrine function normalizes
✓ Excretory functions improve
✓ Musculoskeletal flexibility and joint range of motion increase
✓ Posture improves
✓ Strength and resiliency increase
✓ Endurance increases
✓ Energy level increases
✓ Weight normalizes
✓ Sleep improves
✓ Immunity increases
✓ Pain decreases

Psychological Benefits

✓ Somatic and kinesthetic awareness increase
✓ Mood improves and subjective well-being increases
✓ Self-acceptance and self-actualization increase
✓ Social adjustment increases
✓ Anxiety and depression decrease
✓ Hostility decreases

Psychomotor functions improve:

✓ Grip strength
✓ Dexterity and fine skills
✓ Eye-hand coordination
✓ Choice reaction time
✓ Steadiness
✓ Depth perception
✓ Balance
✓ Integrated functioning of body parts

**Cognitive Function improves:**

 ✓ Attention  
 ✓ Concentration  
 ✓ Memory  
 ✓ Learning efficiency  
 ✓ Symbol coding  
 ✓ Depth perception

 ✓ **Flicker fusion** frequency

**Biochemical Effects**

The biochemical profile improves, indicating an antistress and antioxidant effect, important in the prevention of degenerative diseases.

 ✓ Glucose decreases  
 ✓ Sodium decreases  
 ✓ Total cholesterol decreases  
 ✓ Triglycerides decrease  
 ✓ HDL cholesterol increases  
 ✓ LDL cholesterol decreases  
 ✓ VLDL cholesterol decreases  
 ✓ Cholinesterase increases  
 ✓ Catecholamines decrease  
 ✓ ATPase increases  
 ✓ Hematocrit increases  
 ✓ Hemoglobin increases  
 ✓ Lymphocyte count increases  
 ✓ Total white blood cell count decreases  
 ✓ Thyroxin increases  
 ✓ Vitamin C increases  
 ✓ Total serum protein increases  
 ✓ Oxytocin increases
✓ Prolactin increases
✓ Oxygen levels in the brain increase

**Yoga Compared to Conventional Exercise**

<table>
<thead>
<tr>
<th>Yoga</th>
<th>Exercise</th>
</tr>
</thead>
<tbody>
<tr>
<td>✓ Parasympathetic nervous system dominates</td>
<td>✓ Sympathetic nervous system dominates</td>
</tr>
<tr>
<td>✓ Subcortical regions of brain dominate</td>
<td>✓ Cortical regions of brain dominate</td>
</tr>
<tr>
<td>✓ Slow dynamic and static movements</td>
<td>✓ Rapid forceful movements</td>
</tr>
<tr>
<td>✓ Normalization of muscle tone</td>
<td>✓ Increased muscle tension</td>
</tr>
<tr>
<td>✓ Low risk of injuring muscles and ligaments</td>
<td>✓ Higher risk of injury</td>
</tr>
<tr>
<td>✓ Low caloric consumption</td>
<td>✓ Moderate to high caloric consumption</td>
</tr>
<tr>
<td>✓ Effort is minimized, relaxed</td>
<td>✓ Effort is maximized</td>
</tr>
<tr>
<td>✓ Energizing (breathing is natural or controlled)</td>
<td>✓ Fatiguing (breathing is taxed)</td>
</tr>
<tr>
<td>✓ Balanced activity of opposing muscle groups</td>
<td>✓ Imbalanced activity of opposing groups</td>
</tr>
<tr>
<td>✓ Noncompetitive, process-oriented</td>
<td>✓ Competitive, goal-oriented</td>
</tr>
<tr>
<td>✓ Awareness is internal (focus is on breath and the infinite)</td>
<td>✓ Awareness is external (focus is on reaching the toes, reaching the finish line, etc.)</td>
</tr>
<tr>
<td>✓ Limitless possibilities for growth in self-awareness</td>
<td>✓ Boredom factor</td>
</tr>
</tbody>
</table>

**Select General References**


35. __________. Physiological and biochemical changes following the practice of some yogic and non-yogic exercises. *Journal of Research in Indian Medicine*, 1975, 10(2):91-93.


Physical Activity Readiness Questionnaire

When starting with a new client, it is vital that a Sport Yoga Instructor takes the time to do a proper Health History Screening (if done in a studio, this will most likely be done when the member signs-up). For most individuals, exercise is a safe endeavor. However, for some clients, exercise can involve some risk. It is to both the client’s and the instructor’s benefit that a proper screening is completed. The client will gain the confidence that their trainer is professional and is aware of any health concerns the client might have. The trainer will not only be better prepared to create programs for his/her clients, but will also have the comfort of knowing that they have taken the legally responsible steps to help protect themselves from potential lawsuits.

On the following page is a sample PAR-Q form. It was originally developed by the Canadian Society for Exercise Physiology and was later adopted by the American Heart Association as well as the American College of Sports Medicine. It is considered the minimal standard for entry into a moderate-intensity exercise program.

There are many more forms necessary to run a successful and legally sensible Sport Yoga business. For more information on such forms, please see your attorney or visit http://www.nestacertified.com/jumpstart.html for more than 30 other business forms for your fitness business.
Modified Physical Activity Readiness Questionnaire (PAR-Q)

<table>
<thead>
<tr>
<th>Name</th>
<th>DOB</th>
<th>Age</th>
<th>Home Phone</th>
<th>Date</th>
<th>Work Phone</th>
</tr>
</thead>
</table>

Regular exercise associated with many health benefits, yet any change of activity may increase the risk of injury. Completion of this questionnaire is a first step when planning to increase the amount of physical activity in your life. Please read each question carefully and answer every question honestly:

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
<th>Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>No</td>
<td>1) Has a physician ever said you have a heart condition and you should only do physical activity recommended by a physician?</td>
</tr>
<tr>
<td>Yes</td>
<td>No</td>
<td>2) When you do physical activity, do you feel pain in your chest?</td>
</tr>
<tr>
<td>Yes</td>
<td>No</td>
<td>3) When you were not doing physical activity, have you had chest pain in the past month?</td>
</tr>
<tr>
<td>Yes</td>
<td>No</td>
<td>4) Do you ever lose consciousness or do you lose your balance because of dizziness?</td>
</tr>
<tr>
<td>Yes</td>
<td>No</td>
<td>5) Do you have a joint or bone problem that may be made worse by a change in your physical activity?</td>
</tr>
<tr>
<td>Yes</td>
<td>No</td>
<td>6) Is a physician currently prescribing medications for your blood pressure or heart condition?</td>
</tr>
<tr>
<td>Yes</td>
<td>No</td>
<td>7) Are you pregnant?</td>
</tr>
<tr>
<td>Yes</td>
<td>No</td>
<td>8) Do you have insulin dependent diabetes?</td>
</tr>
<tr>
<td>Yes</td>
<td>No</td>
<td>9) Are you 69 years of age or older?</td>
</tr>
<tr>
<td>Yes</td>
<td>No</td>
<td>10) Do you know of any other reason you should not exercise or increase your physical activity?</td>
</tr>
</tbody>
</table>

If you answered yes to any of the above questions, talk with your doctor by BEFORE you become more physically active. Tell your doctor your intent to exercise and to which questions you answer yes.

If you honestly answered no to all questions you can be reasonably positive that you can safely increase your level of physical activity gradually.

If your health changes so you then answer yes to any of the above questions, seek guidance from a physician.

Participant signature | Date
Biomechanics

✓ Basic Definitions
✓ Anatomical Position and Anatomical Neutral
✓ Planes of Motion
✓ Anatomical Movement Descriptors
✓ Anatomical Axis of Motion
✓ Direction of Motion

Basic Definitions

Kinematics- The study of motion without regard to its causes (forces)
Kinesiology- The scientific and artistic study of human movement
Kinetics- The study of forces acting on a system

Biomechanics- Evaluates the motion of a living organism and the action of forces upon it. Biomechanics is the study of how the body moves and what causes movement either internally (via muscles) or externally (external load or weight). Biomechanics is the application of the Laws of Physics to the human body.

Anatomical Position and Anatomical Neutral

In order to describe the movement of the human body, a standardized reference point has been used for centuries known as Anatomical Position.

Anatomical position is a position of standing erect with the palms facing forward. There is another anatomical reference point known as Anatomical Neutral (a.k.a. Fundamental Starting Position).
Anatomical neutral is a more natural pose with the hands facing the torso.
Planes of Motion

We live in three dimensional (3D) space. In order to describe human movement within this three dimensional space, three planes of motion are used. They are as follows:

The sagittal plane divides the body into right and left halves.
The frontal plane divides the body into front and back halves.

The horizontal plane divides the body into top and bottom halves.
Anatomical Movement Descriptors

- **Anterior**- (a.k.a. ventral) the front of the body relative to another reference point
- **Posterior**- (a.k.a. dorsal) the back of the body relative to another reference point
- **Superior**- Above a reference point
- **Inferior**- Below a reference point
- **Medial**- A position relatively closer to the midline of the body
- **Lateral**- A position relatively farther away from the midline
- **Proximal**- A position closer to a reference point
- **Distal**- A position farther from the reference point
- **Bilateral**- refers to both sides
- **Unilateral**- Refers to only one side
- **Superficial**- Near the surface
- **Deep**- Further beneath the surface
- **Cephalic**- Toward the head
- **Caudal**- Toward the bottom
- **Prone**- Lying face down
- **Supine**- Lying on one’s backside

Anatomical Axis of Motion

Each anatomical movement is achieved according to its joint makeup and is bound by the laws of motion around an axis.

The **Anatomical Axis of Motion** describes a movement that occurs in a plane along an axis running perpendicular to the plane. The **longitudinal axis** contains movements that occur in the transverse plane along the longitudinal axis. For example, the movement of turning one’s neck to look left and right is about the longitudinal axis. The **anterior-posterior axis** includes movements in the frontal plane occur along the anterior-posterior axis. For example, the movement of raising one’s arm to the side as if completing a lateral raise (shoulder abduction) is about the anterior-posterior axis. The **coronal axis** describes movements that occur in the sagittal plane occur along the coronal axis. For example, the movement kicking a leg forward (hip flexion) is about the coronal axis.
### Sagittal Plane Basic Movements (About a Coronal Axis)

<table>
<thead>
<tr>
<th>Movement</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flexion</td>
<td>A bending movement where the relative angle between two adjacent segments decreases.</td>
</tr>
<tr>
<td>Extension</td>
<td>A bending movement where the relative angle between two adjacent segments increases. <em>Hyperextension</em> is a movement which continues past anatomical (zero) position. (a.k.a. Extension beyond neutral.)</td>
</tr>
</tbody>
</table>

### Frontal Plane Basic Movements (About an Anterior-Posterior Axis)

<table>
<thead>
<tr>
<th>Movement</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abduction</td>
<td>Movement away from the midline of the body</td>
</tr>
<tr>
<td>Adduction</td>
<td>Movement towards the midline of the body</td>
</tr>
</tbody>
</table>
**Transverse Plane Basic Movements (About a Longitudinal Axis)**

<table>
<thead>
<tr>
<th>Movement Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Internal/Medial rotation</strong></td>
<td>The inward turning of an anterior surface. A position of internal rotation is any point inward from neutral.</td>
</tr>
<tr>
<td><strong>External/lateral rotation</strong></td>
<td>The outward turning of an anterior surface. A position of external rotation is any point outward from neutral.</td>
</tr>
</tbody>
</table>

**Scapula:**

<table>
<thead>
<tr>
<th>Movement Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protraction</td>
<td>Abduction of the scapula</td>
</tr>
<tr>
<td>Retraction</td>
<td>Adduction of the scapula</td>
</tr>
<tr>
<td>Elevation</td>
<td>Raising of the Scapula (Shrug)</td>
</tr>
<tr>
<td>Depression</td>
<td>Lowering of the Scapula</td>
</tr>
</tbody>
</table>
### Other Specialized Movements:

<table>
<thead>
<tr>
<th>Movement</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Lateral Flexion</strong></td>
<td>Spinal Movement in the Frontal Plane</td>
</tr>
<tr>
<td><strong>Circumduction</strong></td>
<td>A cone-shaped movement by the body. Circumduction does not require rotation.</td>
</tr>
<tr>
<td><strong>Dorsiflexion and Plantarflexion</strong></td>
<td>Only occurs in the foot</td>
</tr>
</tbody>
</table>
| **Supination**            | *At wrist:* Movement of the forearm where the palm rotates to face forward from neutral to anatomical position at the radioulnar joint  
  *At ankle:* Created by plantarflexion, tarsal inversion and forefoot adduction                                                               |

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**Images:**

- Lateral Flexion: Spinal Movement in the Frontal Plane
- Circumduction: A cone-shaped movement by the body.
- Dorsiflexion: Images showing Dorsiflexion and Plantarflexion at the ankle.
- Supination: Images showing Supination and Pronation.
Intro to Muscle Structure and Function

- Anatomy & Physiology
- Connective Tissue
- Functional Characteristics

**Anatomy and Physiology of Muscles**

**The Muscular System**

The muscular system is the anatomical system most affected by exercise. The framework for the body is provided by the bones and joints. However, movement is enabled by specific muscles contracting and relaxing. The increase in the size of the muscle is known as hypertrophy. **Hypertrophy** is an increase in the size of myofibrils inside muscle fibers. **Hyperplasia** is an increase in the number of muscle cells in the body with a corresponding increase in muscular size. The phenomenon of hyperplasia is extremely rare, and is only seen in very advanced bodybuilders and professional athletes.

Muscle is a structure composed of tissues which produce the movements of the body through muscular contractions. Muscles that are capable of voluntary contraction are referred to as striated muscle, while involuntary muscles, except the heart, are termed smooth muscle.

**Skeletal muscle or striated muscle cells** are some of the largest cells in the body. **Skeletal muscle** controls voluntary movements, and is innervated by the **somatic nervous system**. Skeletal muscle is composed of bundles of parallel fibers. Each fiber is a multinucleated (many nucleuses) cell created by fusion of several mononucleated embryonic cells. **Striated muscles** are covered with a thin layer of connective tissue (epimysium), a fibrous sheath from which septa perimysium pass dividing the muscle into bundles of fibers or fasciculus. Each fasciculus contains a number of parallel fibers separated by connective tissue called septa endomysium, the sheath of delicate reticular fibrils which surround each muscle fiber. Embedded in the muscle fibers (cells) are filaments called myofibrils, further divided into sarcomeres. They are called striated because they have striations of light and dark bands created by the repeating actin and myosin filaments in the sarcomeres. Myofibrils are enveloped by sacroplasmatic reticulum. The living part of the muscle fiber cell is called sarcoplasm, and the cell membrane is called the sarcolemma (capable of propagating action potentials). Muscles are divided by layers of fascia to enable it to be innervated from smaller to larger numbers of fibers and sizes. According to the **size principle of recruitment**, smaller numbers of fibers will be selected before larger numbers of fibers to preserve muscular energy by smaller and then larger motor neurons. Furthermore, once a muscle fiber is innervated, it is either on or off, there can be no partial contraction, this is the **all or none theory** of muscle fiber activation.
**Action Potentials**: Muscle fibers contract in response to an electrical signal or depolarization. The signal is generated at the synapse (the neuromuscular junction/motor end plate) and is transferred through an action potential through the muscle fiber membrane.
**Muscle Fiber Types**

There are essentially three muscle fiber types in human muscle:

- **Type I Fibers** – RED, Slow twitch
- **Type IIA Fibers** – PINK, Moderate fast twitch
- **Type IIB Fibers** – WHITE, Fast twitch

**Type I (red/slow twitch) fibers** are fatigue-resistant and have a low glycolytic capacity. They are rich in capillaries and myoglobin (enhancing oxygen delivery). They also have increased number of mitochondria which enhances their ability to oxidize fats. Muscles containing a predominant amount of slow twitch muscle fibers tend toward stabilizing functions rather than prime movers of muscle tissue. Individuals with a greater number of Type 1 fibers tend to excel in endurance related activities that last longer than 3 minutes (aerobic oxidation energy production phase).

**Type IIA (“pink”/moderate fast twitch) fibers** have traits of both Type IA and Type IIB. They are moderately glycolytic and moderately oxidative. Individuals with a greater number or more conditioned Type IIA fibers tend to excel in activities lasting between 30 seconds and 2 minutes with a moderate level of strength and aerobic capacity capabilities (Glycolytic phase of energy production).

**Type IIB (white/fast twitch) fibers** are larger in diameter and well suited for brief, powerful contractions. They have high glycolytic and low oxidative capacity. They have little mitochondria and small capillary beds. These fibers tend to be prime movers of joints. Individuals with a greater number of Type IIB fibers tend to excel in highly explosive activities such as maximal lifts and sprinting or jumping (ATP/CP or phosphagen system of energy production).

**The Sarcomere and the Sliding Filament Theory**

The sarcomere is composed of thin filaments (chains of globular actin associated with troponin and tropomyosin to connect thin and thick filaments) and thick filaments (organized bundles of myosin)

**Structure of the sarcomere**

- Z-lines define boundary of single sarcomere
- M-line runs down center of sarcomere
- I-band contains thin filaments only
- H-zone contains thick filaments only
- A-band contains thick filaments in their entirety without any overlapping portions of thin filaments
Muscular contraction of the sarcomere

The sarcomere is stimulated by a motor neuron (nerve cell). The link between the nerve terminal ending (motor end plate) and sarcolemma is the neuromuscular junction (space between = synapse). Depolarization of motor neurons releases neurotransmitters (Acetylcholine - ACH) from the nerve terminal, which diffuses (fans out) across the synapse and binds receptors on the sarcolemma. If enough receptors are stimulated, the permeability (ability to transmit fluid through its walls) of the sarcolemma is altered and the action potential of the muscle fiber is generated.

Shortening of Sarcomere

The action potential is conducted along the sarcolemma and T-system (throughout interior of muscle fiber) which causes the sarcoplasmic reticulum to release calcium into the sarcoplasm.

Calcium then binds to troponin, causing tropomyosin strands to shift, and exposing myosin-binding sites on actin filaments. Free myosin molecules then move toward, and bind, exposed sites, forming actin-myosin cross-bridges. These cross-bridges pull on actin molecules, drawing thin filaments toward the center of the H-zone and a shortening of the sarcomere.

The binding of myosin to actin activates ATPase in myosin, providing the energy to dissociate the myosin head from the binding site of the actin filaments. Myosin returns to its original position and is free to bind another actin molecule and repeat the process, further pulling into the H-zone.

Relaxation of the sarcomere

Calcium is pumped back into the sarcoplasmic reticulum, and myosin dissociates from thin filament. ATP is re-synthesized, and the sarcomere returns to its original dimensions. In the absence of calcium, binding sites are covered with tropomyosin molecules.
**Stimulus and Muscle Response**

**Stimulus Intensity**
Individual muscle fibers generally exhibit an all-or-nothing response. The strength of contraction of a single muscle fiber cannot be increased. Whole muscle does NOT exhibit an all-or-nothing response. Tonus is a continual low-grade contraction of a muscle, essential for both voluntary and involuntary muscles.

**Simple Twitch**
Response of a single muscle fiber to a brief stimulus at or above threshold. The Latent Period is the time between stimulation and onset of contraction. The Relaxation Period occurs when a muscle is unresponsive to stimulus (absolute refractory period) followed by a time when a greater-than-normal stimulus is needed to elicit a contraction (relative refractory period).

**Summation and Tetanus**
When a fiber is exposed to very frequent stimuli, muscle cannot fully relax. The contractions begin to combine, becoming stronger and more prolonged (temporal summation). The contractions become continuous when the stimuli are so frequent that the muscle cannot relax (tetanus).
Connective Tissue

There are three layers of connective tissue, or fascia, which surround, protect, and enable separate innervation of muscle fibers with a muscle. The *endomysium* surrounds individual muscle fibers. The *perimysium* surrounds fasciculi (bundles of fibers). The *epimysium* completely surrounds muscle and is continuous with the endomysium and perimysium. Continuations of the epimysium form tendons that become continuous with the periosteum (outer layer of bone).

**Fascia** is a sheet or band of fibrous tissue. Groups of muscles are contained within compartments of fascia. Fascia can also act as a site for muscle attachment (ex: latissimus dorsi).

A **tendon** is a fibrous cord, consisting primarily of collagen, which attaches muscle to bone. Tendons must be able to transmit force generated by muscles, and are therefore not meant to be stretched!
Functional Characteristics of Muscle

The main function of skeletal or striated muscle is to produce movement of joints.

There are many different muscle fiber arrangements for specific muscles. Each muscle is anatomically named according to its location, size, shape, action, origin or insertion points, or muscle fiber direction.

<table>
<thead>
<tr>
<th>Fusiform Muscles</th>
<th>Parallel Fibers: Spindle-Shaped fiber arrangements in a muscle</th>
<th>Biceps</th>
</tr>
</thead>
<tbody>
<tr>
<td>Penniform Muscles</td>
<td>Feather shaped fiber arrangements within a muscle, in which the fibers run diagonal to a tendon running through a muscle</td>
<td>Deltoids (multipennate)</td>
</tr>
<tr>
<td>Fan-Shaped Muscles</td>
<td>Muscles that have a single insertion and a spread out origin</td>
<td>Pectoralis Major</td>
</tr>
</tbody>
</table>

Roles of skeletal muscle

Prime Mover: A muscle that acts directly to bring about a desired movement
Assistant Mover: A muscle that assists to bring about a desired movement
Agonist: A muscle responsible for producing a specific movement through concentric muscle action
Antagonist: A muscle responsible for opposing the concentric muscle action of the agonist (more susceptible to injury).
Stabilizer: A muscle responsible for stabilizing an adjacent segment
Neutralizer: A muscle responsible for eliminating or canceling out an undesired movement

Net Muscle Actions

Concentric Muscle Action
- Shortening of a muscle fiber against a load
- “Raises” the load
- “Accelerates” the load
- Ex: up phase of a dumbbell bicep curl

Eccentric Muscle Action
- Lengthening of a muscle fiber against a load
- “Lowers” the load
- “Decelerates” the load
- Ex: down phase of a dumbbell bicep curl

Isometric Muscle Action
- Where a muscle neither lengthens nor shortens against a load (no net joint movement).
A co-contraction of agonist and antagonist muscles.
- Ex: holding the elbow at 90° with a dumbbell

**Isotonic Exercise**
- Exercise where a concentric and/or eccentric action is generated to move a load through a range of motion

**Isokinetic Exercise**
- Exercise on a specialized piece of equipment where the muscle action is speed controlled
Intro to Joint Structure and Function

✓ What Are Joints
✓ Bone
✓ Characteristics of Synovial Joints
✓ Types of Synovial Joints
✓ Joint Forces
✓ Joint Range of Motion
✓ Joint Stability
✓ Stretching

What Are Joints?

A Joint is an articulation between two bones, which is used to connect one component of a structure with one or more other components. The design of a joint is determined by its function and the nature of its components. Once a joint is constructed, the structure of the joint will determine its function. Joints that serve a single function are less complex than joints that serve multiple functions.

Purpose of joints:

- **Levers** - For motion and restriction of motion
- **Support** - The skeletal system is a passive system and can only move by muscular action. Vice versa, the muscular system, an active system can only move with the support of the skeletal system.
- **Protection** - The easiest example is the ribcage.
- **Storage** - The bone matrix is composed of Calcium, Phosphate and Magnesium.
- **Blood cell formation**
Joint types:
Joint typing is based on the type of materials and the methods used to unite bony components

**Synarthrodial (nonsynovial joints)** are semi-movable joints [i.e., the sacroiliac (SI) and Pubis]

**Diarthrodial (synovial joints)** are freely movable joints. Most joints that we will work with as instructors [i.e., the elbow and knee]

**Bone**

**Types of Bone**

<table>
<thead>
<tr>
<th>Name</th>
<th>Example</th>
<th>Picture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Short</td>
<td>The bone is wider than it is long; tarsals and carpals</td>
<td></td>
</tr>
<tr>
<td>Flat</td>
<td>Pelvis</td>
<td></td>
</tr>
<tr>
<td>Irregular</td>
<td>Vertebrae</td>
<td></td>
</tr>
<tr>
<td>Long</td>
<td>The bone is longer than it is wide; femur, humerus</td>
<td></td>
</tr>
<tr>
<td>Sesamoid</td>
<td>Patella</td>
<td></td>
</tr>
</tbody>
</table>
Biomechanical Characteristics of Bone

Bone Tissue
- One of the body’s hardest structures
- 60-70% of bone are made of the minerals calcium and phosphate, and the connective tissue collagen
- Collagen gives bone its ability to withstand tensile loads (also bone’s ductile properties)
- The minerals give bone ability to withstand compressive loads (also bone’s brittleness)
- 25-35% water

Architecture of Bone
Compact/Cortical Bone:
- Dense, compact tissue on the exterior of bone that provides strength and stiffness to the skeletal system.

Spongy/Cancellous Bone:
- Lattice-like and having high porosity, it is capable of high energy storage.
- Found on interior of bones and in the ends of long bones. Made up of small flat pieces of bone (trabeculae) that adapt to the direction of the imposed stress/force on bone.

Davis’s Law: states that tissue will adapt and grow in the line with resistance forces.
- Bones respond best to compressive forces.
- Lateral forces may cause the greatest stress and potential damage. However, the bone will still have adaptation abilities. Such forces may have the greatest risk in young athletes/individuals with epiphyseal plate (growth plate) slippage during the years of greatest pre-pubescent growth between the ages of 11 and 14.

Long Bones (bones of the appendages)
- Diaphysis (Cylindrical shaft composed mostly of compact bone surrounding a cavity of bone marrow)
- Epiphysis (dilated ends, composed of spongy bone surrounded by thin layer of compact bone)
- Epiphyseal Plate (disk of cartilaginous cells separating diaphysis and epiphysis – site of longitudinal growth)
- Periosteum (fibrous sheath, surrounds long bone, site of attachment to muscle tissue)

Forces on Bones (Types of Load on Bones)
- Compression
  - A force pressing the ends of bone together, creating shortening and widening of the structure
- Tension
  - A force pulling a bone apart, creating lengthening and narrowing of the bone
- Shear
  - A force applied parallel to the surface, creating deformation internally in an angular direction
- Torsion
A twisting force that creates shear stress over the entire material

- **Bending**
  A force causing a change in the angle of the bone, offsetting in the horizontal plane. The material will bend in the region where there is no direct structural support

**Stress, Strain and Sprain***

- **Stress**
  Amount of load per cross-sectional area

- **Strain**
  Deformation of a structure due to stress

- **Sprain**
  Permanent deformation of structure due to excessive or prolonged stress/strain

*Note that these definitions differ from the medical terms (strain = muscle trauma, sprain - ligamentous trauma)*
Characteristics of Synovial (Diarthrodial) Joints

All synovial joints have 5 basic features
1. Articulating bones are separate

2. The bones are held together by a capsule of fibrous connective tissue

3. The capsule is lined by a synovial membrane

4. The articulating surfaces are covered by cartilage, usually hyaline but can be fibrocartilage (in the latter case the joint is classified as an atypical synovial joint, e.g. sternoclavicular joint and temporomandibular joint)

5. There is a small amount of synovial fluid between the articulating bones

Articular Endplate
The ends of bones, consisting of layers of hyaline cartilage, compact bone and spongy bone

Articular Cartilage
Hyaline cartilage consisting of tough, fibrous connective tissue
It forms a shock absorbing, smooth, resilient, low friction surface for movement of one bone over another
Distribution is greater on regions that are congruent during normal weight bearing activities

Fibrocartilage
A type of cartilage having: parallel, thick, collagenous bundles. Wedges of fibrocartilage, called menisci, disks, and labrums are used to:
- Increase stability
- Provide shock absorption
- Facilitate movement

Joint Capsule
Outer layer
- Dense fibrous tissue, completely encircles ends of bones
- Attached to periosteum
- Reinforced by ligamentous and musculotendonous structures that cross joint
- Low vascularization
- High innervation (detects rate and direction of motion, compression and tension, vibration, pain)

Inner layer
- Highly vascularized
- Low innervation
- Contains synovial membrane
- Synthesizes synovial fluid
Synovial Membrane and Fluid
- A liquid that reduces friction in the joint; the joint changes viscosity in response to joint movement (one of the reasons for the importance of a warm-up)
- Similar to blood plasma but with 2 additional substances (Hyaluronate and Lubricin)

Ligaments
- Connect bone to bone
- Comprised of collagen
- Collagen is arranged to handle both tensile loads and shear loads
- Maintain the contact surfaces at the joint!
- They do this by either limiting or completely preventing “unwanted” (potentially harmful) motion
- Ligaments are the passive stabilizers of the joint - not meant to be stretched!!!
### Types of Diarthrodial Joints

<table>
<thead>
<tr>
<th>Joint Type</th>
<th>Movement</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Saddle</strong></td>
<td>2 saddle shaped surfaces allowing 2 degrees of freedom</td>
<td>Carpo-metacarpal Joint of the thumb</td>
</tr>
<tr>
<td><strong>Condyloid</strong></td>
<td>Biaxial; one plane of movement that dominates 2 planes of motion</td>
<td>Tibiofemoral Joint, Interphalangeal Joint</td>
</tr>
<tr>
<td><strong>Hinge</strong></td>
<td>One degree of freedom</td>
<td>Humeroulnar</td>
</tr>
<tr>
<td><strong>Plane</strong></td>
<td>Flat surface that allows translation between two bones</td>
<td>Acromio-clavicular Joint</td>
</tr>
<tr>
<td><strong>“Gliding”</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Pivot</strong></td>
<td>One Degree of freedom; movement in one plane; pronation, supination, rotation</td>
<td>Atlantoaxial Joint</td>
</tr>
<tr>
<td><strong>Multiaxial</strong></td>
<td>“Ball and Socket;” 3 degrees of freedom, freely movable, allowing motion in all planes</td>
<td>Hip Joint</td>
</tr>
</tbody>
</table>
**Joint Forces**

*Joint Forces* are produced from the orientation of the contact surfaces of the joint and the forces being placed on the lever.

<table>
<thead>
<tr>
<th><strong>Compression:</strong> Force upon the lever is directed toward the contact surfaces</th>
<th><strong>Distraction:</strong> Force upon the lever is directed away from the contact surfaces</th>
<th><strong>Shear:</strong> Force that lies parallel to the contact surface. If two forces are present and are in opposite directions. Think friction or a rubbing force</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Compression Diagram" /></td>
<td><img src="image2" alt="Distraction Diagram" /></td>
<td><img src="image3" alt="Shear Diagram" /></td>
</tr>
</tbody>
</table>

**External Force Application and Anchor Points**

- Anchor Points are the points at which load enters and exits the body
- The way a load affects the joints between these points depends on the relationship between the two points
- Passive stabilization may decrease the active stabilization requirements at the joint
  - Increasing neurological energy, less able to do load and vice versa
Joint Range of Motion

*Rotary/Angular Motion* is measured in degrees or radians

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**Determining ROM at a Joint**

Linear measurements are unsatisfactory. Professional judgment is the most effective. As an Instructor, your judgment is the key in determining the correct ROM for the individual. Joint mobilization is an increase in ROM after a determined point.

**ROM Training**

*Passive ROM* is joint movement created by an external force. Muscles involved are encouraged to relax.

*Active ROM* is performing ROM independently under the power of the muscles surrounding the joint.

*Reciprocal inhibition* is the activation of a muscle will inhibit tension in it’s antagonist.

*Ballistic ROM* is controlled or uncontrolled inertia.

**Neuromuscular Response to Stretching:**

*Golgi Tendon Organ*: sensory receptor that inhibits tension development in a muscle and initiates tension in its antagonist

*Muscle Spindle*: sensory receptor that provokes reflex contraction in a stretched muscle and inhibits tension in its antagonist.
## Normal Joint ROM

<table>
<thead>
<tr>
<th>Joint</th>
<th>Movement</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ankle</strong></td>
<td>Dorsiflexion</td>
<td>10-20°</td>
</tr>
<tr>
<td></td>
<td>Plantarflexion</td>
<td>45°</td>
</tr>
<tr>
<td></td>
<td>Inversion</td>
<td>30°</td>
</tr>
<tr>
<td></td>
<td>Eversion</td>
<td>20°</td>
</tr>
<tr>
<td><strong>Shoulder</strong></td>
<td>Flexion</td>
<td>160-180°</td>
</tr>
<tr>
<td></td>
<td>Horizontal Flexion</td>
<td>135°</td>
</tr>
<tr>
<td></td>
<td>Extension</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Shoulder Abduction</td>
<td>160-180°</td>
</tr>
<tr>
<td></td>
<td>Adduction</td>
<td>50-75°</td>
</tr>
<tr>
<td><strong>Hip</strong></td>
<td>External Rotation</td>
<td>45°</td>
</tr>
<tr>
<td></td>
<td>Internal Rotation</td>
<td>35-40°</td>
</tr>
<tr>
<td></td>
<td>Flexion</td>
<td>90-120°</td>
</tr>
<tr>
<td></td>
<td>Extension</td>
<td>15-30°</td>
</tr>
<tr>
<td></td>
<td>Abduction</td>
<td>30-45°</td>
</tr>
<tr>
<td></td>
<td>Adduction</td>
<td>30°</td>
</tr>
<tr>
<td><strong>Wrist</strong></td>
<td>Supination (radioulnar)</td>
<td>90°</td>
</tr>
<tr>
<td></td>
<td>Pronation (radioulnar)</td>
<td>90°</td>
</tr>
<tr>
<td><strong>Spine</strong></td>
<td>Lumbar Flexion/Extension</td>
<td>12-20° between each vertebrae (total with thoracic - approx 75-90° flexion and 30° extension)</td>
</tr>
<tr>
<td></td>
<td>Lumbar Flexion Lateral</td>
<td>3-8° between each vertebrae (total with thoracic - approx 35° each side)</td>
</tr>
<tr>
<td></td>
<td>Lumbar Rotation</td>
<td>1-5° between each vertebrae (total with thoracic - approx 30° each side)</td>
</tr>
<tr>
<td></td>
<td>Thoracic Flexion/Extension</td>
<td>3-12° between each vertebrae</td>
</tr>
<tr>
<td></td>
<td>Thoracic Flexion Lateral</td>
<td>5-8° between each vertebrae</td>
</tr>
<tr>
<td></td>
<td>Thoracic Rotation</td>
<td>2-9° between each vertebrae</td>
</tr>
<tr>
<td></td>
<td>Cervical Flexion/Extension</td>
<td>3-12° between each vertebrae (approx 45° flexion and 55° extension)</td>
</tr>
<tr>
<td></td>
<td>Cervical Flexion Lateral</td>
<td>0-9° between each vertebrae (approx 40° each side)</td>
</tr>
</tbody>
</table>
Joint Stability

*Closed-packed Position*

Joint position in which there is max contact between two joint surfaces, and in which the ligaments are taut, forcing two bones to act as a single unit. For example, a “locked” (fully extended) knee or elbow.

Very stable, but vulnerable to injury due to decreased mobility and end range of muscular system.

*Loose-packed Position*

Joint position with less than max contact between joint surfaces and in which contact areas are frequently changing. For simplicities sake, you can look at this as any other joint position that is not closed-packed (not locked).

Less stable than closed-packed, but not as susceptible to injury because of increased mobility and muscular ability.

*Joint Stability and Exercise*

**Passive Stabilization:**

  **Internal passive stabilization**
  By noncontractile components (ex: Ligaments)
  Needed when: Anatomically no muscular support (ex: lateral knee), physiologically no muscular support (ex: no motor pattern), active insufficiency

  **External passive stabilization**
  Ex: Bench

**Active Stabilization:** Generated from muscular system

**Static:**
Through an isometric contraction of various muscular groups to prevent movement at a joint
Not very functional, but is often required for proper force distribution

**Dynamic:**
This is stabilization that takes place throughout motion. The prevention of undesirable motions is controlled by dynamic stabilizers in order to maintain relative positions of the appropriate segments.
Types of Stretching

There are various forms of stretching and means of achieving flexibility. Depending upon the goal of the individual and current level of conditioning, certain forms of stretching may be more appropriate than others.

Static Stretching
Static stretching requires a gradual lengthening of the muscle by holding a position at the first point of resistance for 20-30 seconds to allow the GTO to override the muscle spindle and allow the muscle to relax and reach a greater ROM.

Dynamic Stretching
Dynamic stretching involves constant, controlled motion through a full ROM to stimulate blood flow and warm-up the desired muscle group.

Ballistic Stretching
Ballistic stretching is a quick, explosive movement that usually involves bobbing, bouncing, and jerking to prepare muscles for an explosive maximal lift or sport related movement.

PNF
PNF or Proprioceptive neuromuscular facilitation involves the use of a partner-assisted stretch involving both passive and active muscle actions. PNF utilizes the principles of autogenic and reciprocal inhibition by contracting the agonist against a partner while the antagonist relaxes, allowing the antagonist to reach a new ROM. For example, in a lying hamstring stretch, the partner would be used as a wall (not applying force) while the person being stretched contracts their hamstrings against the partner for 6-10 seconds to enable the muscle to relax (autogenic inhibition) then gains an increased ROM by contracting the quadricep to raise the leg higher as the hamstrings relax (reciprocal inhibition). This should only be performed by experienced and trained fitness professionals

SMFR
Self-myofascial release or SMFR utilizes the principle of autogenic inhibition as the muscle contracts due to the pressure from a Styrofoam roller (active release due to external pressure on muscle or connective tissue). The individual maintains their position until the GTO overrides the muscle spindle and continues rolling along the length (perpendicular to the roller) of the muscle in the same fashion.
Summary

As stated in the beginning of this section, Sport Yoga has tremendous benefits to offer your clients. It is vital, however that the Sport Yoga instructor have a strong grasp of human structure and function. It is not only important that you, the instructor, understand how the body moves. It is more important you understand how it is meant NOT to move. Sport Yoga must be taught so no unnecessary or excessive strain is put on the joints. Therefore, the instructor must understand what types of forces are going through each joint in every pose. Furthermore, the non-contractile tissues that are not meant to be stretched (tendons and ligaments) should be protected while the contractile tissues that should be stretched (the muscles) are lengthened.