









Physiology of Stretching

White Crow Yoga

Learning Objectives

Students Should Be Able To:

- Understand biomechanical processes and interactions as a way of balancing forces and energies throughout the body 
- Define the terms muscle origin, muscle insertion and stretching 
- Differentiate between flexibility and mobility 
- Understand dissociation and proper joint centration 
- Explain joint mobility and stability 
- Identify 2 categories of movement limitations 
- Explain 3 factors that determine joint movement 
- Understand the role of muscle receptors and the CNS in movement 

Learning Objectives (Continued)

- Explain the role of spinal cord reflexes during muscle contractions ❤️
- Summarize how the muscle spindle stretch receptor helps protect the muscle from overstretching or tearing ❤️
- Define ballistic, passive and facilitated stretching techniques ❤️
- Describe how we can use reciprocal inhibition (RI) to increase muscle length ❤️
- Define the role of the Golgi tendon organ (GTO) in PNF stretching ❤️
- Employ and Assess Reciprocal Inhibition and GTO techniques in several yoga poses ❤️

Understand biomechanical processes and interactions as a way of balancing forces and energies throughout the body

“You must balance all of the energies in each part of the body.” – BKS Inyengar



“Understanding the forces that act upon the body and how the muscles and joints interact is one of the keys to balancing the forces and energies within the body.” (Ray Long)

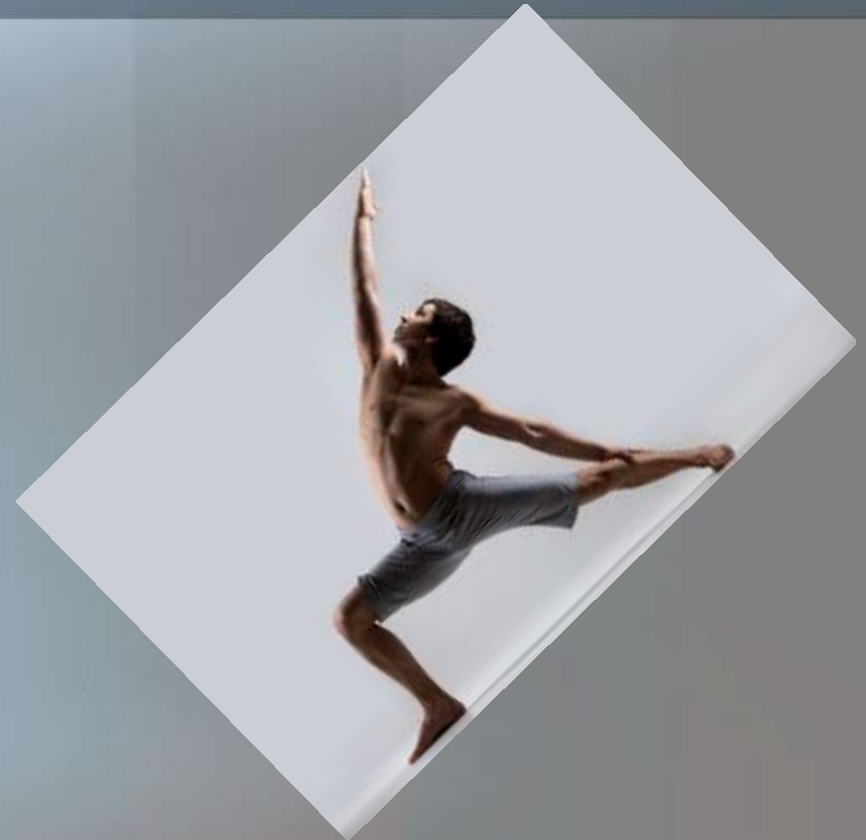


The brain controls the skeletal muscles by signaling them via the CNS to contract or relax. This causes joint movement.

Muscle groups surround joints and produce movement by contracting. These are the agonists or prime movers.

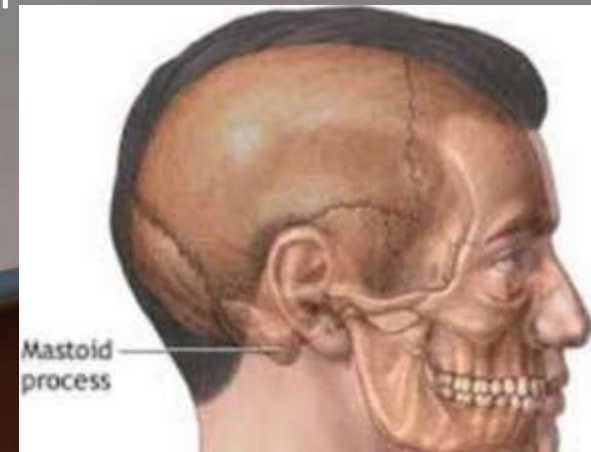
Synergist muscles aid the prime movers while antagonist muscles oppose the prime movers.

Working together, the various muscles work to balance the energies within the body.



Define the terms muscle origin, muscle insertion and stretching

- 2 Types of Muscle Attachments: Origins and Insertions
 - Origins and Insertions are distinguished by the relative degree of movement of the bone to which they attach
- Muscle origins generally attach to bones that provide stability
- Insertions are at the more mobile attachment
- Example
 - SCM (sternocleidomastoid) runs from the sternum to the mastoid process
 - Mastoid process is more mobile while chest is more stable
 - Mastoid process is insertion (mobile)
 - Sternum is origin (stable)



Source: <https://youtu.be/dfY3STzRH7Q>



Stretching is moving the origin
and insertion farther apart



Flexibility and Mobility

- Now that we know what stretching means, we can use it to understand flexibility
- Flexibility: Ability of a muscle to temporarily stretch or lengthen



Flexibility and Mobility

- Mobility: Ability of a joint to actively move through its intended range of motion.
- We could be flexible, yet lack mobility
 - If we can passively hold a static stretch so the muscle is very lengthened, we would have good flexibility
 - But, if we can't actively move that joint and muscle with proper alignment, then we are not mobile even though we have flexibility

Flexibility and Mobility

- Flowing yoga poses are beneficial for mobility
 - We need to learn to 'track' or move with good alignment
 - For example, can you flow the front knee in and out of warrior 1 or 2 without dropping the knee or hip out of alignment
 - This calls for optimal joint centration or positioning of joints
 - This creates better neurological development, needed for healthy movement
 - We need to sometimes move the spine and limbs together
 - For example, flow the front knee in/out of warrior 1, open the abducted arms, then close the abducted arms in front of the chest while rounding the spine
 - This helps our neuromuscular system learn to coordinate movement and benefits us in ways that static flexibility doesn't
 - Of course, flexibility is needed, but it is not the only component to movement

Flexibility and Mobility

- Flowing yoga poses are beneficial for mobility
 - Think about a baby crawling – they move arms, legs, spine
 - They don't keep the spine stable – they let it move!
 - What happens if we don't sometimes move spine/limbs together?
 - Gym exercises usually call for bilaterally moving extremities around a fixed spine
 - This locks the thorax and causes hypermobility compensations in the limbs



Joint Centration and Dissociation

- Earlier, we mentioned joint centration. This is proper alignment of a joint that allows optimal distribution of workloads
- Dissociation refers to joints being able to move independently of each other
 - For example, can you move the femur in the hip joint without moving the pelvis and spine?
 - We need to be able to move together, and separately

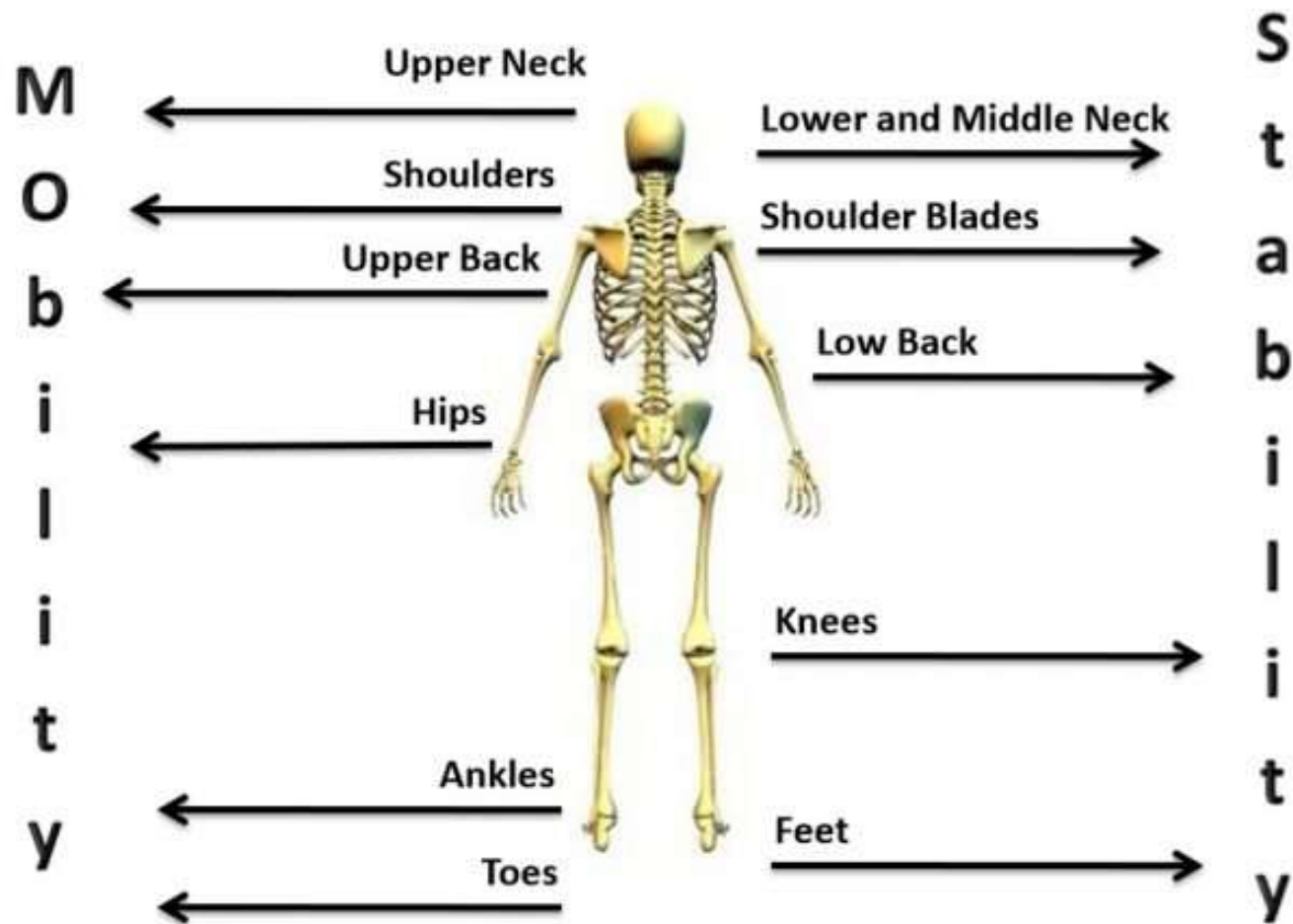
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Joint Mobility and Stability

- Some joints need more mobility than others, but all movable joints need some balance of mobility and stability
 - Each joint's balance of mobility and stability depends on the intended function
 - The more ligaments a joint has, the tighter or more stable the joint is
 - For example, the hip has more ligaments, making it a more stable joint
 - The shoulder has fewer ligaments, making it a more mobile joint
- Stability depends on the tone of the muscles surrounding the joint, the health of the joint and the centration of the joint
 - This means it also depends on dissociation of the joint, because the ability to separate movement within a joint depends on muscles around the joint as well as joint health

Joint By Joint Concept



Movement Limitations

- What stops you from moving further in a yoga pose?
- 2 Things: Tension or Compression
- There may be multiple things that contribute to these, but they all come down to 1 of these 2 things
- Tension: Soft tissue limitation, such as tightness in the muscles or ligaments
 - You've hit a boundary that may change over time
- Compression: Skeletal structure limitation
 - You've hit a boundary that will not change due to bone structure
 - You may 'go around it' by moving in a different way, such as widening the hands in down dog or 4 limbed staff, but you can't change the shape of your bones

3 Factors that Determine Joint Movement

- Bone Shape
- Joint Capsule and Ligaments Around Joint (Capsuloligamentous Structures)
- Muscles Surrounding the Joint

Bone Shape

- A deep socket (hip) has more limited movement but great stability
- A shallower socket (shoulder) has more mobility, but less stability

Joint Capsule and Ligaments

- These structures fasten bones to each other
- A joint capsule surrounds a synovial joint and has 2 parts: an outer fibrous layer and an inner synovial layer
- If the joint capsule is more lax, there's more mobility
- The thickness of ligaments within a joint contributes to stability. Thicker ligaments create more stability
- Thinner, more malleable ligaments create allow more mobility
- You do not want to endeavor to create a lot of stretch in the ligaments
 - They are tight for a reason – to hold the joints together!

Muscles Surrounding the Joint

- Tight muscles limit mobility
- You need enough tightness and strength to maintain stability
- You need enough flexibility to maintain mobility
 - It's a balancing game!
- Limited mobility in 1 joint can create hypermobility in other joints
 - The body does whatever it can to create the intended movement
 - This means compensations

Proprioceptors

Definition:
Sensory organs in muscles, tendons and joint capsules that sense the joint position or state of muscle contraction or muscle length

“Receptors within joints and muscles detect movement and changes in muscle tension and length. These receptors signal the CNS, which respond by regulating the contractile state of muscles.” This impacts joint ROM.

Ray Long, Key Poses of Yoga

3 Types of Proprioceptors (Muscle Receptors)

Type	Location	Function
Muscle Spindles	Embedded in muscles	Provide feedback used to control movement and posture
Golgi Tendon Organs	Interface of muscles and tendons and joint receptors	Signals muscle to relax when it contracts too much
Low Threshold (slowly adapting) Joint Mechanoreceptors	Embedded in Joint Capsules	Helps with spatial awareness

3 Types of Stretching

Type of Stretching	Description
Ballistic	Uses 'jumping' type actions. Vinyasa flow series movements are examples. This is useful for 'resetting' muscle length to that attained previously. Sun Salutations are examples.
Passive	Uses body weight, gravity and synergist/agonist muscle groups to create a stretch. The body is placed in a position and held for a longer period to allow stretch receptors to acclimate. Holding passive stretches for longer periods also lengthens the non-contractile elements of muscle, such as fascia.
PNF (Proprioceptive Neuromuscular Facilitation)	Involves briefly contracting muscles targeted for stretching, which invokes the GTOs, signaling the muscle to relax so the stretch can deepen

Muscle Receptors and the CNS

- Muscle spindle stretch receptors work with the Central Nervous System to protect the muscle from overstretching or tearing
- When a muscle stretches, the muscle spindle sends a signal to the spinal cord which signals the muscle to contract and resist the stretch
- This protects the muscle and tendon from tearing and is called a “spinal cord reflex arc”
- When the muscle spindle detects a change in length and tension, it signals the muscle to contract
 - It is saying, “Hold up! You are stretching me too far or too fast, so I better contract to keep you from tearing.”

How Can We Use This Knowledge?

- Never force the body in a stretch. This intensifies the firing of the muscle spindle, causing the muscle to contract, which is the opposite of what you are trying to do
- Instead, work with the spinal cord reflex arcs to decrease the reflex contraction and then ease deeper into the pose
 - Holding the stretch 30-60 seconds decreases firing of muscle spindle, allowing muscle to relax
 - Try coaxing the muscle spindle to reduce its firing by going into a stretch, backing out of it for a few period, and then seeing if you can go back into it a little deeper
 - For example, go into Uttanasana, then go to Ardha Uttanasana for a few breaths, then see if you can go deeper into Uttanasana

Reciprocal Inhibition

- When the agonist muscle contracts, the antagonist relaxes
- This is a primitive spinal cord reflex known as reciprocal inhibition
- We can consciously access this to deepen a stretch by purposely contracting the opposing muscle from the one we are trying to stretch
- For example, in Paschimottanasana, contracting the quads signals the hamstrings to relax

Golgi Tendon Organ

- If the GTO receptor senses an increase in tension, it tells the muscle to relax (which is the opposite of the muscle spindle reflex, which tells the muscle to contract)
- The GTO forms the basis for proprioceptive neuromuscular facilitation (PNF)
- In PNF, we temporarily contract a muscle to stimulate the GTO, which in turn creates a relaxation response so we can get a deeper stretch
- For example, in Janu Sirsasana:
 - Find the 'set length' by going to a level where you feel a good stretch, but not over stretching
 - Then, create a hamstring contraction by slightly bending the knee and pressing the heel into the floor
 - You may even want to drag the foot along the floor as you slightly bend the knee, but only contract the muscle to 20% or less of its maximal force and hold for 8-10 seconds
 - Then relax for 1 breath
 - Contract the quad muscle by straightening the knee to take the hamstring out to a new 'set length' and see if you can bend a little deeper into the stretch

PNF

- Spend a few months stretching before employing the GTO technique
- Maintain proper joint alignment while stretching
- Focus on using PNF on one pose per yoga session and do no more than 3 cycles of the stretch using the GTO technique
- Ray Long's stance is that we should allow 48 hours recovery before trying the GTO technique on the same muscle again
 - Other studies do not make this recommendation (recommend less or more)
 - <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3588663/> study used 5 straight days with PNF stretches

PNF

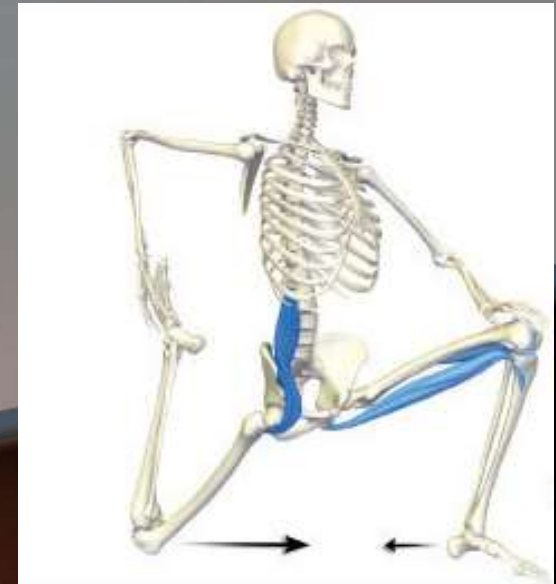
- The ACSM (American College of Sports Medicine) recommends PNF stretching be performed with a 6 second contraction followed by a 10-30 second assisted stretch. McCallister et al (2004) found that longer recovery days between PNF sessions enhanced flexibility, with 96 hours of rest between sessions optimal
- *McCallister TL, et. al. (2004). Days of rest between stretching bouts increased hamstring flexibility. Journal of Athletic Training. Supplement 39(2), 99-100.*

GTO and Facilitated Stretching

- In Gomukhasana, attempt to pull the hands apart which affects the muscle-tendon junctions of the infraspinatus and teres minor muscles of the rotator cuff, the front of the deltoid and the upper pecs (in the lower arm of the pose) as well as the subscapularis (part of rotator cuff), latissimus dorsi and teres major (in the upper arm of the pose).
- The firing of GTO creates a relaxation responses, so you will usually find you can grasp the hands closer together, as the GTO firing created some slack in the pose.
 - Some students find it works best to release the 'pulling apart of the hands' and then they find a deeper place in the pose

GTO and Facilitated Stretching

- Let's look at Facilitated Stretching of the Hip Flexors in this Modified Lunge Pose
 - The knee of the back leg and foot of the front leg are fixed on the mat
 - Attempt to drag the back knee toward the front foot, eccentrically contracting the psoas, which fires the GTOs
 - Contract the front leg hamstrings and attempt to drag the front foot toward the back knee
 - The front foot is fixed, so the force of this contraction is transmitted to the back leg psoas, causing even more firing of the GTOs of that muscle, creating a relaxation response
 - Try it now!



Putting It All Together

Let's practice Janu Sirsasana again as we review the principles

1. Assume the pose with a moderate stretch, which **fires the muscle spindle reflex**, causing the hamstrings to contract
2. Contract the quad and lighten the hamstring stretch by bending the knee, drag the foot along the floor. Hold this bent knee position for 2-3 breaths while you are somewhat backed off from the pose. **This reduces the firing of the muscle spindle**, which is desirable since the muscle spindle firing will cause contraction and we want to relax
3. Contract the quad, straightening the knee as you draw the hamstrings out to length. This quad contraction causes **reciprocal inhibition**, which further relaxes the hamstring
4. Attempt to press the heel into the ground by contracting the hamstrings, which **fires the GTO** and relaxes the hamstring